PVSYST 7

Pumping Systems
Hydraulic circuit

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INTRODUCTION

This document consists of tutorials for the simulation of pumping systems. This first chapter describes the basic aspects on the characteristics of hydraulic circuits.

More tutorials on different features of PVsyst are in preparation and will be added in the future. The complete reference manual for PVsyst is the online help that is accessible from the program through the “Help” entry in the menu, by pressing the F1 key or by clicking on the help icons inside the windows and dialogs.

Contents

Chapter 1: Characteristics of the hydraulic circuits

1.1 Deep Well

When drilling a well, the first question to ask is "how much water can I pump in the short and medium term, and what is the quality of this water? To do so, a pumping test must be carried out.

What is a pumping test? The basic concept of the pumping test is very simple: water is extracted (by pumping or drawing) from a well or borehole, thereby lowering the water level.

The water level in the extraction well and the pumping rate are observed over a period of time, as are various other parameters, where possible. The way the water level reacts to pumping is then analyzed to obtain information on the performance characteristics of the borehole and the hydraulic properties of the aquifer.

There are many types of tests to choose from intermittent or continuous, short or long duration, low or high pumping rate, etc.

Which other parameters or characteristics of water that should be observed, in addition to those that are obvious, that is, the water level and pumping rate in the well being assessed?

The main difficulty encountered when studying groundwater (in relation to flow measurements in a river, for example) is that one works blindly because it is impossible to see the aquifer and directly observe its behavior.

<u>Aquifer:</u> A layer of rock, sand, or earth that contains water or allows water to pass through it.

Information about the borehole and the aquifer can only be deduced by looking at how the water level reacts to pumping. Pumping tests can be performed for a several reasons, <u>including</u>:

- To evaluate the reliable long-term performance (or production output) of a borehole, and therefore determine whether the borehole can be considered a "success" and to how many people will it be able to supply.

- To assess the hydraulic performance of a borehole, generally by its yield-drawdown characteristics. What should be the drawdown to provide a certain amount of water?
  Drawdown: A drop in the water table level, proportional to the flow rate pumped

- To deduce the hydraulic properties of the aquifer. Pumping tests are the standard method (and may be the only one) to determine the hydraulic properties of the aquifer, such as transmissivity and storage coefficient, or to reveal the presence of hydraulic limits.

- To test the operation of the pumping and observation equipment to be sure that everything is working safely and efficiently and, if necessary, confirm that the contractors have done their job properly.

- To assess the effects of this extraction on neighboring boreholes (sometimes called interference).

- To determine the impact of the extraction on the environment.

Any extraction of groundwater ends up having an impact, it is just a matter of place and time, and it remains to be seen whether this impact is acceptable by:

- providing information on water quality. Is the water quality sufficient for the intended use? Is it stable in the long term?

- Should we expect problems such as taking saline or polluted water after long periods of pumping?

- Defining optimal operating regimes (especially for multi-well pumping), choose the most suitable pumping station for long-term use, and assess the probable pumping and / or treatment costs.

- Determining the exact depth at which the permanent pump should be installed in the borehole.

There are many types of tests from which we have to choose the most suitable:

- Tiered test: designed to determine the short-term relationship between the yield and the drawdown of the borehole tested. It consists of pumping in the borehole, with a series of bearings at different flow rates, the flow rate usually increasing at each level. Last level should approach the estimated maximum yield for drilling

- Constant flow test: performed by pumping at a constant flow rate much longer than in the step test, it is primarily designed to provide information on the hydraulic characteristics of the aquifer. It is only possible to infer information relating to the storage coefficient of the aquifer if the data come from appropriate observation boreholes.

- Ascent test: consists of observing the rise in water levels after the pumping stops at the end of a constant flow test (and sometimes after a step test). It is useful for checking the characteristics of the aquifer deduced from other tests but is only valid if a non-return valve (foot valve) is placed on the discharge column, otherwise the water is forced back into the borehole. These tests can be carried out individually or in combination. In general, a full suite of tests begins with a step test, the results of which help determine the pumping rate of the constant rate test and ends with the ascent test. The test concept can be adapted for use in boreholes of various sizes (small, medium, or large), the main differences being the pumping rate, the duration of the test and the complexity of the observation system.

In PVsyst we take the ground level as reference, referring to Figure 1, we have the following entities:

HT = HG + HS + HD + HF,

where:

- **HG**: Head due to the height of the outlet pipe above the ground (assuming that outlet pressure is negligible).
- **HS**: Static head due to the depth of the water level in the well, in absence of any pumping.
- **HD:** Dynamic drawdown height: in a borehole, the effective water level is dynamically lowered by the extraction of water flow (see below). It depends on the flow rate at each moment.
- **HF**: Friction losses in the piping circuit, which depend on the flowrate.

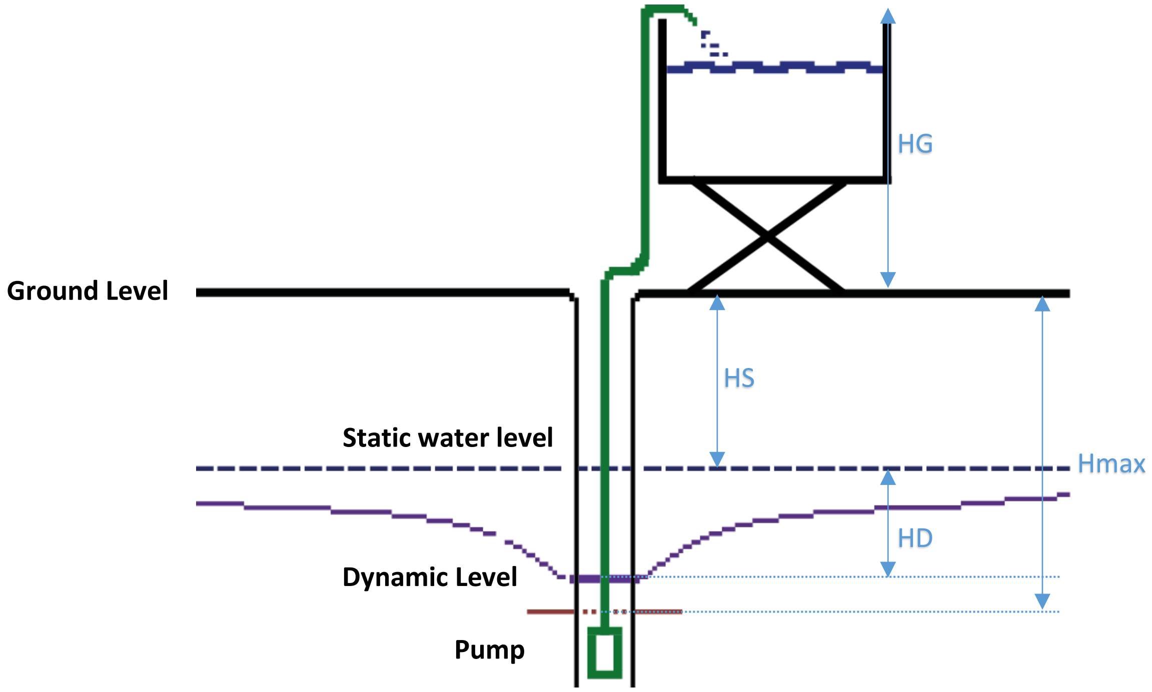

Figure 1: Pumping system sketch and notations.

For this system, in the "Pumping Hydraulic definitions" dialog, you will be asked to specify:

- The static depth. This may also be given in seasonal or monthly values, in the “Water Needs" next dialog.
- The maximum pumping depth, corresponding to the inlet aspiration level. The system will stop the pump when the dynamic level reaches this level, avoiding dry running.
- The depth of the pump, always below **Hmax.**
- The borehole diameter (in cm).
- The specific drawdown expressed in [m / m3/h]: this is a characteristic of the borehole and the surrounding ground.

1.2 Lake or River

Pumping systems from a lake or river are similar to deep well systems, but with some technical simplifications:

- The pump may be placed near the source (no more than 4-5 m above the water surface, less at high altitudes, to avoid cavitation problems).
- The pump is not necessarily of "Submersible" type, making it cheaper with an easier maintenance.

Remember that the Pressure or Head is mainly related to the difference between the input and output levels. The pump must provide a total head resulting of several contributions.

In PVsyst, we take the ground level as reference as shown in Figure 2, with:

HT = HG + HS + HF,

where:

- **HG:** Head due to the height of the outlet pipe above the ground (assuming that outlet pressure is negligible).
- **HS**: Static head due to the depth of the water level, with respect to the ground.
- **HF**: Friction losses in the piping circuit, which depend on the flowrate.

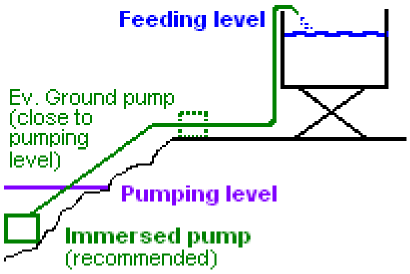

Figure 2: Lake or river pumping systems sketch.

For this system, in the "Pumping Hydraulic definitions" dialog, you will be asked to specify:

- The lake or river level depth, with respect to the ground. This may also be given in seasonal or monthly values, in the “Water Needs" next dialog.
- The depth of the pump should be strictly less than 5m above the depth of the source but can also be submerged.

1.3 Conclusion

In this document, we presented the characteristics of hydraulic circuits for both deep well and lake/river.

In the next chapter, we will demonstrate the basic approach on creating your first project for pumping systems.