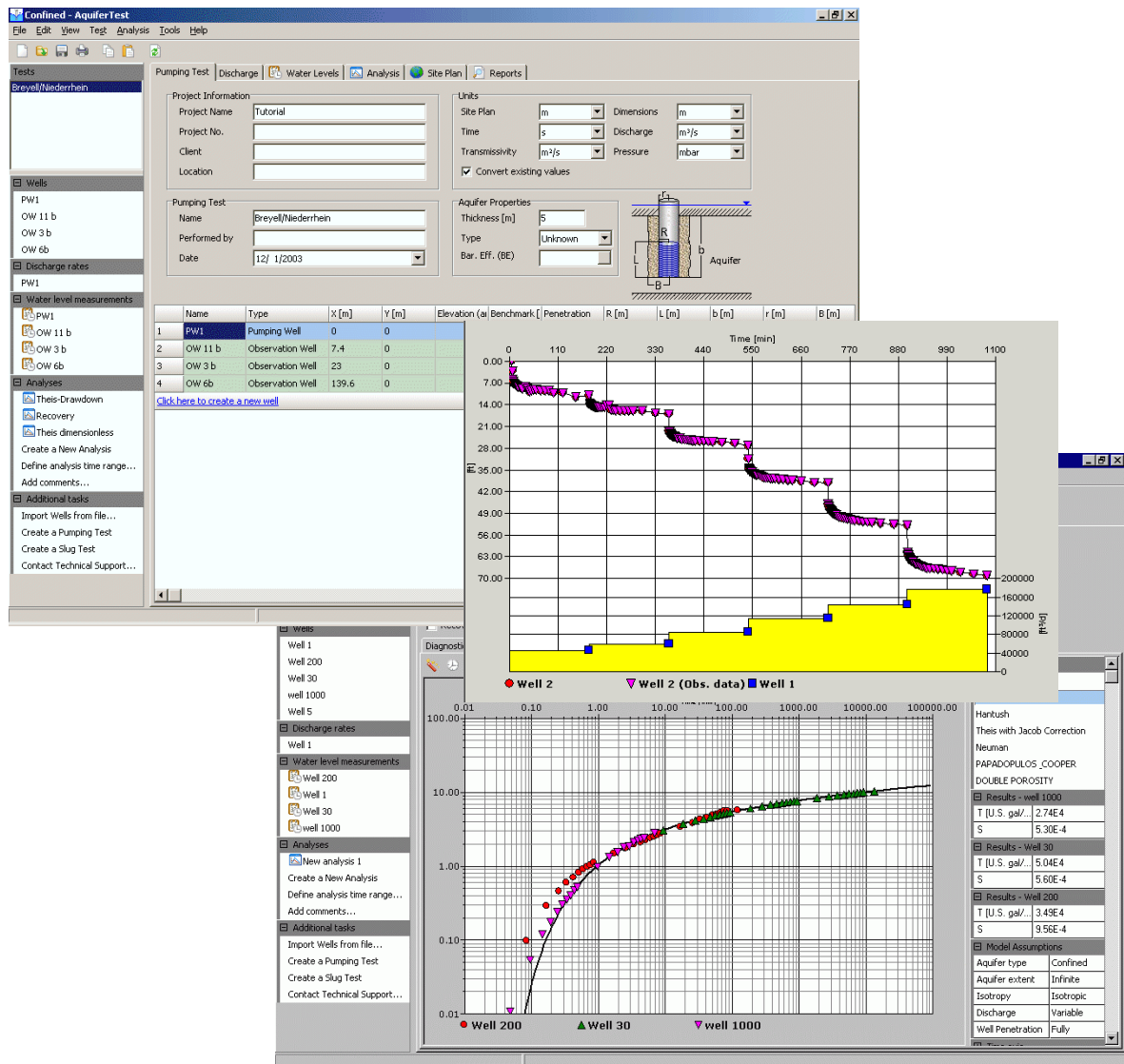


# AquiferTest Pro v.4.1

## Demo Tutorial

Advanced Pumping Test & Slug Test Analysis Software



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Waterloo Hydrogeologic, Inc., A Schlumberger Company

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# Table of Contents

<b>Introduction</b>	<b>3</b>
Limitations of Demo Version	3
<b>Main Features</b>	<b>3</b>
Project Set-up Features	4
Data Entry Features	4
Data Analysis Features	4
Graphing and Printing Features	5
<b>Exercise 1: Confined Aquifer Pumping Test Analysis</b>	<b>5</b>
Project Details	6
Project Navigator	6
Project Information	6
Entering Discharge Data	7
Entering Water Level Data	8
Creating an Analysis	9
Time vs. Drawdown	9
Theis Analysis	10
Contouring Drawdown	18
Determining the effect of the second pumping well	22
<b>Exercise 2: Predictive Analysis</b>	<b>26</b>
Returning to static level conditions	28
Creating a Report	30
<b>Exercise 3: Single Well Analysis</b>	<b>31</b>
Interpreting Well Effects with Derivative Analysis	34
<b>Exercise 4: Slug Test Analysis</b>	<b>36</b>
Hvorslev Analysis	39
Bouwer & Rice Analysis	40
Creating a Report	41

# Introduction

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**AquiferTest Pro** from Waterloo Hydrogeologic is the latest software technology for graphical analysis and reporting of pumping and slug test data. This powerful yet easy-to-use program has everything you need to quickly calculate the hydraulic properties of your aquifer using a comprehensive selection of pumping and slug test solution methods for:

- Confined aquifers
- Unconfined aquifers
- Leaky aquifers, and
- Fractured rock aquifers

In addition, it is possible to analyze the effects of well interference, and also to account for:

- Recharge and barrier boundary conditions
- Wellbore storage
- Partially penetrating pumping and observation wells
- Multiple Pumping Wells
- Variable pumping rates.

**AquiferTest Pro** can be used as a predictive analysis tool, to calculate water levels / drawdown at any given point based on estimated transmissivity and storativity values. This new functionality allows you to optimize the location of pumping wells, effectively plan your next pumping test.

This demo tutorial has been designed to explore many features of **AquiferTest Pro**, and has been divided into three sections:

- Exercise 1: Confined Aquifer Pumping Test Analysis
- Exercise 2: Predictive Analysis
- Exercise 3: Single Well Analysis
- Exercise 4: Slug Test Analysis

## Limitations of Demo Version

The Demo version of AquiferTest is designed to provide you with a brief overview of the capabilities of the software. The following limitations exist:

- The Save and Save As features have been disabled
- Maximum of 20 data points
- A watermark “Demo Version” will appear on all print templates

## Main Features

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For your convenience a description of the main program features has been included below.

## Project Set-up Features

- Customizable units for length, time, discharge, conductivity, and transmissivity
- Import basemaps from common graphic formats (.dxf, .bmp, .wmf., .emf, .jpg)
- Display well locations on the basemap
- Enter company information and import company logo for printed results

## Data Entry Features

- Intuitive data entry forms
- Cut-and-paste data from Windows clipboard
- Import well locations and geometry from a text file
- Import and filter data from virtually any datalogger file
- Save datalogger import templates (huge time saver!)
- Customizable water level datum (top-of-casing, sea level, or benchmark)
- On-screen display of water level vs. time graph
- Quickly navigate through all data using the Project Navigator

## Data Analysis Features

**AquiferTest** supports pumping test solutions for the following conditions:

- Confined Aquifers
- Unconfined Aquifers
- Leaky Aquifers
- Fracture Flow (Dual Porosity) Aquifers
- Fully and partially penetrating Pumping wells and/or Observations wells or Piezometers
- Infinite extent of Aquifer or bounded by recharge or barrier boundary
- Isotropic or Anisotropic Aquifer
- Constant or Variable discharge rates
- Single or Multiple pumping wells
- Well losses and well storage

In addition, the following analysis tools are available:

- Use the Diagnostic Plots to select the appropriate solution method for your aquifer conditions
- Select from a comprehensive list of pumping and slug test solution methods for confined, unconfined, leaky, and fractured rock aquifers and then adjust the assumptions to fit your particular model
- Simultaneously analyze data from several different pumping tests
- Easily compare and interpret different solution methods for the same data set
- Analysis Status Report tells you when data is missing and how to correct the problem
- Easily remove selected data from an analysis graph
- Fit your data using manual or automatic curve matching (for all data series, or only for selected data in a series)

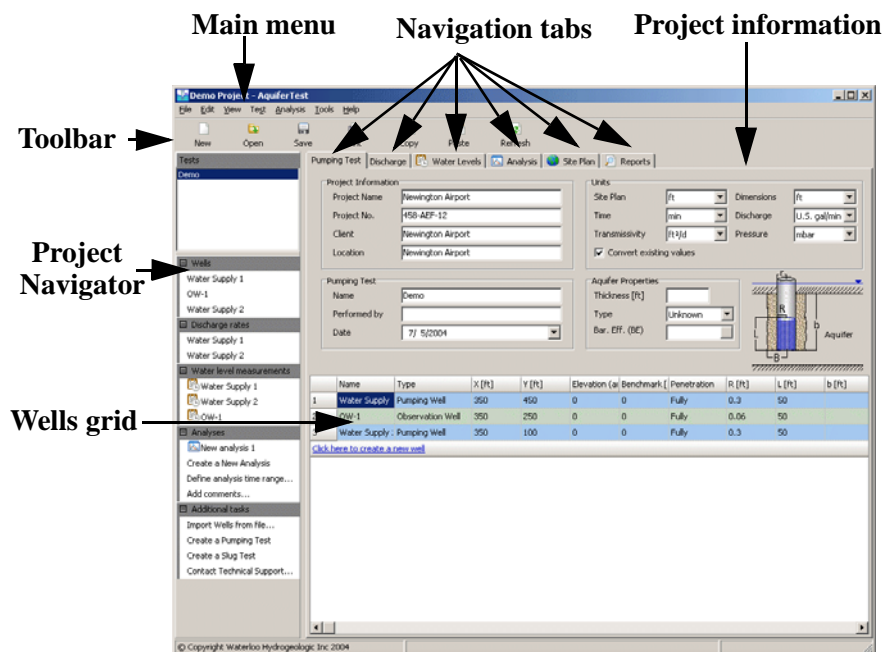
## Graphing and Printing Features

- Customize the appearance of the graphs (titles, fonts, lines, axes, symbols, colors, etc.)
- Print the map view, tabulated test data, and analysis graphs using professional report layouts

## Exercise 1: Confined Aquifer Pumping Test Analysis

If you have not already done so, **double-click** the **AquiferTest Demo** icon to start the program. The **AquiferTest** splash screen will appear followed by a blank project.

- [1] Select **File/Open** and browse to the folder AquiferTest\Demo\.
- [2] Locate the file DemoProject.HYT, and click [**Open**] and the following window will appear:



The **AquiferTest** window is set up so the information can be entered in logical succession from left to right using **Navigation tabs**.

- **Pumping Test** tab (or Slug test, as the case may be) contains project, test, and aquifer information including units.
- **Discharge** tab (pumping test only) contains discharge data for the pumping wells.
- **Water Levels** tab contains data for observation wells, pumping wells, and piezometers used in the selected test.

- **Analysis** tab houses all functions needed to perform all analyses available in **AquiferTest**.
- **Site Plan** tab allows wells to be plotted on a site map, and also contour drawdown data
- **Reports** tab allows you to tailor the printed report to your specifications.

## Project Details

The pumping test was conducted at Newington Airport, which overlies a 40-foot thick sand and gravel aquifer. There are 3 fully-penetrating wells in the area (**Water Supply 1**, **Water Supply 2**, and **OW-1**). **Water Supply 1** was pumped at 150 GPM (gallons per minute) for 24 hours. **OW-1** is located 200 feet south of **Water Supply 1**. **Water Supply 2** will be activated in the second exercise

The objective of this section is to examine drawdown data from **OW-1** and determine the aquifer transmissivity and storativity. The project basics have already been established including the units and site map (.bmp).

## Project Navigator

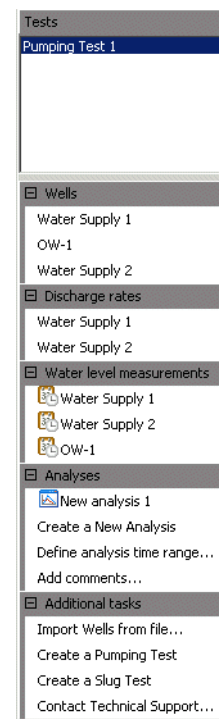
The project navigator allows you to easily switch between all functional parts of **AquiferTest**.

Clicking on any well in their respective frames will take you to that part of the program where that information is displayed or required (i.e. clicking on **OW-1** in the **Water Levels** frame will take you to the **Water Levels** tab and activate **OW-1** for water level data entry)

Two lower frames of the **Project Navigator** also provide access to the most frequently used functions of **AquiferTest**. From here you can access any analysis you have created, create a new analysis, define time range for the data used in analysis, add comments to the analysis, import wells from a data file, create a new pumping test, create a new slug test, and contact tech support.

You can hide the **Project Navigator** by choosing **View/Navigation Panel**.

You can collapse any and all frames in the **Project Navigator** by clicking the [-] button beside the header of each frame.



## Project Information

The top portion of the **Pumping Test** tab contains information that describes the project details, test details, units, and aquifer parameters. Most of the information has been entered for you; however, some additional information is required.

- [3] In the **Pumping Test** frame:
- **Pumping Test Name:** Confined Aquifer Analysis
  - **Performed by:** Your Name
- [4] In the **Aquifer Properties** frame:
- **Aquifer Thickness:** 40
  - **Type:** Confined
  - **Bar. Eff.:** leave blank

As mentioned before, the units have been preset in this example, however you can easily change them using the drop-down menus beside each category and selecting the unit from the provided list.

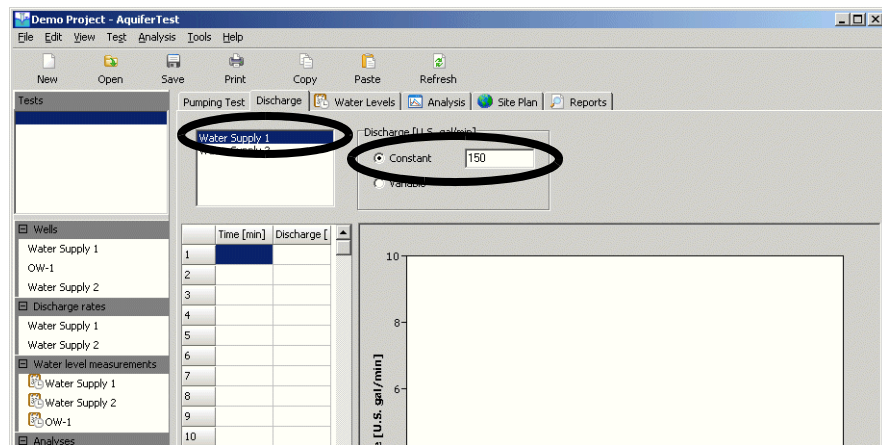
The **Convert existing values** checkbox allows you to convert the values to the new units without having to calculate and re-enter them manually.

On the other hand if you created a pumping test with incorrect unit labels, you can switch the labels by de-selecting the **Convert existing values** option. That way, the physical labels will change but the numerical values remain the same.

## Entering Discharge Data

Now you need to enter the discharge data for your **Water Supply** wells.

- [5] Click on the **Discharge** tab and activate **Water Supply 1** by choosing it from the wells list in the top left corner of the form.
- [6] Select **Constant** and enter the discharge rate of **150 US gal/min**, as shown below.



For this exercise, the pumping well **Water Supply 2** will not be used; this well will be “turned on” in the second exercise, in order to see the effects of multiple pumping wells.

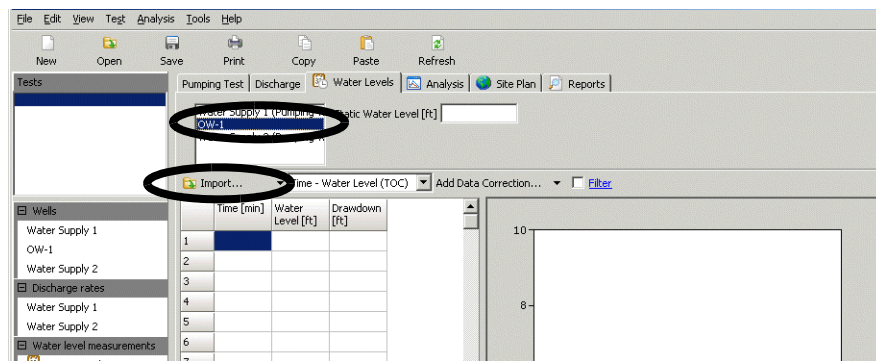



## Entering Water Level Data

In this section, you will import observation water level data from an Excel spreadsheet.

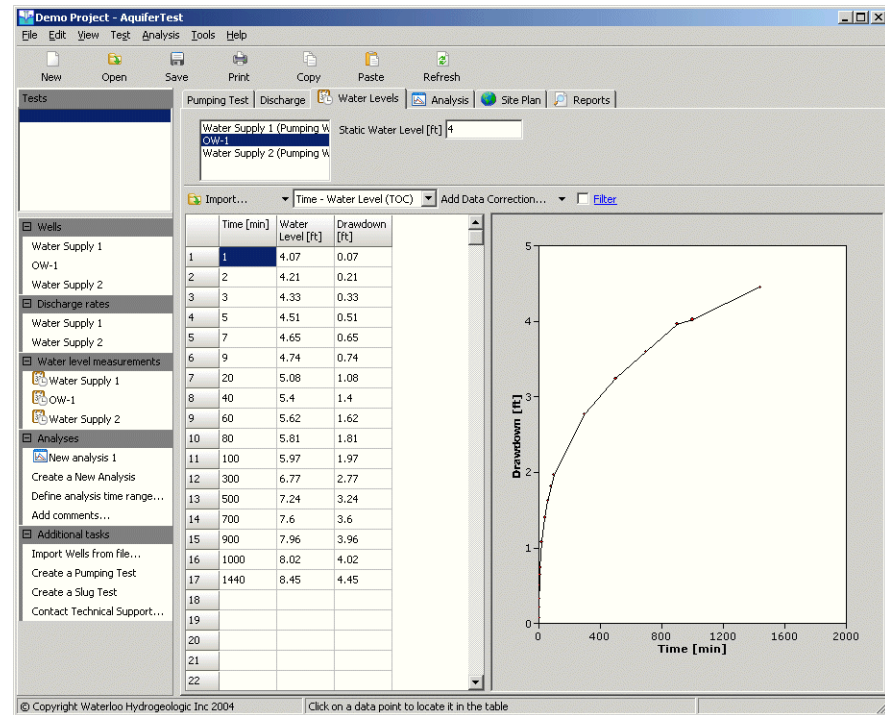
**AquiferTest** can also import data from a datalogger file or a delimited text file, and even paste from the Windows clipboard; this flexibility is important as your pumping test data can be stored in different formats.

- [7] Click on the **Water Levels** tab.
- [8] Select **OW-1** from the wells list in the top left corner of the form
- [9] Enter **4.0** as **Static Water Level**
- [10] From the main menu, select **File / Import / Water level measurements**, or click on the **Import** button (circled below)



- [11] In the dialog that appears, browse to the folder **AquiferTest\Demo\**.
- [12] Locate the file **OW-1.xls** file and click **[Open]**. The Water level measurements will appear in the table.
- [13] Click on the  (**Refresh**) button in the toolbar, to refresh the graph. You will see the calculated drawdown data appear in the **Drawdown** column and a

drawdown graph displayed on the right.



Over the 24-hour pumping test, water levels in the observation well dropped almost 4.5 feet.

## Creating an Analysis

In this section, you will create the analysis graphs, and calculate the aquifer parameters.

### Time vs. Drawdown

[14] Click on the **Analysis** tab.

[15] In the **Data from** frame, check the box beside **OW-1**.

The screenshot shows the 'Analysis' tab in the software. The 'Data from' section has a list box with 'OW-1' selected and checked. The 'Analysis Name' field contains 'New analysis 1'. The 'Appendix' field is empty. The 'Analysis performed by' field is empty. The 'Analysis date' field shows '9/23/2004'. Below these fields, a note states: 'Analysis is based on assumptions from Theis. Use the Analysis panel to modify the assumptions, or [click here](#) to select a new method.'

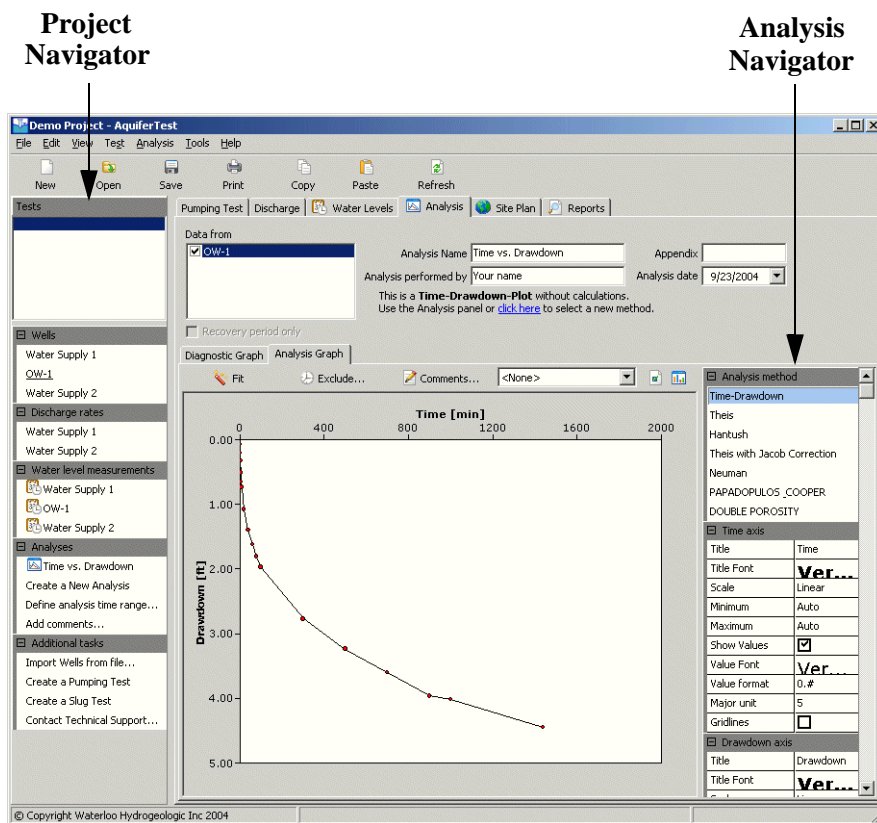
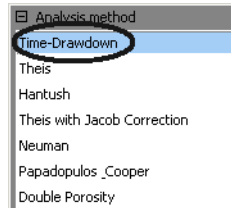
The first analysis you will perform on the data is the basic Time vs. Drawdown plot.

[16] At the top of the **Analysis** tab, complete the general information about the analysis as follows:

- **Analysis name:** Time vs. Drawdown
- **Performed by:** your name

- **Date:** choose current date from the drop-down calendar

[17] Select **Time-Drawdown** from the **Analysis Method** frame in the **Analysis Navigator**.



The Time vs. Drawdown analysis appears in the **Analyses** frame of the **Project Navigator**.

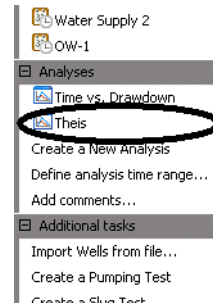
In the next section you will create Theis analysis of your data.

## Theis Analysis

- [18] Create a new analysis by selecting **Analysis/Create New Analysis** or clicking **Create New Analysis** in the **Analyses** frame of the **Project Navigator**.
- [19] At the top of the **Analysis** tab, complete the general information about the analysis as follows:

- **Analysis name:** Theis
- **Performed by:** your name
- **Date:** choose current date from the drop-down calendar

You will see the **Theis** analysis name is added to the analyses list in the **Analyses** frame of the **Project Navigator**.

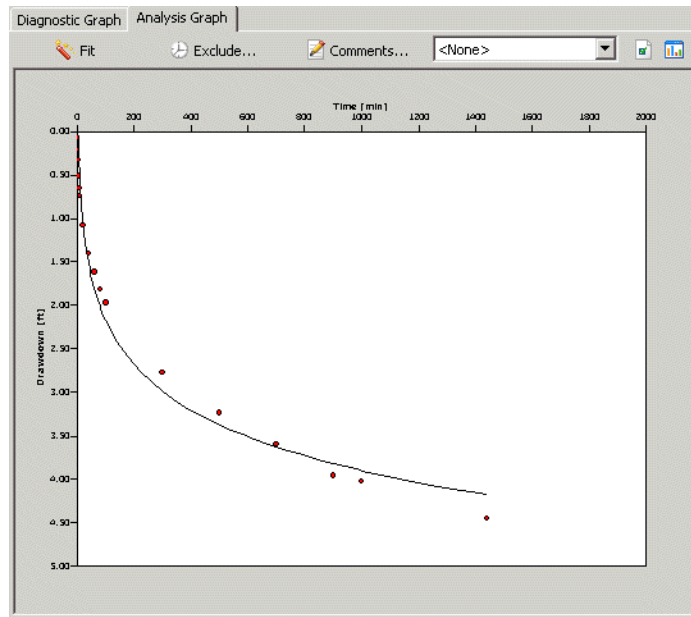


Theis is the default analysis selected for a pumping test for a confined aquifer.

[20] Click the **Automatic Fit** button above the graph to automatically fit the curve to the data.



Your graph should now look similar to the one shown below.



There are numerous graph and display options, such as gridlines, axis intervals, symbol size, and line properties. Feel free to experiment with these options now.

**AquiferTest** automatically calculates the **Transmissivity** and **Storativity** values and they are displayed in the **Results** frame of the **Analysis Navigator**:

Neuman	
PAPADOPULOS_COOPER	
DOUBLE POROSITY	
Results - OW-1	
T [ft <sup>2</sup> /d]	3.02E3
S	7.06E-4
Model Assumptions	
Aquifer type	Confined
Aquifer extent	Infinite

It is also possible to display the analysis using a dimensionless time drawdown plot (conventional Theis type curve). To see this option,

- [21] Expand the **Display** frame under the **Analysis Panel** (to the right of the main analysis graph).

Analysis method	
Time-Drawdown	
Theis	
Hantush	
Theis with Jacob Correction	
Neuman	
Papadopoulos_Cooper	
Double Porosity	
Model Assumptions	
Aquifer type	Confined
Aquifer extent	Infinite
Isotropy	Isotropic
Discharge	Constant
Well Penetration	Fully
Time axis	
Drawdown axis	
Diagram	
Display	
Data Series	<input checked="" type="checkbox"/>
Type Curve	<input checked="" type="checkbox"/>
Derivation of data points	<input type="checkbox"/>
Derivation of type curve	<input type="checkbox"/>
Dimensionless	<input type="checkbox"/>

- [22] Activate the **Dimensionless** option, as circled below.

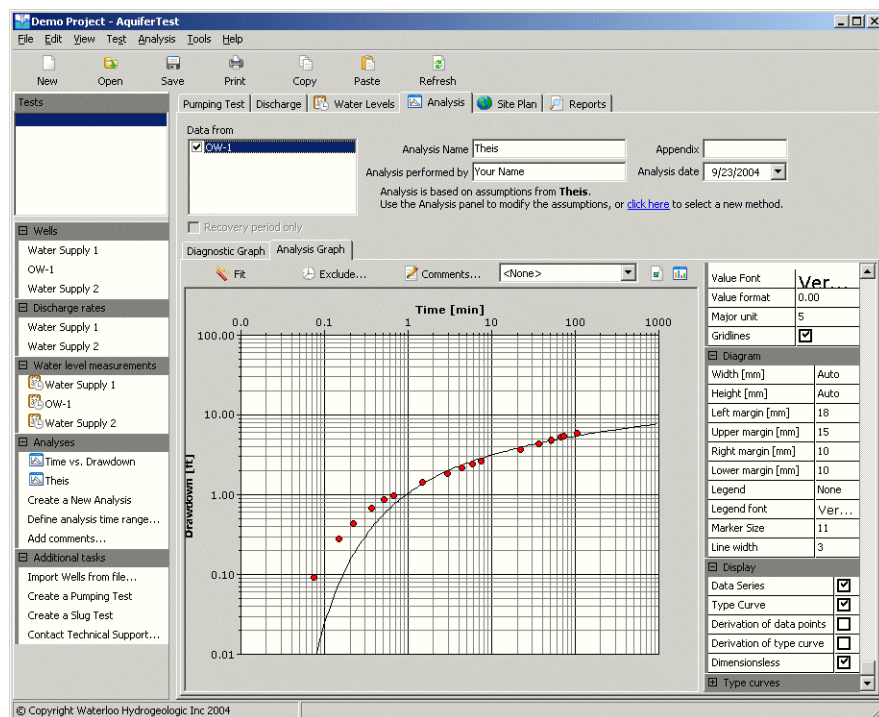
Display	
Data Series	<input checked="" type="checkbox"/>
Type Curve	<input checked="" type="checkbox"/>
Derivation of data points	<input type="checkbox"/>
Derivation of type curve	<input type="checkbox"/>
Dimensionless	<input checked="" type="checkbox"/>

- [23] Expand the **Diagram** frame (under the **Analysis Panel**)

[24] Increase the **Marker size** to 11.

Diagram	
Width [mm]	Auto
Height [mm]	Auto
Left margin [mm]	20
Upper margin [mm]	15
Right margin [mm]	10
Lower margin [mm]	10
Legend	Bottom
Legend font	<b>Verdana</b>
Marker Size	11
Line width	3

The plot should be displayed similar to the one shown below.



**AquiferTest** has automatically fit the data to the curve, and calculated the aquifer parameters. However the fit includes all the data which is sometimes not the desired case. For example you may wish to place more emphasis on the early time data if you suspect the aquifer is leaky or some other boundary feature is affecting the results.

In this pumping test, there is a boundary condition affecting the water levels / drawdown between 700 - 1000 feet south of **Water Supply 1**. You need to remove the data points after time = 100 minutes.

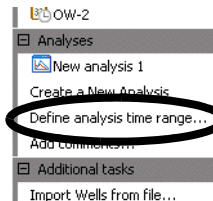
There are several ways to do this, either by de-activating data points in the analysis (they will remain visible but will not be considered in analysis) or by applying a time limit to the data (data outside the time limit is removed from the display). You will examine both options.

[25] Return the graph to its original view by setting the following options in the

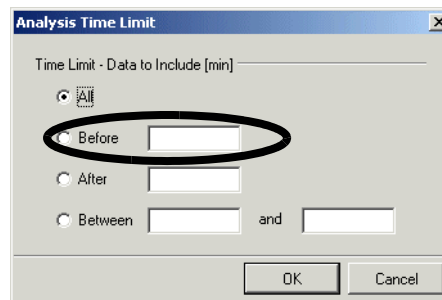
Analysis Panel:

- **Display** frame
  - **Dimensionless:** unchecked
- In the **Time** frame:
  - **Scale:** linear
  - **Minimum:** 0
  - **Maximum:** 2000
  - **Gridlines:** unchecked
- In the **Drawdown** frame:
  - **Scale:** linear
  - **Minimum:** 0
  - **Maximum:** 5
  - **Gridlines:** unchecked

[26] From the main menu, select **Analysis / Define Analysis Time Range**, or click **Define analysis time range** in the **Analyses** frame of the **Project Navigator** panel




The following dialogue will be produced:

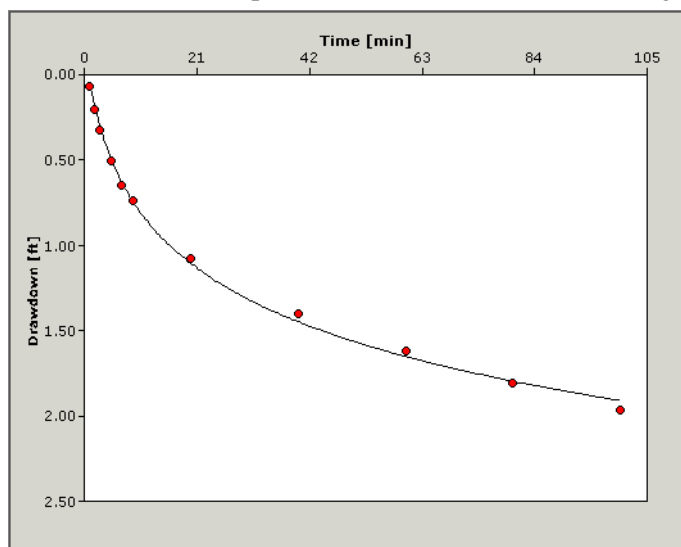


- [27] Select **Before** and type in **101**. This will include all the data-points before 101 minutes and will remove all the data-points after that period.
- [28] Click **[OK]** and note that all points after 100 minutes have been temporarily hidden from the graph view.
- [29] Now, you will modify the graph properties to focus on the early time data.
- [30] Set the Maximum value for the **Time** axis to **105**.

[31] Set the Maximum value for the **Drawdown** axis to 2.5

Time axis		Drawdown axis	
Title	Time [min]	Title	Drawdown...
Title Font	Verdana	Title Font	Verdana
Scale	Linear	Scale	Linear
Minimum	0	Minimum	0
Maximum	105	Maximum	2.5
Show values	<input checked="" type="checkbox"/>	Show values	<input checked="" type="checkbox"/>
Value Font	Verdana	Value Font	Verdana
Value Format	0.##	Value Format	0.00
Major unit	10	Major unit	10
Gridlines	<input type="checkbox"/>	Gridlines	<input type="checkbox"/>

[32] Click the  **Fit** (**Automatic Fit**) button above the graph to automatically fit the curve to the data. The points after 100 minutes are no longer visible.




With the later points excluded, the calculated parameters in the **Results** frame have changed to

- Transmissivity = 4.48E3 ft<sup>2</sup>/day
- Storativity = 4.27E-4

You will now utilize the other method to exclude data points from the graph. First you need to restore the graph to the original view.

[33] Select **Define analysis time range**

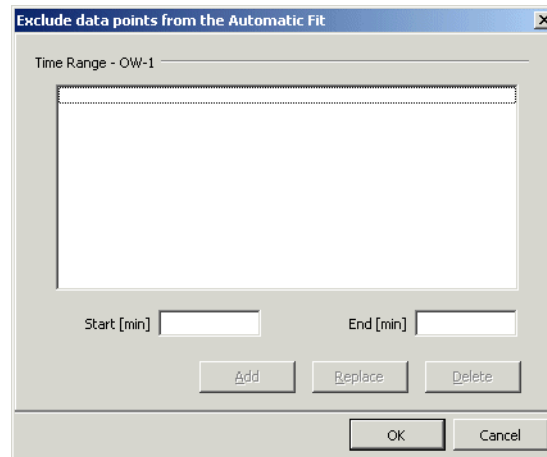
[34] Choose **All** and click **[OK]**.

[35] You will now exclude the late time data points from the graph. Click the  (**Exclude**) icon above the graph





The following dialogue will be produced:



Whereas the **Define analysis time range** requires you to enter the range in which the data is to be INCLUDED, the **Exclude** function works the opposite way and requires that you define a time range in which the data will be EXCLUDED. Both perform the similar function, however in different situation one may be more appropriate than the other. Use your discretion for selecting the appropriate method.

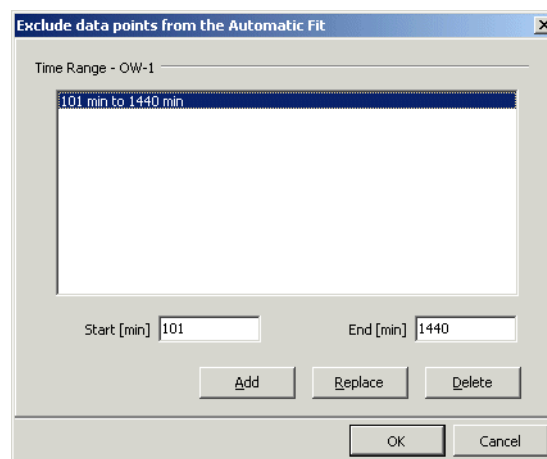
To define a new period for data exclusion,

[36] Type in **101** in the **Start** field

[37] Type **1440** in the **End** field


[38] Click [**Add**]

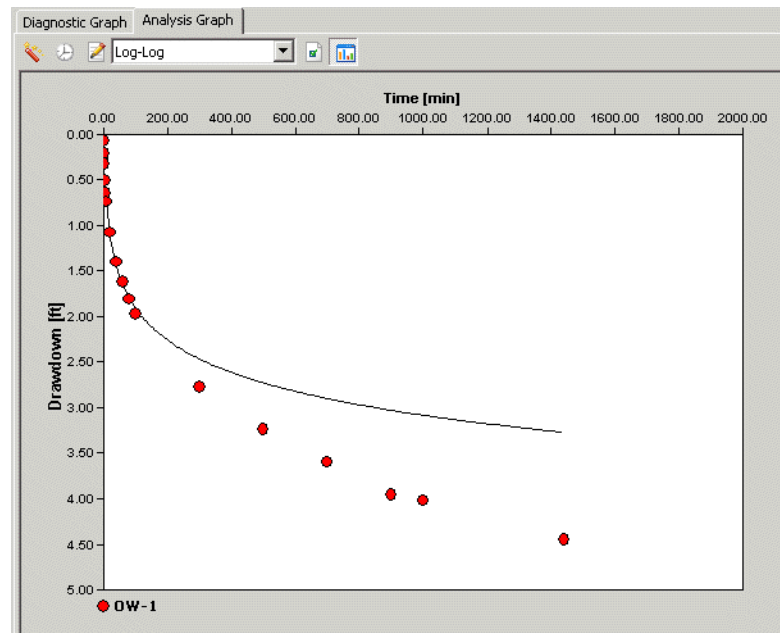
[39] Select and highlight the added period (as shown below), and click [**OK**]



[40] Modify the graph properties as follows:

- Set the Maximum value for the **Time** axis to **2000**.
- Set the Maximum value for the **Drawdown** axis to **5.0**

- [41] Click the  **Fit** (**Automatic Fit**) button above the graph to automatically fit the curve to the data.



Observe, the curve change is identical to the **Define analysis time range** option (as evident from the calculated parameter values in the **Results** frame), however the points are still visible.

The parameters in the **Results** frame should now be similar to the following:

- Transmissivity = 4.48E3 ft<sup>2</sup>/day
- Storativity = 4.27E-4

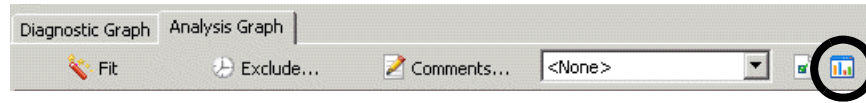
**AquiferTest** calculates the best fit line, however that line may not always be ideal. There are two ways in which you can adjust the curve.

- [42] If you suspect that the aquifer does not conform to the Theis assumptions (confined, infinitely extending, isotropic aquifer), change the assumptions in the **Model Assumptions** frame of the **Analysis Navigator**

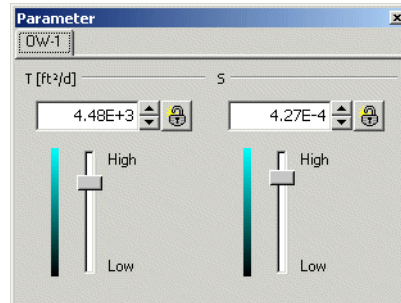
S	4.27E-4
Model Assumptions	
Aquifer type	Confined
Aquifer extent	Infinite
Isotropy	Isotropic
Discharge	Constant
Well Penetration	Fully
Time axis	

- [43] Or, use **Parameter Controls** to manually adjust the curve fit.

To activate parameter controls, click the parameter controls button above the graph




The dialogue shown below allows you to change curve fit, and resulting parameters that are calculated in this analysis.



Use the slider-bars to increase or decrease a specific parameter and observe as the relative position of the curve and datapoints change in response. Alternately you can use the up / down arrow keys on your keyboard. You can also simply type in a value in the provided field.

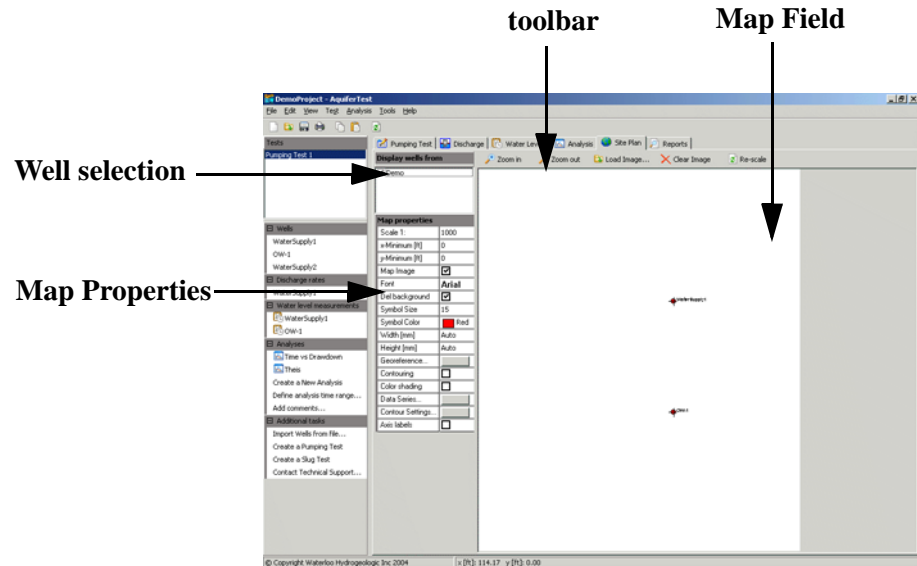
[44] Close the **Parameters** dialog, by clicking on the [X] button in the upper right corner.

[45] Restore the best fit parameter values, by clicking on the  button.

## Contouring Drawdown

At this stage it may be advantageous to visualize the drawdown data. You can do so by using the mapping component of **AquiferTest** located in the **Site Plan** tab.

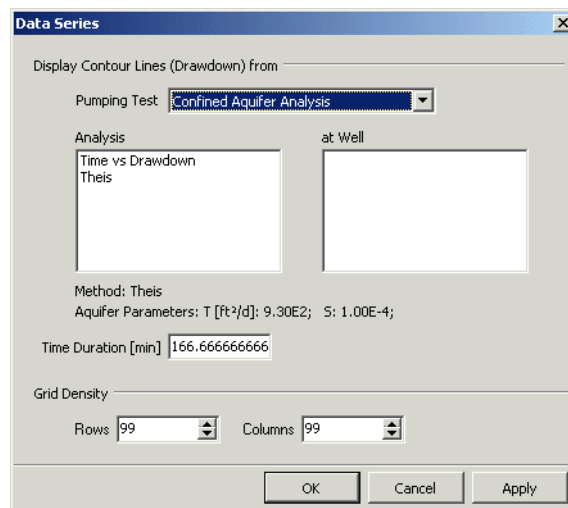
[46] Click on the **Site Plan** tab



- **Map View** - displays the map (if loaded) and the wells from the selected test(s)
- **Toolbar** - provides buttons for map manipulation tools
- **Well selection** - choose the test from which you wish the wells to be displayed
- **Map properties** - provides options for formatting the display properties of the map and contours

[47] To obtain a better view of the wells, you may need to zoom out from the default map view. Before displaying contours, you need to select the data series on which the contours will be based.

[48] Locate the **Data Series** field in the **Map Properties** frame, and click on the button in the right portion of that field. The following dialogue will load:



[49] Select **Theis** under the **Analysis** frame

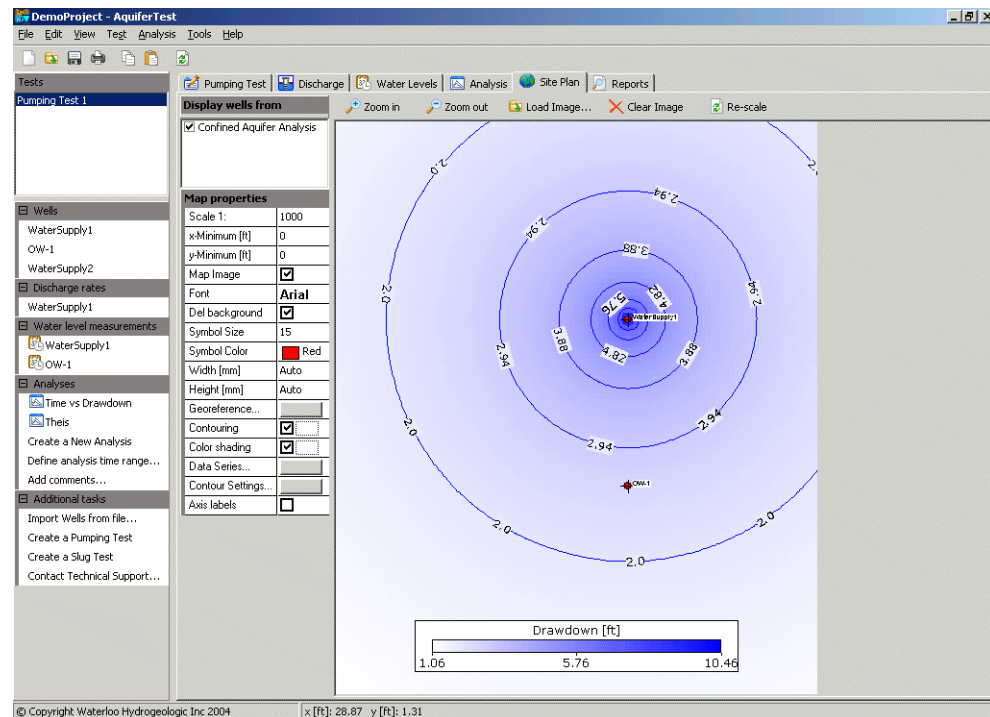
[50] Select **OW-1** in the **at Well** frame

[51] Leave the remaining settings, and click **[OK]**

[52] In the **Map properties**, check the box beside **Color Shading**

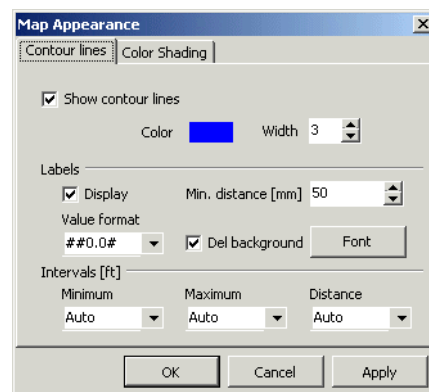
[53] In the **Map properties**, check the box beside **Contouring**

Your map display should then be similar to the image shown below



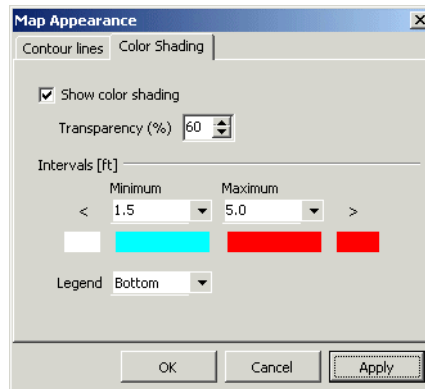
You may now modify the color of the color shading and contour lines, following the instructions below.

[54] In the Map properties locate the **Contour Settings** and click on the button in the right portion of that field. The following dialogue will load:

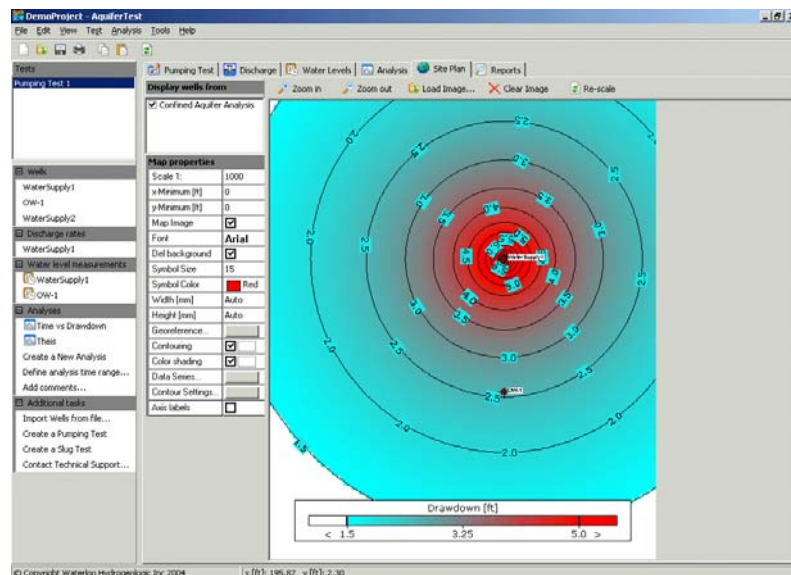


[55] In the **Contour Lines** tab, load the color options, and select Black.

- [56] For the **Interval Distance** value, type 0.5
- [57] For the **Minimum** value, type 1.5
- [58] Click **[Apply]** to apply the changes and update the map view.
- [59] Click on the **Color Shading** tab in the **Map Appearance** dialog, and specify the following settings:
- For the **Minimum** value, type 1.5
  - For the **Maximum** value, type 5.0
  - For the **Minimum** color, select Blue
  - For the **Maximum** color, select Red
  - For the **>** color, select the same Red color:



- [60] Click **[OK]** to apply the changes and update the map view, and close the Map properties dialogue. The Map window should look similar to the image shown below:



- [61] Before proceeding, turn off the color map and contour lines:
- In the **Map properties**, remove the check mark beside **Color Shading**

- In the **Map properties**, remove the check mark beside **Contouring**

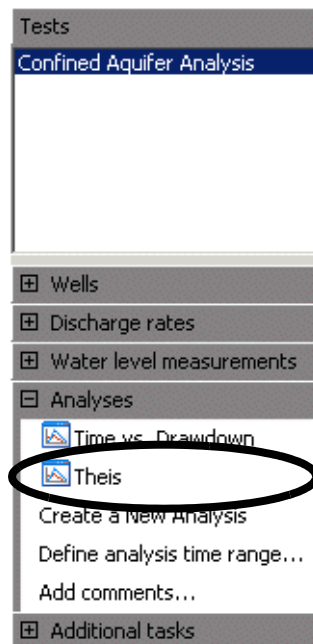
## Determining the effect of the second pumping well

Now that you have calculated the aquifer parameters, you can use the **AquiferTest** to predict the effects of applying additional stresses on the aquifer system. In the next example, we will activate the second pumping well, and determine what affect this will have on the drawdown observed at the observation well.

Before proceeding, you must first “lock” the aquifer parameters. Locking the parameters will ensure that the current values for Transmissivity and Storativity will not be changed when applying the automatic fit.

[62] Return to the **Analysis** tab

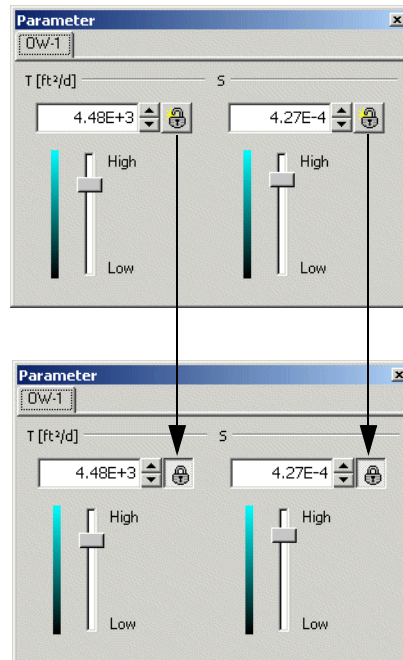
[63] Select **Theis** from the **Analyses** frame of the **Project Navigator**



[64] Load the Parameter controls by clicking on the Parameter control icon



[65] Click the lock icons beside each parameter.



[66] Click on the **Pumping Test** tab

[67] In the **Wells** table, select WaterSupply2 from the well list. To “turn on” the second pumping well, change the type from **Not Used** to **Pumping Well**

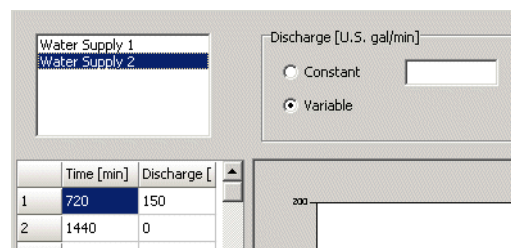
[68] Click on the **Discharge** tab

[69] Select **WaterSupply2** from the well list

[70] Select the **Variable** discharge option

[71] Enter the following pumping rates in the table:

Time	Discharge
720	150
1440	0

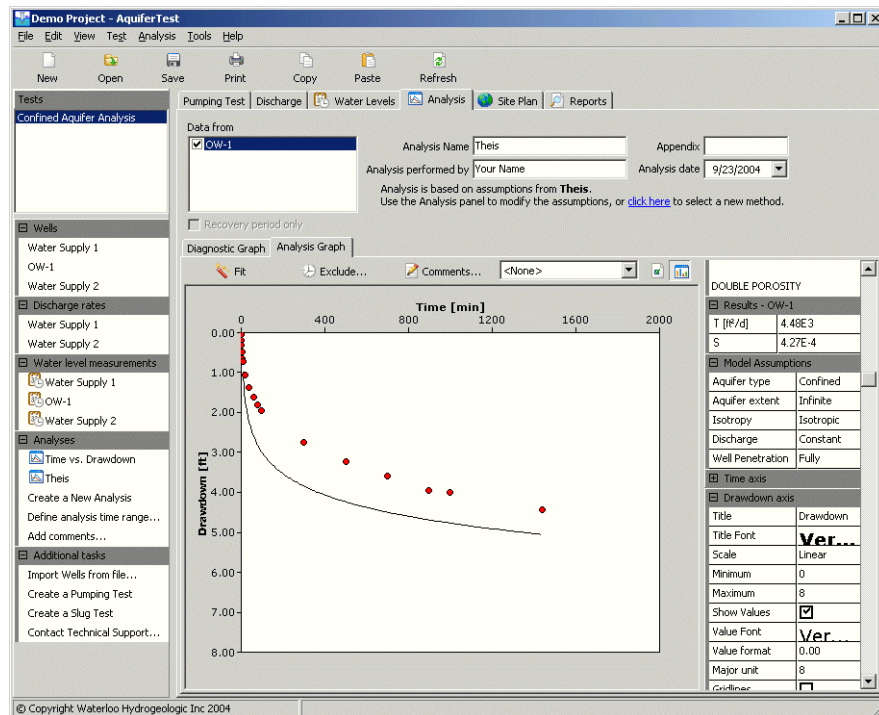


These values indicate that the **Water Supply 2** well was turned on at the same time as the **Water Supply 1**, however, whereas **Water Supply 1** pumped for 1440 minutes (24 hours) at a constant discharge of 150 US gal/min, **Water Supply 2** only ran at that rate for 720 minutes (12 hours) and was then shut off.



- [72] Click on the **Analysis** tab
- [73] Click **Theis** in the **Analyses** frame of the **Project Navigator** to return to your Theis analysis. The analysis graph contains a new theoretical drawdown curve, which is now much steeper, as a result of the second pumping well.
- [74] To view the full effect, you need to modify the graph settings.
- Expand **Drawdown axis** frame
  - Change the **Maximum** to **8**

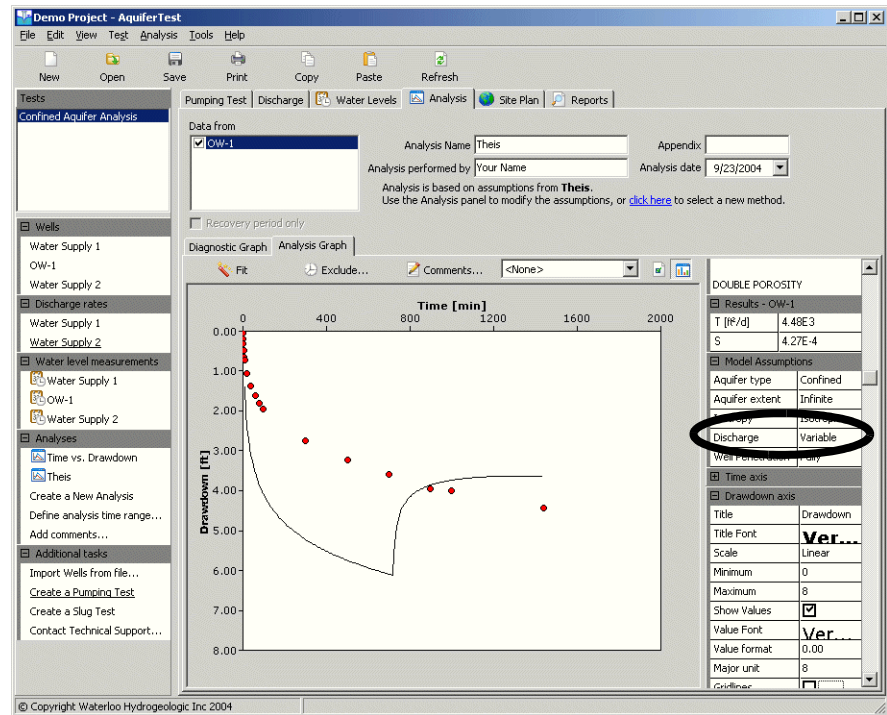
Your display should appear similar to the one shown below:



By default, the analysis assumes that the discharge is constant; if a variable discharge rate is entered, it will be calculated into a constant average value for the entire pumping duration. You can change that in the **Model Assumptions** frame of the **Analysis Navigator**.

- [75] Expand the **Model assumptions** frame
- [76] In the **Discharge** field select **Variable**. The analysis graph should now be

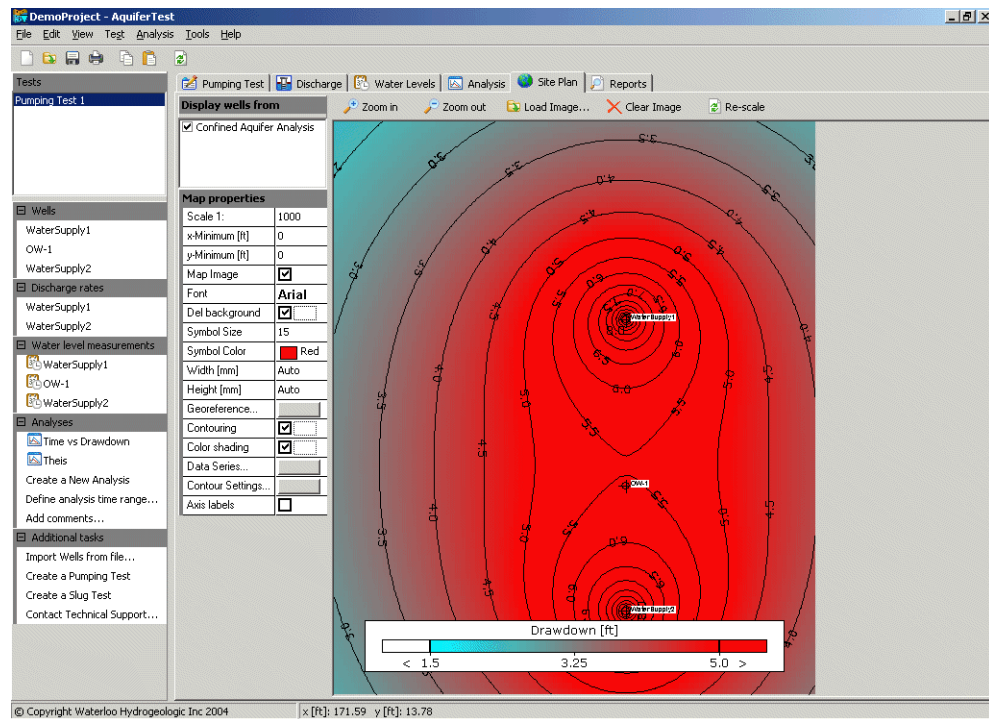
similar to the one shown below.



You will notice that after 720 minutes, the theoretical drawdown curve rises sharply which is equivalent to a sudden recovery. This coincides with the pumping well “WaterSupply2” being shut off after 720 minutes. As a result, the total discharge from the two wells decreases to 150 gpm (from 300 gpm) and the resulting drawdown is less.

- [77] To see the effect of the second pumping well graphically, click on the **Site Plan** tab
- [78] In the **Map properties**, check the box beside **Color Shading** and **Contouring**.

Your map should look similar to the following:



You may re-scale the map, by entering a scale value of 1:2000 in the **Map Properties** frame. In addition, you can move the legend position to the top of the map.

In the next section you will predict the drawdown at a new location.

## Exercise 2: Predictive Analysis

Sometimes it is necessary to determine how the pumping well(s) will affect other wells in the area (e.g. if there are private water wells nearby), however it is not practical to drill and install an observation well at this new location. In this exercise you will simulate a well at a specific location and determine how the pumping wells affect the drawdown.

- [1] Return to the **Pumping Test** tab
- [2] Create a new well by clicking “Click here to create a new well” link under the wells grid.

Wells		Site Plan							
	Name	Type	X [ft]	Y [ft]	Elevation (a)	Benchmark [	Penetration	R [ft]	L [ft]
1	Water Supply	Pumping Well	350	450	0	0	Fully	0.3	50
2	OW-1	Observation Well	350	250	0	0	Fully	0.06	50
3	Water Supply	Pumping Well	350	100	0	0	Fully	0.3	50

[Click here to create a new well](#)

For the new well set the information as follows:

- **Name:** OW-2

- **Type:** Observation Well
- **X:** 700
- **Y:** 850
- **L:** 50
- **r:** 0.25
- **R:** 0.30

The well is created as “Observation” by default, however, you can change the type of any well by clicking in the **Type** field once to activate it and then again to produce the drop-down menu.

[3] Click on the **Water Levels** tab.

[4] Select **OW-2** from the frame in the upper left corner.

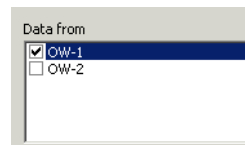
[5] Enter **0** as the **Static Water Level**.

Now you need to enter water level data for the new well. You will enter a few “dummy” points which will be used to set the timeline for the curve. The water level measurements can be any values, but for simplicity, a value of 1 will be used.

Enter the following values in the **Water Level** table:

Time	Water Level
<b>1</b>	<b>1</b>
<b>500</b>	<b>1</b>
<b>1000</b>	<b>1</b>
<b>1440</b>	<b>1</b>

[6] Click **Theis** from the **Analyses** frame of the **Project Navigator** to move to your Theis analysis. Note that the second observation well, **OW-2**, now shows up in the **Data from** list.



[7] Check the box next to **OW-2** to display this data set.

For this dummy well, you will not apply the Automatic fit, since there are no observed water levels, and the automatic fit would be meaningless. Instead, you will use the Transmissivity and Storativity values that were calculated for OW-1 (in the first part of this exercise). Then, assuming that the aquifer parameters are identical at OW-2, you will manually assign these identical values, and observe the theoretical drawdown curve.

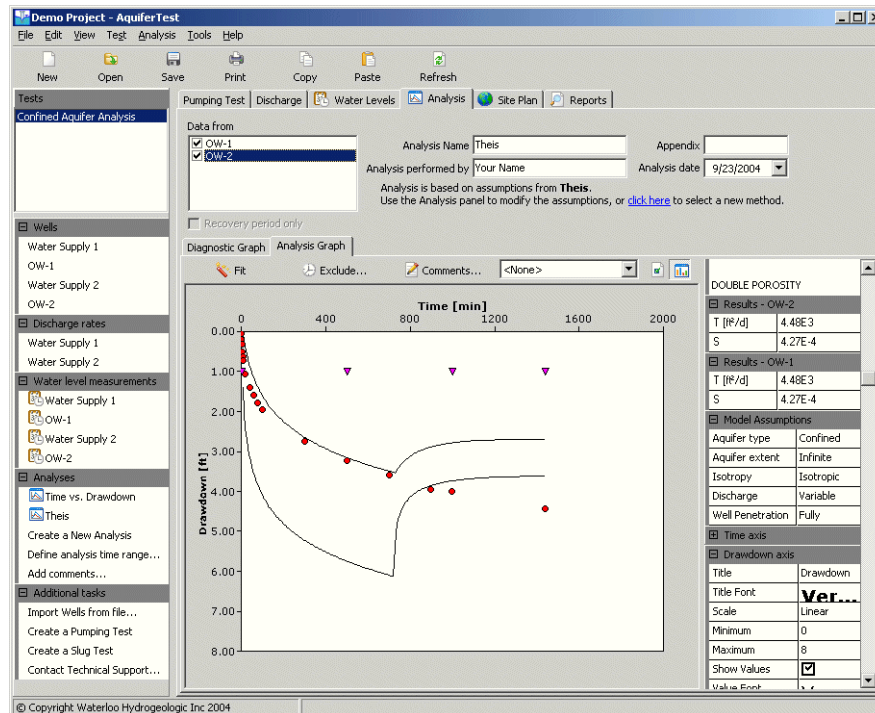
Under the **Results** frame, set the parameters for OW-2 to those values that were calculated for **OW-1**:

**Results - OW-2, T, type: 4.48E3**

**Results - OW-2, S, type: 4.27E-4**

Results - OW-2			Results - OW-2	
T [ft <sup>2</sup> /d]	9.99E3	→	T [ft <sup>2</sup> /d]	4.48E3
S	2.47E-3	→	S	4.27E-4
Results - OW-1			Results - OW-1	
T [ft <sup>2</sup> /d]	4.48E3		T [ft <sup>2</sup> /d]	4.48E3
S	4.27E-4		S	4.27E-4

Your graph should now look similar to the one shown below:



The upper curve is the predicted drawdown in well OW-2. The curve is the predicted drawdown that would occur, if there were two pumping wells, one running at 150 US gal/min for 24 hours, and another with the same pumping rate, but for only 12 hours. You can see that the drawdown at OW-2 is less than that observed at OW-1. This occurs because OW-2 is located further away from the pumping wells, so the effect is not as pronounced.

Using this procedure, you can predict drawdown in a well at any distance with various parameters.

## Returning to static level conditions

**AquiferTest** can also be used to predict how long it will take for water levels to return to static conditions once the pumping test has concluded.

[8] Return to the **Discharge** tab

[9] Select **Water Supply 1**.

The test lasted 1440 minutes and it ran at a constant discharge of 150 US gal/min. Now that you are considering the time after the pump was shut off, it is necessary to define a stop time, and as such, you must use the **Variable** discharge type.

[10] Select **Variable** in the **Discharge** frame

[11] In the **Discharge** table enter the following values:

<b>Time</b>	<b>Discharge</b>
<b>1440</b>	<b>150</b>
<b>8640</b>	<b>0</b>

You also need to turn off **Water Supply 2**.

[12] Select **Water Supply 2**.

[13] Set the discharge type to **Constant**

[14] Enter **0** for the **Discharge** rate.

Next, you need to establish the timeline for **OW-2**.

[15] Click on the **Water Levels** tab

[16] Select **OW-2** from the wells list. In addition to the data you already have there, enter the following values:

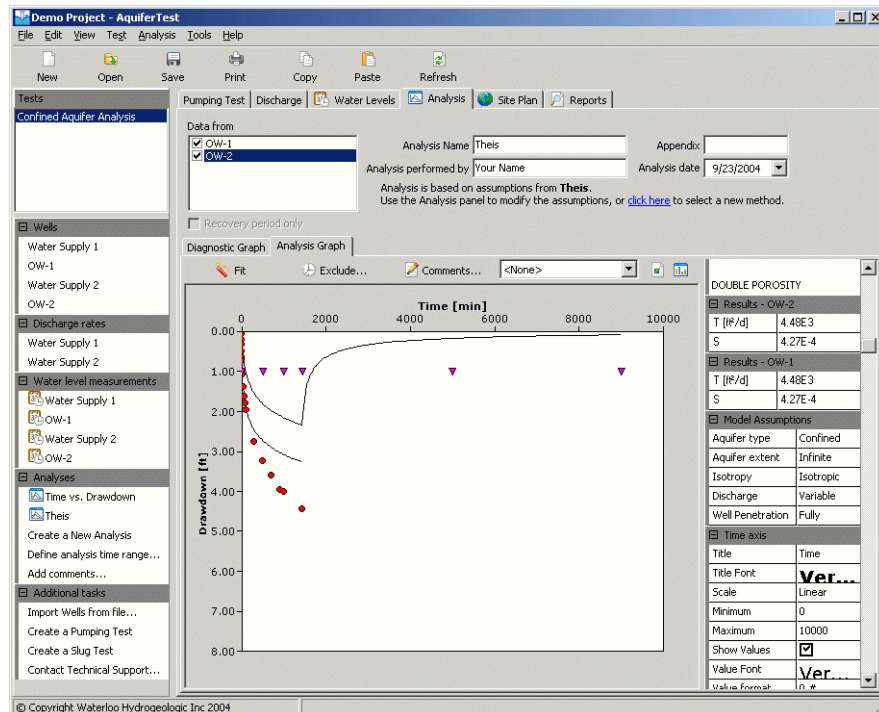
<b>Time</b>	<b>Water Level</b>
<b>5000</b>	<b>1</b>
<b>9000</b>	<b>1</b>

[17] Click on **Theis** under the **Analyses** frame of the **Project Navigator** to return to your Theis analysis.

[18] Expand the **Time** axis, and set the **Maximum** to **10,000**



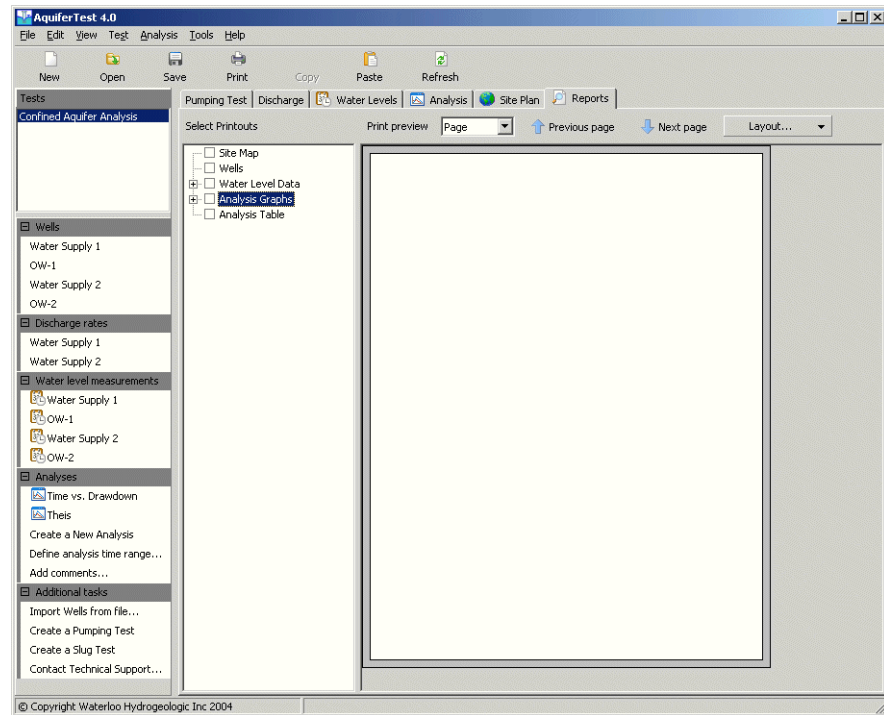
You can see the theoretical drawdown curve for **OW-2** rises sharply when the pumping well is shut off (at 1440 min) and begins to recover. It takes approximately 7000 to 8000 minutes (~5.5 to 6 days) for the water to return to static conditions.



## Creating a Report

Now that you have entered your test data and conducted the appropriate analyses you may want to print out a report. Using **AquiferTest** you can print out the information from any part of the **AquiferTest** that is currently active, or you can choose which reports to print at the same time using the **Reports** tab.

[19] Click on the **Reports** tab, and the following window will appear.



To the left of the print preview is the **Report navigator tree**. This tree contains all the data that has been entered and/or calculated in **AquiferTest**. From this tree you can choose which sections to include in your report and which to leave out.

[20] Expand all the nodes of the tree.

[21] Check the box beside **Site Map**, **Wells**, **Analysis Graphs**, and **Analysis Table**. Note that checking the box beside **Analysis Graphs** automatically includes each analysis available for the test.

You can define your company information and logo under **Tools / Options**.

[22] To print the selected reports select **File/Print** or simply click the  **Print** button in the toolbar.

## Exercise 3: Single Well Analysis

In this example, you will create a new pumping test for a single pumping well, and use the new derivative analysis tools to interpret the data, to determine if there was storage in the pumping well.

- [1] Create a new pumping test by selecting **Test / Create a Pumping test** from the main menu.
- [2] Fill in the information required for the new pumping test.



In the **Pumping Test** frame enter the following:

- **Name:** Example 2: Single Well Analysis
- **Performed by:** Your Name
- **Date:** Filled in automatically with the current date

In the **Units** frame fill in the following:

- **Site Plan:** m
- **Dimensions:** m
- **Time:** s
- **Discharge:** l/s
- **Transmissivity:**  $\text{m}^2/\text{s}$
- **Pressure:** mbar


In the **Aquifer Properties** frame enter the following:

- **Thickness:** 3
- **Type:** Confined
- **Bar. Eff.:** leave blank

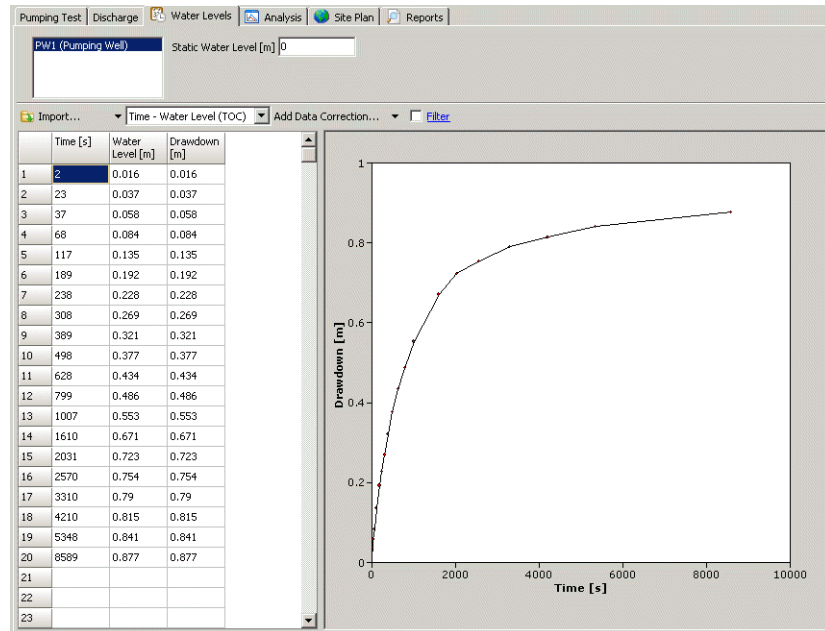
- [3] “**Click here to create a new well**” link under the first well to create a new well.  
Define the following well parameters for this well:

- **Name:** PW1
- **Type:** Pumping Well
- **X:** 0
- **Y:** 0
- **r:** 0.35
- **R:** 0.35

For this pumping test, there is only one well; PW1 was used for both pumping and for recording drawdown measurements.

- [4] Click on the **Discharge** tab to enter the discharge rate for the pumping well.
- [5] In the **Discharge** frame select the “**Constant**” option
- [6] Enter the following discharge rate: **0.5**.
- [7] Click on the **Water Levels** tab to enter the water level data for the pumping well.
- [8] Type **0** in the **Static Water Level** field.
- [9] In this exercise you will import data from an MSExcel file. From the main menu, select **File / Import / Water level measurements**.
- [10] Navigate to the folder “AquiferTest\Demo\” and select the file **PW-1.xls**
- [11] Click **Open**. The data should now appear in the time - water levels table.
- [12] Click on the  (Refresh) button in the toolbar, to refresh the graph. You will see the calculated drawdown data appear in the **Drawdown** column and a

drawdown graph displayed on the right.




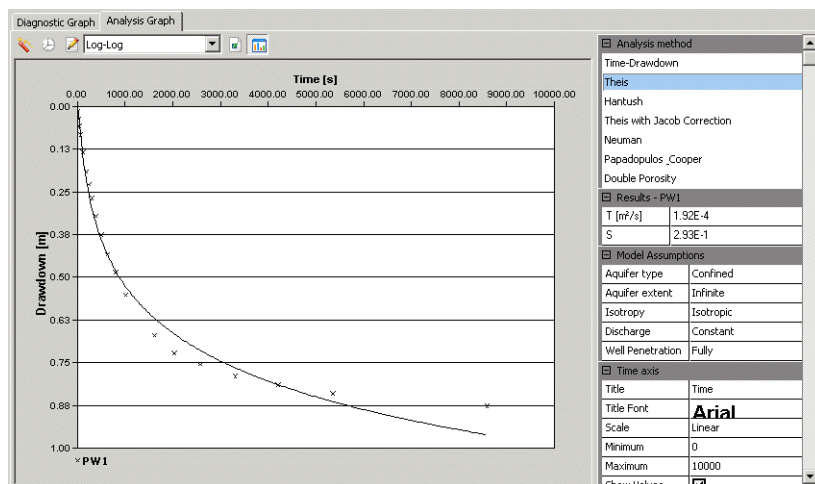
Now you can create the analysis. First, start with the standard Theis Analysis for a Confined Aquifer (assuming that Well Storage is negligible).

[13] Click on the **Analysis** tab.

[14] In the **Data from** window, select **PW1**. The type curve and data are displayed on the graph.

[15] In the **Analysis Name** field, type “**Theis Analysis**”

[16] Click on the  **Fit** (Automatic fit) button, and the curve will be fit to the data, as shown in the image below.



The calculated values for the aquifer parameters are:

T: 1.92 E-4 m<sup>2</sup>/s

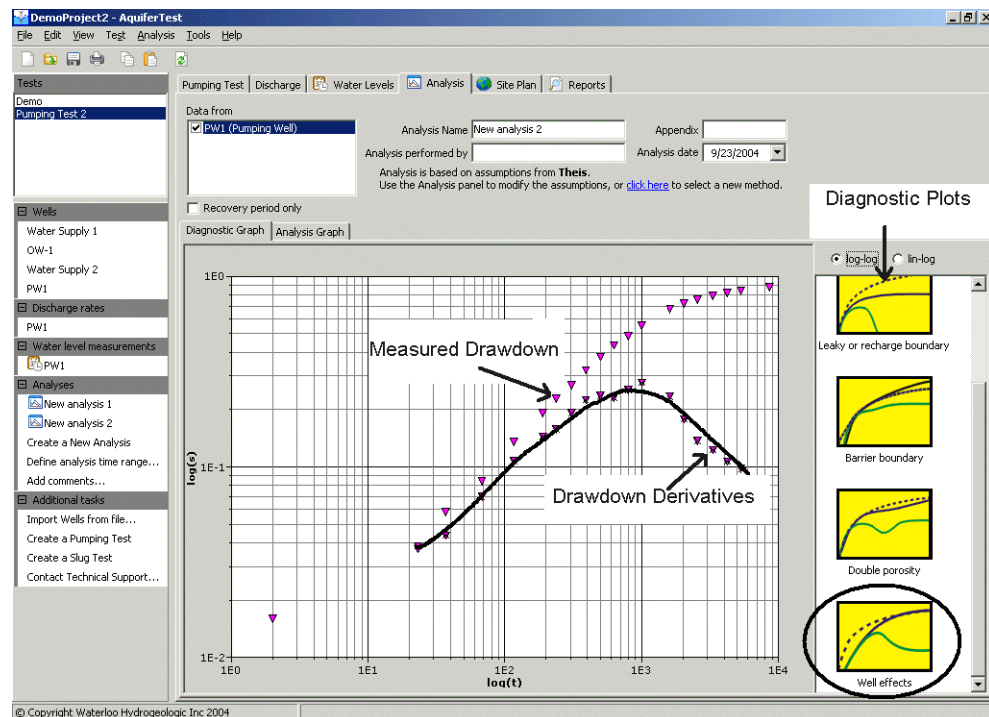
S: 2.93 E-1

Now, you will use the Diagnostic plots to determine if there was storage in the pumping well.

## Interpreting Well Effects with Derivative Analysis

[17] Click on the **Diagnostic Graph** tab, and the following window will appear

**NOTE:** The symbol types may vary for your project..



The **Diagnostic Graph** window contains the **Measured Drawdown** data and the calculated **Drawdown Derivatives**. The derivative data is distinguished by an X through the middle of each data symbol. To the right of the graph window, you will see 5 yellow **Diagnostic Plots**, with a variety of curves. The plots are called diagnostic, since they provide an insight or “diagnosis” of the aquifer type and conditions. Diagnostic plots are available for a variety of aquifer types, well effects, and boundary conditions, which include:

- Confined
- Leaky aquifer or Recharge Boundary
- Barrier Boundary
- Double Porosity or Unconfined Aquifer
- Well Effects (WellBore storage)

Each diagnostic graph contains 3 lines:

- Theis type curve (dashed black line)

- Theoretical drawdown curve under the expected conditions (solid black line)
- Drawdown derivative curve (solid green line).

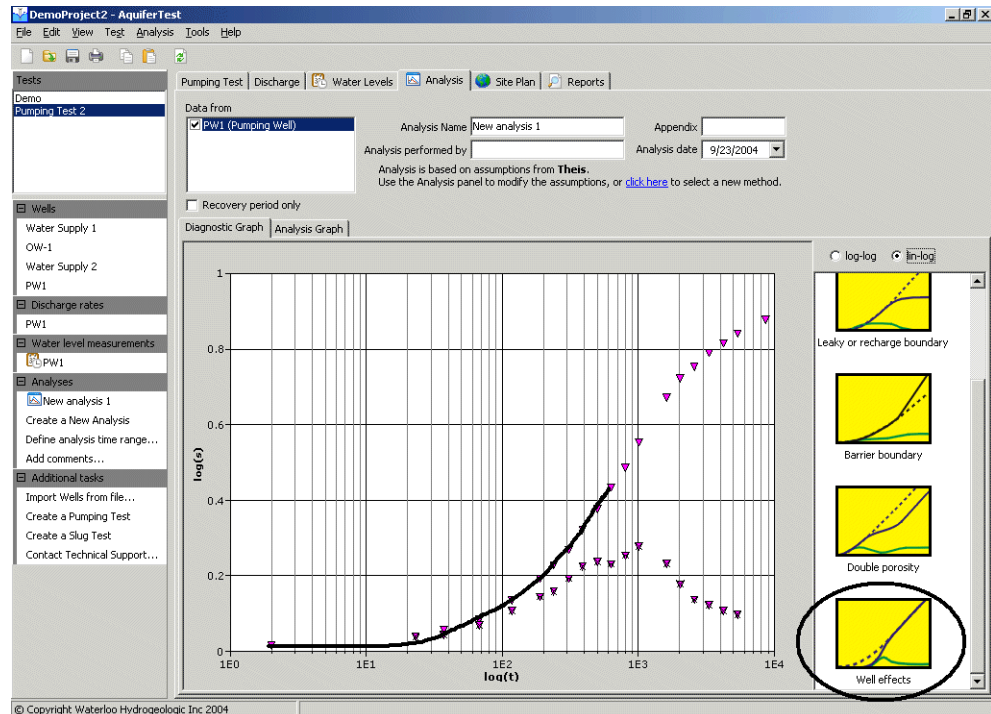
These plots can be displayed on a log-log or semi-log scale, by selecting the appropriate radio button above the diagnostic graphs.

For this pumping test, the presence of well effects (well bore storage) can be confirmed by comparing the derivative drawdown data (outlined in the image above) to the green line in the Well Effects diagnostic plot (circled in the image above). You can see the curves are very similar in shape. However, the observed drawdown values did not stabilize and reach a constant. Therefore, it would have been ideal if the pumping duration had been extended, and there was additional data available for the late pumping durations.

Nevertheless, the drawdown curve is characteristic of well bore storage conditions: at the beginning of the pumping test, there is a delay in drawdown as a result of storage in the pumping well, and the drawdown deviates from the theoretical Theis curve. As pumping durations increase, the drawdown curve becomes more similar to the theoretical Theis curve.

These well effects are more easily identified in the semi-log plot.

[18] **Lin-Log** radio button above the yellow diagnostic graphs. The following window will appear.




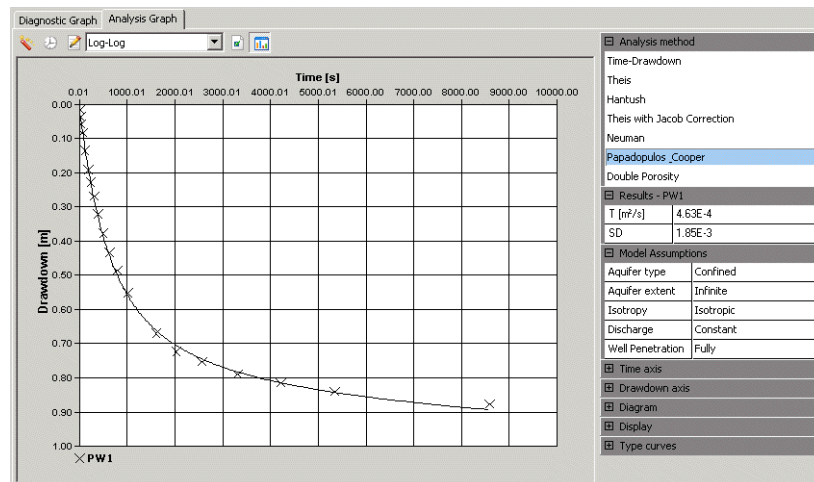
In the Semi-Log plot, you can compare the observed drawdown curve to the diagnostic plots. In this example, it is evident that the observed drawdown curve displays delayed drawdown (outlined in the image above), then returns to the typical Theis curve as pumping duration increases. When comparing this to the diagnostic plot for Well Effects (circled in the image above), there is strong evidence indicating the presence of well effects during this pumping test.

Now that you are confident that there is a wellbore storage component, you can select the appropriate solution method (Papadopoulos - Cooper), and calculate the aquifer parameters.

[19] Return to the **Analysis Graph** tab.

[20] From the main menu, select **Analysis / Create Analysis considering Well Effects**.

[21] Click on the  **Fit** (Automatic fit) button, and the curve will be fit to the data, as shown in the image below



The calculated values for Transmissivity using the Papadopoulos Cooper method is:

T: 4.63 E-4 m²/s

Compare this to the value calculated using the Theis method (1.92 E-4 m²/s), you can see that the value is greater by a factor of more than 2. Therefore, the Theis solution should not be used, since it assumes there is no storage in the pumping well, and will produce incorrect results.

You may create a report using the instructions provided earlier in this tutorial.

The next section of this demo exercise will explore creating and analyzing a slug test.

## Exercise 4: Slug Test Analysis

During a slug test, a slug of known volume is lowered instantaneously into the well. This is equivalent to an instantaneous addition of water to the well, which results in a

sudden rise in the water level in the well (also called a “falling head” test). The test can also be conducted in the opposite manner by removing water from a well (called a “bail” or “rising head” test). For both types of tests, the water level recovery is measured. The Hvorslev method is a popular method for evaluating slug test data.

The instructions in this exercise assume that you are familiar with navigating AquiferTest, and already have the Demo Project.HYT open.

To create a slug test,

- [1] Select **Test/Create a Slug test** or click **Create a Slug Test** link in the **Additional Tasks** frame of the **Project Navigator**.

Note that a new slug test is now displayed in the **Tests** frame of the **Project Navigator**, all wells have been set to “Not Used”, project information has been carried over from the pumping test and the rest of the information - such as slug test information, units, and aquifer parameters - has been reset to default states.

- [2] Enter the following information in the upper portion of the **Slug Test** tab:
  - Set units to:
    - **Site plan:** ft
    - **Dimensions:** ft
    - **Time:** s
    - **Discharge:** N/A
    - **Transmissivity:** ft<sup>2</sup>/d
    - **Pressure:** N/A
  - **Slug test name:** Example Slug Test
  - **Performed by:** your name
  - **Aquifer thickness:** 40
  - **Aquifer type:** confined
  - **Bar. Eff.:** leave blank

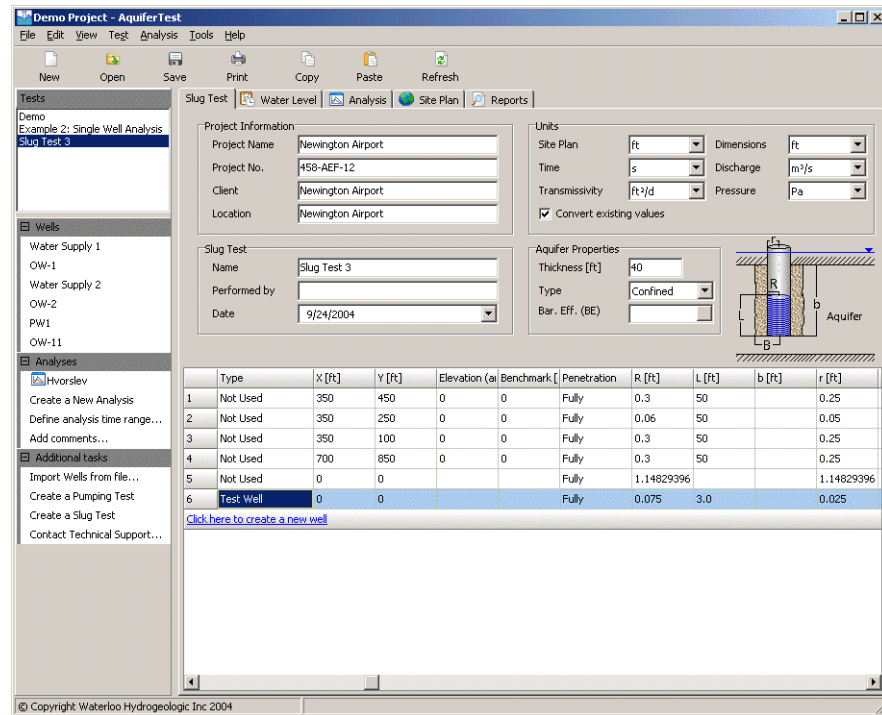
Next, you need to add the test well at which this test was performed.

- [3] Click **Click here to create a new well** link under the **Wells** table.

Set the parameters for the new well as follows:

- **Name:** OW-11
- **Type:** Test Well (set by default)
- **R:** 0.075
- **L:** 3.0
- **r:** 0.025

The **Slug Test** tab should now look similar to the following:



There is no discharge in the slug test, hence there is no **Discharge** tab.


[4] Click on the **Water Level** tab to enter the water level data for the slug test.

[5] Enter **Static Water Level** of 13.99

[6] Enter a **WL at t=0** of 14.87

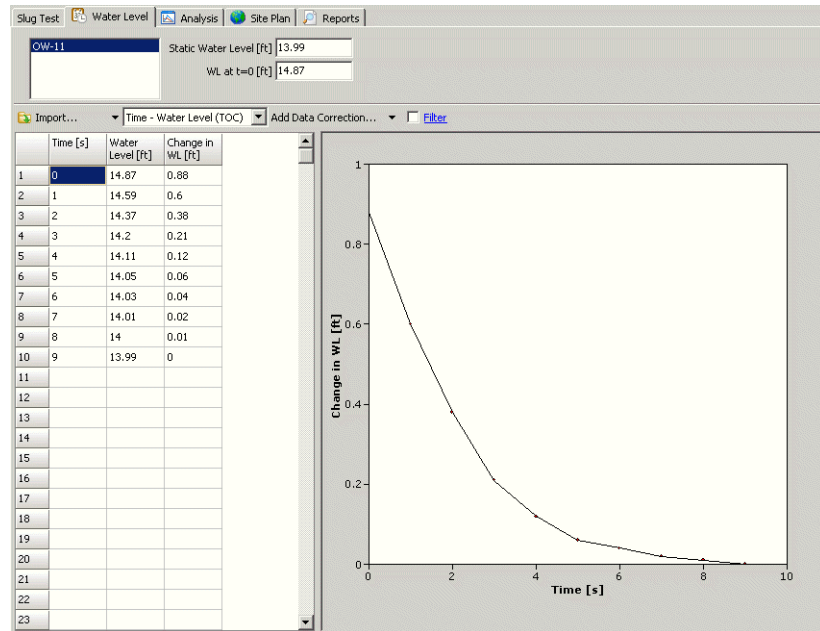
[7] Enter the following data into the **Water Levels** table:

Time [s]	Water Level [ft]
0	14.87
1	14.59
2	14.37
3	14.2
4	14.11
5	14.05
6	14.03
7	14.01
8	14.0
9	13.99

[8] Click on the  (Refresh) button in the toolbar, to refresh the graph. You will see the calculated change in water level data appear in the graph displayed on



the right.



You have now entered all the required data for this test.

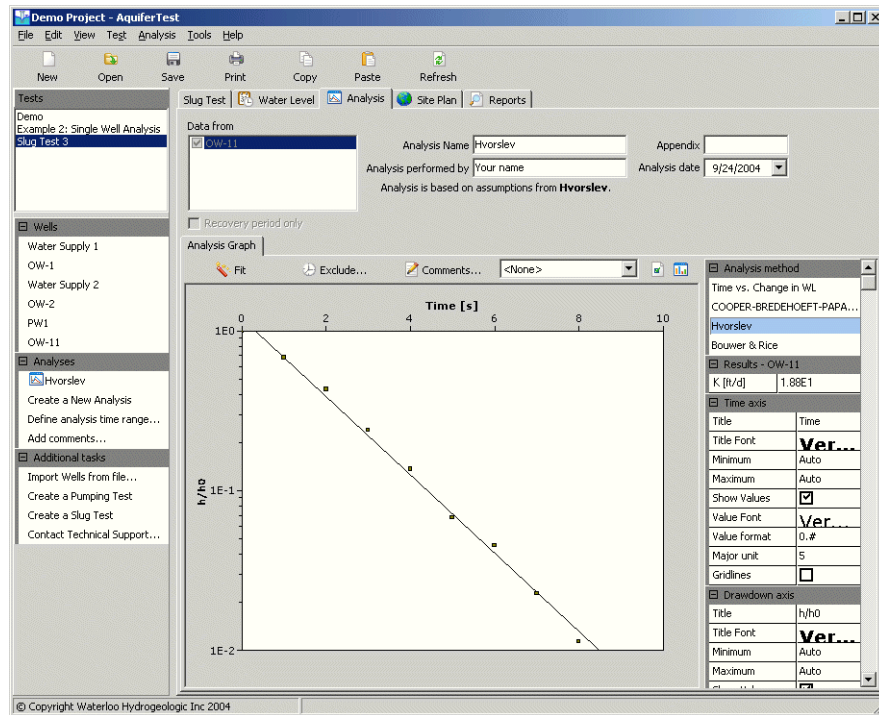
## Hvorslev Analysis

- [9] Click on the **Analysis** tab. Similar to the pumping test, the top portion of the tab contains the analysis information. Fill in the following fields:
  - **Analysis name:** Hvorslev
  - **Performed by:** your name
  - **Date:** choose current date from the drop-down calendar
- [10] In the **Analysis method** frame of the **Analysis Navigator** choose **Hvorslev**.
- [11] Perform autofit on the data by pressing the **Fit** button above the graph

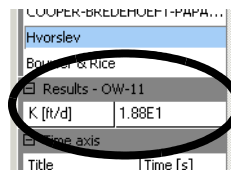




The **Analysis** tab should resemble the picture below:



The Hydraulic Conductivity value is calculated and displayed in the **Results** frame of the **Analysis Navigator**:



Similar to the pumping test analysis, you can use the **Parameter Controls** to adjust parameters in the slug test analyses. The parameter controls dialogue is dynamic, changing to suit every test. In the Theis analysis, the transmissivity (T) and storativity (S) were calculated. In Hvorslev analysis, it is conductivity (K). If you choose to switch to another test, the available parameters will change accordingly.

## Bouwer & Rice Analysis

You can perform a Bouwer & Rice Analysis on the same data.

[12] From the main menu, select **Analysis/Create a New Analysis**

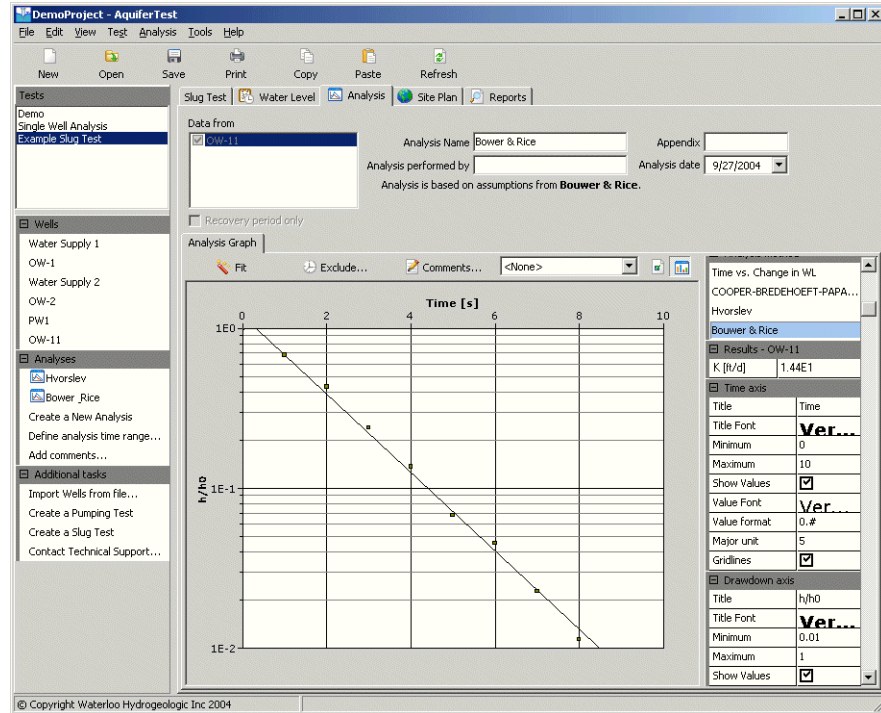
[13] Select **Bouwer & Rice** from the **Analysis method** frame of the **Analysis Navigator**.

Complete the information for the analysis as follows:

- **Name:** Bouwer & Rice
- **Performed by:** your name

- **Date:** choose current date from the drop-down calendar
- [14] Click the **Fit** button above the graph to perform autofit.

Your analysis window should look similar to the following:

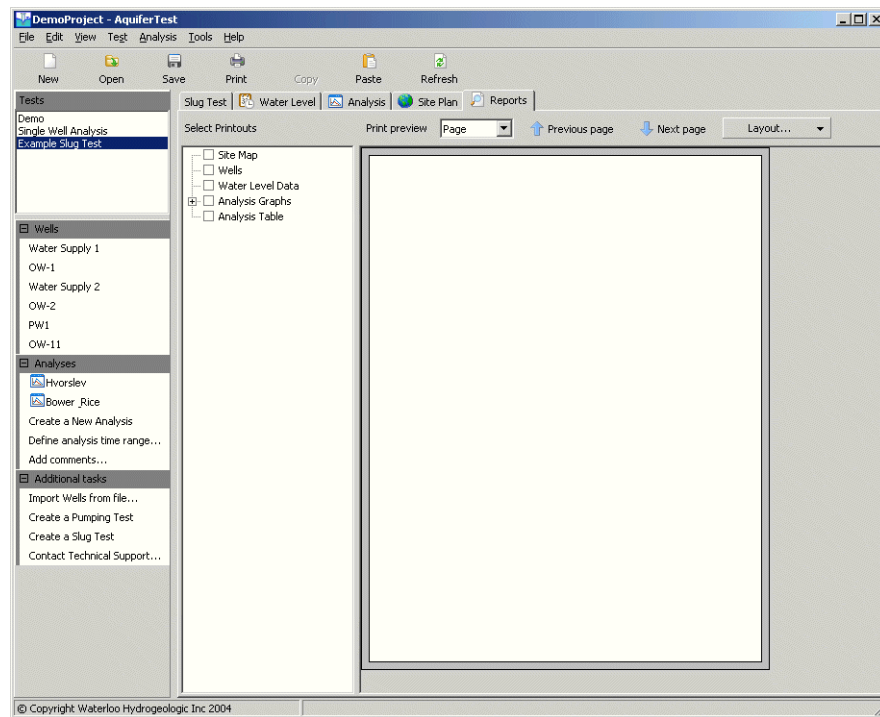


The conductivity values calculated for Bouwer & Rice (14.4 ft/d) is similar to that calculated using the Hvorslev method (18.8 ft/d).

## Creating a Report

Now that you have entered your test data and conducted the appropriate analyses you may want to print out a report. Using **AquiferTest** you can print out the information from any part of the **AquiferTest** that is currently active, or you can choose which reports to print at the same time using the **Reports** tab.

- [15] Click on the **Reports** tab. The following window will appear:



[16] Expand the nodes in the **Report navigator tree**. Check the boxes beside **Water Level data** and **Analysis Graphs**.

You can define your company information and logo under **Tools / Options**.

[17] To print the reports select **File/Print** or click the **Print** button in the toolbar.

This concludes the **AquiferTest Pro Demo Tutorial**.

# INDEX

## A

Automatic Curve Fitting 17

## B

Bouwer & Rice Analysis 40

## C

Color Shading 20

Contouring Drawdown 18

## D

Derivative Analysis 34

## E

Entering Discharge Data 7

Entering Water Level Data 8

## F

Features 3

## H

Hvorslev Analysis 39

## I

Import Data 8

## M

Manual Curve Fitting 17

Multiple Pumping Wells 22

## P

Papadopulos Cooper Analysis 36

Predictive Analysis 26

## R

Reports 30

## S

Single Well Analysis 31

Slug Test Analysis 36

## T

Theis Analysis 11