United States Environmental Protection Agency
Office of Solid Waste and Emergency Response
April 1992

Rene

Ground Water Forum

MONITORING WELL DEVELOPMENT GUIDELINES FOR SUPERFUND PROJECT MANAGERS

Ruth Izraeli* Doug Yeskis, Mark Collins, Kathy Davies, Bernard Zavala

The Ground Water and Engineering Forums were established by EPA professionals in the ten EPA Regional Offices. The Forums are committed to the identification and resolution of scientific, technical and engineering issues impacting the remediation of Superfund and RCRA sites. The Forums are supported by and advise OSWER's Technical Support Project, which has established Technical Support Centers in laboratories operated by the Office of Research and Development, Office of Radiation Programs, and the Environmental Response Team. The Centers work closely with the Forums in providing state-of-the-science technical assistance to EPA project managers.

This document provides well development guidelines and recommended additional sources of information. It was developed by the Superfund Ground Water Forum and draws upon U.S. Army Corps of Engineers and draft RCRA SW-846 field protocols. Comments from ORD and Regional Superfund hydrogeologists have been incorporated. These guidelines are applicable to the great majority of sites. However, unusual, site-specific circumstances may require alternative approaches. In these instances, the appropriate Regional hydrogeologist should be contacted to establish alternative development protocols.

Introduction

The goal of ground-water sampling is to obtain water samples that best represent natural undisturbed hydrogeological conditions. Adequate well development is critical to minimize the introduction of biases into the sampling effort. Well development is necessary because every drilling method disturbs the geologic materials around the well bore to some extent. Development processes are used to try to ensure proper hydraulic connection between the well and the geologic materials in the vicinity of the well. This is done by stressing the formation around the screen so that mobile, artifact particulates are removed. This process is necessary to obtain a ground water sample which is as similar as possible to *in situ* conditions.

One of the major goals of well development is to produce a well capable of yielding ground-water samples of acceptably low turbidity. Excess turbidity may alter water quality and result in erroneous chemical analysis (particularly for unfiltered metals samples which require acid preservation).

Turbidity in ground-water samples is minimized by well development. Proper well development creates a graded filter pack around the well screen. When pumping is first initiated, natural materials in a wide range of grain sizes are drawn into the well, producing very turbid water. However, as pumping continues, the natural materials are drawn into the filter, producing an effective filter pack through a sorting process. This sorting process begins when the largest particles of natural materials are retained by the filter pack, resulting in a layer of coarse particles against the well screen. With continued development, this process produces progressively finer layers until an effective graded filter is produced, which then minimizes turbidity. Development is also necessary to remove any foreign materials introduced during drilling, such as drilling water and mud.

These guidelines are directed toward the development of relatively permeable (i.e., $K>10^{-6}$ cm/sec) aquifers. However, it is sometimes necessary to screen wells in water-bearing zones containing significant quantities of silt and clay, which would not normally be considered producing aquifers. Low-yielding wells located in marginal aquifers often cannot be developed using standard methods. For a discussion of the construction and development of wells in low-yielding forma-

Technology Innovation Office
Office of Solid Waste and Emergency Response
U.S. EPA, Washington, DC

Walter W. Kovalick, Jr., Ph.D., Director

*Hazardous Waste Management Division
U.S. Environmental Protection Agency
Region VI
1445 Ross Avenue
Dallas, TX 75202

tions, see Aller et al. (1989), Gass (1989), and Paul et al. (1988).

Wells constructed in bedrock may require special protocols. For example, wells constructed as open boreholes (cased to monitored zone) generally should not be developed using a surge block due to the potential for damaging the borehole walls. Bedrock wells constructed with screens may be developed in two stages, before and after the screen is installed. Since bedrock wells may require special development protocols other than those described here for wells in unconsolidated aquifers, Regional hydrogeologists should be consulted when designing bedrock well development procedures.

Finally, it is important to note that there are some hydrogeologic environments, such as fine-grained "marginal" aquifers and karst terraines, where excess turbidity may still exist even after optimizing well construction (e.g., filter pack size and thickness, screen size, drilling technique) and development.

Development Methods

The common methods for developing wells are described by Aller et al. (1989) and Driscoll (1986) and include:

- Overpumping
- Backwashing
- Surging
- Bailing
- Jetting
- Airlift pumping
- Air surging

Well development procedures that have the potential to alter ground-water quality should not be used. Therefore, methods which involve adding water or other fluids to the well, or use air to accomplish development, are not recommended. Generally unsuitable methods for monitoring well development include jetting, airlift pumping, and air surging. However, air development techniques may be used if they offer site-specific advantages over other methods, and extreme care is taken to prevent air from contacting the screened interval. Air development techniques must only be implemented by an experienced operator.

Recommended monitoring well development methods include pumping, overpumping, bailing and backwashing, in combination with some form of surging. The most effective combination and timing of these methods must be determined through field testing, or from experience developing wells in similar hydrogeologic regimes.

Movement of ground water into the well in one direction generally results in bridging of the particles, and a means of inducing flow reversal is necessary to break down the bridging and produce a stable filter. Aller et al. (1989) state that one of the most effective and efficient methods to induce flow reversal is through careful use of a properly-constructed surge block. For a more detailed description of proper usage of a surge block and other methods of achieving flow reversal, see Aller et al.

One example of a well development field protocol is described below:

1. Record static water level and total well depth.

2. Set the pump and record pumping rate and turbidity. Pump until turbidity (as measured by a nephelometer) reaches desired level or stabilizes.

3. Discontinue pumping and surge the well.

4. Measure depth to the bottom of the well. If more than 10% of the screen is occluded by sediments, remove excess sediment by bailing.

5. Reset the pump, recording pumping rate and turbidity. Pump until turbidity reaches desired level or stabilizes. If the well has been properly designed, the amount of pumping required to achieve the desired turbidity level will be substantially less than required in the first pumping cycle.

6. Repeat surging and pumping until the well yields water of acceptable turbidity at the beginning of a pumping cycle. A good way to ensure that development is complete is to shut the pump off during the last anticipated pumping cycle, leaving the pump in place, and restart it some time later. The turbidity of the discharge water should remain low.

The pumping rate used during development must be greater than the highest rate expected to be used during subsequent purging and sampling. In fact, recent field experience suggests that extremely low (i.e., 100 to 500 ml/min) purging and sampling pumping rates may significantly reduce the turbidity of ground-water samples (Puls et al., 1990). The pump intake should be placed close to, or within, the well screen interval.

The development techniques listed above are most efficient in wells with screens having the greatest area open to the aquifer. Therefore, continuous slot, or wire wrapped screens are recommended for use in formations where adequate development is expected to be difficult. The additional cost of continuous slot screen is typically more than compensated for by significantly less cost in development time and subsequent well purging times.

Development Criteria

Development should continue until clear, artifact-free, formation water is produced. Water quality parameters such as specific conductance, pH, temperature, and turbidity should be measured during development, and should stabilize before development is stopped. Turbidity measurements are the most critical development criteria. Other parameters should be used to provide supplemental information regarding aquifer conditions, and stabilization of these parameters is indicative of the presence of formation water. If water was added during well construction or development, two to three times the volume of water added must be removed. Finally, the well should be producing visually clear water before development is stopped.

Experience has shown that development may take from less than an hour to several days, depending on the formation, development procedures, and well characteristics or construction. In some marginal aquifers such as glacial tills and interbedded sands and clays, it may not be possible to attain the 5 NTUs turbidity target level used as guidance in RCRA. However, poor well construction practices, failure to emplace an adequate filter pack, poor selection of screen slot size and sand pack materials, as well as inadequate development may result in high turbidity levels. In these situations, the PRP or contractor must demonstrate that the well has been constructed properly and all reasonable efforts have been expended to develop the well. The determination of whether to abandon the well or address the turbidity problem during sampling and analysis should be made by the project manager in consultation with a Regional hydrogeologist.

After development is completed, wells should be allowed to stabilize and re-equilibrate before sampling. The time necessary for stabilization depends on the characteristics of the aquifer and the geochemistry of the parameters to be monitored. Generally, high permeability formations require less time (i.e., several days) than low permeability formations (i.e., several weeks).

Development Documentation

Monitoring well development must be thoroughly documented to verify that foreign materials have been removed, formation water is being sampled, and turbidity has reached acceptable levels or stabilized.

The following data should be recorded before and during well development:

1. Date and duration of development

2. Water level from the marked measuring point on the top of casing before and 24 hours after well development.

3. Depth from top of well casing to the top of any sediment present in the well, before, during, and after development.

4. Types and quantity of drilling fluids introduced during drilling and development.

5. Field measurements (e.g., turbidity, specific conductance, pH, dissolved oxygen, temperature) taken before, during, and after well development.

6. Volume and physical characteristics of developed water (e.g., odor, color, clarity, particulate matter).

7. Type and capacity of pump and/or bailer used and pumping rates.

8. Detailed description of all development methods used.

Glossary

Backwashing The surging effect or reversal of water flow in a well that removes fine-grained material from the formation surrounding the borehole. Only formation water is used during this process.

Jetting Bursts of high-velocity water injected into the well.

Overpumping Pumping at rates generally greater than those used during sampling or well purging. Commonly combined with surging of the well.

Surge Block A plunger-like tool, consisting of leather or rubber discs sandwiched between steel or wooden disks that may be solid or valved, that is used in well development.

Surging A well development technique where the surge block is alternately lifted and dropped within the borehole above or adjacent to the screen to create a strong inward and outward movement of the water through the well intake.

Turbidity Solids and organic matter suspended in water.

References

Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielsen, and J.E. Denne, 1989. Handbook of Suggested Practices for the Design and Installation of Ground-water Monitoring Wells: Technology Support Center, Environmental Monitoring Systems Laboratory, EPA600/4-89/034, United States Environmental Protection Agency, 398pp.

Driscoll, Fletcher G., 1986. Ground Water and Wells; Johnson Division, St. Paul, Minnesota, 1089pp.

Gass, T.E., 1989. Monitoring Wells in Non-aquifer Formations, Water Well Journal, v. XXXXII, no. 2, pp. 27-28.

Paul, D., C. Palmer, and D. Cherkauer, 1988. The Effect of Construction, Installation and Development on the Turbidity of Monitoring Wells in Fine-grained Glacial Till. Ground Water Monitoring Review, v. 8, no. 1, pp. 73-82.

Puls, R.W., J.H. Eychaner and R.M. Powell, Colloidal-Facilitated Transport of Inorganic Contaminants in Ground Water: Part I. Sampling Considerations, Environmental Research Brief, USEPA, EPA/600/M-90/023, December 1990.

U.S. Army Corps of Engineers, Missouri River Division, 1990. Installation of Ground-water monitoring wells and exploratory borings at hazardous waste sites, Chapter 6: Well development, pp. 38-44.