Federal Remediation Technologies Roundtable Meeting Summary

November 14, 2013

FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
Arlington, VA
November 14, 2013

ACTION ITEMS

- The potential topic for the next FRTR meeting in spring 2014 is risk-based decision making and alternative end points.
- Individuals interested in presenting on risk-based decision making and alternative end points at the next FRTR meeting should contact a steering committee member.
- Participants are encouraged to send feedback on FRTR meetings, FRTR Presents webinars, and suggestions for the FRTR website to their agency's steering committee representative.

WELCOME/INTRODUCTION/ADMINISTRATIVE BUSINESS

William (Bill) Lodder Jr., Department of Interior (DOI) Office of Environmental Policy and Business Compliance, welcomed participants to the 46th meeting of the Federal Remediation Technologies Roundtable (FRTR). FRTR works to build a collaborative atmosphere among federal agencies involved in hazardous waste site cleanup and has been meeting twice a year since 1991 to discuss current and relevant topics. Topics discussed at recent FRTR meetings have included site characterization and monitoring, vapor intrusion, remediation of fractured rock sites, green remediation, and optimization. The theme of this meeting was emerging contaminants.

FRTR was established with the goal of bringing together the top federal cleanup program managers and other remediation community representatives to share information and learn about technology-related efforts of mutual interest, discuss future directions for national site remediation programs and their impact on the technology market, and interact with technology development programs to inform partnerships pursue subjects of mutual interest. Since its inception, collaboration between FRTR member agencies has led to technology transfer tools, such as technology screening matrices, cost and performance studies and databases, compilation of technology assessment reports, as well as decision support tools. FRTR also has undergone many changes over the years. A working group (Present and Future Directions Subgroup) was recently established to examine the mission of FRTR and evaluate its future direction. An executive steering committee (that evolved from the Present and Future Directions Subgroup) comprised of representatives of FRTR member organizations also was established and has made a lot of progress in the past year.

In closing, Bill acknowledged the contributions of the meeting organizers: John Quander, U.S. Environmental Protection Agency's (EPA) Technology Innovation and Field Services Division (TIFSD), Bill Hagel (EPA Region 3), Robert Kirgan U.S. Army Environmental Command (USAEC), Jessica Burns (EMS, Inc.), and the executive steering committee.

EMERGING CONTAMINANTS TECHNICAL SESSIONS

EPA Perspective on Groundwater Cleanup

James Woolford, Director of the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) provided an overview of EPA and Superfund groundwater cleanup policies, challenges in cleaning up contaminated groundwater, progress that has been made in Superfund groundwater cleanup, and 2011-2012 optimization observations and needs. He also discussed

Superfund's Draft Groundwater Remedy Completion Strategy and the next steps for the document.

EPA's historical groundwater protection initiatives include the 1984 Ground-Water Protection Strategy, the 1989 National Oil and Hazardous Substances Pollution Contingency Plan, or NCP, and a 1991 report, *Protecting The Nation's Ground Water: EPA's Strategy For The 1990's*, that describes EPA's groundwater protection strategies for the 1990s. Today, protection of groundwater is one of EPA Administrator Gina McCarthy's seven priorities.

Much progress has been made in cleaning up and restoring contaminated groundwater over the past 30 years. Many types of Superfund sites with groundwater remedies in place have now been cleaned up to levels specified by the sites' Remedial Action Objectives (RAOs), or, where remedies have not achieved RAOs, significant reductions in concentrations have occurred. The technical approaches to cleaning up contaminated groundwater at Superfund sites have changed since the 1980s. Between 1986 and 2011, a declining trend in the use of pump and treat technologies has been observed while the use of in situ treatment, including bioremediation, chemical treatment, and permeable reactive barriers, has increased. However, an assessment conducted in 2011-2012 identified several technical and programmatic optimization needs in groundwater treatment. Since groundwater remediation is a component at more than 90% of Superfund sites where a remedy has been selected, groundwater cleanup can take decades to achieve completion, and federal agencies, states, and potentially responsible parties (PRPs) spend hundreds of millions of dollars annually on groundwater remedies, EPA developed a guidance document in 2013 that is intended to help focus resources toward the efficient and effective completion of groundwater remedies.

The Draft Groundwater Remedy Completion Strategy presents a recommended framework for evaluating Superfund groundwater remedy performance and decision making to help facilitate achievement of remedial action objectives and associated cleanup levels. The guidance document helps focus tight resources toward efficient and effective completion of groundwater remedies, provides a flexible structure for development of a site-specific completion strategy, and promotes stakeholder consensus on metrics to evaluate progress and plan for moving forward with groundwater remedies. The document is currently available for public comment on the following website: http://epa.gov/superfund/gwcompletionstrategy/. Comments are due on December 20, 2013 and can be submitted via e-mail to gwcompletionstrategy@epa.gov. The next step is to distribute the document to states, tribes, other federal agencies, PRPs, environmental non-governmental organizations, and other Superfund stakeholders.

The following EPA resources address key EPA groundwater policies and remedy optimization and are publicly available:

- Key EPA Superfund Groundwater Policies: http://www.epa.gov/superfund/health/conmedia/gwdocs/
- *Protecting the Nationals Ground Water: EPA's Strategy for the 1990, Publication 2 1Z-1020, office of the Administrator, July 1991.* http://www.epa.gov/superfund/policy/remedy/pdfs/21z-1020-s.pdf

- Remedy optimization:
  http://www.epa.gov/superfund/cleanup/postconstruction/optimize.htm
  http://www.cluin.org/optimization/

Question: A new training on Five-Year Reviews will soon be offered by EPA. How does optimization fit into the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review process?

Answer(s): The training being referred to was developed by the EPA's Federal Facilities Restoration and Reuse Office (FFRRO) rather than the Superfund program. Optimization and the Five-Year Review process required by CERCLA or FFRRO program policy are separate from one another but can interact. For instance, a Five-Year Review is not optimization in and of itself, but it can identify that a remedy needs to be optimized or utilize the data from a previous optimization.

Question: How does one avoid the need for issuing a Record of Decision (ROD) amendment at a site where adaptive management with a flexible remedy is being implemented?

Answer(s): As part of a broader effort, EPA is looking for ways to identify in a ROD more clearly, what the scope of the remedy is, and the potential remedies that might follow. We are going to need site-specific metrics to determine whether good progress is being made toward meeting remedial action objectives. The EPA Superfund Draft Groundwater Remedy Completion Strategy lays the foundation for making a decision to move forward with groundwater remedies, making changes to the remedies, etc. (and it may require a ROD amendment).

Managing Chemical & Material Risks: DoD's Emerging Contaminant Program

Paul Yaroschak, Deputy for Chemical & Material Risk Management, Office of the Under Secretary of Defense (Installations & Environment), provided an overview of the nature of risks and issues posed by emerging contaminants and the Department of Defense (DoD) initiative to address these risks and issues.

DoD considers emerging contaminants as chemicals and materials that have pathways to enter the environment and present real or potential unacceptable human health or environmental risks, and either do not have peer-reviewed human health standards or standards/regulations are evolving due to new science, detection capabilities, or pathways. DoD's emerging contaminants program dates back to 2004, when perchlorate detections in groundwater and drinking water led to a disagreement between DoD and regulators over response actions. Since then, DoD has developed a three-tiered process called "scan-watch-action" for the management of emerging contaminants.

The scan-watch-action process is comprised of over-the-horizon scanning for emerging contaminants, including reviewing literature, periodicals, and regulatory communications; conducting qualitative Phase I and quantitative Phase II impact assessments in five DoD functional areas (Environmental, Safety and Health; Mission/Readiness; Acquisition; Operation and Maintenance of DoD Assets; and Cleanup); and developing and ranking Risk Management Options (RMOs). DoD has so far screened over 600 emerging contaminants, conducted 32 Phase

I and 11 Phase II Impact Assessments, and developed 60 RMOs that have since turned into Risk Management Actions. As of November 2013, over one dozen emerging contaminants are on the watch list while seven contaminants are on the action list.

Some of the emerging contaminants that have high risks for DoD include perchlorate, sulfur hexafluoride (SF_6), hexavalent chromium (Cr^{6+}), and lead. DoD's response to site-specific risks posed by perchlorate has been increasingly robust since 2004, and over $114 million has been invested in the research and development of perchlorate substitutes. Risk Management Actions also have been taken for SF_6 and include the issuance of DoD policy on SF_6 capture and recycling; Research, Development, Test and Evaluation on substitutes for mission critical applications; and coordination with the Electric Power Research Institute on substitutes for electrical infrastructure. In 2009, DoD issued a policy memorandum that discusses minimization of Cr^{6+} use in existing weapons systems, platforms, facilities, and equipment. A Defense Federal Acquisitions Rule that minimizes the use of Cr^{6+} in new DoD acquisitions also was passed. Risk Management Actions undertaken by DoD for lead have included Research, Development, Test and Evaluation on lead-free munitions; participation with industry in a consortium on lead-free electronics; and the development of a DoD blood lead standard (currently underway) in response to a National Academies of Science study that found overwhelming evidence that the Occupational Safety and Health Administration's standard provides inadequate protection for DoD firing-range personnel and for any other worker populations covered by the general industry standard.

Another initiative undertaken by DoD is the integration of sustainability into DoD acquisition programs. The goal of the initiative is to increase sustainability of systems, platforms, and supporting infrastructure, and lower total ownership costs for equipment. Sustainability analyses are comprised of an assessment of life cycle costs and a lifecycle sustainability assessment that looks at relative impacts.

Question: How does the DoD address contaminants on the scan-watch-action process "watch" list that are also going through an Integrated Risk Information System (IRIS) assessment?
Answer(s): DoD uses IRISTrack to monitor the contaminant(s) in question. When a contaminant is in the research step in the IRIS process, DoD continues to hold the contaminant in the "watch" category before making the decision of whether to put it on the "action" list.

Question: Are you developing an industry standard? If so, with whom do you work?
Answer(s): We collaborate with numerous organizations that are also doing life cycle work. We also have worked with a sustainability consortium in the past and may work with them again if we develop a standard. Lockheed Martin, which is potentially in our industry group, also is interested in doing a pilot project.

Question: How do you derive your numbers?
Answer(s): We collect the best information available.

Question: Is the Sustainability Remediation Forum (SURF) involved?
Answer(s): We have not connected with SURF.

EPA Overview of Emerging Contaminants

Dr. Cheryl Hawkins, EPA OSRTI Assessment and Remediation Division, presented an overview of emerging contaminants of concern from EPA's perspective. The presentation discussed the sources, health effects, exposure pathways, analytical methods and remediation methods for trichloroethene, lead, dinitrotoluene (DNT), 1,4-dioxane, perchlorate, asbestos, and dioxin. A list of useful EPA resources for each contaminant also was provided.

Since 1994, EPA's Office of Solid Waste and Emergency Response (OSWER) policy has been to limit exposure to residential soil lead levels such that a typical child or group of similarly exposed children would have no more than a 5% probability of exceeding a 10 micrograms per deciliter (µg/dL) blood lead level as predicted by the Integrated Exposure Uptake Biokinetic (IEUBK) model. For non-residential sites, the health protection goal is to limit exposure to soil lead levels for women of child-bearing age such that their fetus would have no more than a 5% probability of exceeding a 10 µg/dL blood lead concentration. However, recent health studies on lead toxicity conducted by the Centers for Disease Control and Prevention have concluded that a10 µg/dL blood lead level is too high and any level of lead is unsafe for children. Consequently, EPA has proposed updates to IEUBK model variables. The majority of the proposed variables have been peer reviewed and are awaiting EPA management approval. The EPA website on lead can be located at: http://www2.epa.gov/lead. More information on how EPA is addressing lead at Superfund sites can be found at: http://www.epa.gov/superfund/lead/index.htm.

DNT is a probable human carcinogen and has been shown to have effects on the nervous and cardiovascular systems. Sources of DNT include explosives and manufacturing of polyurethanes. Toxicity values are available for two of the six isomers of DNT—2,4-DNT and 2,6-DNT—though the Agency for Toxic Substances and Disease Registry suggests that all isomers are equally toxic. Remediation methods for DNT include natural degradation by oxidation, photolysis, and biodegradation; adsorption on activated carbon; electrochemical oxidation of wastewater; in situ chemical oxidation with iron sulfide activated persulfate; and incineration and alkaline hydrolysis for soils. Bioremediation as a cleanup method is currently under investigation. In 2008, EPA issued a drinking water health advisory for DNT, which can be found at: http://www.epa.gov/safewater/ccl/pdfs/reg_determine2/healthadvisory_ccl2-reg2_dinitrotoluenes.pdf . General information can be found within a technical factsheet on DNT at: http://www.epa.gov/fedfac/pdf/technical_fact_sheet_dnt_january2013.pdf.

Another chemical of interest to EPA is 1,4-dioxane, which has been linked with liver and kidney damage and is a probable human carcinogen. Sources of 1,4-dioxane include a widely used solvent miscible in water, a stabilizer for chlorinated solvents (trichloroethene, or TCA), and impurity in consumer products. Exposure occurs primarily through occupational sources (primarily inhalation) but also can stem from surface water and groundwater. The chemical properties of 1,4-dioxane create a challenge for analysis. Remediation methods include pump and treat with advanced oxidation processes (for example, hydrogen peroxide and ultraviolet radiation; hydrogen peroxide and ozone) and ex situ bioremediation with bioreactors. Phytoremediation currently is being explored as a cleanup method as well. A 2013 technical

factsheet on 1,4-dioxane can be found at: http://www.epa.gov/fedfac/pdf/technical_fact_sheet_14-dioxane_2013.pdf. A 2010 IRIS Toxicological Review on 1,4-dioxane can be located at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=205170.

Perchlorate is a naturally occurring chemical but also is frequently manufactured for use in rocket fuel explosives, fertilizers, and bleach. Health effects include disruption of thyroid function in iodine uptake. Perchlorate also is likely a carcinogen. People can become exposed through drinking water or ingestion of food (perchlorate has been detected in food crops and milk). Analysis for perchlorate generally is conducted using ion chromatography with mass spectrometry of water samples using EPA Method 314.0, 314.1, 332.0, 6860 or LC/HPLC-MS EPA Methods 331.0, 6850. Remediation techniques include both in situ and ex situ treatment. Ex situ treatment consists of ion exchange (removal), bioremediation via a bioreactor (destruction), or electrodialysis/reverse osmosis (removal). In situ treatment typically consists of bioremediation or permeable reactive barriers, both of which result in destruction of the chemical. A 2012 technical fact sheet on perchlorate can be found at: http://www.epa.gov/fedfac/pdf/technical_fact_sheet_perchlorate.pdf. Information on perchlorate in drinking water can be located at: http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm.

Trichloroethylene (TCE) is an intermediate product in the dechlorination process of tetrachloroethylene (PCE), but also is used in metal degreasing operations and textile production. Health effects of TCE include liver and kidney toxicity, neurotoxicity, endocrine disruption, and carcinogenesis. Inhalation due to vapor intrusion and drinking water are the main routes of exposure for humans. TCE is prevalent at many hazardous waste sites and has been detected at about 761 Superfund sites and 45% of Resource Conservation and Recovery Act (RCRA) sites. Analysis for TCE can be conducted using gas chromatography/mass spectrometry (GC/MS) in the laboratory or via field instruments. Remediation methods include pump and treat using air stripping or granular activated carbon, bioremediation, monitored natural attenuation, or phytoremediation. EPA has numerous resources on TCE. September 2011 IRIS toxicity values can be found at http://www.epa.gov/IRIS/subst/0199.htm. Information on TCE in drinking water is located at http://water.epa.gov/drink/contaminants/basicinformation/trichloroethylene.cfm. EPA's vapor intrusion guidance is located at http://www.epa.gov/oswer/vaporintrusion.

Dioxin is a highly toxic by-product of certain industrial activities and combustion (e.g., Agent Orange, paper pulp bleaching, and forest fires). Health effects include reproductive and developmental problems, as well as carcinogenesis. Dioxin is bioaccumulative and a persistent environmental pollutant found throughout the world. Human exposure occurs predominantly through food. Two hundred and eight possible congeners of varying toxicity exist, with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) being considered the most toxic. In 2012, EPA issued the final *Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1.* The review report provides hazard identification and dose-response information on TCDD and the most up-to-date analysis of non-cancer health effects from TCDD exposure. It also includes an oral reference dose for TCDD of 0.7 picograms per kilogram (pg/kg) per day, which has been placed in IRIS. More information on dioxin can be found at: http://cfpub.epa.gov/ncea/CFM/nceaQFind.cfm?keyword=Dioxin. In addition, EPA's Dioxin

Tool Box is a useful resource that can assist Superfund Project Managers in the sampling and analysis of dioxin-contaminated soils. The Tool Box is located at: http://www.epa.gov/superfund/health/contaminants/dioxin/dioxinsoil.html.

Question: Do you have any comments on perfluorooctane sulfonate (PFOS) or perfluorooctanoic acid (PFOA)?

Answer(s): PFOA and PFOS are increasingly becoming issues at EPA, Air Force, Army and Navy sites. There are 593 known sites with PFOA or PFOS contamination. These chemicals are present at sites where fire fighting training had been conducted. EPA is interested in issuing recommendations to the regions to use health advisories when dealing with PFOA and PFOS. Though EPA has collaborated with DoD, developing IRIS values for these chemicals has been difficult. The important factor when dealing with a contaminant that does not have an IRIS value is human exposure.

SERDP/ESTCP Research Efforts on Emerging Contaminants

Dr. Andrea Leeson (SERDP/ESTCP) discussed the Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP)'s recent research efforts on emerging contaminants. SERDP/ESTCP aims to focus research efforts on gaining an understanding of the fate, transport, and treatment options for emerging contaminants before the need for treatment arises. Currently, research is centered on 1,4-dioxane, perfluoroalkyl chemicals (PFCs), and N-nitrosodimethylamine (NDMA).

Existing treatment options for 1,4-dioxane, which include in situ oxidation, advanced oxidation, and bioremediation, are expensive to implement and a universal remedy is not yet available. In 2005, SERDP released a Statement of Need (SON) to develop remedial alternatives for several emergent contaminants, including 1,4-dioxane. Some of the studies funded by SERDP/ESTCP in response to the SON focused on developing a better understanding of microbial degradation of 1,4-dioxane. However, the studies have not led to a field application of a technology. Consequently, another SON was released in Fiscal Year (FY) 2013 seeking innovative research to develop cost effective in situ remedial alternatives for 1,4-dioxane-contaminated groundwater. Proposed projects also would need to give consideration to common co-contaminants and how these co-contaminants impact the proposed treatment technology. Eight projects responding to the SON were selected and are being conducted by universities, laboratories, and private consulting firms. Most of the selected projects are now in the beginning phases of the research process, with results expected in about three years. Two additional projects addressing 1,4-dioxane are being conducted by Dr. Pat Evans, who is focusing on sustained in situ chemical oxidation of 1,4-dioxane using slow release chemical oxidant candles, and by Dr. Rob Hinchee, who is focusing on 1,4-dioxane remediation by extreme soil vapor extraction.

PFCs are widely used in aqueous film-forming foam (AFFF), which was developed in the 1960s by the Navy and the 3M Company for use on hydrocarbon fuel fires. Environmental release of PFCs has historically resulted from testing or emergency activation of fire suppression systems in hangars, leaks from storage tanks and pipelines, and firefighter training exercises. PFCs of interest include PFOS and PFOA. Site investigations have not typically included analysis for PFCs and the scope of their potential impact in the environment is difficult to define.

Many conventional treatment approaches are not effective for PFCs in water. Technologies currently available to treat PFCs in water include granular activated carbon for drinking and landfill water, and reverse osmosis for higher concentration industrial waste streams. Bench-scale research to develop alternative treatment approaches continues. In FY 2011, SERDP released a SON on in situ remediation of perfluoroalkyl contaminated groundwater. Objectives included improving understanding of mechanisms involved in fate and transport processes in groundwater under varying conditions, determining the impact of co-contaminants on fate and transport processes, improving understanding of behavior of perfluoroalkyl contaminants under typical remedial technologies for co-contaminants, and developing remedial strategies for perfluoroalkyl contaminants. Three project proposals were selected in response to the SON. One project, conducted by the University of Georgia, was unsuccessful in meeting its objective of investigating the feasibility of a novel scheme for the remediation of PFC-contaminated groundwater, while two projects being conducted at the Colorado School of Mines and Oregon State University are still ongoing. SERDP released a subsequent SON for FY 2014 for research on in situ remediation of perfluoroalkyl-contaminated groundwater. The objectives for the SON include developing cost-effective, in situ remedial approaches for treating perfluoroalkyl-contaminated groundwater, assessing the impact of common co-contaminants on the remedial process, and determining the necessity for treatment train approaches to facilitate treatment of co-contaminants. Four projects were selected in response to the SON. The work is still ongoing.

NDMA, a potent mutagen, teratogen, and carcinogen, often co-occurs with rocket fuel and is difficult to treat. SERDP initiated research efforts on NDMA in 2005 with two projects: (1) In situ bioremediation treatment of groundwater with propane gas and oxygen distributed in the subsurface to stimulate propanotrophs; and (2) Ex situ treatment of groundwater using biological fluidized bed reactor. Both investigations were conducted by Paul Hatzinger at Shaw Environmental, Inc. and indicated that NDMA treatment by both in situ and ex situ biotreatment is possible. Ex situ metal catalyst treatment also showed promise.

More information on SERDP/ESTCP emerging contaminant research and other initiatives is available at: http://www.serdp.org or http://www.estcp.org.

Measuring Poly/Perfluorinated Alkyl Substances in the Environment

Dr. Mark Mills, EPA Office of Research and Development (ORD), reviewed reaction pathways and analytical methods for PFCs related to PFOA. PFCs are constituents in manufacturing and industrial applications such as textile and paper treatments, surfactants, wetting agents, cleansers, and firefighting foams. The chemicals in these products may be introduced into the environment through direct use, disposal via drains and wastewater treatment, or via landfills (for example, discarded paper and paints). As a result, PFCs are found in surface water and groundwater, wastewater treatment residuals, soil, and sediment.

Two PFCs – PFOS and PFOA have been detected in humans, wildlife, and environmental matrices worldwide. Studies on laboratory animals and wildlife have indicated that PFOS and PFOA show developmental toxicity and are highly persistent and bioaccumulative. However, little data exist about their presence in their environment. Fate and transport data of perfluoroalkylated substances (PFASs), which include PFOS and PFOA, also are limited and subject to significant uncertainties due to difficulty in quantitatively measuring these compounds.

To responsibly manage sites with PFC contamination, it is important to be aware of the reaction pathways for these chemicals and monitor for the relevant compounds. PFOS is produced by electrochemical fluorination, while PFOA is produced by a telomerization process that adds two carbon units to the polymer in a linear fashion. The processes generate different residual and associated chemicals, which degrade into some of the problem products encountered in the environment. PFASs are chemically different than many traditional contaminants. For instance, PFASs are more hydrophilic, have fluorocarbon chemistry, and are often found at very low levels and in difficult matrices. Typical analytical methods include extraction (solid phase and accelerated solvent extraction), cleanup, and measurement using chromatography paired with tandem mass spectrometry (MS/MS). Quality assurance and quality control checks are critical to ensuring high data quality and can include measures such as analysis of blanks to identify sample contamination, accounting for ion suppression or enhancement, surrogate recoveries, and matrix spikes. Methods of measurement are complex (see sample method on slide 20 of the presentation) and extreme precautions need to be taken to prevent contamination by Teflon, since PFCs are present in many Teflon materials.

Industry continues to modify their formulations to meet consumer needs and regulatory drivers. Changes include shorter carbon chain lengths (<C6), use of polyfluorinated chemistries such that compounds not completely saturated with fluorines, and use of alternative chemistries for linkages (e.g., more ether and oxetane linkages to the polymer).

A SERDP-funded research project evaluating the use of in situ chemical reductive defluorination to manage groundwater impacted by the perfluoroalkyl acids found in AFFF is set to start in FY 2014. The project will be conducted over a period of three years by collaborating scientists at Purdue University, the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center, EPA ORD, and Jackson State University. The goal for the research is to address the reductive reaction mechanisms and pathways (intermediates) for defluorination of PFOS and associated PFASs. In turn, this is expected to facilitate the design of an in situ strategy for remediation of PFAS-contaminated groundwater at military sites with minimal adverse impacts.

Sources of information provided by Dr. Mills on PFAS and other chemicals can be found on slide 27 of his presentation.

Advances in Emerging Contaminant Detection, Remediation, and Exposures: Update on the Superfund Program

Dr. Heather Henry, National Institute of Environmental Health Sciences, provided an overview of Superfund Research Program (SRP)-funded projects on emerging contaminants. SRP funds Multiproject Center Grants that consist of integrated biomedical and environmental science and engineering research teams. SRP also awards grants to small businesses, investigator teams, and training coordinators. The majority of research funded by SRP addresses legacy Superfund contaminants including arsenic, mercury, polychlorinated biphenyls (PCBs), TCE, and PCE. However, grantees also investigate emerging contaminants. SRP's list of emerging contaminants includes 1,4-dioxane, nanoparticles, perchlorate, PFOA, phthalates, polybrominated flame retardants (including polybrominated diphenyl ether, or PBDE), triclocarban, and triclosan.

Contaminants are studied from non-biomedical (remediation, fate and transport), biomedical standpoints, or both.

Emerging contaminant work conducted by grantees under SRP includes the following projects:

- *Meta-Omics of Microbial Communities Involved in Bioremediation* – investigated by Lisa Alvarez-Cohen at the University of California, Berkeley SRP. The project aims to identify and study aerobic and anaerobic microbial communities that can remediate TCE and 1,4-dioxane. As part of the project, bioremediation techniques were applied to soil from a Superfund site in California contaminated with dioxane and other organic compounds. Results of this study showed degradation of dioxane by cometabolism with tetrahydrofuran or propane amendments. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES47050027
- *Development of a High Performance Bioprocess for Eliminating 1,4-Dioxane in Water* – investigated by Joseph Salanitro at Microvi Technologies. The primary goal for this research is the development of a high-rate biological treatment pathway for eliminating 1,4-dioxane in water resources. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=R43ES22123
- *Oxidative Remediation of Recalcitrant Contaminants with Persulfate* – investigated by David L. Sedlak and Fiona M. Doyle at University of California, Berkeley. The goal for the project is to test new approaches for oxidizing contaminants that are difficult to treat with existing technologies (such as PCBs, 1,4-dioxane, and PFOA) and apply these approaches to create more robust and efficient treatment systems. The researchers are currently working with aquifer sediment collected from a series of different hazardous waste sites to understand the relationship between geochemistry and persulfate activation rates. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES47050103
- *Improving the Treatment of Contaminated Aquifers by Developing Direct-Push Oxidant Candles with Pneumatic Circulators Direct* – investigated by Mark Christenson at AirLift Environmental, LLC. AirLift Environmental and the University of Nebraska had previously developed slow-release oxidant-paraffin candles that slowly dissolve and intercept the contaminant when inserted into low permeable zones. Pneumatic circulators that aerate or release bubbles at the base of the candle and prevent the oxidant from sinking while greatly facilitating its horizontal distribution had also been developed. The goal for the current project is to develop slow-release oxidant candles with aerators tips that can be inserted into contaminated aquifers by direct push to remove chlorinated solvents and petroleum prods from contaminated aquifers. Direct-push technology would eliminate the need for wells and is expected to decrease effort and cost of installing slow-release oxidants. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=R41ES22530
- *Transport, Transformation, and Remediation of Contaminants in the Environment* – investigated by Kate M. Scow at the University of California-Davis. Research objectives for the 20-year project (1995-2015) include providing fundamental knowledge about the processes controlling the transport and transformation of contaminants, especially those related to complex mixtures; developing molecular-based and biosensor technologies and integrated tools for monitoring bioremediation and natural attenuation; and developing new

models of reactive transport in groundwater and applying them to predict chemical exposure risks and remediation. Recent investigations have focused on how biochar application in soil may provide benefits through reduced contaminant mobility. Results from batch experiments demonstrate that biochars, and walnut shell biochar in particular, have a high binding capacity for the heavy metals (cadmium, lead, nickel, and copper) and organic compounds (ciprofloxacin, triclosan, triclocarban, monuron, diuron, linuron) that were studied. These findings indicate that while biochar soil application may provide benefits through reduced contaminant mobility, higher application rates of pesticides will be required in agricultural settings where soil-active pesticides are used. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?PROJECT_ID=P42ES46990010

- *Nanoparticle-Based Strategies for Remediation of Contaminated Sediments: Implications, Synergies, and Antagonistic Effects with Associated Nano-Bioremediation* – investigated by Mark Weisner, Claudia Gunsch, Heileen Hsu-Kim at Duke University. The project aims to investigate whether interactions between microorganisms and two nanoremediation candidates – titanium dioxide (TiO_2) nanoparticles and nanoscale zero valent iron – would promote or inhibit the remediation of contaminated sediment and pore water. Researchers are focusing on the polybrominated flame retardant decabrominated diphenyl ether, BDE-209, among other contaminants. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/ProgressReports.cfm?Project_ID=P42ES103560105
- *Safe and Cost Effective Water Remediation, Enabled by an Online Perchlorate Analyzer* – investigated by Philippe Dekleva at Advanced Microlabs, LLC. The project involves the development of an online perchlorate analyzer to facilitate remediation efforts. The online device has been taken to a site in southern California to test remediated water and was found to work well. Researchers plan to improve the user interface and analysis software. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?PROJECT_ID=R44ES17200&searchTerm=perchlorate
- *Discovery of Xenobiotics Associated with Preterm Birth* – Investigated by Roger Giese at Northeastern University. The long-term goal of this project is to discover xenobiotics that contribute to preterm birth. The researchers have recently designed and prepared a new kind of extractive "tea bag" to extract chemicals from samples. The tea bag contains one or more adsorbents and concentrates analytes from large biological and environmental samples to make detection of the analytes easier. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES171980101
- *In Situ Sampling Tool for Assessing Bioavailability* – Investigated by Rolf Halden at Arizona State University and Nancy Denslow and the University of Florida. The project presents a novel strategy for determining bioavailability of sediment-borne contaminants. The in situ sampling/bioavailability determination (IS2B) tool enables simultaneous determination of contaminant levels in bulk water and pore water at low method detection limits. Laboratory and field studies are being conducted with contaminated sediments from Lake Apopka, concentrating on two traditional and three emerging sediment contaminants (p,p'-dichlorodiphenyldichloroethylene, fipronil, dieldrin, triclosan, and triclocarban). More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=R01ES20889

- *Environmentally Persistent Free Radicals* – Investigated by the Louisiana State University SRP. Louisiana State University researchers have discovered that chlorinated aromatic hydrocarbons and substituted phenols chemisorb to the surfaces of particulate matter where they reduce the metal and form a free radical. Researchers also have found these environmentally persistent free radicals (EPFRs) associated with ultrafine particulate matter are also persistent in biological media. An interdisciplinary collaboration with Health Sciences Centers in New Orleans and Shreveport was formed to explore the impacts of these emerging pollutant particle systems. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES13648
- *Environmentally Persistent Free Radicals in Contaminated Soils* – Investigated by Robert L. Cook at Louisiana State University. EPFRs have been found at levels 30 times higher in the pentachlorophenol (PCP) contaminated soils from a Superfund site, a former wood-treatment facility, than in pristine soil samples from the neighboring area. The project aims to systematically explore the formation of EPFRs within PCP-contaminated soils. More information on this project can be found at: http://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES136480102

A search tool is available at http://tools.niehs.nih.gov/srp/search/index.cfm to assist users in learning more about SRP-funded research projects.

Research Panel Discussion

Question: Do the presenters have any information on the uses of PFCs, such as PFOA and PFOS, in chrome plating, and what are some of the other sources of the chemicals?

Answer(s): Biosolids are sources of PFOA and PFOS. Leachate often contains these chemicals as well. In addition, these products can enter wastewater because they are often disposed down the drain. The plating industry has historically used PFCs, but is now interested in and looking for alternatives.

Question: How do we approach the analysis of emerging contaminants without cleanup levels and subsequently conducting risk assessments and setting remedial action goals?

Answer(s): A white paper produced several ago can answer some of these questions. The paper provides several scenarios. The main concern is human exposure. *[A link to the white paper was not provided.]*

Question: Please expand on the "tea bag" technology.

Answer(s): The tea bag can absorb many analytes. It acts as a very rapid sponge to absorb materials for later analysis. The technology is very practical and is particularly useful when highly trained staff is not available. For example, the tea bag can be placed directly into the source of drinking water, such as well water or rain barrel, and then taken to a laboratory for later analysis.

Question: Is there a communication mechanism between researchers within different organizations, such as DoD, EPA, and the National Institutes of Health (NIH), to ensure collaboration and prevent redundancy in funded research?

Answer(s): There is communication among agencies within ESTCP/SERDP which includes representatives from agencies such as EPA and DoD. NIH is not yet part of the ESTCP/SERDP collaboration. One of the application requirements for NIH SRP funding is listing of all other funding sources to ensure that applicants are not receiving duplicate funding for the same project. NIH typically handles coordination by looking for overlap when making awards. Within EPA, certain groups of researchers coordinate their work. There are initiatives that come and go that bring together researchers and research. In EPA's ORD, national program directors ensure that the projects funded support EPA's mission.

Question: A lot of hardrock mines and metals associated with tailings exist on DOI lands. Can the presenters discuss remediation efforts for metals within their respective agencies?

Answer(s): DoD look at metals largely in aquatic sediments, but metals are not big risk drivers at groundwater sites. Metals resulting from munitions training at DoD ranges present issues for surface media, however. NIH has funded work at the University of Arizona that examines mine tailings, particularly at the Iron King Mine. Another NIH-funded project included work at a uranium site in the west, but the funding cycle for that particular project has been completed. NIH is also working with the Colorado School of Mines on a bioavailability assay at a Superfund site on the North Fork of Clear Creek in Colorado. Within EPA's ORD, research efforts on mine sites are underway.

Question: Of the projects ESTCP/SERDP funds, how many have EPA participation? The question is being raised because many federal agencies may not be aware of the ESTCP/SERDP funding program and that they can actively compete for resources.

Answer(s): About 25-30% of projects have EPA participation. A lot more opportunity exists for EPA collaboration with ESTCP/SERDP. ESTCP/SERDP encourages EPA involvement in our workshops, though agencies often face constraints in the ability to travel.

WORKING LUNCH

End States Subcommittee Update

Skip Chamberlain, U.S. Department of Energy (DOE), reported that a framework document on alternative approaches to endpoints is being developed. A National Academies-sponsored workshop to help develop policy and assist federal sites undergoing closure was held several weeks ago. A second workshop will be held January 9-10 in the Washington, D.C. area. In addition, the Interstate Technology and Regulatory Council was provided funding this year to assemble a team on alternative endpoints. In its first year, the team will examine case studies to determine where alternative approaches to closing sites have been used. In the second year, a guidance document will be developed. A panel session on alternative endpoints also was approved and will be held at the 2014 Battelle conference in Monterey. Tom Nicholson (U.S. Nuclear Regulatory Commission) and Paul Beam (DOE) have been working on content for the session.

GSR Subcommittee Update

Carol Dona provided an update on recent work conducted by the Green and Sustainable Remediation (GSR) subgroup. The subgroup also has been working on optimization since 2012 and is now the GSR and Optimization subgroup. Members of the subgroup include representatives from the Navy, Army, Air Force, DOI, DOE, EPA, and USACE. Carol welcomed other FRTR participants to join the subgroup, which holds semi-monthly conference calls.

GSR and Optimization subgroup projects include:

- Preparing a two-hour presentation for the spring 2014 FRTR Presents webinar.
- GSR evaluation tools and websites. Three publicly available agency tools exist: SiteWise™ (Navy/Army/USACE/Battelle tool), Sustainable Remediation Tool or SRT (Air Force), and Spreadsheets for Environmental Footprint Analysis or SEFA (EPA). However, both Navy and Air Force web sites are currently down for upgrading, the USACE tool site is being disabled, and the FRTR web site has been transferred to EPA. Alternate locations to provide easy access to different users are being considered for the tools, including EPA's CLU-IN website, the FRTR website, SURF, SERDP/ESTCP websites, and FEDCENTER.
- Pilot studies on various GSR analysis tools at the Travis Air Force base (two sites) and the Alameda Naval Air Station. The goal of the project was to use pilot study findings to make recommendations for follow up action, including developing a strategy for how to apply the pilot study findings to remediation sites. Both pilot studies are now complete and project reports are under final review
- ESTCP project comparing DoD's GSR Evaluation Tools (SiteWise and SRT) to a full life cycle analysis at three Air Force sites, two Navy sites, and one Army site. The study found that the DoD tools have distinct advantages over the life cycle analysis tool, SimaPro, with respect to cost, ease of use, and ability to share files for collaboration, peer review, and documentation. Findings also suggested that all three tools generally predict similar results, but a more consistent and complete conversion factor database is needed.
- Inclusion of GSR in remedy selection process to evaluate most sustainable technologies and approaches to achieve Remedial Action Objectives. DOE and DOD are seeking a site-wide, risk-informed approach to establish endpoints and an exit strategy that potentially includes GSR Best Management Practices and quantitative analyses with tools such as SiteWise and SRT. Consequently, DOE has drafted a GSR contact and incentive language based on USACE guidance, which is currently under review.

Carlos Pachón (EPA OSRTI) commented that an ASTM standard, which outlines a process for taking actions to reduce environmental footprints and points to quantitative methods, depending on complexity of the remedy, is expected to be released shortly. Several training sessions and panels on GSR are also planned for the 2014 Battelle conference in Monterey. In addition, a webinar on GSR was held in the late summer with over 200 participants. At least two sessions on GSR also will be held at the 2014 NARPM Annual Training Program. A good turnout is expected as 60-70 participants attended the GSR sessions at the 2012 NARPM Annual Training Program.

Kirby Biggs (EPA OSRTI) commented that TIFSD has a national strategy for optimization. The strategy emphasizes incorporating optimization into all stages of the cleanup process.

FRTR Business: Next Meeting

Bill Lodder provided an update on the FRTR steering committee. He stated that risk-based decision making and alternative end points are being considered as topics for the next FRTR meeting.

The FRTR website is being migrated from USACE to EPA's servers. EPA has been working to update the URL to an epa.gov domain. The website should be officially transferred soon. The steering committee also plans to update/upgrade the site and will discuss organizing a subgroup to work on the site at the next steering committee meeting (November 15, 2013). The goal is to begin discussing possible changes to the site in the next 30-60 days. Bill encouraged FRTR participants to contact their agency steering committee representative with any comments or suggestions for the site.

A webinar on large and dilute plumes was held on May 1, 2013. The webinar was successful and the steering committee is looking into holding similar sessions in the future. The National Academies study (*Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites*, available at http://dels.nas.edu/Report/Alternatives-Managing-Nation/14668) is a potential topic. The steering committee will coordinate with EPA to discuss implementing this idea. The committee also would like to hold a webinar on GSR in the near future. FRTR participants are encouraged to contact Bill Lodder with any ideas for webinar topics.

EMERGING CONTAMINANTS TECHNICAL SESSIONS (CONTINUED)

Occurrence of Two Perfluorinated Chemicals (PFOA and PFOS) at Select Navy Installations

David Barclift, Naval Facilities Engineering Command (NAVFAC) Atlantic, provided general information on PFCs, their chemical properties, and a case study of the former South Weymouth Naval Air Station (NAS). PFCs are extremely stable and do not hydrolyze, photolyze, or biodegrade under typical environmental conditions. These chemicals are also persistent in the environment and have high potential to absorb to substrates. PFCs are currently being studied by several research programs, since much is still unknown about these compounds.

PFOA and PFOS are fully fluorinated PFCs that are very stable and have lipid- and water-repellent properties. Studies have shown they have the potential to bioaccumulate and biomagnify in wildlife. PFOA and PFOS are widely used in a variety of industrial and commercial products including textiles and leathers, photography, metal plating, semi-conductors, and pesticides. Another persistent PFC is AFFF, which is widely used for fire-fighting by military and municipal fire departments. AFFF is a complex mixture of fluorocarbon surfactants, hydrocarbon surfactants, and solvents designed to spontaneously spread over hydrocarbon-fuel fires to extinguish flames and to prevent re-ignition. The Navy currently analyzes media for only PFOA and PFOS using federal drinking water guidelines (0.4 µg/L for PFOA and 0.2 µg/L for PFOS). PFOA and PFOS can be used as potential indicator chemicals for other PFCs, but if toxicity information becomes available for other PFCs, the Navy may reevaluate its current approach.

The former South Weymouth NAS in Weymouth, Massachusetts had recently been undergoing investigations to delineate the nature and extent of PFOA and PFOS at the site. The site was used

continuously until it closed in 1997 under the Defense Base Closure and Realignment Act (BRAC) of 1990. Prior to site closure, several inadvertent releases of AFFF were reported from hose nozzles, aboveground storage tanks, and a pump room. Part of the site was also used for firefighting training exercises, involving the use of AFFF. In addition, an estimated 5,000-10,000 gallons of AFFF, reportedly contained in the oil-water separator connected to a sanitary sewer, were spilled in 1987.

The Navy identified PFOA and PFOS as two compounds likely present in AFFF that will serve as indicators for perfluorinated chemicals. The project team agreed in 2009-2010 that the path forward called for the delineation of the nature and extent of PFOA and PFOS at Hangar 1 and the Fire Fighting Training Area (FFTA). Sampling took place in 2010-2011. In both locations, PFOS or PFOA exceeded concentrations set by a short-term provisional health advisory issued by EPA in 2009 in several of the wells sampled. At Hangar 1, PFOA and PFOS were detected at the highest concentrations in the areas where AFFF was used or released or spilled and decreased downgradient. Highest concentrations of PFOA were associated with location of former aboveground storage tanks. At the FFTA, highest concentrations of PFOA were associated with training area. In both areas, migration patterns of PFOA and PFOS were slightly different and high concentrations of PFOS were more widespread.

An Explanation of Significant Differences issued in 2011 established Land-Use Controls restricting uses of groundwater at the FFTA and the portion of the aquifer at Hangar 1 that is considered a potential drinking water source area and falls under the town's aquifer protection district (APD). The Hangar 1 APD site is now at a critical decision point regarding whether to consider active remediation. The non-APD area at Hangar 1 has been transferred.

AFCEC Emerging Contaminants & Broad Agency Announcement Programs

Dr. Adria Bodour and co-presenter Dr. Janet Anderson, Air Force Civil Engineer Center (AFCEC), discussed AFCEC's emerging issue/emerging contaminant program, its list of issues and contaminants, and its Broad Agency Announcement (BAA) approach. The presenters provided additional details regarding AFCEC's approach to addressing 1,4-dioxane and PFCs. Emerging issues and emerging contaminants are one of the numerous challenges for closing sites under the Air Force's Performance Based Remediation initiative.

The Air Force defines emerging issues as chemicals, materials or items that have the potential to affect the Air Force's ability to execute programs, impacts schedules, increases costs, alters the tech approach, or necessitate the need to develop new partnerships. Emerging contaminants are defined as chemicals in the environment that present real or potential unacceptable human health or environmental risks, and either do not have regulatory cleanup standards or the regulatory standards are changing. AFCEC's emerging issue/emerging contaminant program complements and supports DoD's approach for identifying and responding to emerging contaminants. The program also promotes state-of-the-science decisions within AFCEC, focuses on Air Force Environmental Restoration Program (ERP) priorities and needs, and ensures that the Air Force can achieve site closure (by identifying all environmental liabilities) and has sufficient guidance and technical information needed to address emerging issues/emerging contaminants. Specifically, the program focuses on and works to address technological data gaps. For example, the Air Force supports SERDP/ESTCP and funds demonstration and validation projects, such as

pilot field studies, through AFCEC's BAA Program. Forty-nine contracts have been awarded between FY 2008 and FY 2013 through the BAA Program, focusing on emerging contaminants (31%), biogeochemistry (21%), optimization (16%), and other areas.

Emerging contaminants currently on the Air Force ERP response/action list include 1,4-dioxane and PFCs (PFOA and PFOS). TCE (short-term vapor intrusion risk) and Cr^{6+} also are on the response and action list. The Air Force currently is reviewing or assessing additional chemicals, including 1-bromopropane, benzo[a]pyrene, munitions-related metals, and chemical mixtures. Ex situ technologies, such as chemical oxidation with combined addition of ozone and hydrogen peroxide, have been utilized commercially to destroy 1,4-dioxane, but the cost of applying these technologies can be prohibitive. Several 1,4-dioxane treatment demonstration and validation projects have been funded through the BAA Program. One of the projects aims to demonstrate biodegradation of 1,4-dioxane metabolically or by propanotrophs. Another study aims to demonstrate the application of biomarkers for assessing in situ monooxygenase-catalyzed biodegradation of 1,4-dioxane.

The scope of potential impact of PFCs on Air Force sites is great. AFFF has operationally been the product of choice for addressing fuel fires and the Air Force currently holds in stock nearly 1 million gallons of PFC-based AFFF. AFFF is used on Air Force sites in emergency situations and also has been used historically at over 100 sites in fire fighter training exercises. The cleanup of PFCs is challenging due to the ineffectiveness of many conventional treatment approaches in water. Bench-scale research to develop alternative treatment approaches is underway. The Air Force also released guidance for addressing PFCs in 2012. The guidance lays out the near-term (FY 2014-2019) roadmap for addressing fire training areas. The Air Force also has developed a strategy to investigate fire fighting training areas over the next few years, with mitigation (if necessary) to follow. Presently, only non-fire fighting training areas are currently being sampled at up to 10 bases, but investigations at 181 fire fighting training areas are expected to be conducted over the next several years.

Overall, the Air Force is achieving site closeout and difficult-to-treat sites make up the majority of the sites that remain. To address emerging issues and contaminants, the Air Force has adopted a proactive approach that includes high-level data mining and analysis, funding and support of research initiatives, and development of data-driven guidance to ensure systematic responses and practices. General information on AFCEC's emerging issues/emerging contaminants program can be found at: http://www.afcec.af.mil/environment/technicalsupportdivision/environmentalrestorationtechnicalsupportbranch/emergingissuesemergingcontaminantsprogram.asp. Questions on emerging issues can be addressed to afcec.czte.emergingissues.1@us.af.mil, while questions regarding the BAA Program can be sent to afcec.czte.baa@us.af.mil.

Training Range Environmental Evaluation and Characterization System

Billy Johnson (USACE) discussed the framework and capabilities of the U.S. Army's Training Range Environmental Evaluation and Characterization System (TREECS) and the results of several case studies where TREECS had been applied.

Military firing and training ranges contain residue of munitions constituents (MC) that could migrate to surface water and groundwater off-installation. TREECS is a software program that was developed by the U.S. Army Engineer Research and Development Center to provide range managers a tool for assessing whether MC concentrations in off-range media, such as surface water, sediment, and groundwater, will exceed protective health benchmark concentrations. The software hosts environmental characterization, risk management and evaluation tools and integrates the results for ease-of-use and reliability for MC.

TREECS has two tiers for assessments. Tier 1 consists of screening-level methods that require little data and can be easily and quickly applied. Assumptions, such as steady-state conditions, are used to provide conservative or worst case estimates. If a Tier 1 analysis indicates that protective benchmarks could be exceeded, then there would be cause to proceed to Tier 2 to obtain a more definitive assessment. Tier 2 assessment methods require more detailed site data and more time to set up and apply, but still can be completed relatively quickly. Assessments at this level are more comprehensive and generate more realistic and accurate models.

Validation testing of TREECS was completed at several military installations, including the Massachusetts Military Reservation, where groundwater is contaminated with Research Department Explosive (RDX); Fort A.P. Hill, where surface water and groundwater are contaminated with RDX, trinitrotoluene (TNT), perchlorate, lead, and copper; the United States Military Academy (West Point), where RDX can be found in surface water; and Fort Jackson, where surface water is contaminated with four metals. Non-detectable concentrations or lack of data are often issues at military installation sites. However, TREECS model results were found to be within one order of magnitude of measured concentrations for all validations at the four installations. Results for non-metals such as perchlorate were more accurate than model results for metals due to complexities associated with metal solubility and sorption.

TREECS also was applied to the Borschi Watershed site in Chernobyl, Ukraine in order to demonstrate the applicability of the system for non-military constituents of concern. The Borschi Watershed is located 3 kilometers (1.9 miles) south of the Chernobyl Power Plant, where soil and sediment are contaminated with radiostrontium-90 (^{90}Sr), a fission product resulting from the accident in 1986.

Model inputs included ^{90}Sr concentrations, soil bulk density, soil moisture content, soil porosity, soil erosion rates, local hydrology, and other parameters. The initial soil concentration was computed based upon the ^{90}Sr inventory of 1.0E13 becquerels (Bq). This mass inventory was converted to a soil concentration of 7.9E-7 milligrams per kilogram (mg/kg), and further reduced by 20% to account for the fraction of non-exchangeable ^{90}Sr since the majority of the land was comprised of abandoned agricultural fields. Measurements of ^{90}Sr that was irreversibly bound to soil and sediment varied between 0 and 70% for watershed soils, 10-40% for wetland sediments, and 30-90% for channel sediments. Therefore, the mass concentration of ^{90}Sr that was input to the model was 6.32E-7 mg/kg. Although this is a very small concentration, it produces a substantial amount of radiation due to the high specific radioactivity of ^{90}Sr.

TREECS model results computed a 4.95E10 Bq/year ^{90}Sr flux or 0.5% of the total inventory for year zero (year 2000). The flux estimated from field data was 1.43E10 Bq/yr, or 0.14 % of the

inventory, which is more than three times lower than the computed flux. Sensitivity analyses were then conducted and the baseline test case was repeated for the entire ^{90}Sr inventory at varying solubility of ^{90}Sr in solid form, as well as ^{90}Sr in dissolved form. Solubility of ^{90}Sr did not appear to have a significant impact due to the high rate of dissolution and the small particle size. Likewise, soil erosion and infiltration rates were tested but did not sufficiently change the baseline results. The percentage of non-exchangeable adsorbed ^{90}Sr and the soil-water Water Partitioning Distribution Coefficient (K_d) were found to be the two most sensitive and uncertain factors affecting the amount of export. A K_d value of 200 L/kg was tested with all other inputs set to those of the baseline conditions, which reduced the computed ^{90}Sr export flux to 1.88E10, or 0.19% of the inventory. A Monte Carlo uncertainty analysis was then conducted treating K_d as an uncertain input variable with a range of 100-300 L/kg. Based on this model application, it was concluded that the export of ^{90}Sr from the Borschi Watershed to surface water is predominantly a result of soil pore water containing dissolved ^{90}Sr being diverted to surface waters that eventually flow out of the watershed. The 200-year projections of the model showed an exponential decline in ^{90}Sr export fluxes from the watershed that should drop by a factor of 10 by the year 2100.

Overall, TREECS provides numerous benefits by allowing the prediction of future conditions during site assessments and answering the question of whether a problem may arise in the future. TREECS also can be used to develop and assess mitigation scenarios, as well as help optimize and prioritize data collection sites for future assessment activities. More information on TREECS can be found at: http://el.erdc.usace.army.mil/treecs.

Case Studies Panel Discussion

David Barclift, Adria Bodour, and Billy Jonson participated in the panel discussion of the post-lunch technical sessions.

Question: Could TREECS handle catastrophic events, such as failure of a nuclear power plant?

Answer(s): Yes, if it could be determined how the catastrophic event would change mass loading rates, climate, and other parameters. The values could then be plugged into TREECS to develop a model.

Question: Please explain how a new chemical could be added to TREECS.

Answer(s): Adding a new chemical to TREECS is fairly easy. We already have several databases with information on many chemicals. A custom data field could also be created if the chemical's properties are known.

Question: Please explain what the presentation on the Borschi Watershed site meant by ^{90}Sr being irreversibly bound to the soil and sediment.

Answer(s): Irreversibly bound means that the ^{90}Sr was bound so tightly that it was chemically unavailable for export.

Question: In the discussion of the South Weymouth Naval Air Station, it was mentioned that PFOA and PFOS had different migration rates. Was this a surprise and if so, why?

Answer(s): Yes. However, PFOS has been observed to migrate further from the source area at other installations. A lot of research is now looking into how the chemicals behave in the environment.

Question: What is our national laboratory capability for analyzing emerging contaminants?
Answer(s): Analyzing PFOS and PFOA in the laboratory generally does not pose capability issues. For example, the South Weymouth Naval Air Station samples were analyzed by a private laboratory with no difficulties. However, some of the precursor compounds for PFOS and PFOA, as well as fluoro-telomers could present capability issues. Some smaller compounds may require multiple pulls using GC/MS/MS or liquid chromatography/MS/MS, but not every laboratory has the necessary equipment. Cross-contamination with Teflon is an additional concern. Analytical capability underscores the importance of collaboration between laboratories and researchers.

Question: What are the next steps for the remedial process at the South Weymouth Naval Air Station site? What phase of investigation is the site in?
Answer(s): The area without productive aquifers is closed. We are at a critical decision point for the contaminated areas at Hangar 1, however, since that area contains a potentially productive aquifer. The local reuse authority may want to use the aquifer as a drinking water source. We preliminarily looked at alternatives, but the decision-making rests with NAVFAC headquarters and BRAC management. BRAC sites are challenging because the goal is to dispose of the property. This would be a policy decision and NAVFAC is working toward making a decision soon.

FINAL COMMENTS AND CONCLUSION

The next meeting will be held during spring 2014. Bill Lodder thanked the meeting organizers, facilitators, and attendees, and the meeting was adjourned.