CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: The Groundwater Pollution and Hydrology Course (AI 20.06002.01.011.014)

DATE/PLACE: July 12–16, 2004
Orlando, Florida

AUTHOR: Bradley Werling

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PERSONS PRESENT AND LOCATION:

Bradley Werling of the Center for Nuclear Waste Regulatory Analyses (CNWRA), attended the Groundwater Pollution and Hydrology Course by Princeton Groundwater, Inc. Instructors included Robert W. Cleary (Princeton Groundwater, Inc.), David M. Nielsen (The Nielsen Environmental Field School), Richard P. Brownell (Malcolm Pirnie, Inc.), and John A. Cherry (Waterloo Centre for Groundwater Research, University of Waterloo). A list of other attendees and sponsors is attached to this report.

BACKGROUND AND PURPOSE OF TRIP:

This professional development course is part of ongoing efforts to train current staff and to maintain awareness of state-of-the-art methodologies and approaches important to the U.S. Nuclear Regulatory Commission (NRC) programs. The course topics include the concepts and principles of hydrology, groundwater pollution, and remediation. The course began as a Princeton University mini-course taught by Robert W. Cleary, in which a semester of hydrology studies was taught within a single week. Presently, the course is taught by a company called Princeton Groundwater, Inc. which is not affiliated with Princeton University.

SUMMARY OF ACTIVITIES:

The course began with Robert Cleary conducting a review of foundational references within the hydrology literature followed by lectures on fundamental and advanced groundwater hydrology. Other topics presented by Robert Cleary during the week-long course included contaminant fate and transport, groundwater monitoring techniques, well-head protection, field techniques for determining hydraulic conductivity, and water movement and monitoring in the unsaturated zone. David Nielsen discussed field methods for site characterization and natural attenuation of petroleum hydrocarbons and methyl tertiary-butyl ether. Lectures on groundwater contamination remediation strategies, technologies, and design were conducted by Richard Brownell. John Cherry presented an overview on the issues concerning groundwater contamination from dense organic solvents. Throughout the course, the explanation of concepts was augmented with practical applications and illustrative case histories.

SUMMARY OF PERTINENT POINTS:

The transport of contaminants by groundwater is a function of many factors. Accurate determination of source term, present location, future migration pathways, and travel times is essential in assessing risk.

Several of the instructors stressed the importance of spending the time and effort to conduct a thorough site characterization. Experience has taught them that development of an accurate site conceptual model normally results in fewer surprises, which generally saves time and effort in the long term. Geology and hydrology at the regional scale and even the local scale is seldom homogeneous.

The dynamic nature of a groundwater system should be accounted for when monitoring for site characterization or performance confirmation. Groundwater flow and geochemistry in unconfined aquifers can change seasonally and in response to anthropogenic effects. Seasonal flow directions can vary substantially. The impact of climate changes on flow direction and magnitude should be examined for long term projects such as geological disposal of nuclear waste. Construction on the land surface and underground can alter groundwater flow patterns and render earlier characterization information obsolete.

For contaminant transport, the variation of groundwater velocities as a function of hydraulic conductivity and effective porosity will have a critical effect on the accuracy of risk assessment predictions. Several pertinent points were raised concerning hydraulic conductivity. Hydraulic conductivity is one of the few parameters in nature that can vary by more than twelve orders of magnitude. In fact, hydraulic conductivity in the unsaturated zone can vary by four orders of magnitude simply due to the moisture content. Rainfall events can create a large surge in movement. Hydraulic conductivity is also a function of the material or medium that the contaminant is moving through. A comprehensive site characterization should include an accurate determination of the hydraulic conductivity for all of the types of materials present. Hydraulic conductivity variability creates groundwater velocity stratification, which is one cause of contaminant plume dispersion. Hydraulic conductivity variability can also create preferential flow paths for contaminant transport.

Often the contaminant velocity is slower than the groundwater velocity. An accurate assessment of the retardation factors, both natural and man-made, is crucial for reliable risk assessment predictions. The solubility of the contaminant influences its ability to be advectively transported. Sorption is a function of the properties of the contaminant and the medium through which the contaminant travels. One goal of a site characterization would be to identify the nature and type of medium located in the potential contaminant flow pathway.

One of the techniques used when performing an accelerated site characterization is on-site data analysis and interpretation. In the past, the quality of such field data was often a concern. However, field data can match the quality of laboratory data when the correct instrumentation and analytical tools are combined with appropriate quality assurance procedures. The point was made that in some cases field samples are more representative of the actual groundwater than laboratory samples because the field samples have not aged or had as much opportunity to change through exposure to *in situ* conditions. When participating in Nye County's Early Warning Drilling Program groundwater sampling events, CNWRA staff typically analyze

samples in the field for a number of parameters and collect other samples for subsequent analyses in the laboratory.

Several methods can be used for drilling boreholes. The advantages of sonic coring, a newer drilling method, were pointed out. Sonic drilling yields a continuous core sample and does not use any drilling fluids. This method provides an excellent sample for stratigraphic and lithologic characterization since the core is continuous and uncontaminated by drilling fluids. The first use of the sonic coring method within the Early Warning Drilling Program occurred when the NC–EWDP–19PB Phase IV well was recently completed.

The three dimensional aspect of contaminant transport should be considered when determining monitoring well locations. A comprehensive understanding of the site is essential to know where to expect to find the contaminant plume as it migrates through the area. Many errors have occurred in the past by incorrect placement of monitoring wells. Entire contaminant plumes have been missed. Underestimations of contaminant concentrations have occurred when the plume is only partially penetrated or when well screens that are large relative to the plume size were used and effectively diluted the contaminant. The use of sophisticated multilevel sampling wells to efficiently investigate the vertical dimension was discussed. Systems that provide multiple monitoring zones from a single borehole help provide more data that can reduce gaps in groundwater models without the burden of drilling additional boreholes. Westbay multi-level groundwater monitoring systems have been used by Nye County, Nevada, in some of the Early Warning Drilling Program wells.

CONCLUSIONS:

This course provides a solid overview and introduction to hydrology and groundwater pollution. It also covers new developments and includes practical advice from the field that seasoned professionals could find beneficial.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

This course provides a solid professional development opportunity for everyone regardless of the level of experience in hydrology and groundwater pollution.

SIGNATURE:

Bradley Wesling

Bradley Werling
Research Scientist

8-3-04
Date

CONCURRENCE:

English Pearcy, Manager
Geochemistry

8/3/2004
Date

for Budhi Sagar
Technical Director

8/4/2004
Date

GROUNDWATER POLLUTION AND HYDROLOGY COURSE
BY PRINCETON GROUNDWATER, INC.

ATTENDEES

Name	Company	Location
Alomar, Lynette	URS Diamond	Wilmington, DE
Benton, Trevor	Bunnell-Lammons Engr, Inc	Greenville, SC
Brown, Carol	St. Johns River Water Mgmt.	Palatka, FL
Clark, Matthew	URS Corporation	Gaithersburg, MD
Colon, Xiomara	Broward Co. Plan. & Env Prot	Fort Lauderdale, FL
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Din, Sajjad	Orange Co. Env. Div.	Orlando, FL
Goulet, Bill	PPG Industries	Lake Charles, LA
Graham Jr., Glennon	Langan Engr. & Env Svcs	Doylestown, PA
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