

**U.S. EPA TECHNICAL SUPPORT PROJECT
GROUND WATER FORUM BUSINESS SESSION SUMMARY**

**May 24-28, 2004
Miami, Florida**



Technical Support Project

GROUND WATER FORUM CO-CHAIRS

Richard Willey, Region 1 • Jeff Johnson, Region 7

Office of Research and Development (ORD) Update

Dave Burden, U.S. EPA's National Risk Management Research Laboratory (NRMRL) Ground Water and Ecosystems Restoration Division (GWERD), Ada, OK

Dave Burden updated the Ground-Water Forum (GWF) on projects being conducted by NRMRL/GWERD:

- GeoTrans, Inc. will complete their draft guidance on capture zone analysis by June 15, 2004. Two *beta* training sessions for capture zone analysis will be conducted in Regions 3 and 9 by the beginning of FY 2005. EPA Headquarters will pay for the travel of one ORD trainer, so the Regions must pay for the travel of the other. Kathy Davies (Region 3) and Herb Levine (Region 9) offered to speak to their management about travel support and report back to the GWF members.

Kathy Davies also mentioned a 1994 EPA document titled, "Methods for Monitoring Pump-and-Treat Performance" (EPA600/R-94/123) that is a precursor to the capture zone guidance in progress. A PDF of the document can be downloaded from the web at www.epa.gov/r10earth/offices/oea/gwf/issue10.pdf.

- ORD will review the fact sheet on the "DNAPL Delineation Assessment Report" drafted by Kathy Davies and Dr. Bernie Kueper (Queen's University). Following the EPA internal reviews, the document will be revised and distributed for external review.
- The next draft of the "Ground-Water Site Characterization for MNA" issue paper will be reviewed by Steve Acree (NRMRL-GWERD), as well as the GWF workgroup. The draft is expected to be ready in two months.
- The report "Performance Monitoring of MNA Remedies for VOCs in Groundwater" (EPA/600/R-04/027) was submitted for printing on May 15, 2004 and is now available on NRMRL/GWERD's webpage (<http://www.epa.gov/ada/pubs/reports.html>).
- The "Measurement of Field Parameters in Groundwater" issue paper is ready for internal and external review.
- The issue paper, "Impact of Ground-Water - Surface Water Interactions on Contaminant Transport at Contaminated Sites" is in partial draft form. The expected publication date is September 30, 2004. The "Case Studies" section was pared down due to project-specific delays and insufficient resources. The current focus will be on geochemical characterization of arsenic at the Industri-Plex Site.

EPA Headquarters Update

Rich Steimle, U.S. EPA's Office of Superfund Remediation Technology Innovation (OSRTI)

Rich Steimle reported that the TSP contractor support budget was trimmed to 75% of the original amount, primarily by combining the TSP meeting with the NARPM Conference and eliminating note-taking and summary writing by EMS. The amount that is spent on contractor support this year will probably be the same amount budgeted next year. Therefore, there is not enough money to continue to hold two fully-supported meetings per year and to fund note takers and the preparation of a meeting summary. To accommodate the new budget, the GWF will hold one short meeting in conjunction with NARPM and one fully-supported meeting each year.

Funding to support EPA's Technical Support Centers also was cut. According to Gareth Pearson (National Ecological Research Laboratory) and David Reisman (NRMRL-Cincinnati), the centers may ask the Regions for funding assistance, for example, when travel is required. Other possible options for managing the cut in resources include capping the amount of support provided to any individual site. Rich expects that the Technical Support Centers will receive about the same amount of funding next year as they received this year, which is less than what the centers received previously.

Dave Burden indicated that OSWER wants the Office of Research and Development (ORD) to continue to fully provide technical support to the Regions, but the money for this support may have to come out of ORD's research funding. Steve Mangion (Region 1 HSTL) recommended that GWF members ask that their Regional Division Directors get involved in the funding negotiations to ensure that equitable funding is available for technical support.

Dave asked that when requesting technical support, Regional staff contact him—not ORD's consultants or subcontractors—directly, and asked that GWF members inform Regional and Headquarters staff of this requirement.

Ken Lovelace, OSRTI

Ground-Water Task Force: Ken Lovelace summarized the work of the Ground-Water Task Force, a component of EPA's One Cleanup Program. Ken serves as the Headquarters lead on the task force. Other participating members from the GWF are Dick Willey (Region 1), Ruth Izraeli (Region 2), and Kathy Davies (Region 3). The goal of the Ground-Water Task Force is to identify priority issues in ground-water cleanup across EPA programs. The task force has decided to write option papers as a means of documenting issues and presenting them to EPA management (after being sent to the Regional programs for comment). The papers will compile various perspectives on the issues and then identify options to address them. The task force has been working on two option papers: "Cleanup Goals Appropriate for DNAPL Source Zones" and "Ground-Water Use, Value, and Vulnerability as Factors in Setting Cleanup Goals." Both option papers are available for download on the Ground-Water Task Force webpage (<http://gwtf.clu-in.org/>). Ken asked that the GWF and other interested parties to review the option papers to determine whether or not the papers comprehensively identify the issues of national stakeholders (described in the "problem statements" section) and which options they would prefer the Agency to pursue to address these issues. The task force will compile comments (due July 31st) and develop a set of recommendations to OSWER management.

As part of an outreach strategy to inform people about the option papers, the task force is offering Internet seminars, which are now archived on the webpage. The webpage also contains a list of the task force membership, meeting summaries, and links to other EPA cleanup programs. The task force will be compiling examples of successful cleanups, where program flexibility was used or where various cleanup programs have worked together successfully.

New Report Available: Ken announced that the report, "The NAPL Remediation Challenge: Is There a Case for Source Depletion?" (EPA/600/R-03/143), by the expert panel on DNAPL remediation is now available on the web at <http://www.epa.gov/ada/pubs/reports.html>. He added that a series of "Questions & Answers" have been developed and shared with the regions to explain issues associated with the report.

Ruth Izraeli (Region 2) commented that the report is interesting and worth reading. She pointed out a cost/benefit analysis of source removal versus long-term O&M contained in the report stating that the average annual cost for O&M is \$180K per year. The analysis suggests that source depletion is justified if the source is less than 20 feet deep, less than 0.1 acre, and the value of the

property is greater than \$1M/acre. Source depletion may also be justified if remedial action objectives other than MCLs are acceptable to all parties. The report concludes that the source cannot always be cleaned up to MCLs, but there may be other reasons to address the source zone. Ruth felt there was an overemphasis on cost in the report. Ruth also felt there were a couple of issues in the document that may be problematic to some, including an assumption that complete source removal is not achievable. The authors talk a bit about complete removals where MCLs have been achieved, but they do not seem to be clear about three orders of magnitude reduction. According to the authors, there has been no peer review for cases where MCLs have been achieved.

Superfund Scorecard: Ken also reported that the Agency is looking at measures for remedies, such as performance measures, progress measures, environmental indicators, and outcome measures (e.g., acres of site available for productive use). A scorecard has been developed to help the Superfund Program measure success in terms other than construction completions. The scorecard is explained in the recent document, "Success for Superfund: A New Approach for Keeping Score" (April 2004) by Katherine N. Probst and Diane Sherman (Resources for the Future), which can be obtained from the Superfund website, or by visiting www.rff.org/rff/Publications/Success-for-Superfund-A-New-Approach-for-Keeping-Score.cfm. Among other things, the proposed scorecard identifies the media of concern at a site and whether or not there is an exposure pathway, whether the pathway has been controlled, whether the level of contamination is being reduced, etc.

Matt Charsky, OSRTI

Matt Charsky announced that the next NARPM meeting will be held the week of May 23rd, 2005, in Phoenix, AZ. He said that there is ample opportunity for the GWF to engage in the planning process for NARPM later.

Workgroup Updates

Document Review Process Workgroup: Luanne Vanderpool (Region 5) indicated that she sent an e-mail to the GWF last week on behalf of the Document Review Process Workgroup. The message contained the final scope for the workgroup. In summary, the workgroup is looking at perceived problems in the GWF's process for reviewing documents. The scope includes the steps for completing a white paper that will contain two parts: one outlining workgroup procedures and one summarizing principles of effective and honorable workgroup participation. Luanne indicated that the workgroup is willing to accept additional comments on the scope.

The workgroup believes that the current GWF's bylaws concerning workgroup procedures are appropriate, but not always followed. The white paper will remind GWF members what the procedures are supposed to be. The workgroup also believes that there are often unclear expectations as to the "when, what, who, why, and how" of a review. How to conduct the review can be especially unclear and may involve the collection of comments for submission or the preparation of a consensus document.

The workgroup also has identified a number of side issues, which are listed on the second page of the final scope. The side issues won't be a focus of the scope but perhaps should be covered by subsequent GWF workgroups. One such side issue is whether or not it should be standard policy that the GWF receive a response to comments following submission of comments on a document. At a minimum, Luanne suggested that the reviewer should know whether or not a response to comments is planned. The issue was raised as to whether or not GWF review of a document can make it appear that EPA has endorsed the document. For example, although EPA cannot endorse a document written by ITRC, it may appear that there has been an endorsement even though GWF comments may or may not have been

incorporated. Speaking as a representative of ITRC, Mavis Kent (Oregon DEQ) noted that the ITRC has a policy of documenting all comments and their responses, but she is interested in finding a resolution to this issue. She added that ITRC documents must consider all the regulatory aspects of an innovative technology, which is the reason for requesting input from EPA, the states, and other stakeholders.

Other side issues include determining whether or not to define criteria for agreeing on which documents to review, and under what circumstances does one represent one's Agency, one's Region, or one's self. The workgroup is recommending that a presentation on ethical standards be given at the next GWF meeting.

1-4-Dioxane Survey Workgroup: Andy Crossland (Region 2) explained that the purpose of the 1-4-dioxane survey distributed by the GWF is to create a database of Superfund and RCRA sites where low detection level analyses of 1,4-dioxane have been conducted. The database could also be used to compare maximum concentrations of 1,4-dioxane with other volatile compounds in order to determine if their occurrence is related. With data submitted from almost all of the Regions, the database contains 57 sites in 17 states. Brian Lewis (California Department of Toxic Substances Control) pointed out that because 1,4-dioxane contamination is known to be a problem in California, the initial reason for a national survey was to provide justification for investigating 1,4-dioxane sites. California and other states have faced resistance to 1,4-dioxane sampling and analysis, so the survey was generated to provide backup for these activities.

Andy summarized trends observed in the data thus far. Preliminary results of graphing the maximum 1,4-dioxane concentrations against maximum 1,1,1-trichloroethane (TCA) concentrations reveal a statistical correlation. In addition, there appears to be a correlation between the compounds at concentrations of ≤ 1 ppm 1,1,1-TCA, but it is unclear whether this correlation is statistically valid. There are some outlying data as well. For example, one 1,4-dioxane manufacturing site did not contain 1,1,1-TCA.

The GWF discussed appropriate next steps and concluded that it should: 1) pass the information to interested parties at EPA Headquarters and in the states; and 2) prepare a short writeup that can be used in the regions to increase the awareness of this emerging issue.

Linda Fielder (OSRTI) announced that she is compiling information on 1,4-dioxane for a webpage on CLU-IN (<http://www.cluin.org/contaminantfocus/default.focus/sec/1,4-Dioxane/cat/Overview/>) This page is designed to be a "one-stop" shopping place for information on 1,4-dioxane.

Branch Chiefs' Meeting

Ken Lovelace (OSRTI) reported that the Branch Chiefs' Meeting (held May 27th at the NARPM meeting) included a discussion of ground-water issues. During the meeting, concern was expressed that Superfund is spending too much money, in general, especially for fund-lead sites. Mike Cook, (Director, OSRTI), said that he wants to establish a set of conditions for when a cleanup would not be funded (e.g., for sites where the water source will not be used as a future drinking water source). EPA needs to set up a dialogue with states to determine on how to get out from under these cleanups. Matt Hale, (Deputy Director, Office of Solid Waste), said that the Ground-Water Task Force was looking at the "bigger picture" issues, but Mike still expressed some concerns about the task force's process and output. Mike wants to move forward and be able to state that EPA has established conditions where the Agency is not going to pay for cleanup.

In response to Ken's summary, Bill O'Steen (Region 4) questioned where policy intersects with regulation. He pointed out that some of the policy options counter to the laws that staff is supposed to be

following. According to Ken, if policy options are written, the Agency would be constrained to follow its existing statutory and regulatory framework.

Ken also noted that the driving forces for policy changes include limited resources and the push for completions (e.g., accomplishments such as construction completions and removal of sites from the NPL). He suggested that the best option may be to prioritize sites for the limited resources. He added Marianne Horinko's suggestion was to put together case studies and assemble a strike team to address pertinent issues.

Kevin Willis (Region 2) also shared his impressions of the Branch Chiefs' meeting. Kevin reported that the Branch Chiefs began with a very short discussion about cleanup versus containment in the context of how to get sites to the operation and maintenance (O&M) stage, where the states would take over lead for the sites. Ground-water issues were also discussed. In terms of funding, there was \$250M nationwide available for remedial assessments, and half of this money has already been spent. According to EPA's attorneys at the Office of General Council, EPA has no legal authority over cleanup after ten years of remedy implementation (unless there is remedy failure, which would restart the clock), so such sites must be turned over to the states. Andy Crossland (Region 2) added that there were three case studies presented on long-term remedial action, one of which was the Wyckoff/Eagle Harbor Superfund site. The case studies were presented in the context of sites that are encountering difficulties getting to the O&M stage, such as interaction with the states or discovering new information that changes the conceptual model, etc.

Bill O'Steen speculated that in the future, ARARs will be waived at Superfund sites, even without state concurrence. Ken responded that if a state does not concur on a ROD, this could become a concern for that state if the site is turned over to them after ten years.

Kevin and Andy said there also was a discussion on technical impracticability (TI) waivers versus monitored natural attenuation. Mention was made that the NRMRL/GWERD in Ada is working on a new TI waiver guidance. According to Kevin, 28 TI waivers have been issued nationwide since the original guidance became available. EPA has not revisited site decisions, and it was reported that states not originally interested in TI waivers are now often requesting them. The last discussion item was the ICIS database, an enforcement database for those sites under enforcement. The database records the remedy selected, how much contaminant mass is removed, etc. There is a workgroup trying to come up with a better measurement, such as the volume of contaminated media removed. This is only a one-time measurement associated with the consent decree.

Regional Experiences in DNAPL Source Area Delineation

Field Screening Using Color Reactive Tubes for Horizontal and Vertical Delineation of Chlorinated Solvent Plumes for Monitoring Well Location and Screen Placement

Dave Jenkins, U.S. EPA Region 4

Summary

EPA Region 4 applied an existing, inexpensive monitoring technology to field screening procedures for locating trichloroethene (TCE) plumes in real time. The procedure, which uses commercially available color reactive tubes, gives field staff ability to locate chlorinated solvent plumes, and place monitoring well screen intervals in the plume without awaiting results from laboratory analyses.

Site and Contamination Description

TCE contamination was investigated near a former electroplating facility located in coastal Florida on a poorly consolidated, clean sand, up to 250-feet thick. Depths to ground water typically are less than 15 feet. Multiple monitoring wells with 10-foot screens installed near the source during previous investigations were uncontaminated, while wells farther downgradient were contaminated. The identity of the source was in question, and the area and volume requiring remediation were uncertain.

Methodology and Sample Matrix Comparisons

Color reactive tubes from various manufacturers have long been used for personal health and safety monitoring. Tubes are available for sensing the presence of many gases in the breathing zone. These well established monitoring methods can be applied to onsite investigations of contamination in soil and water to get real-time information regarding the distribution and concentration of volatile contamination. Tubes that detect total chlorinated solvents down to 8 ppb are available, including carbon tetrachloride, methylene chloride, tetrachloethene (PCE) degradation products (see References).

Initially, soil and ground-water samples were collected between each 20-foot RotoSonic drill rod. A hotplate was used to heat the samples to 100°F in a water bath to encourage volatilization in the VOA vial. Color reactive tubes sampled the head space over these samples. Soil sample results were inconsistent at low concentrations, probably because the preparation method included mixing the soil with distilled water. Low concentrations sometimes were not detected in soil. Results from undiluted ground-water samples were more consistent, but much slower because of the need to withdraw the drill string, install inflatable packers and a pump, purge the sample interval, withdraw and decontaminate the pump assembly, then reset the drill string for the next interval.

Field tests showed that sampling the head space in RotoSonic sample bags or bagged direct push cores was as effective in locating contaminated intervals, but hours faster than collecting water samples using a pump and inflatable packer. Tubes with low detection levels identified the upper and lower edges of contaminated zones. Tubes with higher detection levels provided relative indication of the degree of contamination in the zone. Oil Red O dye was used to test the samples with higher tube readings for the presence of DNAPL, but DNAPLs were not detected even from tubes with readings up to 100 mg/L in the head space, and 1,500 µg/L total chlorinated solvents based on laboratory analysis. These samples probably were too far from the source area to show NAPL. After monitoring well installation, defensible, confirmatory results were obtained by traditional laboratory methods from samples in monitoring wells with screens known to be located in the dissolved TCE contaminated zone.

Benefits and Conclusions

Color reactive tubes can reduce investigation costs by pre-screening samples selected for laboratory analysis, by confirming which soil borings or direct push locations require monitoring well installation, and by helping assure proper vertical placement of monitoring well screens. Useable results are available onsite, without waiting for fixed or field laboratory results, eliminating drill rig standby costs. Definition of contaminant distribution is faster, cheaper, and better because unneeded monitor wells are not installed.

Previous investigations at this site probably used photo ionization detectors (PIDs) and flame ionization detectors (FIDs) to identify contaminated intervals. High readings on a FID may have been misinterpreted as an interval contaminated with chlorinated solvents, instead of methane bubbling off a deeper chlorinated solvent plume. The misinterpretation resulted in multiple monitoring wells with shallow screens which produced non-detect sample results within the contaminated area of the plume, and one monitoring well installed at the bottom of the sand without the benefit of the color tubes to find the “sinking contamination.” It hadn’t sunk that far yet, and the deep well results were non-detect. A third drilling event using the methods described in this paper consistently located the plume. Color reactive

tubes added information to the well location and screen placement decision process which was not previously available in real time.

References

EPA Internet Seminar: *Initial Site Screening Using Dynamic Field Activity, Calloway Drum Recycling Site Auburndale, Polk County, Florida*, <http://www.cluin.org/conf/tio/PASI/>

Florida Dry Cleaner Coalition website: http://www.drycleancoalition.org/download/color_tec.pdf.

Ecology and Environment, Inc., 2003, *An Innovative Field-Based Analytical Method For Low-Level Detection of Chlorinated Solvents in Ground-water and Soil Samples*, <http://www.apbuck.com/gasproducts/kits/colortec.htm>

DNAPL Source Zone Delineation Effort, Telex Communications, Lincoln, NE

Jeff Johnson, U.S. EPA Region 7

During the 1980s, significant levels of several contaminants, predominantly 1,1,1-TCA and 1,1-DCE, were detected in production wells on the Telex Communications, Inc. property in Lincoln, NE. Subsequent ground-water investigations localized the highest detected dissolved concentrations, which were on the order of 200,000 Fg/L 1,1,1-TCA, to a grassy area on the western side of the facility. Ground-water impacts were identified not only in a surficial silty clay but also in an underlying sand unit, and downgradient in the uppermost Dakota. Ground-water impacts were also found to have migrated 2000 feet downgradient and were impacting an existing domestic well. Persistence of the 1,1,1-TCA plume and dissolved concentrations in excess of 10% of the pure phase solubility of 1,1,1-TCA suggested that DNAPL was present in the subsurface at the site. Employee interviews subsequently confirmed that the general area of highest observed, dissolved concentrations had served as a disposal area for waste solvents during operation of the facility under a previous owner.

Dissolved ground-water concentrations in the silty-clay unit and the overall plume geometry in the underlying sand were used to design a ground-water pump and treat system to contain contamination and prevent its downgradient migration. This pump and treat system has, over the ensuing 15 years, reduced dissolved concentrations throughout the plume by 1 to 2 orders of magnitude. However, contaminant concentrations in the suspected source area have stabilized, likely due to the presence of residual DNAPL, and long-term operation of the existing pump and treat system will likely be required to prevent offsite transport from reinitiating the plume. On that basis, more detailed information on horizontal and vertical extent of the source area was deemed desirable for use in determining whether direct removal of the source could be a cost-effective option. The boundaries of the disposal area could not be determined from employee interviews nor from other historical documents and photos of the site; however, for characterization purposes, the area exhibiting ground-water impacts in excess of 1% of the pure phase solubility of 1,1,1-TCA, encompassing an area of 38,000 ft², was projected to represent a conservative maximum outer boundary of the source area. Conventional wisdom suggested, however, that the actual source area was likely much smaller, perhaps more in line with the area exhibiting dissolved concentrations in excess of 10% of the pure phase solubility of 1,1,1-TCA, which encompassed an area of only 7500 ft².

In an attempt to more precisely define source area geometry, 21 Geoprobe borings were advanced within an area which roughly corresponded to the area exhibiting dissolved concentrations in excess of 1% of the pure phase solubility of 1,1,1-TCA and where employee interviews suggested disposal had occurred. Three to four soil samples were collected per boring, with sub-sample location being largely based on PID detector response to the sliced core. Field analysis was performed on a mobile gas chromatograph using EPA Method 8021. Ten percent of all samples were split and sent to an offsite lab for analysis using EPA

Method 8260C. Source area delineation was expected to be largely based upon soil concentrations exceeding equilibrium soil/water partitioning relationships.

Soil sampling analytical results failed to confirm the presence of DNAPL, nor did the results allow clear delineation of source area extent. Detected concentrations were uniformly below 1 mg/kg for all constituents, which is far below concentrations required to produce dissolved contaminant levels historically observed in the suspected source area. Since DNAPL was never directly observed at the site and it was felt that default dissolved concentration thresholds (i.e., 1% and 10% rules of thumb) were inadequate for delineation purposes, no further source removal efforts were undertaken. Failure of this characterization effort presumably relates to the manner in which DNAPL is distributed and moves within the source area silty clays. DNAPL is believed to be distributed along fine-scale fractures within the silty clay, which may not be clearly definable with the methods used (i.e., thin seams of DNAPL were obscured/diluted by the comparatively large soil sample volume.) While source removal was deemed dependant upon a more precise delineation of source area extent, more detailed delineation was not required for successful design and operation of the pump and treat containment system. Remedial goals and hydrogeologic constraints should be considered to be prime determining factors in assessing the needed precision in source area delineation.

Lumino-Mantion Site

Steve Mangion, U.S. EPA Region 1

Over about 35 years, approximately 60 to 100 million gallons of spent solvents were managed at the site. Liquid waste was brought to the site in steel drums and tank trucks. Still bottoms and sludge were placed in two unlined lagoons. These sometimes overflowed and discharged to an unlined drainage ditch and thence directly to a river. Other waste was managed in above-ground tanks. Thus, site history indicated that NAPL was present.

Ground-water contamination is found in both overburden (fluvio-glacial sediments and till about 15 - 50 feet thick in the study area) and Triassic bedrock. NAPL has also been observed in both overburden and bedrock wells, confirming that the site is a NAPL site.

The extent of the NAPL zone was defined by the RPs on the basis of:

- site history;
- direct NAPL observation; and
- indirect indicators, such as effective solubility, presence of alcohols, persistent plume, anomalous plume location.

Indirect indicators were used to also define probable and potential NAPL zones. The indirect indicators were thought to provide "multiple lines of evidence." For purposes of defining an overburden source zone for treatment, EPA's position was that the indirect indicators were better used to infer a NAPL site and not NAPL extent.

To resolve the differing conceptual models, EPA and the responsible parties (RPs) agreed to an intensive field program and criteria to refine the estimated overburden volume contaminated with NAPL. The field program is summarized in the question and answer section below. As a result of the field program, the RPs and EPA have reached agreement on the location and volume of residual and pooled, NAPL-contaminated overburden that will be evaluated for treatment in the feasibility study. The agreed-upon volume is now approximately +/-50,000 cubic yards.

Questions and Answers:

1. What criteria were used to determine likelihood of a DNAPL source zone being somewhere on the site?
< *EPA's position was that site history and direct observation from historic data or from a new field program should be used. The RPs believed that indirect indicators also could be used to define the extent of NAPL. EPA disagreed.*
2. After determining the general existence of a DNAPL source area, was there an attempt to specifically locate and bound the source area?
< *Yes.*
3. For what purpose?
< *To determine what volume of soil should be addressed by remedial technologies.*
4. What criteria were used to make this determination?
< *A comprehensive 1-week field program with: continuous cores to refusal; an agreed upon rationale to select coring locations; visual core inspection; PID screening with an agreed trigger level for further testing; several in the field tests, most importantly with a water and Oil-red-O shake test logging cores; and pre-field investigation soil-spiked samples to test the sensitivity of our approach.*
5. What was considered to be an acceptable degree of accuracy and precision for locating and bounding the source area laterally and vertically?
 - *This was not explicitly stated. In practice, a starting point should always be site history and point-of-entry information coupled with previously obtained data. Even without previous NAPL observation, we could have drawn a line around the waste management area as a starting point for the field program and initial boring location. The field team made decisions in the field about where cores would be located in order to bound the NAPL source zone. EPA expected that the results of the coring program would guide the field team.*
6. If 10% or 1% of the effective solubility for the principle volatile organic compound (VOC) contaminants was used to determine the general existence of a DNAPL source area, how good was this "rule-of-thumb" estimator at predicting the "final" location and boundaries of the source area?
 - *Indirect indicators did not "work," in that they overstated the extent of the NAPL source zone. Note that these indicators may be triggered within the source zone, but that is a "trivial" result. This was a major point of debate between the RPs and EPA. The "rule-of-thumb" is arguably somewhat ambiguous, and could be misunderstood. EPA had argued that the rule of thumb indicates a NAPL site, but should not be used to delineate a NAPL source zone for treatment. The field work bore out EPA's position.*

7. Comments on applicability, benefits, and limitations of this approach at this site?
- *Effective solubility has little value in defining NAPL extent. Consideration of preferential pathways should make this easier to understand; high concentration fingers of contamination may persist downgradient but are not indicative of NAPL- extent. This type of investigation can be done for other sites and has implications for bedrock contamination as well.*
8. If "direct observation" was used for determining the presence of DNAPL, and the location and boundaries of the source area, what were the specific criteria that were deemed acceptable? Comments on applicability, benefits and limitations of this approach at this site?
- *Not sure how to answer this. Keep in mind that we based the drilling program on previously obtained data and data obtained during the NAPL delineation study. Site history was critical in defining likely points of entry. As we gathered new data, the field team looked at the data set as a whole to see if a coherent picture could be formed. Thus, we saw that visual identification, especially with the shake test of material with PID hit above 100 ppm, was conclusive and could be used to define a source area.*
9. How important/helpful was "circumstantial" information (aerial photos, diagrams of facility layout, employee descriptions, etc.) in determining the location of the DNAPL source area? Comments on applicability, benefits and limitations of this approach at this site?
- *Site history is critical and hardly circumstantial!*
10. What were the assumed dimensions (length, width) of the DNAPL source area using 1%, and 10% of the effective solubility, and the "final" estimated source area dimensions?
- *At the end of the day, about 50,000 cubic yards of NAPL source zone, in contrast to estimates based on indirect indicators that ranged from a probable 200,000 cubic yard estimate to a potential 800,000 cubic yard estimate. To reiterate, indirect indicators probably over-estimate the extent of source zones, most likely because of preferential pathways.*

Two experiences in DNAPL delineation

Andy Crossland, U.S. EPA Region 2

Investigations into the extent of DNAPL were conducted at two sites in New Jersey. The level of success in determining the extent of the DNAPL source zone at these two sites illustrate some of the difficulties inherent in investigating source zones in fractured bedrock compared to those in unconsolidated materials. In addition, the methods used, the practical study goals, and the amount of inference needed were also very different.

At the first site, Chemical Leaman Tank lines, DNAPL is present in unconsolidated sands above a clay layer (located 20 feet below ground surface [bgs]). The area was investigated using direct push soil sampling in combination with screening with a PID, Sudan dye and fluorescence techniques. Areas of pooled DNAPL were apparent from a discrete horizon in the cores. The use of Sudan dye on core samples was very effective in delineating an area of residual DNAPL surrounding the pooled DNAPL. Delineation in this case proved to be a reasonable goal, and direct evidence of the source area extent was fairly easily defined. The source area is irregularly shaped, but roughly 140 x 150 feet. Currently there are

plans to target the DNAPL source zone for aggressive in-situ source depletion, probably by chemical oxidation.

The Caldwell Trucking site presented much more challenging conditions. At this site, DNAPL is present in a fractured basalt below the release point. The source area extends to a depth of 50 to 70 feetbgs. A fairly dense array of wells was drilled in the suspected source area and downgradient. In spite of ground-water concentrations being close to saturation levels, no DNAPL was observed during well construction, nor did it collect in any of the wells. The extent of the DNAPL source zone, therefore, could not be rigorously defined in the bedrock and had to be estimated by conservative inference. The source area is potentially more extensive than in the previous example, and cannot be easily bounded. Remedial options here have focused on hydraulic containment, with an in-situ bio-enhancement pilot to reduce mass in the source zone. The distance to downgradient containment wells has been determined based on contours of the percent effective solubility (PES) of the contaminants. Instead of selecting a specific PES contour as the location beyond which DNAPL is unlikely to be present, the gradient in PES was used as an indicator. Wells are being sited just beyond the point where the PESs appear to level out and the contours become more widely spaced. TCE, for example, dropped from 50% PES to less than 5% PES within roughly 200 feet, while the 1% PES contour extended a much greater distance. Using these plots for each of the contaminants, professional judgment was used to select the location of the planned extraction wells. The actual physical extent of the source area is ill defined, but it is assumed that it is not larger than a 300 x 400 foot area.

DNAPL Source Area Delineation: Savage Municipal Water Supply Well Superfund Site

Richard Willey, U.S. EPA Region 1

The Savage Municipal Water Supply Well, constructed in 1960, is located in the town of Milford, in south central New Hampshire. Its source of water is a stream-aquifer system, composed primarily of stratified coarse grained glacial deposits, which is one of the most prolific ground-water producing areas in the state. The total average daily ground-water withdrawals in the site area were estimated to be in excess of 3 million gallons per day (mgd) in 1983. In that year VOCs, primarily PCE, and 1,1,1-TCA, were found in water samples (at concentrations exceeding 800 Fg/L , and 300 Fg/L respectively) from the municipal well during the first state sampling round for these contaminants at public supply wells. The state then ordered the town to cease use of the Savage Well, and a water supply well serving a nearby trailer park.

Investigations of the causes of this ground-water contamination identified four companies that were potentially liable for the contamination. One of these, the OK Tool Co., is the subject of this report. At the OK Tool property, situated about 3500 feet upgradient of the Savage Well, it was determined that chlorinated solvents, primarily (PCE), had leaked from a degreasing tank and entered the subsurface through a floor drain in the building, and at several locations outside the building. Company information indicated that chlorinated solvents had been used since 1957. Initial investigations found PCE concentrations up to 13,000 mg/kg in soils beneath the floor drain, and up to 35,000 Fg/L in newly installed monitoring wells on the property. Subsequent field investigations, which focused on characterizing the lateral and vertical extent of contamination, showed that the overall dissolved contaminant plume was at least 6000 feet in length and 2500 feet in width. And while VOC concentrations varied considerably with depth, contamination was present throughout the saturated aquifer thickness (up to 120 ft) of the overburden aquifer and in the underlying bedrock.

The 1991 record of decision (ROD) called for ground-water remediation to be performed in two operable units, a concentrated plume area (OU-1) and an extended plume area (OU-2). The Consent Decree assigned containment and remediation of OU-1 (the OK Tool area) to EPA and the State of New Hampshire, and remediation of OU-2 to the remaining settling parties. In 1994, vertical profiling of chemical concentrations in the overburden aquifer was conducted within the OU-1 (approximately 1200 x

800 feet), in order to develop design criteria for the planned construction of a ground-water remediation system. Water samples were collected at 5-foot depth intervals (using the Waterloo Profiler; Pitkin, 1999) along several transects oriented transverse to the axis of the plume, and at other selected locations around the OK Tool building, for a total of 394 samples at 34 locations. These data provided the first detailed picture of contaminant distribution in the concentrated plume area. The data also provided a basis for the design and construction of a circular containment structure (approx. 500 x 400 ft) using a soil-bentonite slurry wall for the entire overburden thickness. This was designed to contain an area where the highest concentrations of PCE had been found (all locations where VOCs exceeded 10% of PCE solubility (>24,000 F g/L) and most locations exceeding 1% of PCE solubility (>2,400 F g/L)). The downgradient distance from the former floor drain location to the slurry wall is about 400 feet. A system to extract contaminated groundwater and then re-inject treated water both inside the containment area (to remove contaminant mass and maintain hydraulic control) and outside (to extract and flush isolated hot spots of contamination) was also constructed. In addition, a system to perform soil vapor extraction and air sparging was also installed within the containment area to assist in contaminant mass reduction.

In 1997-1998 vertical profiling was conducted in the area of the former floor drain, in order to three-dimensionally characterize a specific source area that would be targeted for aggressive DNAPL mass reduction. In an area approximately 80 x 180 feet, 257 water and soil core samples were taken at 12 vertical profile locations (Guilbeault, 1999, 2005). At one transect located roughly 15 feet downgradient of the former floor drain, and using a vertical sampling frequency of as little as 0.5 ft, PCE concentrations were found to be as high as 148,700 F g/L (approximately 61% of effective solubility). At this transect location it was estimated that about 90% of the PCE mass flux took place in about 10% of the cross sectional area. At the location of the former tank and floor drain, soil core data did show concentrations to be above the solubility limit for PCE (240,000 F g/L) and Sudan IV dye test results were positive also. Subsequently, in-situ chemical oxidation (ISCO), using potassium permanganate injection, as method of accelerating DNAPL source reduction was tested and implemented. Another ISCO injection was performed in 2004, and additional injections are being scheduled.

Point of view

- The accuracy needed for DNAPL source zone characterization depends largely on the intended use of the data (designation of technical impracticability (TI) zone, delineation of containment area (physical, hydraulic), selection of technology and targeting of specific DNAPL zone(s) for aggressive source mass reduction).
- Increasing the accuracy of characterization is especially warranted where it will decrease the cost and help insure the success of the remedial objective. As a general rule, delineation activities can be considered complete when their continuation will no longer produce a demonstrable improvement in the certainty of the selected remedy or reduce costs of implementing the remedy.
- Where available, historic information on locations of chlorinated solvent use, disposal, and accidental discharge can significantly aid source zone characterization by helping to focus search activities and thereby decreasing investigation costs.
- In unconsolidated formations, DNAPL source zones can be effectively delineated and their architecture approximated using field techniques that vertically profile contaminant concentrations.
- Profiling activities are likely to be most cost effective when using some form of direct push technology (DPT) coupled with field analysis of the samples and real-time decision making to refine the investigation in the field as data become available.

- In permeable unconsolidated formations, natural heterogeneities in permeability produce complex three-dimensional distributions of residual and pooled DNAPL. When contaminant fluxes emanating from and just downstream from these sources, are viewed in a cross-section transverse to ground-water flow, the majority of VOC mass discharge passes through a relatively small cross-sectional area.
- As dissolved contaminants move downgradient from individual source zones their concentrations decline relatively rapidly under the influence of advective, dispersive, and diffusive transport that spreads the contaminant plume. While concentrations may be a fraction of their effective solubilities, they may also be an order of magnitude above their respective MCLs. Concentration declines are most rapid in directions transverse to flow, and are relatively less rapid along the longitudinal axis of contaminant flow paths from each source.
- Rapid spatial declines in concentrations suggest that the likelihood for visual observation of DNAPL (directly, or using hydrophobic dyes) may be limited to the immediate vicinity of pooled or residual DNAPL. Thus, a requirement to visually observe, or to exceed the effective solubility limits as the sole criteria for all DNAPL source zone delineation objectives appears to be unnecessarily stringent and likely to increase investigation costs. While these direct observations may be regarded as “definitive,” chemical concentration data are still needed to guide investigators as to the direction and proximity of DNAPL source areas.
- Cost effective delineation of DNAPL source zones that are adequate to meet a variety of characterization objectives will need to incorporate multiple lines of evidence and field techniques that are appropriate for the hydrogeologic context of the site.
- Exceedence of 1% or 10% of effective solubility for individual components of a chlorinated solvent mixture is a useful rule-of-thumb when evaluating the existence of a DNAPL source area at a site, however, it is a poor estimator of the proximity of DNAPL to the sampling point in permeable unconsolidated materials. It is likely also to significantly overestimate the size of the DNAPL source area. Concentrations in excess of 10% and 1% of the PCE solubility limit have been observed as far as 250 and 2700 feet (respectively) downgradient of the OK Tool DNAPL source area. Direct evidence of DNAPL appears to be localized within 10 feet of the suspected entry points.
- Because DNAPL mass reduction technologies tend to be costly (per unit volume treated), it is usually cost effective to define the source zone(s) with a higher degree of accuracy than would be used for other management decisions. In these situations, the lateral and vertical density of sampling points can be quite high, but the payoff is in reduced remedy implementation costs.

Selected references

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AT&SF Albuquerque Superfund Site

Greg Lyssy, U.S. EPA Region 6

The AT&SF Albuquerque Superfund site is located in the South Valley area of Albuquerque, New Mexico. The topography of the site and the surrounding area is generally flat and gently slopes down toward the Rio Grande. The Rio Grande, which is located approximately one mile west of the site, is the nearest surface water body. The site consists of approximately 28 acres of an inactive wood treating facility that used creosote and other compounds in its wood preservation processes. The facility operated as a wood pressure treatment plant from March 1908 to January 1972 and used primarily creosote and oil mixtures for the manufacture of pressure treated wood products, including railroad cross ties, bridge ties, switch ties, bridge timbers, road crossing materials, bridge piling materials, lumber, stock pen posts and fence posts. A significant thickness of DNAPL has been measured in the ground-water monitoring wells and DNAPL recovery wells at the site. Direct observations of the DNAPL encountered thickness ranged from trace levels to over 8 feet. The DNAPL occurs at depths down to approximately 65 feet.

DNAPL Investigation: Questions and Answers

During the course of the DNAPL investigation, the following information was provided:

1. What criteria were used to determine the likelihood of a DNAPL source zone being somewhere on the site?

< *DNAPL was encountered in shallow borings during the beginning phases of the investigation. There was not DNAPL-denial at the Site. The question became, "how much DNAPL is at the site, and how far has it migrated?" During a 1999 removal action at the site, excavated soil was stockpiled prior to offsite shipment. The overburden pressures created by the stockpiled soils caused DNAPL to bubble out of the ground surface. Historical aerial photographs and process information were utilized to target potential DNAPL source zone areas.*

2. After determining the general existence of a DNAPL source area, was there an attempt to specifically locate and bound the source area? For what purpose? What criteria were used to make this determination?

< *A focused investigation was implemented to determine the lateral and vertical extent of the DNAPL. This information was crucial for the feasibility study, proposed plan, and record of decision. Numerous lines of evidence were utilized to determine the actual spatial extent of DNAPL. These included direct observation through soil borings, effective solubility, cone penetrometer testing, monitoring wells, trenches, and geophysical methods.*

3. What was considered to be an acceptable degree of accuracy and precision for locating and bounding the source area laterally and vertically?

< *The data quality objectives (DQOs) established for the site investigation discussed the definitions for spatial delineation. However, a specific, quantifiable number was not set for the actual delineation. The most important aspect was to determine the vertical boundary of the DNAPL. The Santa Fe Aquifer below the DNAPL plume consists of several thousand feet of sands and gravels. This aquifer is the only source of drinking water for the Albuquerque metropolitan area. As such, the investigation focused on determining the vertical extent. There are not any confining layers to prevent continued downward migration of the DNAPL. At the time of the investigation, the DNAPL was at the very top of the Santa Fe Aquifer. There are an*

estimated 59,000 gallons of DNAPL in the subsurface. Obviously this is a very rough estimate. At the surface, the DNAPL impacted source area is approximately 4 acres.

4. If 10% or 1% of the effective solubility for the principle VOC contaminants was used to determine the general existence of a DNAPL source area, how good was this "rule-of-thumb" estimator at predicting the "final" location and boundaries of the source area?

< *The 1% effective solubility rule was utilized as part of the DNAPL investigation. Due to the heterogeneity of the upper 50 feet of soils, which included sands, silts, clays, and gravels, the effective solubility rule was indeterminate at best for DNAPL delineation. In some areas, the effective solubility rule matched up fairly well with the DNAPL zone using direct observation. In other areas, there was very little correlation. The 1% solubility rule of thumb was therefore not a good estimator at this site.*

5. If "direct observation" was used for determining the presence of DNAPL, and the location and boundaries of the source area, what were the specific criteria that were deemed acceptable?

< *Direct observation was utilized in soil borings, monitoring wells, and trenches. The DNAPL and DNAPL sheen were easily visible on the soil core samples and in the monitoring wells and trenches. The biggest limitation to the direct observation line of evidence is the large number of artificial penetrations into the subsurface necessary to delineate the DNAPL. Historical Site information was absolutely necessary to determine potential source locations and focus the investigation in those areas.*

6. How important/helpful was "circumstantial" information (aerial photos, diagrams of facility layout, employee descriptions, etc.) in determining the location of the DNAPL source area?

< *Circumstantial or historical information was critical in the DNAPL investigation. As stated previously, a large number of artificial penetrations were necessary to delineate the DNAPL. Without the historical information, DNAPL source areas may have been missed. The DNAPL at the Site is not continuous, but there are several DNAPL plumes that are interlaced between the old process area, drip tracks, and unlined surface impoundment.*

7. What were the assumed length and width of the DNAPL source area using 1%, and 10% of the effective solubility, and the "final" estimated source area dimensions?

< *As stated previously, the 1% solubility rule of thumb was not a good estimator at this site for actual DNAPL delineation. This was due to the heterogeneity of the upper 50 feet of soils, which included sands, silts, clays, and gravels. As a result of the heterogeneity, DNAPL plume source estimates were not developed based on the effective solubility. The subsurface investigation indicated extreme changes in lithology over very short distances. Due to these depositional and erosional features, a very low permeability layer would be encountered within five horizontal feet of a gravel layer.*

DNAPL Source Zone Delineation at Sites in Three Different Hydrogeologic Settings

Kathy Davies, U.S. EPA Region 3

Three case studies are presented to illustrate the many variables that can be encountered in characterizing DNAPL source areas at sites in different geologic and hydrologic regimes. Direct physical evidence of DNAPLs is not easy to obtain. Therefore, determining the spatial configuration of the DNAPL source area within the aquifer is best done by using multiple lines of evidence.

The first site is an abandoned sandstone quarry with several lagoons which were used for disposal of liquid chemical wastes (primarily chlorinated solvents) and sludges. Dissolved waste constituents and DNAPL entered the underlying bedrock and moved along secondary permeability features (joints and bedding planes) of the interbedded Triassic sandstones, shales and siltstones. These rocks dip to the northwest and strike to the northeast-southwest. The DNAPL source zone was delineated using both the observed presence of DNAPL in several of the wells and dissolved phase concentrations of the principal DNAPL component in the range of 1 to 10 % of the contaminant's solubility (1900 mg/L) in other wells as an estimator of the likely nearby presence of DNAPL.

Wells were constructed in an iterative manner: first, downgradient and downdip in the vicinity of the lagoons on the south side of the river, and then further northward down the regional dip. Wells were installed on an island in the river and across the river with open intervals corresponding to the geologic intervals intercepted by wells south of the river. DNAPL was observed as far as 1500 feet down dip of the lagoons at a depth of 585 feet. Dissolved phase concentrations of the primary DNAPL constituent were found in wells north of the river. In one well, the concentration of the DNAPL constituent was as high as 1% of the contaminant's solubility, which would be consistent with the presence of DNAPL in the vicinity of the well. Ground-water flow, north of the river, was determined to be towards the river. Therefore, the presence of contamination in wells north of the river resulted from DNAPL transport by gravity flow to the north and not by dissolved phase transport.

The extent of contaminant migration was mapped using concentrations of site related VOCs and knowledge of site hydrogeological conditions. Because the contamination moved primarily through secondary permeability features in the bedrock aquifer, the boundary of the dissolved phase plume and the location of the DNAPL which resides within this fractured matrix can only be approximated. However, knowledge gained during the investigation of the DNAPL source area has led to the implementation of an effective recovery well system for hydraulic containment. It has also provided the basis for determining the appropriate Institutional Controls Plan for ground-water use in areas where site contamination has affected the aquifer or where pumping may adversely impact the efficacy of the ground-water extraction system.

The second site is located in an alluvial aquifer in the Atlantic Coastal Plain. Chlorinated solvents had been disposed in former burn pits. Based on effective solubility calculations (e.g., between 1% and 10% effective solubility for downgradient areas) and partitioning analyses conducted during the remedial investigation, the pits and the area in the vicinity of the pits were determined to be a suspected source of DNAPL. After the remedial investigation, a temporary Geoprobe well was installed in this area and encountered DNAPL. Subsequent efforts were made to delineate the DNAPL source area.

The strategy for delineating the DNAPL consisted of several steps. First, cone penetrometer tests were used to collect real-time, vertically continuous, lithologic descriptions. This information was then integrated with existing lithologic data to develop a three-dimensional hydrostratigraphic model. This model captured the detailed lithofacies distributions and small-scale heterogeneities that influence the migration and potential accumulation of DNAPL. Thus, the optimal sampling locations could be predicted for direct push soil and ground-water sampling. The soil cores were screened for DNAPL using visual identification, organic vapor analysis, hydrophobic dye and shake testing. Strong indication of DNAPL required the collection of a ground-water sample for VOC analysis. Partitioning analyses were completed on the soil contaminant data to provide estimates of residual and mobile DNAPL saturations and compositions.

The ground-water data with the subsequent effective solubility calculations and the soil data with the corresponding soil partitioning calculations were integrated with field testing data to determine the correlation between observed mobile NAPL, positive dye testing and effective solubility of the main

DNAPL component (1,1,2,2-TCA). This analysis determined that a 1,1,2,2,-TCA concentration which was 60% of the effective solubility value was representative of the DNAPL source area.

The third site housed a solvent recycling facility for about 40 years on an old paper mill property. It was approximately five acres in size, bordered by a creek to the north and a steep valley slope to the south. Four to sixteen feet of fill and native silt, sand, and gravel overlie a granitic gneiss with predominant fracture planes dipping to the southeast. Historical contamination consisted of in stream VOCs at several hundred ppb near the Site; contamination was persistent at least one mile downstream. There was highly contaminated groundwater in the overburden, bedrock and emanating from seeps and springs. Concentrations of VOCs in the overburden groundwater were in the range of 10,000 to several hundred thousand ppb.

During the RI, 217 samples were taken. Samples included 10 creek sediments, 96 soil samples from 36 borings, and 68 ground-water samples from 116 Geoprobe borings. Samples were also collected from five overburden monitoring wells, 44 creek piezometers, and 5 ground-water seeps. DNAPL was visually observed in only one soil boring sample in the far northwestern portion of the site and in one creek piezometer. However, samples from 18 locations exceeded 1% of the VOC indicator solubility concentration and samples from 17 locations exceeded 10% of the VOC indicator solubility concentration. After the remedial investigation, angled monitoring wells were installed in the bedrock under the creek. One of the wells encountered recoverable quantities of DNAPL. Work is currently being undertaken to determine the configuration and extent of the DNAPL and the associated dissolved plume in the bedrock.

These three sites illustrate the concept that no single method is likely to be successful in delineating DNAPL source areas at all sites, direct observation of DNAPL may be difficult and using multiple lines of evidence is the preferred technique in determining the spatial configuration of the DNAPL source area.

Bachman Road Site

Mark Henry, Michigan Department of Environmental Quality

The site described was one of two adjacent PCE contaminated sites in Oscoda, Michigan, near Lake Huron. These "Bachman Road" sites have been the focus of research and pilot testing efforts by the University of Michigan (Dr. Linda Abriola, Dr. Peter Adriaens, et al.). The southernmost of these sites was a former dry cleaning business that had evidence of PCE leakage from the machinery and plumbing, through the floorboards, directly to the ground under the crawl space of the building, in addition to poor solvent storage practices at the rear of the building. Investigations were performed which utilized Geoprobe equipment to perform vertical aquifer sampling and continuous coring from the land surface to the lacustrine clay aquitard 27 feet below land surface. The geology consists of a beach sand aquifer underlain by a layer of silty sand and then clay. The soil concentrations near the bottom of the aquifer were found to be approximately 1000 mg/kg and the aqueous PCE concentrations were found to be about 50 mg/L near the source and 10 mg/L at least 100 m downgradient. The soil near the aquitard had a slippery feel upon examination. The researchers chose to test the use of surfactant enhanced aquifer remediation (SEAR) near the source area through the circulation of Tween 80 surfactant between injection and extraction wells. The Tween 80 was removed from the effluent for reuse, and the discharge was plumbed to sanitary sewer. The results of the pilot test were very successful, indicating a greater than 90 % removal rate. The plans are in place for a large-scale implementation of the SEAR technology at this site by the Michigan Department of Environmental Quality.

Spartan Chemical Superfund Site

Mark Henry, Michigan Department of Environmental Quality

The Spartan Chemical Superfund site is located in Wyoming, Michigan, near Grand Rapids. The site had been used as a solvent blending facility with numerous above-ground storage tanks and underground piping. The geology consists a sand and gravel aquifer underlain by a thick clay aquitard over the regional sandstone. The unconfined aquifer is described as three aquifers— shallow, medium and deep—not separated by aquicludes. Contamination in the shallow aquifer exists as ground-water contamination (acetone, BTEX, TCE, PCE, MEK) and as immobile NAPL existing at two vertical intervals a few feet under the ground-water surface. This was very evident from continuous Geoprobe cores collected near the source area. The middle portion of the aquifer is relatively uncontaminated. The deep aquifer is highly contaminated (acetone, toluene, methylene chloride, TCE, 2-methyl-4-pentanone, MEK) and it suspected that free-product mixed-NAPL at the base of this aquifer is confined within the bowl-like clay topography that exists under the source area. Near the source area, a SEAR pilot test was performed. Prior to the introduction of the surfactant, a aqueous tracer test was performed to demonstrate hydraulic capture of the test system. At the conclusion of the testing it was observed that much more NAPL was removed from the aquifer through the tracer test than was additionally removed by the SEAR. This may demonstrate that in some cases it maybe beneficial to hydraulically flush the suspected source area prior to the implementation of other remedial technologies, or that pilot technologies should be tested in parallel to simple ground-water extraction for a fair comparison of its effectiveness.

Discussion

Kevin Willis (Region 2) mentioned a site in Region 2 where indirect methods for delineating DNAPL did not work. This particular site had a disposal area, but significant contaminant concentrations were not detected even though site managers knew there was DNAPL located at greater depths. Bill O'Steen (Region 4) responded that he also has worked on a site where DNAPL was present, but ground-water contaminant concentrations were very low. The explanation at this particular site for this observation was that the DNAPL comprised mainly high molecular weight organics, with a smaller portion of low molecular weight organics. The higher molecular weight organics primarily remained in the DNAPL and did not dissolve into the groundwater at appreciable concentrations. Bill observed that the only common denominator at these sites is that NAPL is present; the method for characterizing the sites will be different, based on individual site conditions.

Steve Mangion (Region 1) commented that this point is the heart of the existing guidance. Based on a site's history and waste disposal practices, etc., if NAPL is believed to be present, then one proceeds to characterizing the site. However, the approach to characterizing a site will not be the same at all sites. Jeff Johnson (Region 7) concurred with this assessment and noted that he would like the final guidance to give project managers flexibility and the ability to use their own judgment in determining the best methods for characterizing their DNAPL sites. Jeff said he hopes the guidance will not be prescriptive.

Judy Canova (South Carolina DHEC) observed that the presentations of regional case studies represented a range of sites with known contamination and history to others with very little information known. She said this range of sites illustrates why methods for DNAPL delineation should not be prescribed. It would not be wise to require that DNAPL be found in the subsurface in order to conclude that it is there, nor that DNAPL is necessarily present if concentrations detected in groundwater are at 1% of the contaminants' solubility. Judy also described a site in South Carolina at which DNAPL that was less than 5 feet deep was excavated. During the excavation, she observed both small globules of a coal-tar-like material as well as a pool of DNAPL. She observed that there was no continuous "blob" of DNAPL, and it was evident how many of the wells completely missed the DNAPL. This direct observation demonstrates how difficult locating a DNAPL at depth could be.

Steve Mangion stated that he is comfortable with the rule-of-thumb indicator that if contaminants are present at 10% of their effective solubility, then DNAPL is present. He is uncomfortable with concluding, however, that NAPL must be present nearby. Jeff Johnson commented that he would like to see such a percentage determined for individual sites, based on the site-specific conditions. Kathy Davies (Region 3) added that determining the presence of NAPL at a site not only depends on effective solubility, but on multi-line evidence that includes site history, trend analysis, and location of contamination.

Dick Willey commented that the definition of the term “delineation” must vary from site to site. He suggested the word delineation is a “soft” term used to describe the target area for specific sites or for perhaps for specific remedial actions. Bill suggested that every guidance document should have a disclaimer noting that site conditions can be dynamic and change over time with regard to characterization and remediation. Ken Lovelace added that he’s not certain that defining delineation is the issue, as much as defining what one is attempting to delineate. For example, just what is meant by the source zone? Dick Willey concurred that delineation may be defined when certain site-specific criteria are met. Ken also said that delineation is a function of the types of remedies one may be evaluating. For example, technologies may or may not apply, and the range of methods one evaluates will determine what to look for in the source zone and how delineation is defined.

Mark Henry (Michigan DEQ) shared information about induced polarization, a geophysical method for locating DNAPL that has gone from the experimental stage to the production phase. Induced polarization uses a series of electrodes in a line to induce a current into the ground to depths of up to 150 feet. A NAPL will develop a surface charge based on its capacitance. When the charge is released, an area of NAPL can be discerned to 1 m². After the data are integrated, a 3-dimensional representation of NAPL is portrayed. For further information, Mark has an article on the technology, which he can provide.

Teleconferences

Co-chairs Jeff Johnson and Dick Willey indicated that they received a proposal from a GWF participant that the GWF as a whole review and approve the monthly teleconference minutes prior to distribution and posting on the TSP webpage. The current procedure specifies that the co-chairs review and approve the minutes. The co-chairs initially considered asking the GWF to vote on this proposal, but after discussions with Rich Steimle and EMS staff, they decided, based on logistical and budgetary constraints, to continue current process. Requests for edits following distribution can be submitted to the co-chairs for consideration and re-posting, however.

Dick also proposed a disclaimer be put on the GWF’s website:

In an effort to foster scientific and technological advances in hydrology, and promote their proper application through actual field situations, the Ground-Water Forum encourages full and frank discussion of all technical matters and related issues that come forth. As such, the individual positions reported herein do not necessarily represent the policies of the EPA, the individual states, or other organizations that participate in Forum activities."

Those present agreed that the draft disclaimer was acceptable and may also be used on each document that the GWF issues. Dick offered to e-mail the draft disclaimer to the entire GWF for comment and subsequent discussion on the July conference call.

Kathy Davies recommended that a scientific ethics course be provided to the GWF at a future meeting.