

Interpretation of Constant Rate Test in confined infinite aquifer using observation borehole hydrograph

This lesson explains, how to start a project and interpret a constant rate pumping test using Theis (1935) solution.

Conceptual model

A constant rate pumping test is conducted in infinite alluvial aquifer. The 15-m thick horizontal sand layer is deposited between low-permeable clay layers (**Figure 1**). The fully penetrating well is pumped for three days with the constant rate of 150 m³/day, and manual drawdown measurements are conducted in a fully penetrating monitoring well, that is located 5 m from the pumping well. The monitoring well is screened over the entire thickness of the sand layer.

The drawdown measurements are presented in Table 1.

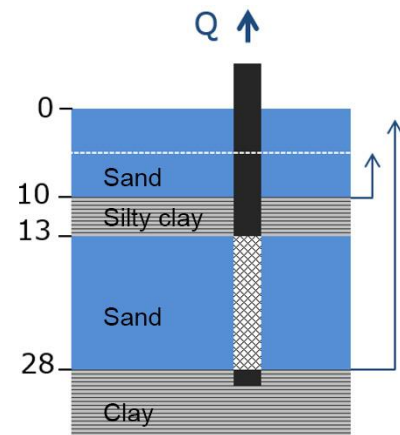


Figure 1. Conceptual model

Open project, input data to ANSDIMAT

ANSDIMAT interpretation requires two types of files:

- *.eat file contains original input data, such as borehole design and drawdown measurements;
- *.oat file contains interpretation solutions, matching curves, plots and reports.

During usual interpretation process (full version of ANSDIMAT is required) the following steps are conducted:

- *.eat file and other auxiliary data files are created in Editor mode (*Aquifer test Analysis/New Project*). The files are created in a specified folder that should be unique for every project;
- *.eat file and other input data files are edited by user in Editor and then converted by user to *.oat file with the same name;
- *.oat file is used for interpretation, analysis and plots.

Creating and editing of .eat file is the topic of Lesson 2. For this lesson, the *.eat and the *.oat files have already been created, and you will use them for interpretation.

Download the [project files for the Lesson 1](#) that are available from the tutorial section of the ANSDIMAT website. Copy the folder Lesson_1 on your hard drive. Open ANSDIMAT, then use the command *Aquifer test Analysis/Open Project*. A pop-up window opens letting you select the file to open.

A drop-down menu in the right bottom corner allows to select .eat (Editor files) or .oat (interpretation files): select .oat files then select the file Lesson_1.oat. When clicking on “Open”, a new window opens displaying the data from Table 1 as a plot (Figure 2). The data is visible on the left of the screen.

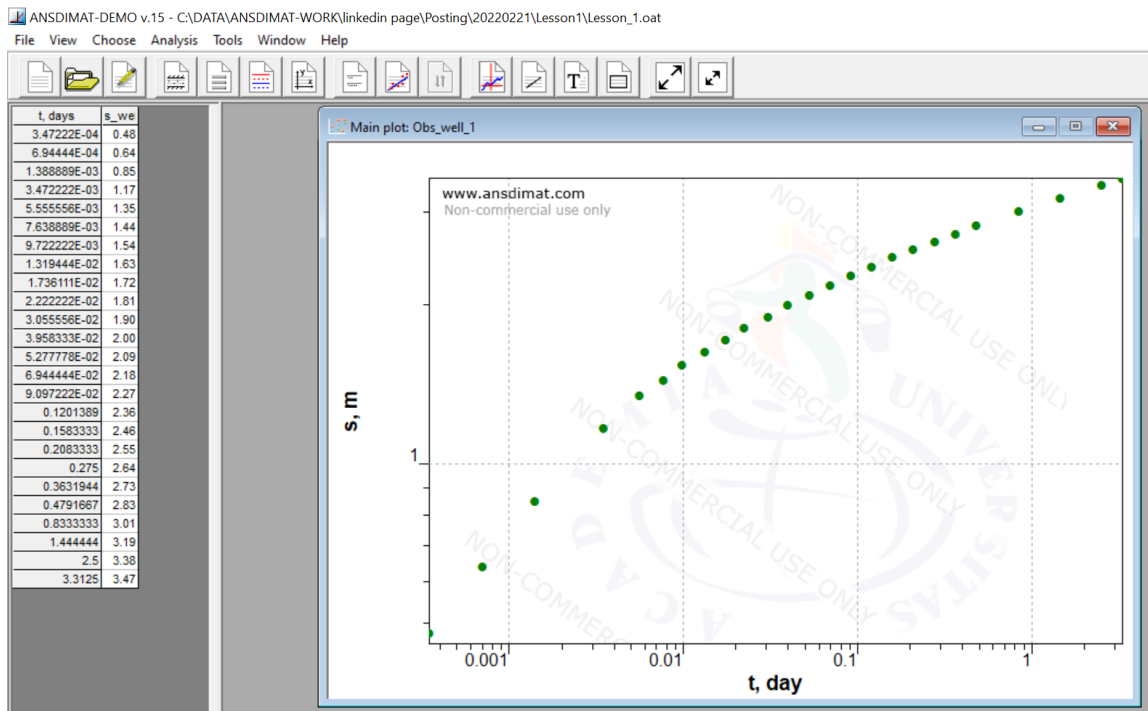


Figure 2. Aquifer Test Interpretation main plot window

To review inputs, you can go to the Editor at any time using menu “*Aquifer Test Analysis/Editor*”. In the Editor mode, you will be able to see and edit the data that were input in ANSDIMAT for this lesson. You will need to save any change you make and re-create the .oat file, then reopen it in order to make these changes available for interpretation. This topic is not within the scope of Lesson 1 and it is covered in [Lesson 3](#).

Aquifer test settings for interpretation

To begin interpretation, the first step is to select the conceptual model and the type of plot. This is done in the “*Choose*” menu. By default, the conceptual model is the one selected when creating the .eat file and the default plot is drawdown vs time (logarithmic scale). Depending on the nature of the aquifer, this selection may have to be modified. Once model and plot type have been selected, a series of applicable functions is provided to fit the test data.

The menu “*Choose/Model*” (Figure 3) offers various options for the conceptual model and boundary conditions. This pumping test is conducted in a confined infinite aquifer, and the most suitable conceptual model (Confined aquifer: This solution) has already been selected.

The menu “*Choose/Test conditions*” offers a series of options regarding how the test was conducted. In this case, it is a test at a single constant pumping rate from a single well. These options are already selected.

The menu “*Choose/Plot*” allows choosing the plotting options for interpretation. By default, the drawdown (s) is displayed against time on a logarithmic scale. The plot by default is $s - \lg(t)$: choose the $\lg(s) - \lg(t)$ plot (if not already selected) and click “Ok” to apply and close the window. Only the options in black are available that are dependent on selected conceptual model.

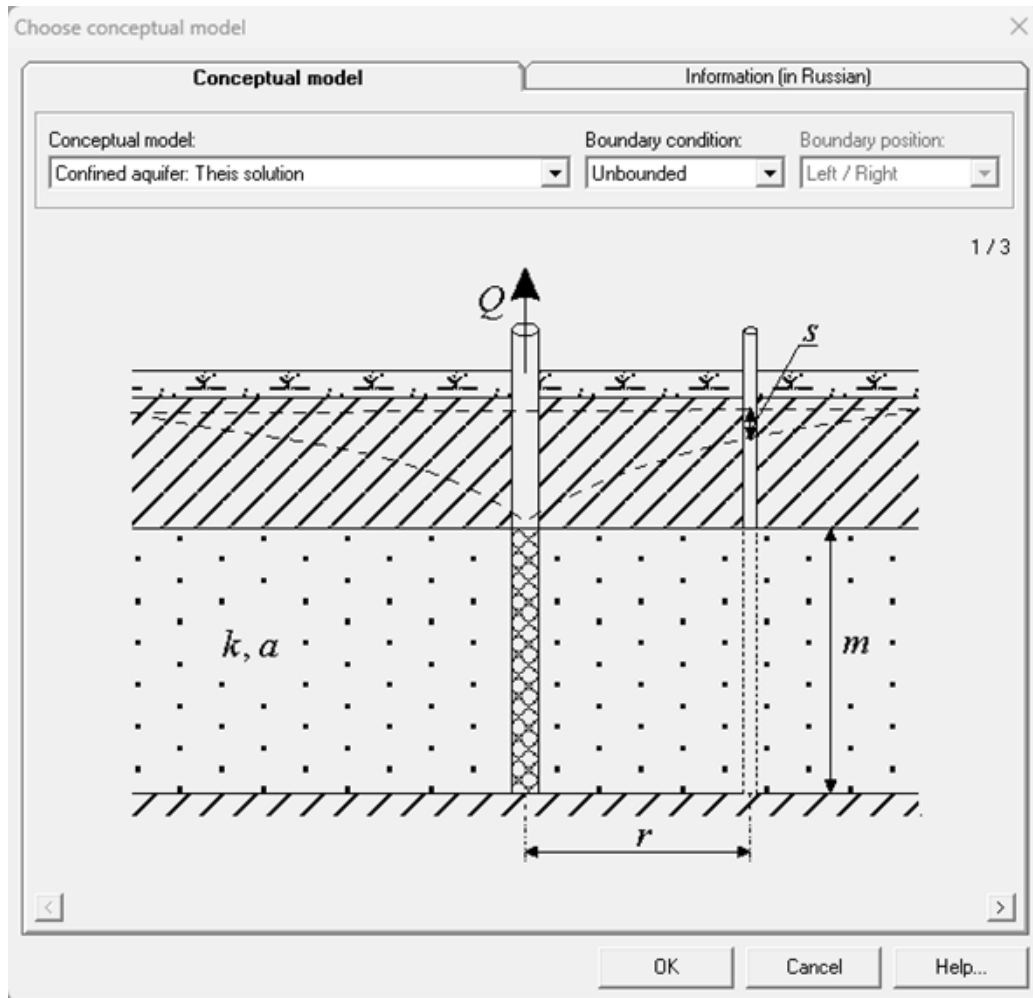


Figure 3. Dialog window for conceptual model selection

The menus “*Choose/Well*” and “*Choose/time*” allow selection and deselection of specific wells and times for interpretation. Specific individual wells or time periods can be excluded from the current interpretation, while still keeping them in the project. For this interpretation you should keep selected wells and times unchanged (default settings).

The menu “*Tools/Observation data symbol*” offers options to change the marker shape and color for data points and the color of the curve.

For more information on the functions of the “Choose” menu and the different options provided, please refer to the Help file. It is readily accessible from any of the pop-up windows by clicking on the “Help” button.

Interpretation

For this lesson we will use the method of manual matching. Other interpretation methods will be explored in other lessons.

Go to “*Analysis/direct solution*” and choose the solver from the drop-down menu. Select “Function of Theis”. This will allow interpretation of aquifer test data with the Theis (1935) analytical solution, that is based on the most simplifying assumptions for a confined unlimited aquifer. Assumptions and simplifications of Theis solution can be reviewed at https://en.wikipedia.org/wiki/Aquifer_test

To interpret the test, you need to fit the chosen function (in this case the function of Theis) to the data points. You can do that by changing the numbers in the fields “*Transmissivity*” and “*Hydraulic diffusivity*”, then press the “*Apply*” button and visually check the quality of the match. Once plotted, curves stay on screen so they can be compared. You can use the “*Clear*” button to delete previously plotted curves. When you are satisfied with the match, press “*OK*”. As the aquifer is composed by fine grain sediments, expect hydraulic conductivity between 1 and 3 m/d. Note that hydraulic diffusivity for confined aquifer corresponds to the ratio between hydraulic conductivity and Specific storage ($a^* [m^2/d] = K[m/d] / S_s[1/m]$). An example of acceptable match for this interpretation is presented in **Figure 4**.

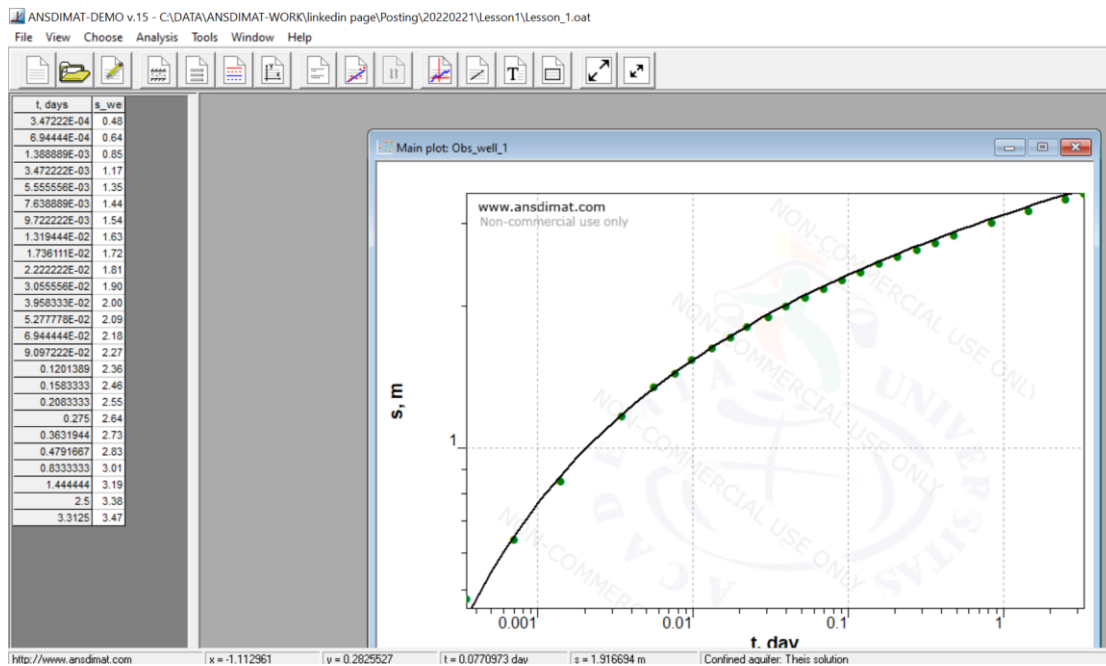


Figure 4. Example of manual match for $\lg(s)\text{-}\lg(t)$ plot

In a different case, it may not be possible to fit all of the data with the Theis function, or the fit obtained is poor. If the curve diverges significantly from the data points, it can mean that the conceptual model is inadequate. In this case, you can use the command *Choose/Model* to select another concept. When conducting an interpretation, use your conceptual understanding of data to select most adequate conceptual model and analytical solution(s). Although this example is simple, an interpretation can be an iterative process: do not hesitate to try different analytical solutions and concepts. It is generally recommended to select analytical solutions in order of increasing complexity.

Presentation and reporting

Use the commands “*Tools/Plot title*”, “*Tools/Show legend*”, “*Tools/text*” and “*Tools/show parameters*”, to display a title, a legend, the interpretation results and other user-specified text. An example of report- ready plot is presented in **Figure 5**. After your layout is complete, you can copy the plot to the clipboard (“*Tools/Copy and clipboard*”), export plotted data and curves in EXCEL (“*Tools/Create Excel plot*”) or copy data time series in ASCII format (“*Tools/Copy data*”).

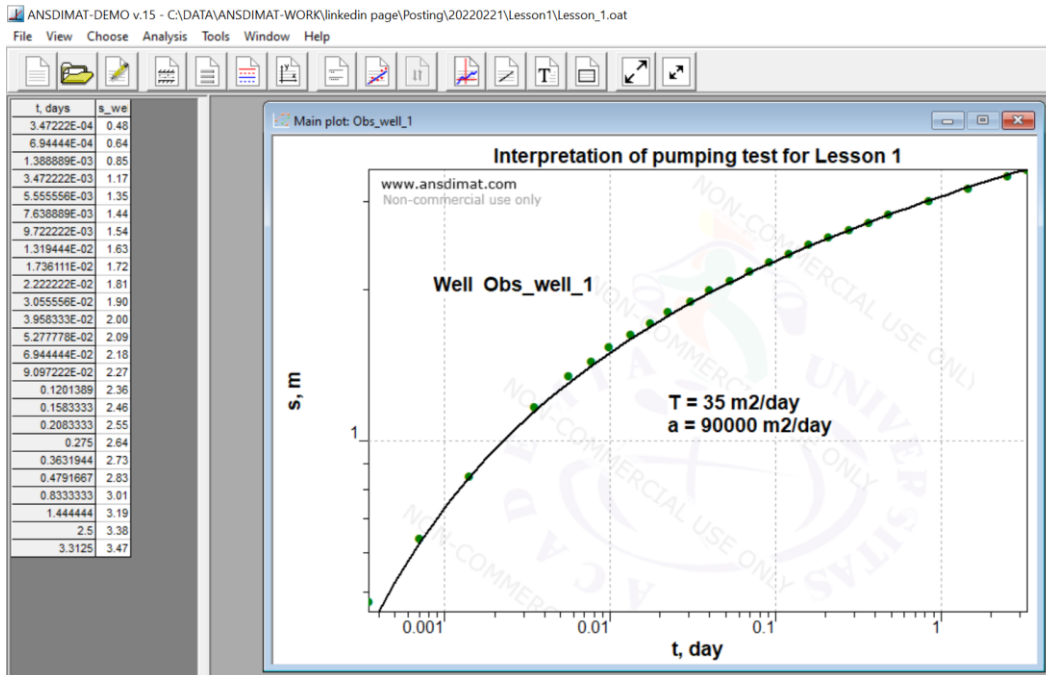


Figure 5. Example of figure for reporting with well name and aquifer properties

To export the plot in the internal ANSDIMAT format, use the command “*File/Aquifer test analysis/Save plot*” from the “Aquifer test analysis” menu. When you later load a saved plot, all corresponding interpretation settings will be uploaded as well, so the applied analytical solution and the interpretation results will be displayed.

This concludes the first lesson. The project files and support documents can be downloaded from the tutorial section of the ANSDIMAT website. The help file contains further information about the functions and the menus that were used in this lesson. Finally, do not hesitate to contact the technical support (support@ansdimat.com) if you have issues, questions or feedback you would like to share about this lesson.

Table 1

min	day	Drawdown, m
0.5	0.0003	0.48
1	0.0007	0.64
2	0.0014	0.85
5	0.0035	1.17
8	0.0056	1.35
11	0.0076	1.44
14	0.0097	1.54
19	0.0132	1.63
25	0.0174	1.72
32	0.0222	1.81
44	0.0306	1.90
57	0.04	2.00
76	0.05	2.09

min	day	Drawdown, m
100	0.07	2.18
131	0.09	2.27
173	0.12	2.36
228	0.16	2.46
300	0.21	2.55
396	0.28	2.64
523	0.36	2.73
690	0.48	2.83
1200	0.83	3.01
2080	1.44	3.19
3600	2.50	3.38
4770	3.31	3.47

References: Theis C.V. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage // Transactions, American Geophysical Union. 1935. Vol. 35, pt. 2. P. 519–524.