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Using Pressure Transducers at Varying Depths to Determine Aquifer Parameters and Gas Flow Effects in Water Wells

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Summary

Numerous concerns have been expressed by water well owners related to gas migration into their wells. Typical measurements of gas flow rates in water wells involve gas flow meters or flow through cells. An alternative method is suggested consisting of installing several pressure transducers at various depths along with measuring the top of water levels in the well with electoral tape / sonic water level meters to compare fluid readings at different depths during the pumping test.

A pumping test conducted on a water supply well that also produces gas showed that water levels read at the air/surface water interface give vastly different results with pressure transducers placed deep in the well. Pressure transducers placed at different depths show deviations from each other due to the nature of the gas flow in the water column.

Theory & Method

Commercially available transducers report water levels but actually measure fluid pressures. The fluid pressures are converted to water levels using typical water pressure gradients. The addition of gas into the water column should change the density of the fluid column and be reflected in fluid pressure deviations compared to a column of water with no dissolved gases.

Two phase flow theory (1) in vertical pipes have differentiated gas and water flow under six recognized conditions:

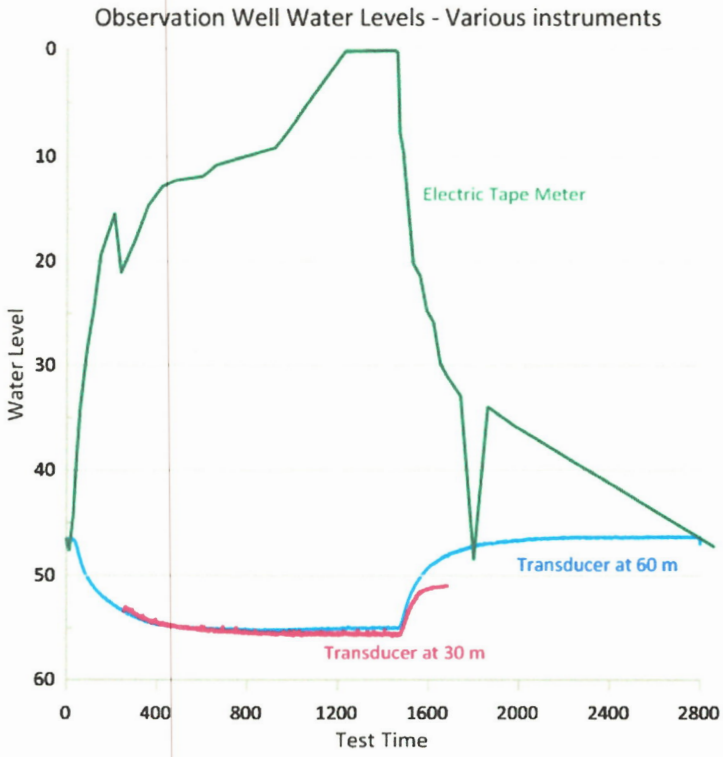
1. Dispersed Flow – gas bubbles less than 1.5 mm in diameter and evenly dispersed throughout the well bore.
2. Annular Flo – gases concentrate along centre of pipe, liquid along the edges
3. Bubbly Flow – small bubbles coalesce into large bubbles with the volume of gas in the pipe greater than 25%.
4. Slug Flow – gas flow consists largely of large bubbles.
5. Churn Flow – gas plugs and liquid flow are oscillatory.
6. Mist Flow – largely gas with water mist.

These gas – water flow regimes are dependent on the velocity of gas and water moving up through a vertical column and have been mapped graphically (1).

A 48 hour pumping test (24 hours flow, 24 hours buildup) was conducted on a water supply well in south-eastern Saskatchewan that obtains water from the Judith River Formation. The well was pumped at a rate of 310 cubic metres per day and fluid levels were measured in the producing well and in an observation well located 60 metres away from the producing well.

Results & Conclusions

A graph showing water levels as measured by pressure transducers at 30 m and 60 m depth and with an electrical tape measuring the depth to the top of the "water" column is as follows:



The top of water column measurement (green) provides no usable data with respect to aquifer interpretation whereas the two pressure transducers show more typical pumping test results. The transducers do show some deviations between each other due to increasing gas flow rates during the pumping portion of the test. The transducer at 30 m (red) shows "noisy behavior" which upon closer inspection is likely a result of bubbly or slug flow conditions.

Additive Information

Gas flow rates and the nature of gas flow can be calculated from deviations from normal water level readings. The method can also be applied to non-pumping water wells where gas flow may be occurring through a static water column.

Additional research would include installing more pressure transducers, recording pressure measurements at more frequent time intervals, and measurement of gas flow rates and compositional and isotope analysis.

References

(1) Two – Phase Flow, Theory and Applications, Kleinstreuer, C. Taylor and Francis, 2003