Aquifer testing: Correcting water level data for barometric fluctuations

Water level observations made during aquifer tests are susceptible to distortions due to the influence of fluctuations in barometric pressure. These distortions can be significant in aquifer test cases where interference due to pumping effects are small, because barometric pressure effects can make up a large proportion of the total observed water level fluctuations It is therefore important to consider, and correct for, effects of barometric pressure changes when analysing aquifer test water level data.

Document Purpose

This practice note provides a guide for practitioners of aquifer testing, to ensure that they correctly account and correct for barometric pressure effects during aquifer tests. The method(s) discussed in this document are not mandatory, but rather are an option that can be used.

Barometric fluctuations in water level records

The potential for barometric pressure changes to affect water levels has long been recognised. However, the practice of measuring high resolution barometric records has only really become common place with the use of electronic down-well pressure transducers with data logging capabilities, and that are not vented to the atmosphere. The pressure measurement recorded by an unvented pressure transducer is the total pressure, i.e. sum of standing head of water above the transducer plus the pressure induced by the atmosphere. In order for a non-vented logger record to represent changes in water levels (i.e. the actual water level record), the barometric pressure must be subtracted.

When water level records are compared to barometric pressure records some wells/aquifers exhibit a response to barometric change, i.e. a drop in barometric pressure may correspond to a rise in water levels. The sensitivity of this response is termed barometric efficiency (BE), and high efficiencies relate to sensitive responses to changes in barometric pressure.

As aquifer tests are concerned only with pumping induced water level changes rather than actual water levels, barometric efficiency needs to be calculated in order that appropriate corrections can be made to data sets where large barometric changes have occurred. At the extreme, a 100% efficient aquifer will yield clearer pumping induced changes if no barometric correction is used on an observation dataset (i.e. the raw non-vented logger dataset being water pressure plus barometric pressure).

In some circumstances, water level changes attributed to barometric pressure effects can outweigh the actual pumping-induced drawdown of an aquifer test. To offset this potential imbalance, and reduce the inherent risk of error associated with it, it is recommended that aquifer tests be designed to induce more than 0.2 m of pumping induced drawdown at the observation well(s). This can be achieved by increasing the pumping rate and/or using observation wells close to the pumped well.

Unconfined/confined aquifer theory

In confined aquifers the transmission of barometric effects is very close to being instantaneous, with barometric efficiency described as the change in water level as a proportion of any given change in barometric pressure.

Unconfined aquifers can also exhibit a time lagged response as air must move in and out of the overlying vadose zone to transmit the change in pressure. The barometric efficiency of an unconfined aquifer is therefore also a function of time (lag).

Recommend method for barometric correction

Confined/semi-confined aquifers

- In the case of a non-vented logger, correct logger record for barometric pressure. This will provide a record of actual water levels above the logger at the site.
- Correct water level record for any antecedent trends.
- Correlating changes in water level with changes in barometric pressure over a period of no pumping (e.g. before an aquifer test) will provide a short term estimate of barometric efficiency. A minimum no pumping period of 24 hrs is recommended. *N.B.* a period of barometric pressure change is required to form a correlation. Alternatively (considered best practice where possible), a well outside the influence of pumping could be used to monitor barometric pressure effects during the aquifer test.
- A plot of water level change (as metres) vs. barometric pressure change (as metres of H_2O[1]) will yield a (negative[2]) slope equal to BE, which can then be used to correct observed water levels for the duration of the test:

$$DD = WL_{obs} - BE \times \Delta P_{atm} \qquad \textbf{Eq 1}$$

and

$$WL_{obs} = P_{measure} - P_{atm} \quad \textbf{Eq 2}$$

Where DD is the pumping-induced drawdown, WL_{obs} is the observed water level in the well, $P_{measure}$ is the pressure measured by an unvented pressure transducer in the well, and P_{atm} is the measured barometric pressure. All variables are measured in the same pressure unit: metres of water.

Unconfined - aquifers

The same method for confined aquifers but an adjustment of barometric times to account for any lag (if identified) must be made.

Note: It is recommended that a correlation is carried out for each test period as experience in Canterbury aquifers indicates that long term barometric efficiency is often not constant. This is likely to be due to BE being dependent, to some extent, on regional water levels, causing subtle changes in the aquifer which may for example change to amount of confinement.

Reporting

Whenever a correction for barometric efficiency has been made to observations this correction must be justified. For example if the method used is the one above then ideally a correlation plot will submitted with the aquifer test report.

Further reading

Clark, W.E. 1967. *Computing the barometric efficiency of a well*. J. Hydraul. Div. Am. Soc. of Civil Engineers. 93 (HY4):93–98.

Furbish, D.J. 1991. *The response of water level in a well to a time series of atmospheric loading under confined conditions.* Water Resour. Res. 27:557–568.

Quilty E.G., and E.A. Roeloffs. 1991. *Removal of barometric pressure response from water level data*. J of Geophys Research 96(B6): 10,209-10,218.

Rasmussen, T.C., and L.A. Crawford. 1997. *Identifying and removing barometric pressure effects in confined and unconfined aquifers*. Ground Water 35:502–511.

Rojstaczer, S., and D.C. Agnew. 1989. *The influence of formation material properties on the response of water levels in wells to earth tides and atmospheric loading*. J. Geophys. Res. 94(B9):12403–12411.

Spane, F. A. 1999. *Effects of Barometric Fluctuations on Well Water-Level Measurements and Aquifer Test Data*. Pacific Northwest National Laboratory Washington **www.osti.gov/bridge/servlets/purl/15125-OVJJgQ/webviewable/15125.pdf**

Weeks, E.P. 1979. *Barometric fluctuations in wells tapping deep unconfined aquifers*. Water Resour. Res. 15:1167–1176.

[1] 1 kPa equals approximately 10.19745 cm of H_2O at 4ºC

[2] The negative slope is reflective of the inverse relationship between groundwater levels and atmospheric pressure change (e.g., water levels decline with an increase in atmospheric pressure).

Barometric efficiency (BE) correction example plots

Figure 1 Logger data records - Uncorrected

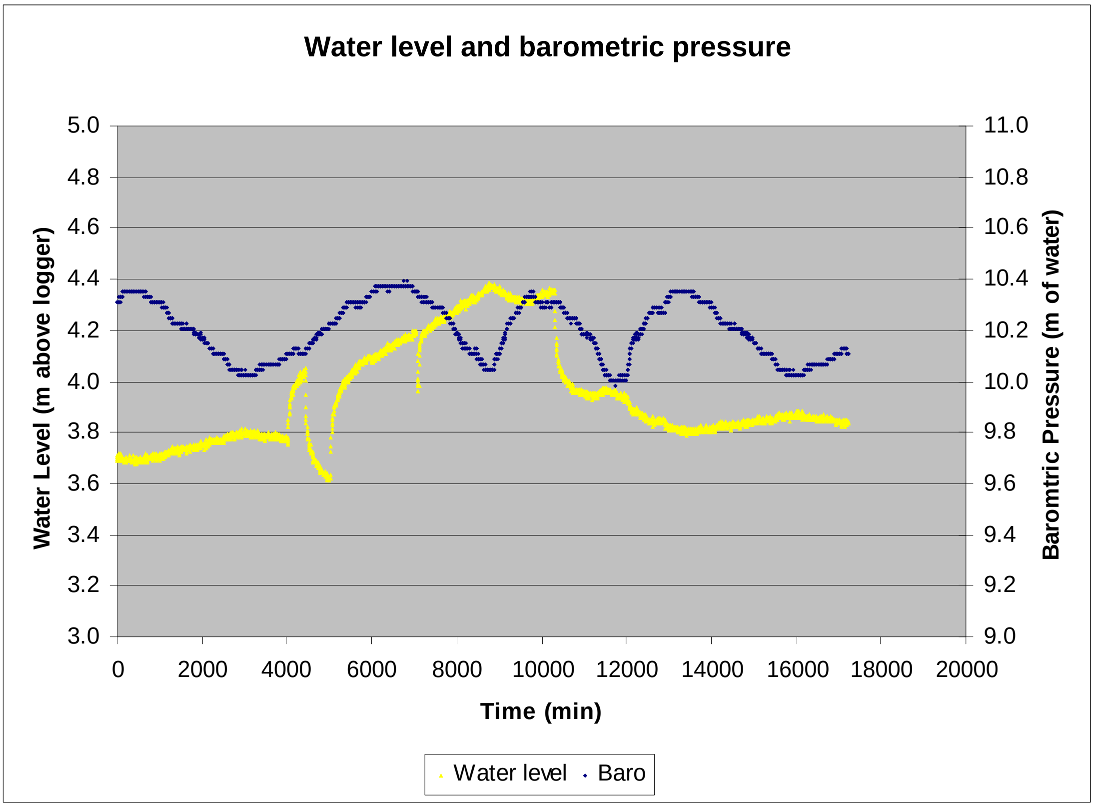

Figure 2 Water level above logger and barometric data record

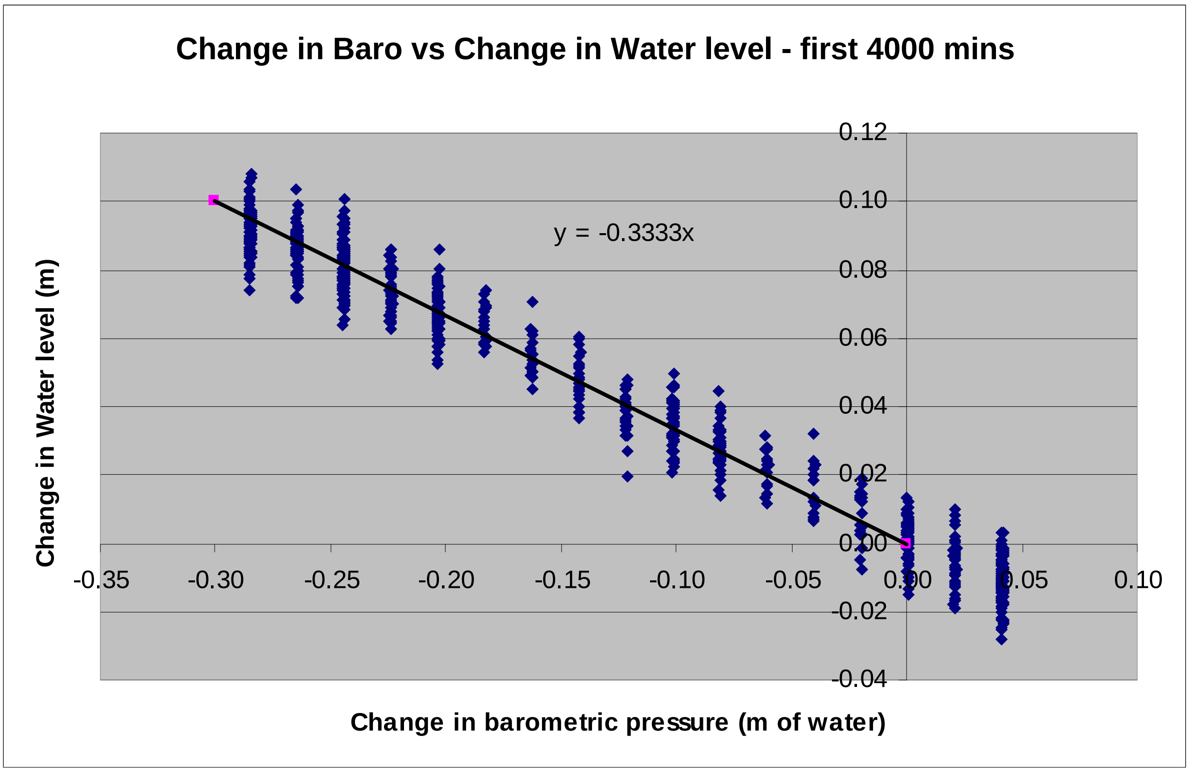

Figure 3 Water level - barometric correlation showing 33% BE

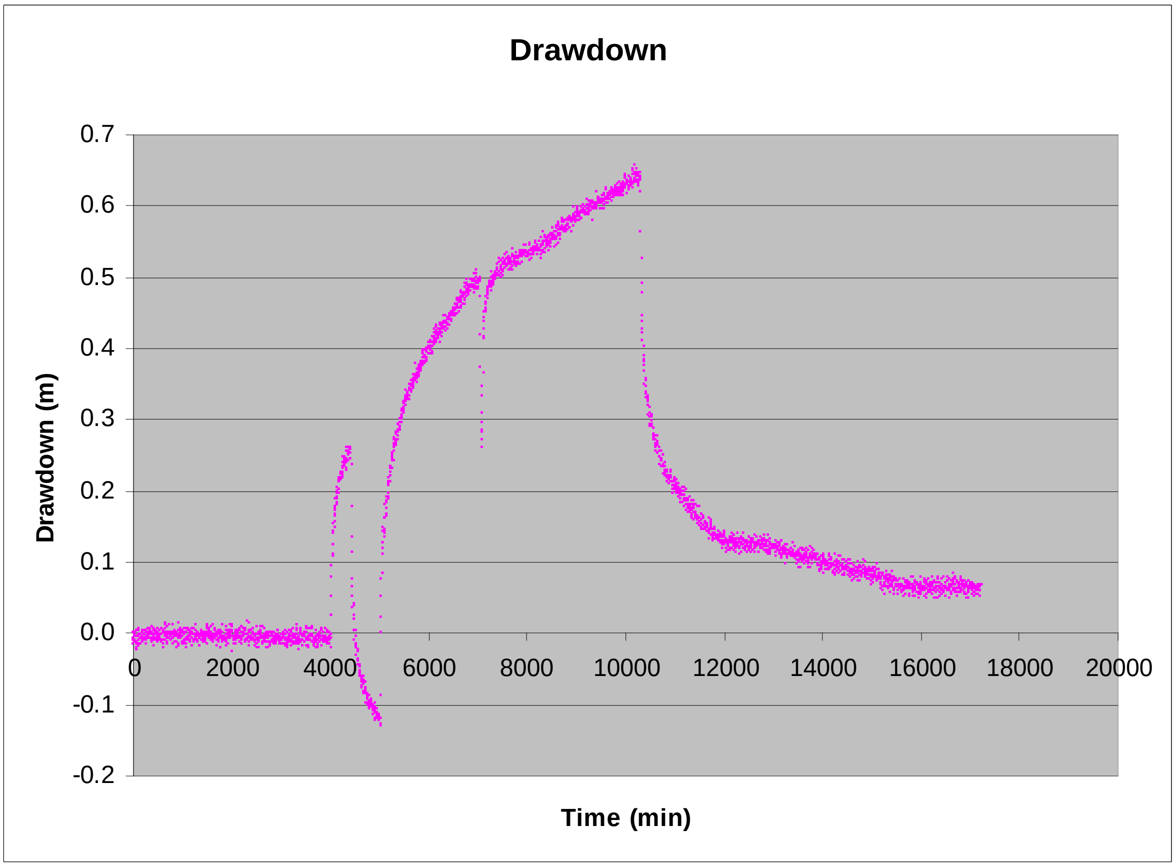

Figure 4 Drawdown data corrected for 33% BE