Learning Lab Demonstration Schedule

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Sunday, April 8

7:00-7:25 p.m.
Using Augmented Reality (AR) to Interact with and Visualize Data in the Environmental Industry
(Presented by: Arcadis)

8:00-8:25 p.m.
Aerial Photography Using a Drone
(Presented by: Geotech)

Monday, April 9—CSM Innovations

10:05-10:30 a.m.
Visualization Method for Evaluating MNA and Enhanced Biodegradation (Presented by: Porewater Solutions)

10:55-11:20 a.m.
Remediation Geology: Deeper Dive into Geology-Focused Conceptual Site Models (CSMs)
(Presented by: Burns & McDonnell)

11:45 a.m.-12:10 p.m.
Graphic Stratigraphic Logging Tool
(Presented by: Burns & McDonnell)

12:35-1:00 p.m.
Environmental Applications of Unmanned Aerial Vehicles (UAVs) (Presented by: Arcadis)

1:00-1:25 p.m.—OUTSIDE Demonstration—presented in front of the Convention Center on the esplanade.
Better Distribution of In Situ Amendments in Groundwater through Better Real-Time Control of Injection (Presented by: Cascade Drilling)

1:25-1:50 p.m.
Using HoloLens and an Android Tablet to Create an Augmented Reality (AR) Environment
(Presented by: GHD)

2:15-2:40 p.m.
3-D Printing of CSMs
(Presented by: Geosyntec Consultants)

3:05-3:30 p.m.
Demonstration of Physics-Based Management Optimization (PBMO™) Technology for Supporting Environmental Remediation
(Presented by: HydroGeoLogic, Inc.)

3:55-4:20 p.m.
3-D Models with Augmented Reality and Microsoft HoloLens (Presented by: Parsons)

Tuesday, April 10—Horizontal Wells & Sensor Innovations

8:00-8:25 a.m.
Engineered Horizontal Well Screen Design Software (Presented by: Directional Technologies)

8:50-9:15 a.m.
Real-Time Drilling Fuild Comparison: Bentonite versus Biopolymer (Presented by: Directed Technologies Drilling, Inc.)

9:40-10:05 a.m.
Using Real-Time Monitoring to Rapidly Assess and Adjust Groundwater Remediation Strategies (Presented by: In-Situ, Inc.)

10:30-10:55 a.m.
Real-Time Open Water Monitoring of Engineering Controls Applied during Selective Sediment Removal Scenarios Using FDS Connect (Presented by: Field Environmental Instruments, Inc.)

11:20-11:45 a.m.
RemScan™ Technology: Rapid Measurement of Petroleum Hydrocarbons in Soil (Presented by: Ziltek Pty., Ltd.)

12:10-12:35 p.m.
Thermal NSZD Dashboard for Continuous Monitoring (Presented by: GSI Environmental, Inc.)

1:00-1:25 p.m.
WaterlooAPS™ (Presented by: Cascade)

Wednesday, April 11—Software & Bio Innovations

8:00-8:25 a.m.
RACER Software (Presented by: AECOM)

8:50-9:15 a.m.
ENFOS Remediation Program Management Expert System Demonstration (Presented by: ENFOS, Inc.)

9:40-10:05 a.m.
SVEET (Presented by: Pacific Northwest National Laboratory)

10:30-10:55 a.m.
Training for Environmental Monitoring Performance Optimization (TEMPO) (Presented by: Geosyntec Consultants)

11:20-11:45 a.m.
Using ISMs to Evaluate MNA, Enhanced Anaerobic Bioremediation, and Bioaugmentation at a Chlorinated Solvent Site (Presented by: Microbial Insights, Inc.)

12:10-12:35 p.m.
REMChlor-MD (Presented by: Clemson University)

1:00-1:25 p.m.
BioPIC (Pathway Identification Criteria)

1:50-2:15 p.m.
Interactive Tour of the ENVIRO.wiki: Help Us Shape Its Future (Presented by: Draper Aden Associates)

2:40-3:05 p.m.
MODFLOW 6 (Presented by: U.S. Geological Survey)

3:30-3:55 p.m.
Fractured-Rock Geophysical Toolbox Method Selection Tool (FRGT-MST) (Presented by: U.S. Geological Survey)

3:55-4:20 p.m.
1DTempPro (Presented by: U.S. Geological Survey)

Thursday, April 12—Sampling Innovations

8:00-8:25 a.m.
VaporSafe™ (Presented by: Groundswell Technologies)

8:50-9:15 a.m.
Tips and Techniques: Pilot Testing, Pressure Field Verification, Locating VOC Sources, and Evaluating VI Pathways Using the Vapor Pin® (Presented by: Cox-Colvin & Associates, Inc.)

9:40-10:05 a.m.
Vapor Intrusion (VI): Quantitative Decision Framework Tool (Presented by: Jacobs)

10:30-10:55 a.m.
TIGER™ Sampler (Presented by: GSI Environmental, Inc.)

11:20-11:45 a.m.
Demonstration of Dynamic Closed Chamber (DCC) Method for Natural Source Zone Depletion Assessment (Presented by: Golder Associates)

12:10-12:35 p.m.
Passive CO_2 Flux Traps for Measuring Field NSZD Rates (Presented by: E-Flux)

12:35-1:00 p.m.
BioTherm: A Model for Temperature Effects on NSZD (Presented by: E-Flux)

Sunday, April 8, 7:00-7:25 p.m. (Arcadis)

Using Augmented Reality (AR) to Interact with and Visualize Data in the Environmental Industry

Participants will gain an understanding of how augmented reality (AR) is transforming the capability to interact with and visualize data in the environmental industry.

Augmented reality is a new technology that combines digital holograms with the physical environment. This presentation will demonstrate the industry's first AR application which links with existing 3-D models on environmental projects. The result is an immersive experience in the site's data, allowing one to walk around inside of the groundwater data and 3-D plume. This learning lab will include a live demonstration of AR that shows why it is an unprecedented tool for communication of complex site conditions to owners, regulators, and the public. Participants will be provided the opportunity to try the AR themselves at the end of the demonstration.

Sunday, April 8, 8:00-8:25 p.m. (Geotech)

Aerial Photography Using a Drone

This demonstration will explain how aerial photography can be taken by small, unmanned aircraft.
Platform type: Multi-Rotor (four four-pitch rotors)
Rotor Tip to Rotor Tip Dimensions: 31 1/2 inches (80.1 cm)
Operating Temperature: -10°C – 50°C
Take-off Weight: 7 lbs. 13 oz. (3539g)
Hovering Accuracy (GPS Mode): Vertical: ±31 in. (0.8 m) Horizontal: ±98 in. (2.5 m)
Maximum Yaw Angular Velocity: 180°/s
Maximum Tilt Angle: 35°
Maximum Horizontal Flight Velocity: 35 mph (30 knots, 15 m/s)
Wind Limits: 35 mph (30 knots, 15 m/s) continuous or gusts of 25 mph (22 knots, 11 m/s)
Vertical Speed Limits: 800 feet/min. (4.1 m/s)
Supported Flight Batter: LiPo 6S
Operational Ceiling: 12,000 Feet/min. (4.1 m/s)
Maximum Payload: 1 lb. 8 oz. (680 g)
Operational Ceiling: 1.5 mile (2.4 km)
Maximum Power Consumption: 800 Watts (1.1 hp)

Monday, April 9, 10:05-10:30 a.m. (Porewater Solutions)

Visualization Method for Evaluating MNA and Enhanced Biodegradation

This demonstration will present theory and case study applications of a modified radial diagram method for delineating biodegradation zones in groundwater. This method applies to both natural and enhanced attenuation remedies. The audience for this course includes environmental professionals, state and federal regulators, and site owners.

Evaluation and monitoring of monitored natural attenuation (MNA) or enhanced in situ biodegradation (EISB) typically require complex spatial and temporal trend analysis for multiple chemicals of concern, their daughter products, and a suite of redox indicators. It is imperative that the results of these scientific analyses be clearly illustrated so that the processes and efficacy of attenuation are readily understood.

A modified radial diagram method has been employed in a FREE software tool (Visual Bio) to simplify this analysis, so that visual aids can be prepared which clearly demonstrate MNA / EISB trends for VOC parent species, daughter products, and redox indicators using only two figures. This modified radial diagram method improves the clarity of MNA and EISB analyses, and substantially reduces the number of figures needed to review chemical trends.

The benefits of this visualization program are demonstrated for a Superfund Landfill Site in Michigan (MNA) and Plattsburgh Air Force Base (MNA). The visual aids prepared using this method improve the ability of non-technical audiences to see the effects of naturally-occurring attenuation in groundwater. Fewer figures are needed than a typical MNA demonstration using this modified radial diagram method. Figures are relatively quick and easy to prepare.

Monday, April 9, 10:55-11:20 a.m. (Burns & McDonnell)

Remediation Geology: Deeper Dive into Geology-Focused Conceptual Site Models (CSMs)

By applying environmental sequence stratigraphy (ESS) methodology, learn how a focus on geology data collection and data analysis results in more cost-effective groundwater site remediation strategies.

This is a demonstration of the emerging best practice, ESS, presented by the team that developed the practice. The technology focuses on extracting the maximum value of existing subsurface/geologic data to create a detailed description of the subsurface "plumbing" that is a primary control on groundwater movement and contaminant migration. The audience will experience the three-step ESS process of (1) evaluating the stratigraphic depositional environment, (2) formatting existing data to emphasize vertical grain size distribution, and (3) correlate and map out the major sand bodies that control fluid flow. Then the outcome results will be demonstrated in a more effective site management strategy. As a bonus, a borehole logging form for new data collection will be presented that focuses the data acquisition/observations captured at the drill site to optimize the subsequent ESS analysis.

Monday, April 9, 11:45 a.m.-12:10 p.m. (Burns & McDonnell)

Graphic Stratigraphic Logging Tool

Participants will be introduced to facies-based description of sedimentary successions and graphical stratigraphic logging forms and techniques. This is an alternative to USCS-based logging cores that serve as the basis for geologically-sound conceptual site model (CSM) development.

Graphical logging of a site's sedimentary column is a tried and true geologic practice used by stratigraphers to record stratigraphy of cores or outcrop to depict lithologic character, heterogeneities and record key depositional indicators. This represents a facies-based approach that can be used to guide correlations between locations. However, when recording observations of borehole stratigraphy in the environmental industry, it is common to rely largely on USCS codes, simple strip log depictions, and text descriptions of variable detail to log variations in "soil" types. This presentation will introduce a logging form and methodologies that can be effectively implemented in field drilling programs to efficiently capture key stratigraphic information that leads to more robust and geologically plausible data correlations and CSMs. The graphical approach emphasizes the capture of vertical grain size trends, contact characterizations, recognition of key primary and secondary sedimentary structure, rapid visual percentage estimates of textural components, compositional character, rounding and sorting using a standardize symbology and methodology. Using core examples presented in high-resolution imagery a hands-on lab demonstration will be presented in which practitioners of any skill level will log virtual core using these methods and assess the benefits of its use for their project goals.

Monday, April 9, 12:35-1:00 p.m. (Arcadis)

Environmental Applications of Unmanned Aerial Vehicles (UAVs)

Participants will gain an understanding of multiple environmental applications of unmanned aerial vehicles (UAVs) including complex topographic analysis, incident response support, or vegetative health assessments.

Augmented reality is a new technology that combines digital holograms with the physical environment. This presentation will demonstrate the industry's first AR application which links with existing 3-D models on environmental projects. The result is an immersive experience in the site's data, allowing one to walk around inside of the groundwater data and 3-D plume. This learning lab will include a live demonstration of AR that shows why it is an unprecedented tool for communication of complex site conditions to owners, regulators, and the public. Participants will be provided the opportunity to try the AR themselves at the end of the demonstration.

Monday, April 9, 1:00-1:25 p.m. (Cascade Drilling, Technical Services Div.)

Better Distribution of In Situ Amendments in Groundwater through Better Real-Time Control of Injection

Participants will learn the latest technology to facility better distribution of in situ amendments in groundwater through better control of injection using real-time control based on feedback loops including pressure, flow, oxidation reduction potential, groundwater elevation, pH, and conductivity.

The contact of in situ chemicals with contaminant mass is one of the biggest challenges in achieving effective remediation. However, there have been few developments with injection technology since its inception in early 2000. To enhance delivery

of liquid reagents, a new injection manifold was designed to enhance controlling injection flows and associated pressures to design specifications (typically maximum flow rates below fracture pressures and groundwater mounding) while eliminating operator error associated with manual control of ball valves either at a single injection location or multiple manifolded injection locations (e.g., 10). Based on experience at hundreds of injection projects, it is not uncommon for chemistries to not meet remediation expectations because injection flows and pressures were not managed to design specifications developed to achieve contact.

Considering the tens of millions of dollars invested in in situ remediation each year, it makes sense that a more robust injection manifold be developed to ensure they are injected properly. It is expected that overall remediation performance of the industry will improve with this more focused attention to controlled and digitally documented injection.

In order to achieve better injection control a manifold system was developed using more robust flow monitoring with digital magnetic flow meters over traditional digital turbine flow meters that tend to plug frequently and can be difficult to calibrate. Additionally, electronic ball valves tied into digital pressure sensors ensure flow rates are not exceeded that could result in pressure exceedences and result in fracturing of the target interval and uncontrolled distribution of reagents. Since all pressure and flow data are digitally recorded, documentation of injection performance is readily available to confirm design specifications were achieved. Just relying on periodic documentation by injection operators reading pressure and flows from gauges or flow meters does not provide the resolution needed to determine if injection was performed pursuant to design specifications.

This technology demonstration will demonstrate to participants that improvements to injection technology are in development and they can determine where and how to best apply to their sites. It will also provide participants with a great understanding of limitations with current injection approaches which allow them to direct more focus to controlling these issues when traditional injection is utilized.

Monday, April 9, 1:25-1:50 p.m. (GHD)

Using HoloLens and an Android Tablet to Create an Augmented Reality (AR) Environment

Learn the basics of how to navigate through your site data in an augmented reality (AR) environment. Information that would normally be limited to a traditional monitor is presented with the assistance of headsets and/or tablets visualizing 3-D objects and will encompass conceptual site models for multiple business sectors.

This demonstration will walk through some of the unique ways to interact with AR technology. AR is the real-time overlaying of information on top of the viewer's real-world environment. This overlay allows the viewer to interact with 3-D virtual objects as if they were present in the world around them. The focus will be on two readily available tools used to create an AR environment: a HoloLens and an Android tablet. With these tools, the user can view a 3-D model of a TCE plume, potential building designs, or visualize the results of an air model's temporal projection results.

The HoloLens is an untethered headset developed by Microsoft® and employs a variety of sensors used to scan the user's movements and surroundings to enhance the experience of the wearer. Android tablets are much more affordable, and therefore more common than AR headsets; however, they are more limited regarding built-in sensors. Tablets and phones can generate a "Magic Window" effect that overlays the back-camera video with information "augmenting" what is captured in that camera.

Monday, April 9, 2:15-2:40 p.m. (Geosyntec Consultants)

3-D Printing of CSMs

3-D printing is a novel tool for communicating environmental data. This demonstration will introduce the technology to attendees and allow hands-on interaction with 5 to 10 different 3-D printed models, representing a variety of potential applications.

3-D printing is a powerful tool for creating physical models of 3-D structures that exist solely in digital form. While the use of 3-D modeling software to visualize environmental data is becoming increasingly common, digital 3-D models can only be viewed on a computer screen using specialized software or as 2-dimensional figures. 3-D printing is a unique and innovative way to leverage these digital 3-D models for the creation of physical scale models. Over the last five years, the cost of desktop 3-D printers has decreased 10-fold, and printers are now widely available for less than $1,000 USD. The variety of materials available for 3-D printing has also expanded over the past few years and includes: acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), polycarbonate, flexible polyurethane, and many others. The printing process starts with a digital 3-D

mesh file. The 3-D mesh file is then "sliced" using specialized software which then generates a tool path for each layer. A 3-D printer then uses this input file to deposit a sub-millimeter bead of melted plastic onto a glass plate to build the shape layer by layer. The resulting models can capture the attention of the intended audience and communicate complex, 3-D environmental data unlike any other visualization tool. Applications for 3-D printing for environmental projects include: geologic block models, landfill scale models, models generated from high resolution site characterization datasets, and complex 3-D conceptual site models coupling geology and contaminants.

Monday, April 9, 3:05-3:30 p.m. (HydroGeoLogic, Inc.)

Demonstration of Physics-Based Management Optimization (PBMO™) Technology for Supporting Environmental Remediation

PBMO™ helps environmental scientists and engineers predict the effectiveness of different environmental contaminant remediation strategies or water resource management practices. The computer models relied on for this task can support cleanup or resource management design, but they cannot, by themselves, determine the solution that best balances multiple objectives, design options, and regulatory requirements. PBMO™ uses advanced optimization algorithms in conjunction with computer models to evaluate many more options than simple modeling or expert analysis and to determine the best solution.

Historically, finding the best solution using computational approaches has required hundreds to thousands of computing hours, but PBMO™ solves these same problems in a fraction of the time and has provided optimized management solutions for a variety of environmental remediation and water resource projects. Benefits have included reducing potential human health risks, conserving natural resources, realizing significant cost savings, and attaining cleanup goals in a timely manner. The breadth of opportunity for applying PBMO™ to challenging environmental and water resource management problems is immense. The more complex the problem, the more value PBMO™ provides in finding optimal solutions.

The Leaning Lab demonstration will consist of showcasing the tool via a live computer-based demonstration of optimizing a remedial design that relies on pump and treat technology.

Monday, April 9, 3:55-4:20 p.m. (Parsons)

3-D Models with Augmented Reality and Microsoft® HoloLens

Participants will gain an understanding of the basic concepts of augmented reality and virtual reality. In addition, they will learn how these two technologies, which emerged primarily from the entertainment industry, can be practically applied to the science and engineering fields.

Hands-on demonstrations of augmented reality will be conducted using the Microsoft® HoloLens. Three-dimensional (3-D) models applicable to environmental science (including a groundwater contaminant plume), engineering, architecture, and construction disciplines have been optimized, and will be deployed for use on tablets and headgear. Participants will don the headset and experience “touching” and manipulating these holographic models via augmented reality. With simultaneous display of the viewer’s perspective displayed on a screen, all participants will “see” the live demonstrations. The current and future state of these technologies will be discussed, providing a framework for the audience to understand current capabilities and limitations, and anticipated future enhancements and applicability.

Tuesday, April 10, 8:00-8:25 a.m. (Directional Technologies)

Engineered Horizontal Well Screen Design Software

This demonstration will illustrate state-of-the-art, automated, horizontal remediation well (HRW) software developed specifically to aid in the proper design of horizontal wells. Proper design of horizontal wells requires a more detailed understanding of long screen sections and porous media conditions along the targeted areas. The lab will be interactive where multiple designs will be performed with audience input.

Directional Technologies, Inc. has developed a proprietary horizontal well screen design software enabling well design parameters to be matched to site conditions. The software achieves an effective longitudinal variation of extraction or injection rates along the entire screen length. Programmed as a powerful Windows-based application, this software has been used to successfully design horizontal remediation wells globally across a wide range of hydrogeologic conditions.

The Learning Lab will illustrate how the program completes two interconnected tasks:

- Computing transient pressure changes and energy losses associated with air/water flow through and along the slotted well screen of a horizontal well.
- Simulating transient air/water pressure changes in a three-dimensional, partially-saturated or saturated, anisotropic porous medium surrounding the well screen.

Coupling these tasks with site information such as geologic conditions, borehole data, aquifer hydrogeologic properties, and well alignment allows the user to predict performance and evaluate and optimize the design in real time before the well is drilled.

Additionally, the learning lab will illustrate through case studies the software's input parameters and interpretive capabilities, facilitating the optimization of screen design parameters for remedial applications.

Instructors will also demonstrate how horizontal well design is inherently different from vertical well design. Specifically, the software allows for a much longer horizontal screen section to be placed in a target formation. A typical horizontal well may contain from 50 to 1,000 feet of well screen versus a traditional vertical well that contains less than 50 feet of screen. Horizontal alignment provides the opportunity to create a much larger treatment volume from a single location. HRW design software allows design details to be considered to provide a balance of screen dimensions and operational parameters appropriately matched to the hydrogeologic properties of the various porous media surrounding the screen.

Wells are an expensive part of a remediation system. Properly designed and operating wells are required for effective in situ remediation systems. Horizontal wells can be applied for soil vapor extraction, hydraulic control, injection of treatment chemicals, air sparging, chemical oxidation, groundwater recirculation systems, and other applications over the lifetime of the well. To obtain maximum performance, efficiency, and cost effectiveness, each well must be properly constructed.

Tuesday, April 10, 8:50-9:15 a.m. (Directed Technologies Drilling, Inc.)

Real-Time Drilling Fuild Comparison: Bentonite versus Biopolymer

Participants will see, in real time, the difference in performance between bentonite drilling fluid and biopolymer drilling fluid, with respect to well development and hydraulic conductivity between the well and surrounding formation.

Horizontal remediation wells may be drilled and installed with traditional bentonite drilling fluid, or biodegradable polymer fluids that have been developed for the environmental industry. This demonstration shows the difference in performance of the two types of drilling fluid, particularly in the area of well development and the resulting hydraulic connection between the well and the surrounding formation.

A desktop demonstration of the two drilling fluids is provided, showing head-to head comparison of wall cake formation, simulated well development, and subsequent penetration of water into simulated formation materials.

Tuesday, April 10, 9:40-10:05 a.m. (In-Situ Inc.)

Using Real-Time Monitoring to Rapidly Assess and Adjust Groundwater Remediation Strategies

Real-time monitoring of geochemical reactions in the target formation during injection provides a refined understanding of site geology and enables dynamic adjustments to a remediation strategy. This demonstration shows how continuous data from sub 2-inch multiparameter sondes, combined with telemetry and cloud-based data management software, reduces uncertainty, and optimizes treatment strategies and effectiveness.

Tuesday, April 10, 10:30-10:55 a.m. (Field Environmental Instruments, Inc.)

Real-Time Open Water Monitoring of Engineering Controls Applied during Selective Sediment Removal Scenarios Using FDS Connect

Through a live software and monitoring equipment demonstration participants will learn 1) the difference between telemetry and real-time field data, 2) the options currently available for real-time field instrument communication, 3) the value of true real-time field data collection as applied to a specific long-term open water monitoring project, and 4) lessons from long-term field equipment deployment.

Field Environmental Instruments, Inc. and Field Data Solutions will demonstrate its software application Connect™ coupled with a string of real-time monitoring equipment. Connect™ captures, transmits, integrates, processes, evaluates, stores, and

reports true real-time data signals from a variety of commonly used field-based environmental monitoring instrumentation. The software application will be coupled with a demonstration of a unique configuration of long-term water quality monitoring equipment configured to measure the efficacy of engineering controls during a sediment removal project at multiple depth and compared to background.

Field Environmental Instruments, Inc., has been providing monitoring instrumentation and environmental sampling equipment solutions to its clients for 22 years. Field Data Solutions has been providing integrated true real-time field data and monitoring equipment solutions since 2012. Two phases of long-term water quality monitoring have been completed and a third is currently underway at the field project representing more than a year of continuous data.

Tuesday, April 10, 11:20-11:45 a.m. (Ziltek Pty. Ltd.)

RemScan™ Technology: Rapid Measurement of Petroleum Hydrocarbons in Soil

The audience will learn how RemScan™ is used in the field with a focus on its ease of use and speed of measurement. A soil reference standard will be used to demonstrate the accuracy of the system against standard gas chromatography (GC)-based laboratory analysis. RemScan™ is a handheld infrared device for the rapid infield measurement of petroleum hydrocarbon contaminants in soil. The technology was commercialized by Ziltek, a company that develops and markets innovative environmental technologies globally.

Current industry practice for analyzing petroleum hydrocarbon contamination in soil involves sending soil samples to an off-site laboratory for the analysis of total petroleum hydrocarbons (TPH) using GC, with standard turnaround times of 5 to 10 days. This is a relatively costly, time-consuming process and limits the amount of data points that can be collected due to budgetary considerations.

RemScan™ can be used to measure crude oil contamination infield in soil in less than 20 seconds, with similar performance to laboratory assays. The infrared device uses diffuse reflectance technology, where a mid-infrared beam hits the soil surface and reflects back to a detector, generating an onscreen measurement of TPH. No solvent extraction or hazardous chemicals are required; it is a direct measurement.

This innovative technology (US Patents 8759775, 8914312) is being used successfully on a variety of sites by multinational oil companies to accelerate site closure, decrease laboratory analysis costs and to collect more data points for better sampling statistics and increased confidence in decision making. Infield applications include stockpile segregation, site assessment, bioremediation monitoring, spill delineation and cleanup validation.

The RemScan™ technology has been independently validated by Battelle, a not-for-profit US-based environmental testing authority, and was recently accredited under ISO 14034 Environmental Technology Verification (VerifiGlobal) and has a U.S. EPA Method application pending. The technology concept has been published widely including in the peer-reviewed Soil Science Society of America Journal.

Tuesday, April 10, 12:10-12:35 p.m. (GSI Environmental, Inc.)

Thermal NSZD Dashboard for Continuous Monitoring

The Thermal NSZD technology measures the rate at which natural biodegradation destroys free-phase product (LNAPL) in the subsurface by measuring the heat released by the microbial reactions. Unlike conventional monitoring well methods, this new technology provides a quantitative measure of the gallons of LNAPL destroyed by biodegradation each year. During this learning lab demonstration, participants will view a live demonstration of the temperature monitoring components and learn how these values are converted to rates of LNAPL degradation. Furthermore, participants will view a live demonstration of the Thermal NSZD Dashboard.

Thermal NSZD is a continuous thermal monitoring system that is used to estimate the daily and cumulative mass of LNAPL destruction in the subsurface by microbial activity. The conversion of net temperature change to mass degradation is based upon a series of thermodynamic equations developed by Colorado State University. Thermal NSZD measures the heat generated by biodegradation processes using a vertical series of thermocouples, which can then be converted to a biodegradation rate. Temperatures are corrected from a non-impacted background location to remove seasonal temperature effects in the subsurface.

The Thermal NSZD Dashboard is a secure, web-based service that automatically downloads temperature data via wireless communication every day from the user's Thermal NSZD Stations; performs all of the necessary calculations; and provides the "bottom line" on the gallons of LNAPL biodegraded per acre per year.

Key benefits of Thermal NSZD include:

- One-time installation of Thermal Monitoring Stations, with minimal operations and maintenance (O&M) and no additional site visits required for sampling events
- Quantitative measure of on-going NSZD rates, which can be used to compare against performance of other active remediation technologies
- Continuous, remote monitoring of NSZD rates
- Lower costs when compared to conventional monitoring methods and other LNAPL remediation technologies

Additional information, including a demonstration of the dashboard, can be obtained at thermalnszd.com.

Tuesday, April 10, 1:00-1:25 p.m. (Cascade)

WaterlooAPS™

The objective of the combined technology tool string approach is to provide site investigators and decision makers with the multiple types of information that are essential in developing an accurate and robust conceptual site models (CSMs) upon which to base management decisions. Recent developments in combining multiple measurement technologies in single direct push tool string have advanced these capabilities.

The WaterlooAPS™ was the first direct push tool to combine injection logging and measurement of hydraulic head with groundwater sampling. More recently, tools such as the MiHPT combine direct sensing with injection logging and CPT tool strings have long combined strain gauges with other sensors to provide additional context. The WaterlooAPS™, the premier direct push groundwater profiling tool, has been modified to incorporate additional technologies into the tool string. In addition to the injection logging capability for hydrostratigraphic measurements (index of hydraulic conductivity, Ik) the APS now includes a downhole pressure transducer for hydraulic head measurements when the potentiometric surface is below the suction limit; electrical conductivity measurements of the formation; and laser-induced fluorescence screening for aromatic NAPLs using the Ultra Violet Optical Screening Tool (UVOST). The demonstration will cover an overview of the technologies, the rationale for tool selection and how these data can be used to support dynamic high resolution site characterizations and the development of CSMs.

Wednesday, April 11, 8:00-8:25 a.m. (AECOM)

RACER Software

This demonstration will provide an introduction to the RACER software. What it is, how it works, key features, and a computer demonstration of the software.

- What is RACER?
  - Acronyn
  - Commercial-off-the-shelf
  - History
  - MS_Windows based
  - Credible, auditable and defensible budget-level estimates.
  - Quick, automated, consistent and repeatable method to estimate and document costs
- How does it work?
  - RACER uses a "parametric" estimating methodology:
  - Input Parameters + Logic = Required Items
  - Input Parameters + Algorithms = Quantities
- Key Features:
  - Parametric estimating method
  - GUI Overview
  - Media
  - Programs
  - Cost Database
  - Life Cycle Stages
  - Extensive Library of Technologies

    - Preferences
    - More Customization
    - Scenario Analysis
    - Portfolio analysis
- Demo—Setting up an Estimate

Wednesday, April 11, 8:50-9:15 a.m. (ENFOS, Inc.)

ENFOS Remediation Program Management Expert System Demonstration

Participants will learn best management practices associated with environmental remediation liability management and project management controls. Areas of focus will include lifecycle stages, scope of work management, schedule management, and cost management within a framework of automated workflow and integrated business processes.

ENFOS Environmental Liability Management software is an enterprise cloud solution used for responsible parties and their environmental consultants, contractors, and laboratories. ENFOS is designed specifically as an expert system for remediation and decommissioning programs. The system supports the planning, management, control, and reporting of all aspects of remediation programs including project portfolio management, financial management, environmental data management, and compliance.

Wednesday, April 11, 9:40-10:05 a.m. (Pacific Northwest National Laboratory)

SVEET

A computer tool will be demonstrated that facilitates the process of compiling appropriate data and conducting analyses to determine if sources of volatile contaminants in the vadose zone have been diminished sufficiently that groundwater is protected. The spreadsheet-based SVEET tool enables users to access and interpolate between the results of thousands of pre-modeled scenarios to support evaluation of the need for remediation, soil vapor extraction (SVE) performance, and/or when SVE can be terminated.

SVEET provides defensible information to support decisions about the need for remediation or the endpoints of remediation. SVEET software results are derived from thousands of rigorous simulations of three-dimensional, multi-phase contaminant transport under natural conditions conducted using the Subsurface Transport over Multiple Phase (STOMP) code on the Department of Energy's high-performance computing resources. These simulations include recharge-driven processes, vapor-phase processes, and mixing into the groundwater, all demonstrated to be important for estimating contaminant transport.

SVEET is a mature tool already being used for remediation applications. Since its development in 2013, the SVEET tool has been downloaded (from http://bioprocess.pnnl.gov/SVEET_Request.htm) by approximately 500 users, and applications include use at the DOE Hanford Site to terminate an SVE system. ESTCP funding (ER-201125) enabled extension of the SVEET tool to the VIETUS tool, which provides vapor concentration outputs and linkage to a vapor intrusion evaluation approach. A current ESTCP project (ER-201731) will extend the capabilities of SVEET. Updates will include expanding the range of inputs for vadose zone thickness, source configuration, moisture conditions, and contaminant options, as well as extending the output to include estimates of shallow soil vapor concentrations for vapor intrusion analyses (integrating the core elements of the VIETUS software).

The demonstration will use the existing tool and discuss the incorporation of these updates.

Wednesday, April 11, 10:30-10:55 a.m. (Geosyntec Consultants)

Training for Environmental Monitoring Performance Optimization (TEMPO)

This will be the official release of "TEMPO", an interactive, immersive learning tool for contaminated site investigation and remediation design. Participants will receive an introduction to the tool, and guidance on its use and applicability. Participants can then take the information back to their respective organizations and roll it out as an internal training tool.

TEMPO, "Training for Environmental Monitoring Performance Optimization", is a free training and educational tool developed as a collaboration between Stanford, Queen's University and Geosyntec Consultants. The development program was funded by ESTCP through its technology transfer statement of need. TEMPO is the "front-end" of the SERDP-funded "DIVER" project, which developed reality-based high resolution virtual sites that can be investigated in a realistic and immersive manner. TEMPO presents the user with a choice of seven different sites to be investigated, either via the conceptual site model (CSM) module or the performance monitoring optimization module.

Under the CSM module, users are presented with a phase 1 report from a potentially contaminated site and a map-based GUI. Site investigations using a variety of tools (boreholes, MIP, monitoring wells, DYE-LIF, biological tools) are designed and completed in a near instantaneous manner. The user is asked to develop a CSM that addresses a number of predefined metrics (location of aquitards, plume size and mass, NAPL source locations, mass discharge) and is then assessed against the "truth" following completion.

The developers of TEMPO believe that it offers a free, well supported powerful training and learning tool for early career professionals in the workplace as well as senior tertiary and post-tertiary students interested in contaminant hydrogeology and remediation.

Wednesday, April 11, 11:20-11:45 a.m. (Microbial Insights, Inc.)

Using ISMs to Evaluate MNA, Enhanced Anaerobic Bioremediation, and Bioaugmentation at a Chlorinated Solvent Site

In situ microcosms (ISMs) provide the chemical, geochemical, and microbiological lines of evidence needed to cost-effectively screen remediation alternatives. Participants will gain a practical understanding of study design and data interpretation along with brief introductions to molecular biological tools (MBTs) including qPCR, SIP, and CSIA.

Site managers have frequently turned to laboratory microcosms or small pilot studies to evaluate bioremediation options. However, duplication of in situ conditions in the laboratory is difficult and the results often do not correlate to the field. Pilot studies are performed in the field but are often prohibitively expensive as an investigative tool.

Most often, ISMs consist of an assembly of two or three units. Each unit corresponds to a different potential treatment option (e.g., MNA, biostimulation, and bioaugmentation) and contains passive samplers for quantification of contaminant concentrations, geochemical conditions, and contaminant degrading microorganisms. ISM units are suspended in an impacted monitoring well for 30 to 90 days and recovered for analysis.

Typical ISM units

1) MNA Unit: Contains no electron donor or other amendments and represents existing site conditions. The MNA unit serves as the control to evaluate the effectiveness of enhanced bioremedation strategies.
2) Biostimulation (BioStim) Unit: Amended with a specified electron donor (e.g., lactate, emulsified vegetable oil, etc.), electron acceptor (e.g., oxygen, sulfate), other amendment designed to promote biodegradation.
3) Bioaugmentation (BioAug) Units: Pre-inoculated with a commercial culture and amended with an electron donor.

Passive samplers in each ISM unit

1) Chemistry (COC): Passive diffusion bag sampler for contaminant concentrations and daughter product formation.
2) Geochemistry (GEO): Quantification of geochemical parameters including electron acceptors and dissolved gases.
3) Microbiology (Bio-Trap): Bio-Traps are passive microbial samplers designed for analysis by a variety of MBTs including qPCR quantification of key microorganisms such as *Dehalococcoides*.

The demonstration will include a case study where ISMs were used to evaluate MNA, enhanced anaerobic bioremediation, and bioaugmentation at a chlorinated solvent site.

Wednesday, April 11, 12:10-12:35 p.m. (Clemson University)

REMChlor-MD

This demonstration will provide a hands-on exploration of the contaminant transport and remediation model, REMChlor-MD. This free program simulates the effects of matrix diffusion on dissolved plumes, and the demonstration will highlight a pre-release Beta version of the model.

ESTCP funded the development of REMChlor-MD, a free screening level model that simulates transport of dissolved chlorinated solvents from a concentrated source zone considering the effects of partial or complete source remediation at some time after the initial release. The model simulates plume transport with matrix diffusion, and can consider enhanced degradation of parent and daughter compounds as a function of space and time in both the high and low permeability zones. Use of the program will be illustrated through application to several examples of contaminant transport and remediation that involve matrix diffusion.

Wednesday, April 11, 1:00-1:25 p.m.

BioPIC (Pathway Identification Criteria)

This demonstration will describe how to implement BioPIC (Pathway Identification Criteria), a validated systematic approach for selecting the most efficacious remediation approach, with emphasis on impact on degradation rates. While earlier frameworks had focused on anaerobic reductive dechlorination, the BioPIC framework highlights the importance of all biodegradative mechanisms (abiotic, oxidative and aerobic).

The approach focuses on using the most appropriate parameters of interest in order to achieve desired degradation rates. The parameters to be measured under this scheme include dechlorinating bacteria abundance (i.e., Dhc), concentrations of reductase dechlorination (RDases) genes, biogeochemical parameters controlling rate of attenuation, magnetite and other ferrous minerals. Observations made for dozens of sites were used to develop the decision matrix and BioPIC, an Excel spreadsheet that allows users to insert their own specific parameter values to ascertain which remedial path to follow. Over 32,000 samples resulted in a database of >437,000 data points in a database associating parameters concentrations with rate of attenuation in the well transect to develop the database behind BioPIC.

Wednesday, April 11, 1:50-2:15 p.m. (Draper Aden Associates)

Interactive Tour of the ENVIRO.wiki: Help Us Shape Its Future

ENVIRO.wiki (formerly www.ERwiki.org) is expanding. We need your input on how to best serve your needs. Join us for a brief tour of ENVIRO.wiki, learn about our expanding coverage, and provide your ideas on how to grow!

ENVIRO.wiki (formerly the ER wiki), was created to compile the latest academic, industrial and government research into short 'Wikipedia type' summaries full of current information, technical challenges and vast links to the original reports, project summaries and technical literature, all in one condensed place. Join us for an interactive walk through of the Enviro.wiki and participate in a discussion on the thought process behind the starting, creating and continuing work on the site. This interactive tour will allow the participants an opportunity to see the behind the scenes of the site development and contribute to the continued creation of the wiki by providing feedback on the existing site and debating the future.

Stop by for a tour of the wiki and take the opportunity to shape its future.

Wednesday, April 11, 2:40-3:05 p.m. (U.S. Geological Survey)

MODFLOW 6

This demonstration will present the new capabilities of MODFLOW 6, including the ability to tightly couple multiple groundwater models, simulate full three-dimensional anisotropy, and route water between MODFLOW packages. Participants will also develop an understanding of the new input structure, and how existing models can be translated into the new format. Redesigned to improve user experience and accommodate future features, MODFLOW 6 introduces a model coupling framework to the program that, for more than 30 years, has been used by academics, private consultants, and government scientists to accurately, reliably, and efficiently simulate groundwater flow.

Originally released in 1984 and updated in 1988, 1996, 2000, and, most recently, 2005, the sixth core version of MODFLOW was redesigned from the ground up to incorporate many of the new advances in groundwater modeling developed over the past decade. Many of these new advances are based on the use of more flexible grids to discretize an aquifer system or the capability to couple other hydrologic processes with groundwater flow. MODFLOW 6 uses an object-oriented framework that allows new packages and models to be added to the software, and allows any number of models to be tightly coupled together at the matrix level, with special emphasis placed on designing a program that can be expanded in the future. The Groundwater Flow (GWF) Model is the first model to be released in the MODFLOW 6 framework. It supports regular MODFLOW grids consisting of layers, rows, and columns, and it also supports more flexible grids that may conform to irregular boundaries or have increased resolution in areas of interest.

Solutions for solving groundwater flow can be formulated using a Newton-Raphson approach or the traditional approach available in previous versions. There are also methods for handling full three-dimensional anisotropy. To modernize user interaction with the program, the MODFLOW 6 input structure was redesigned. Within package input files, information is divided into blocs, and informative keywords are used to label numeric data and activate options. This new input structure was designed to make it easier for users to adjust simulation options in an intuitive manner, reduce user input errors, and allow new capabilities to be added without causing problems with backward compatibility. It is expected that MODFLOW 6 will be

the primary model code for the simulation of groundwater systems by the U.S. Geological Survey. It has been rigorously tested and reviewed and is being actively developed. It is expected that this new version will keep MODFLOW as the simulation code of choice by the groundwater community.

Wednesday, April 11, 3:30-3:55 p.m. (U.S. Geological Survey)

Fractured-Rock Geophysical Toolbox Method Selection Tool (FRGT-MST)

This demonstration will provide an overview of the Fractured Rock Geophysical Toolbox--Method Selection Tool (FRGT-MST), a spreadsheet-based software program to guide the planning of geophysical characterization and monitoring at fractured-rock sites. Participants will gain hands-on experience using the program.

Geophysical technologies have the potential to improve site characterization and monitoring in fractured rock, but the appropriate and effective application of geophysics at a particular site strongly depends on project goals (e.g., identifying discrete fractures) and site characteristics (e.g., lithology). No method works at every site or for every goal. New approaches are needed to identify a set of geophysical methods appropriate to specific project goals and site conditions while considering budget constraints. it is envisioned the FRGT-MST will (1) equip remediation professionals with a tool to understand what is likely to be realistic and cost-effective when contracting geophysical services, and (2) reduce applications of geophysics with unrealistic objectives or where methods are likely to fail.

The FRGT-MST facilitates identification of geophysical methods most likely to be appropriate for project goals and site conditions. The “toolbox” comprises 30 surface, cross-hole, and borehole geophysical methods. Additionally, hydrologic tests appropriate to fractured rock are included. The user enters information in two tables for site parameters and project goals. Based on user entry, a third table is populated with indicators for which methods support specified goals and are feasible at the site. Worksheet appendices provide detailed information on various methods.

The instructors will present overview of the FRGT-MST's underlying principles and operation. Hands-on exercises will provide participants with practical experience using the spreadsheet-based software.

Additional information about the FRGT-MST is available at https://water.usgs.gov/ogw/bgas/frgt/ and in the associated journal article: Day-Lewis, F.D., Johnson, C.D., Slater, L.D., Robinson, J.L., Williams, J.H., Boyden, C.L., Werkema, D., and Lane, J.W., 2016, A Fractured Rock Geophysical Toolbox Method Selection Tool: Groundwater. doi:10.1111/gwat.12397.

Wednesday, April 11, 3:55-4:20 p.m. (U.S. Geological Survey)

1DTempPro

This demonstration will provide an overview of 1DTempPro, a user-friendly USGS software program for analysis of vertical one-dimensional (1-D) temperature to estimate groundwater/surface-water exchange.

Temperature is a naturally occurring tracer, which can be exploited to infer the movement of water through subsurface saturated and unsaturated zones and between aquifers and surface-water bodies, such as estuaries, lakes, and streams. This Learning Lab will provide an introduction to 1DTempPro, a graphical user interface to the U.S. Geological Survey code Variably Saturated 2-Dimensional Heat Transport (VS2DH), which numerically solves the flow and heat-transport equations. Pre- and postprocessor features allow the user to calibrate VS2DH models to estimate vertical groundwater/surface-water exchange and also hydraulic conductivity for cases where hydraulic head is known. The software supports (1) automated parameter estimation, (2) layer heterogeneity, and (3) time-varying specific discharge.

Additional information about 1DTempPro is available from https://water.usgs.gov/ogw/bgas/1dtemppro/ and the associated journal article, Koch, F.W., Voytek, E.B., Day-Lewis, F.D., Healy, R., Briggs, M.A., Werkema, D., and Lane, J.W., Jr., 2015, 1DTempPro V2: New Features for Inferring Groundwater/Surface-Water Exchange, Groundwater, doi:10.1111/gwat.12369, 6p.

Thursday, April 12, 8:00-8:25 a.m. (Groundswell Technologies)

VaporSafe™

Participants will learn how to deploy VaporSafe™ continuous automated near real-time vapor concentration and pressure monitoring to rapidly identify and confirm indoor sources of TCE (e.g., false positives), determine whether vapor intrusion is occurring, identify vapor entry locations and preferential pathways, and prevent acute toxic exposures via automated

response. Participants will learn how to set up system components, access and navigate the web dashboard and raw and processed data, set automated response criteria, and interpret observations.

The continuous monitoring system is comprised of a customized laboratory-grade gas chromatograph equipped with various detectors for rapidly measuring TCE, PCE, vinyl chloride and other VOC concentrations indoors, in subsurface vapors, and outdoors at levels sufficient to meet regulatory requirements. Other features include multiplexing to allow for continuous monitoring from up to 30 locations, evaluation of spatial and temporal concentration dynamics, measurement of pressure and pressure differential, and efficient data management of the hundreds of data points collected each day via cloud-based automated data-processing, visualization, alerting, and response capabilities. The approach incorporates automated calibration runs and delivery of daily quality status reports.

Continuous monitoring and response represent a comprehensive risk characterization and prevention option for consultants, responsible parties and the regulatory community.

Thursday, April 12, 8:50-9:15 a.m. (Cox-Colvin & Associates, Inc.)

Tips and Techniques: Pilot Testing, Pressure Field Verification, Locating VOC Sources, and Evaluating VI Pathways Using the Vapor Pin®

Vapor Pin® technology provides a secure platform for consultants to quickly and accurately collect subslab data (soil gas screening data, soil gas samples for laboratory analysis, and subslab pressure readings) used in source characterization studies, the assessment of vapor intrusion potential, and the effectiveness of vapor (VOC and radon) mitigation systems. Vapor Pin® is a small subslab vapor port that is installed in minutes using commonly available hand tools (hammer drill, drill bits, and dead blow hammer). Once installed, the Vapor Pin® can be secured, making it suitable for multiple sampling events, or simply used to gather data during a single event. After the sampling is complete, the Vapor Pin® can be retrieved for reuse.

The fact that Vapor Pin® is installed in a rapid, yet minimally intrusive manner, allows practitioners to cost-effectively gather high resolution active soil gas data sets. This increased site coverage provides a better understanding of the spatial variability beneath sites. When used with screening tools, such as multi-gas meters or PIDs, areas of interest such as hot spots and preferential pathways can be quickly identified and targeted for analytical sampling.

A major advantage of the Vapor Pin® over other subslab vapor ports is that a leak-proof seal between the port and the concrete is formed immediately by the silicone sleeve that covers its outer edge. Recent enhancements to the Vapor Pin® allow it to connect to a variety of sampling devices through a barb fitting, Swagelok® compression fitting, or quick connect valve. As a result, the Vapor Pin® can be quickly and reliably connected to a wide variety of vapor screening instruments, evacuated canisters, bottle vacs, absorbent tubes, manometers, etc. In addition, a variety of attachments have been developed to allow for the collection of soil gas samples at greater depths and isolate VOC-impacted slabs.

The Vapor Pin®, first introduced to the market in 2011, is becoming the standard tool for subslab investigations with tens of thousands in use in North America, South America, Australia, Europe, Africa, and Asia.

Thursday, April 12, 9:40-10:05 a.m. (Jacobs)

Vapor Intrusion (VI): Quantitative Decision Framework Tool

This demonstration will familiarize attendees with the use of the Quantitative Decision Framework for evaluating the vapor intrusion potential of buildings.

The Naval Facilities Engineering Command (NAVFAC) Expeditionary Warfare Center (EXWC), NAVFAC Atlantic, and CH2M HILL (now Jacobs) conducted a research project titled, “A Quantitative Decision Framework for Assessing Navy Vapor Intrusion Sites - NESDI Project #476.” The project involved developing and analyzing a database of empirical data from Navy sites where the potential for subsurface vapors related to historical releases of volatile organic compounds (VOCs) to migrate into buildings (i.e., vapor intrusion) has been investigated. Single and multivariate analysis of geological and building factors potentially influencing vapor intrusion (VI) was performed to identify the key factors and the relationships between them in support of a quantitative decision framework. The work initially focused on industrial buildings but is being extended to cover residential structures.

The main elements of the quantiative decision framework are:

- A flow chart showing the overall process step-by-step and providing “off ramps” for clear-cut cases of very low VI potential and leading to a scorecard for other cases.

- The scorecard allows a more in-depth evaluation of “grey zone” cases using multiple lines of evidence and leading to a “vapor intrusion prioritization score.” The range of weights in the scoring system are tailored to emphasize the importance of certain predictor variables identified in the data analysis; sample zone area, average sub-slab concentration, average groundwater concentration, soil type, presence of atypical preferential pathways, and distance to the point at which the chemicals were originally released.

Graphical keys for the interpretation of the VI prioritization score are provided that can be used at several different stages in site management:

- In initial site investigations, to prioritize the need for further evaluations, such as determining when indoor air samples are necessary.
- In site investigations that have progressed to include indoor air sampling, to evaluate if the observed indoor air concentrations are likely the result of VI or background sources.
- In planning for long-term stewardship of VI sites, if necessary, at current and future buildings.

The factors highlighted in the quantitative decision framework are either those well accepted in the field or were derived from the data analysis efforts in NAVFAC Technical Report TR-NAVFAC-EXWC-EV-1603 June 2015 available at: https://clu-in.org/download/issues/vi/TR-NAVFAC-EXWC-EV-1603.pdf.

Thursday, April 12, 10:30-10:55 a.m. (GSI Environmental, Inc.)

TIGER™ Sampler

The TIGER™ sampler is a time-integrated sampler for measuring VOC concentrations in groundwater monitoring wells. Attendees will learn how to deploy and retrieve the samplers from monitoring wells and will gain an improved understanding of how the sampler works.

The TIGER™ sampler is a sorbent-based sampler that provides a true average of VOC concentrations in a groundwater monitoring well over a 90-day deployment period. The extended deployment time greatly reduces event-to-event variability in measured VOC concentrations compared to conventional low flow or no purge sampling methods. The reduced event-to-event variability makes it much easier to determine the long-term concentration trend, reducing the number of monitoring events required to evaluate the effectiveness of monitoring natural attenuation or active groundwater remedies.

The TIGER™ sampler utilizes a unique design that isolates the sorbent material from groundwater, eliminating the problems of biofouling and sorbent saturation associated with other sorbent-based groundwater sampling devices. The TIGER™ sampler is a no-purge sampler and can be deployed in a well in less than 15 minutes. As a result, the TIGER™ sampler requires less field labor than conventional samplers. In addition, the sorbent samplers can be shipped to the laboratory at ambient temperatures eliminating the need for coolers and ice.

Participants in the learning lab will be able to handle the TIGER™ sampler gaining an improved understanding of it's design and operation. In addition, participants will be able to deploy a TIGER™ sampler in a mock monitoring well to understand the sampler deployment and retrieval procedures.

Thursday, April 12, 11:20-11:45 a.m. (Golder Associates)

Demonstration of Dynamic Closed Chamber (DCC) Method for Natural Source Zone Depletion Assessment

There is increasing interest in practical methods for estimation of natural source zone depletion (NSZD) rates at petroleum hydrocarbon sites. The dynamic closed chamber (DCC) method is increasingly being used for estimation of NSZD rates but would benefit from technology transfer so that capabilities would be better understood. This presentation will demonstrate how to conduct DCC measurements of carbon dioxide flux and collect air samples for radiocarbon analyses. Participants will see the equipment setup and method, and how data gathered are used to estimate NSZD rates.

Aerobic and anaerobic biodegradation reactions produce CO_2, resulting in its accumulation in soil gas and efflux at the ground surface. Therefore, methods for the measurement of CO_2 efflux have been proposed and demonstrated for the estimation of petroleum hydrocarbon (PHC) depletion rates. The DCC method is one increasingly common method for measurement of CO_2 efflux. The DCC method involves the placement of a chamber on soil and continuous measurement of CO_2 concentrations within the chamber using an infrared detector. The efflux is calculated from the rate of increase of CO_2 inside the chamber on the timescale of minutes. The DCC method offers a snapshot in time of CO_2 efflux measurements, which can be conducted at

multiple locations in a single day. Estimation of NSZD rates from the total CO_2 efflux measurements also requires distinguishing between respiration of natural organics and contaminants. The established method for calculating fraction of CO_2 efflux attributable to fossil fuel carbon relies upon analysis of air samples for radiocarbon content. Radiocarbon, or 14C, is a carbon isotope with a half-life of approximately 5700 years. Contemporary (modern) organic carbon is 14C-rich, while fossil fuel carbon is 14C-depleted. The collection of air samples for radiocarbon analyses can either be conducted using the infrared detector or separate static chamber where CO_2 is allowed to accumulate. Fraction of 14C content of carbon (F14C) is measured by accelerator mass spectrometry (AMS). The focus of demonstration will be on CO_2 efflux measurements and collection of air samples that can be sent to an AMS equipped laboratory for analysis. The demonstration will include a hands-on calculation tool for interpretation of data for NSZD estimates

Thursday, April 12, 12:10-12:35 p.m. (E-Flux)

Passive CO_2 Flux Traps for Measuring Field NSZD Rates

Natural source zone depletion (NSZD) has become a key tool for the management of petroleum- and other LNAPL-contaminated sites. Participants in this learning lab will gain familiarity with NSZD processes, and with the passive CO_2 traps used to measure field NSZD rates.

This presentation will demonstrate the use of passive CO_2 flux traps to measure degradation rates of petroleum (also known as natural source zone depletion, or NSZD) at field sites. The CO_2 flux traps take advantage of the fact that the end product of petroleum biodegradation is CO_2, and they capture CO_2 at the ground surface using a sorbent. The technology is easy to use, does not have moving parts, and does not require power. The captured CO_2 is quantified and then analyzed using radiocarbon dating to distinguish between fossil fuel-derived (ancient) carbon and modern carbon, which results from natural soil processes not related to contamination. The fossil fuel CO_2 flux is used to estimate the NSZD rate through simple stoichiometric assumptions. This demonstration will include: i) a high-level overview of NSZD processes, ii) a description of the passive CO_2 traps and their field use, iii) an explanation of the carbon isotopic correction, and iv) how to use NSZD data for source delineation, NSZD quantification, and providing a baseline for active remedies.

Thursday, April 12, 12:35-1:00 p.m. (E-Flux)

BioTherm- A Model for Temperature Effects on NSZD

Natural source zone depletion (NSZD) is the result of reactions in soil that cause the biodegradation of petroleum and other LNAPL. Participants will gain a deeper understanding of the interdependencies of local soil temperatures and NSZD rates through a hands-on demonstration of the use of a web-based mathematical model.

BioTherm is a numerical model for coupled heat generation and transfer in soil due to NSZD reactions and is available on the web (www.biogenicheat.com). Biodegradation results in the production of CO_2 and heat; BioTherm accounts for this produced heat and estimates local soil temperatures depending on ambient conditions and soil properties. This model, which simulates a LNAPL contaminated site, accounts for site-dependent conditions including i) contaminant concentration profiles, ii) seasonally variable ambient and groundwater temperatures, and iii) site-specific thermal soil properties. BioTherm's NSZD rate predictions can be calibrated to actual measured NSZD rates. These calibrated rates can be used to study the effects of ambient and soil temperatures on the LNAPL conceptual site model and on NSZD.