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EPA Ground Water Currents

Developments in innovative ground water treatment

ResonantSonic℠ Drill Increases Speed and Depth at Hanford

By Gregory W. McLellan, Westinghouse Hanford Company

Westinghouse Hanford Company (WHC) has demonstrated a ResonantSonic℠ drilling method for the Department of Energy (DOE) at the Hanford, Washington site. This service mark technology, developed by Water Development Corporation, can drill two to three times faster than traditional drilling methods-30 to 40 feet (ft.) a day (up to one foot per second in some formations). Additionally, the ResonantSonic℠ drill achieves greater penetration depths—230 ft. at Hanford and over 500 ft. when tested at Sandia by Pacific Northwest Laboratories (PNL). The technology, applicable for both ground water and soil, renders continuous clean core samples because the ResonantSonic℠ drill rod is hollow, which allows for sample tubes to be inserted into the middle of the rod to extract samples. Less soil needs to be drummed because no air, water, mud or other circulation medium is needed for penetration. Contamination is maintained at the wellbore; and, the waste stream of drill cuttings is greatly minimized. The technology can drill at any angle, from vertical to horizontal. It is safe in highly hazardous conditions and has been shown to be cost effective.

At Hanford, the ResonantSonic℠ system was used to drill and complete eight ground water monitoring wells, one carbon tetrachloride monitoring/extraction well and two vadose characterization boreholes. Here's how the system works.

A technologically advanced hydraulically activated drill head transmits pressure waves through a steel drill pipe to create a cutting action at the bit face in order to take a continuous core. A standing wave condition of vibration is created when the steel drill pipe achieves a resonant status; and, massive amounts of power efficiently flow through the pipe to effectuate penetration of any type formation. Excess cuttings are displaced into the borehole wall during drilling as the drill pipe expands and contracts in width, thus reducing any dampening of the vibrations caused by formation swelling. As the hole is advanced, additional sections of the drill pipe are added. The soil enters the drill string through an open-face (core-type) drill bit and is contained in an inner core tube that rests on the inside shoulder of the bit. When the core barrel is filled with soil, as signaled by a position indicator, it is removed via a wire-line retrieval system. As a result, a continuous core of the formation is obtained. After the well is drilled to total depth, a permanent casing for the ground water monitoring well is lowered inside the drill pipe and is seated on the bottom of the well. As the drill is removed, an annular seal is placed between the permanent casing and the formation to prevent downward migration of contaminants along the annulus of the well.

At Hanford, data on the ResonantSonic℠ system was compared to data from a cable-tool system of wells in close proximity to the sonic wells with similar geologic conditions and well purpose. The average drill rate for the 11 wells drilled with the ResonantSonic℠ drill was 23.0 ft. per eight-hour work day; the

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This Month in Currents

This month's *Currents* features news from the Department of Energy.

Ground Water Issues of Interest

From time to time, the Superfund Technology Support Center for Ground Water at EPA's Robert S. Kerr Environmental Research Laboratory publishes "Ground Water Issue" which addresses issues and information needs for those in the held of ground water monitoring and remediation. Four such information issues are summarized below.

Behavior of Metals in Soils

One of the major issues of concern in ground water remediation at Superfund sites is the mobility of metals in the soil environment. Joan E. McLean of the Utah Water Research Laboratory at Utah State University and Bert E. Bledsoe of RSKERL discuss the metals most commonly found at Superfund sites in terms of the processes affecting their behavior in soils as well as laboratory methods available to evaluate this behavior. The retention capacity of soil is discussed in terms of the movement of metals between the other environmental media, including ground water, surface water or the atmosphere. Long-term changes in soil environmental conditions, due to the effects of remediation systems or to natural weathering processes, are also discussed with respect to the enhanced mobility of metals in soils.

The metals selected for discussion are: lead (Pb), chromium (Cr), arsenic (As), cadmium (Cd), nickel (Ni), zinc (Zn), copper (Cu), mercury (Hg), silver (Ag) and selenium (Se). The paper addresses: fate of metals in the soil environment [soil solution chemistry, solid phase formation, surface reactions, anions in the soil environment, soil properties affecting adsorption, factors affecting adsorption and precipitation reactions (competing cations, complex formation, pH, oxidation-reduction, co-waste)]; behavior of the specific metals; computer models; analysis of soil samples (total concentration, sequential extractions, and Toxicity Characterization Leaching Procedure); and evaluating the behavior of metals in soils (sorption, desorption, and kinetics).

A copy of "Ground Water Issue: Behavior of Metals in Soils" can be ordered from EPA's Center for Environmental Research Information (CERI) at 513-569-7562. When ordering, please refer to the Document Number: EPA/540/S-92/018.

Fundamentals of Ground Water Modeling

Ground water flow and contaminant transport modeling has been used at many hazardous waste sites with varying degrees of success. Models may be used throughout all phases of the site investigation and remediation processes. The ability to reliably predict the rate and direction of ground water flow and contaminant transport is critical in planning and implementing ground water remediations.

The issue paper presents an overview of the essential components of ground water flow and contaminant transport modeling in saturated porous media. While fractured rocks and fractured porous rocks may behave like porous media with respect to many flow and contaminant transport phenomena, they require a separate discussion and are not included in this paper. Similarly, the special features of flow and contaminant transport in the unsaturated zone are also not included. This paper was prepared for an audience with some technical background and a basic working knowledge of ground water flow and contaminant transport processes. A suggested format for ground water modeling reports and a selected bibliography are included as appendices A and B, respectively.

The paper, "Ground Water Issue: Fundamentals of Ground-Water Modeling," was prepared by Jacob Bear of Technion-Israel Institute of Technology, Milovan S. Beljin of the University of Cincinnati and Randall R. Ross of RSKERL. A copy can be ordered from EPA's Center for Environmental Research Information (CERI) at 513-569-7562. When ordering, please refer to the Document Number: EPA/540/S-92/005.

Suggested Operating Procedures for Aquifer Pumping Tests

One very important aspect of ground water remediation is the capability to determine accurate estimates of aquifer hydraulic characteristics. Paul S. Osborne of EPA's Region 8, provides an overview of all the elements of an aquifer test. The goal of the document is to provide the reader with a complete picture of all the elements of aquifer (pumping) test design and performance and an understanding of how those elements can affect the quality of the final data. It is intended as a primer, describing the process for the design and performance of an "aquifer test" (how to obtain reliable data from a pumping test) to obtain accurate estimates of aquifer parameters. The audience includes professionals involved in characterizing sites which require corrective

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Natural Bioremediation of TCE

By Don Kampbell, Robert S. Kerr Environmental Research Laboratory

The EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL) has demonstrated through laboratory studies that in situ bioremediation can be an effective way to cleanse fuel and solvent contaminated subsurfaces. Although the time period for remediation will take longer than active intervention methods, natural, intrinsic bioremediation can be effective, provided that sufficient indigenous acclimated microorganisms are present.

RSKERL discovered that intrinsic bioremediation was occurring in a ground water plume on the east side of Lake Michigan near St. Joseph, Michigan. The plume containing trichloroethene (TCE) was originally characterized to be used as a benchmark to develop methodology for *in situ* treatment by methanotrophic bacteria. However, when the water quality data showed that natural anaerobic degradation of TCE was taking place, RSKERL conducted a series of site characterization studies to develop data on natural biodegration.

Intrinsic bioremediation of TCE was supported by the presence of transformation products (breakdown products of TCE) and further supported by the utilization of oxidation stimulators. For example, oxygen is first consumed in the TCE natural degradation processes; then, the oxidation stimulators of nitrate and sulfate take over the degradation process.

The geological formation at the spill site consisted of a fine sand unconfined aquifer with a thickness of 15 to 30 feet, with the water table at about 40 feet. The suspected point of the surface spill is less than one mile from the lake shore with ground water flow toward the lake. Variable depth ground water samples were collected where high contaminant concentrations were present. Zones in which TCE transformations to breakdown products were occurring were identified. Generally, the upper depth of the ground water had reduced concentrations of TCE which was caused by dilution with percolating rain and/or microbial metabolism processes. Most importantly for determining natural biodegration was the presence of relatively high concentrations of the breakdown products of dichloroethene, vinyl chloride, ethene and methane. Additionally, the plume was not only devoid of dissolved oxygen, but there were also reduced concentrations of nitrate and sulfate. When compared to adjacent control well water with 4.7 milligrams per liter (mg/l) dissolved oxygen, a plume sample had 1,000 times more methane, 100 times less nitrate, ten times less sulfate, six times more bacteria cells and three times more total organic carbon. Additionally, neither chlorinated hydrocarbons nor ethene were detected in the control well. Concentrations of TCE as high as 60 mg/l did not seem to have an adverse influence on degradation processes, since high methane and vinyl chloride were directly related to TCE.

RSKERL plans to conduct similar studies at other spill sites contaminated with fuel and chlorinated solvents. They will conduct field monitoring for extended durations to establish the rate and extent of intrinsic bioremediation in restoring contaminated aquifers. Further details of the field site studies can be obtained from Don Kampbell, RSKERL, at 405-436-8564. An initial report will be available by mid-1994.

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average drill rate for the 10 cable-tool-drilled wells was 12.6 ft. per work day. Cost analyses show that ResonantSonic^{SM} drilled wells are less expensive than traditional methods.

The ResonantSonic^{SM} system has been used at other sites, including various Department of Defense facilities. Additionally, the system is being refined through a DOE Cooperative Research and Development Agreement with WHC, PNL and WDC.

For more information, call Greg McLellan of WHC at 509-376-2260 or Dave Biancosino of DOE at 301-903-7961. A report can be ordered from Greg McLellan.

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action as well as sites which are proposed for ground water development, agricultural development, industrial development or disposal activities.

A copy of "Ground Water Issue: Suggested Operating Procedures for Aquifer Pumping Tests" can be ordered from EPA's Center for Environmental Research Information (CERI) at 513-569-7562. When ordering, please refer to the Document Number: EPA/540/S-93/503.

Evaluation of Soil Venting Application

Another major issue of concern to those involved in ground water remediation is the transport and fate of contaminants in soil and ground water as related to subsurface remediation. Dominic C. DiGiulio of RSKERL presents information that can assist in evaluating the feasibility of using venting. Methods to optimize venting application are also discussed. Information covered in DiGiulio's paper is highlighted below.

The ability of soil venting to inexpensively remove large amounts of volatile organic compounds (VOCs) from contaminated soils is well established. However, the time required using venting to remediate soils to low contaminant levels often required by state and federal regulators has not been adequately investigated. Most field studies verify the ability of a venting system to circulate air in the subsurface and remove, at least initially, a large mass of VOCs. They do not generally provide insight into mass transport limitations which eventually limit performance, nor do field studies generally evaluate methods such as enhanced biodegradation which may optimize overall contaminant removal. The paper addresses: determining contaminant volatility; evaluating air flow; evaluating mass transfer limitations and remediation time; enhanced aerobic biodegradation; location and number of vapor extraction wells; screen interval of extraction wells; and placement of observation wells.

A copy of "Ground Water Issue: Evaluation of Soil Venting Application" can be ordered from EPA's Center for Environmental Research Information (CERI) at 513-569-7562. When ordering, please refer to the Document Number: EPA/540/S-92/004.

To order additional copies of *Ground Water Currents,* or to be included on the permanent mailing list, send a fax request to the National Center for Environmental Publications and Information (NCEPI) at 513-891-6685, or send a mail request to NCEPI, 11029 Kenwood Road, Building 5. Cincinnati, OH 45242. Please refer to the document number on the cover of the issue if available.

Ground Water Currents welcomes readers' comments and contributions. Address correspondence to: Managing Editor, Ground Water Currents (OS-110W), U.S. Environmental Protection Agency, 401 M Street S.W., Washington, DC 20460.

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