City of Lemoore, CA: Water Quality-Based Well Design

Case Study Contact Information

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By using water quality-based well design methods, drinking water utilities can identify water producing zones of better quality water in high arsenic aquifers.

Lessons Learned

New drinking water production wells can be designed and installed in a manner that selectively avoids ground water containing elevated arsenic concentrations. Before the production well is installed, water quality testing is used to identify water producing zones with high arsenic concentrations. Chemical analysis of clay layers surrounding water production zones is used to identify sources of arsenic that may leach into the water.

Testing Phase

A test hole is drilled to a depth below existing low-quality water supply wells, or to a depth of at least 1,000 feet to assess alternative aquifers. To avoid aquifers with elevated concentrations of arsenic and uranium in the San Joaquin Valley of California, well completion depths range from 800 to 1,200 feet.

Geophysical logging is conducted in the test hole to help select water producing zones for testing. For example, the *spontaneous potential* is a measurement of the natural electrical character of the subsurface formations, and is used to distinguish salt water from fresh water aquifers. *Resistivity measurements* are taken to identify various subsurface formations, such as sand and gravel aquifers that are resistive (low conductivity) and clay layers that are non-resistive (high conductivity). Chemical analysis of the clay layers is conducted by collecting clay samples using a specialized borehole sampling tool, and analyzing the recovered samples for total and leachable arsenic using a modified leachability test.

Water samples representative of multiple, vertical zones in the aquifer are collected from a temporary well constructed in the test hole, and analyzed for general physical parameters and minerals including iron, manganese, arsenic, and uranium. Since access to these zones in the aquifer is temporary (only during the drilling process), additional water samples are collected in case more chemical analyses are warranted.

According Michael Guilbert of Provost & Pritchard Engineering Group, Inc., “Current research indicates the source of arsenic in the subsurface may be from leachable arsenic to the water producing zones from clay strata.” For this reason, soil samples are collected in 5-foot intervals and analyzed for various geophysical and chemical parameters.

Background

The City of Lemoore, California, located in the San Joaquin Valley, uses groundwater for their drinking water supply. Municipal and private industrial wells that draw from aquifers in the area often contain arsenic in the range of 30 to 130 micrograms per liter (ug/L). These wells range in depth from 200 to 2,000 feet. The City of Lemoore serves drinking water to about 25,000 people using 7 wells. Over the last 15 years, the City has developed four new drinking water wells (Wells No. 7, 10, 11 and 12) using the techniques outlined in this case study.

Design and Management of Well Construction

The production well is designed based on the results of the water quality and geophysical soils testing. Using these testing results, it is possible to select which water producing zones in the aquifer are best suited to providing high quality drinking water.

Well construction involves drilling a large diameter borehole and installing a permanent well casing. “Well construction management is an integral step in the completion of a successful well and should be conducted by the qualified consultant,” according to Guilbert.

The well most recently completed in the Lemoore area (November 2004) produces water with an arsenic concentration of less than 6 ug/L. The well’s production rate is 1,200 gallons per minute. Engineering and construction observation costs were approximately $75,000, while drilling and well construction costs were about $650,000. Although a less expensive well with much higher arsenic concentrations could have been built, the cost of a treatment facility, along with operations and maintenance would have equaled the more expensive well costs in just a few years of operation.

Related Studies

Related Studies in Oklahoma

The City of Nichols Hills, Oklahoma recently investigated water quality conditions in their existing wells that have arsenic, chromium, and selenium levels that exceed drinking water standards. Nichols Hills draws water from deep portions of the Garber Wellington aquifer that has arsenic concentrations of 20 to 50 ug/L. However, Nichols Hills' wells are located near the aquifer's sandy area, which has lower arsenic levels. The City implemented well rehabilitation and changes to pump operations to comply with the Arsenic Rule. This alternative represented a savings of $3.0 million as compared to treatment alternatives according to the Ground Water Protection Council.

The City of Edmond, Oklahoma's Well No. 26 had a history of producing ground water with arsenic concentrations that exceeded the new drinking water standard of 10 µg/L. To address this problem, geologic and ground water chemical data were evaluated to determine which ground water zone(s) were producing arsenic at concentrations above the drinking water standard. The assessment indicated that several water producing zones had been improperly plugged during earlier rehabilitation operations. To correct the problem it was recommended that a bridge plug could be set to isolate arsenic-productive ground water zones located below the bad plug. After this work was completed, chemical testing of the produced water stream showed that arsenic concentrations had dropped below the laboratory detection limits of 2.0 µg/L with no loss in well yield. Two other wells in Edmond were also successfully rehabilitated using hydrogeologic methods.

Related Studies in Wisconsin

The Wisconsin Department of Natural Resources (DNR) has also used a hydrogeologic solution to prevent the occurrence of arsenic in private wells. In two counties, the DNR established stringent construction standards which have successfully lowered the arsenic concentrations in replacement wells drilled next to existing high arsenic wells.