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Application Note

Low-Flow Sampling of Water Quality Parameters Used in Determining Groundwater Stability

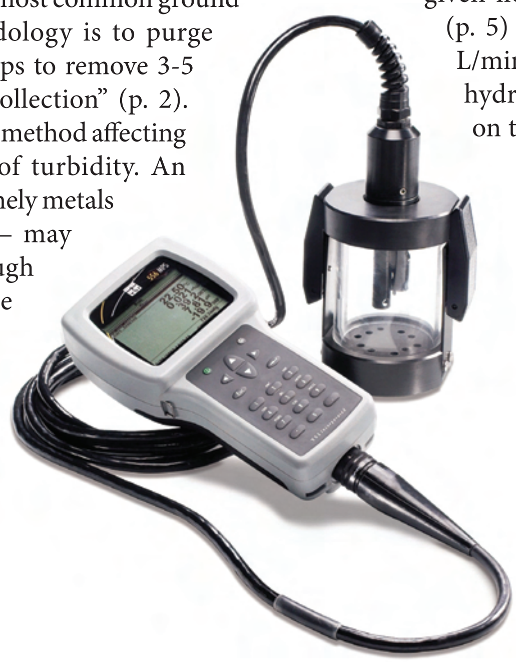
An Overview

In April 1996, the US EPA Office of Research and Development, Office of Solid Waste and Emergency Response, developed and published a document entitled *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (Publication EPA540/S-95/504). Since then, the use of low-flow sampling in ground water has increasingly been used to support site assessment and remedial performance monitoring objectives. There are many documents on this subject and this particular document isn't intended to be all-inclusive. For the purposes of this paper, the focus will be primarily on the water quality parameters used to indicate stable well situations.

The document states that "the most common ground water purging and sampling methodology is to purge wells using bailers or high speed pumps to remove 3-5 casing volumes followed by sample collection" (p. 2). Adverse impacts can occur through this method affecting sample quality by increasing levels of turbidity. An overestimation of certain analytes – namely metals or hydrophobic organic compounds – may affect results with this method through the inclusion of otherwise immobile artifactual particles. Filtration of these turbid particles has proved undesirable in rectifying the turbidity problem and may, in fact, bias the results of contaminant concentration on the low side by potentially removing mobile (contaminant-associated) particles. These problems can often be mitigated by using low-flow purging and sampling to reduce sampling-induced turbidity.

The benefits of low-flow sampling include (pp. 5,6):

- Samples which are representative of the mobile load of contaminants present (dissolved and colloid-associated)
- Minimal disturbance of the sampling point thereby minimizing sampling artifacts
- Less operator variability and greater control
- Reduced stress on the formation (minimal drawdown)
- Less mixing of stagnant casing water with formation water
- Reduced need for filtration and therefore less time required by the operator
- Smaller purging volumes decrease potential disposal costs
- Better sampling consistency



YSI 556 MPS and 5083 flow cell for groundwater applications or anytime water is pumped from its source.

In order to minimize the hydraulic stress placed on an aquifer during purging and sampling, the technique of using low-flow sampling is recommended. This is typically done through the use of an adjustable rate pump to remove water from the screened zone at a rate that will cause minimal drawdown of the water level in the well. Drawdown is measured in the well concurrent with pumping using a water level meter. Low-flow sampling does not require a specific flow rate or purge volume. "Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. Water level drawdown provides the best indication of the stress imparted by a given flow rate for a given hydrological situation" (p. 5) Typical flow rates on the order of 0.1-0.5 L/min are used, but this depends on site-specific hydrogeology (p. 5) Low-flow sampling relies on the ability to collect samples after water level and measured field parameters stabilize over three consecutive readings taken three to five minutes apart.

It's important to note that, "parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action" (p. 4).

Parameter Stabilization

It is recommended that water quality parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen [DO], oxidation-reduction potential [ORP], temperature, and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by [ORP], [DO], and turbidity...Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate, and equipment specifications for measuring indicator parameters" (p. 5).

(continued)

Instruments such as the YSI 556 multiparameter instrument can simultaneously measure parameters while utilizing a flow cell to give continuous data.

The document also states, "It should be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU)" (p. 5).

The YSI 556 multiparameter instrument simultaneously measures parameters while utilizing a flow cell to give continuous data. This method reduces the chance that changes in chemical concentrations are induced by the sampling technique.

"In-line water quality indicator parameters should be continuously monitored during purging" (p. 7). Water level drawdown should also be checked periodically as a guide to flow rate adjustment with the goal being minimal drawdown (<0.1 m) during purging (p.7). "Measurements of water quality parameters should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters being measured have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for [ORP], and ± 10% for turbidity and DO...[These] guidelines are provided for rough estimates" (p. 8)

Many state agencies encourage the use of low-flow sampling because it's designed to collect a sample that most truly represents the water in the screened section of the aquifer surrounding the monitoring well. It does not come from water that is mixed within the well by a bailer or inertial sampler, nor does it come from an average of water that flowed the full length of a long screened interval.

Conclusion

The low-flow sample can most often be trusted to best represent the contamination or lack thereof in the aquifer because it was produced by a process that minimizes stress on the aquifer or well. Low-flow sampling also reduces the variability in sampling technique that is inherent in traditional bailing and purging procedures. In summary, low-flow reduces the physical and chemical stresses, reduces the variability in sample procedures, increases the ability to determine well stabilization by continuously monitoring water quality parameters, and reduces the chance that changes in chemical concentrations are induced by the sampling technique.

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YSI 5080, ground water hard-sided carrying case with enough space for the YSI 556 MPS, a 4- or 10-meter cable, flow cell, manual, membrane kit, probe guard, batteries, and calibration solutions.

References

U.S. Environmental Protection Agency. EPA540/S-95/504 Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. ONLINE. 1996. Office of Research and Development & Office of Solid Waste and Emergency Response.
Available: http://www.epa.gov/ahaazvuc/pubs/issue.html [6 Dec. 2005].