The Conference is organized and presented by Battelle.

Battelle’s environmental engineers, scientists and professionals offer focused expertise to government and industrial clients in the U.S. and abroad. Combining sound science and engineering solutions with creative management strategies, Battelle works with clients to develop innovative, sustainable, and cost-effective solutions to complex problems in site characterization, assessment, monitoring, remediation, restoration, and management. Every day, the people of Battelle apply science and technology to solving what matters most. At major technology centers and national laboratories around the world, Battelle conducts research and development, designs and manufactures products, and delivers critical services for government and commercial customers. Headquartered in Columbus, Ohio, since its founding in 1929, Battelle serves the national security, health and life sciences, and energy and environmental industries. battelle.org
Conference Sponsors

As the Conference organizer and presenter, Battelle gratefully acknowledges support of the following Conference Sponsors. Their financial contributions help defray general operating costs of planning and conducting the Conference. The corporate descriptions they provided appear on pages 99-105.
The Twelfth International Conference on Remediation of Chlorinated and Recalcitrant Compounds will be conducted May 31-June 4, 2020, in Portland, Oregon. The Conference is organized and presented by Battelle. Sponsors include other leading organizations active in site remediation research and application. Attendance is expected to be 1,500 to 1,700 scientists, engineers, regulators, and other environmental professionals representing universities, government and regulatory agencies, and R&D and manufacturing firms from around the world.
The Exhibit Hall, the Welcome Reception, and display of the Group 1 Posters will open Sunday evening, May 31. The Conference technical program will begin Monday morning, June 1, when Conference Chairs, Stephen Rosansky and Rick Wice, both of Battelle, will conduct the Plenary Session. The theme of the plenary Session is, “Climate Change: Insights from Science, Imperatives for Action.” The featured speaker, Dr. Rosina Bierbaum (Dean Emerita, School of Natural Resources and Environment, University of Michigan; Weston Chair in Natural Economics, University of Maryland), will review the latest findings in climate science, including the ability to attribute observed changes in frequency and intensity of some extreme events to climate change, new evidence on sea level rise and ice melt, and shifting species and ecosystem disruption.

The technical program, to be held Monday afternoon, June 1, through Thursday, June 4, will consist of more than 1,000 platform and poster presentations in 88 breakout sessions, as well as five panel discussions.

Sessions and panels are organized according to major topic areas that will address the innovative application of existing and new technologies and approaches for characterization, treatment and monitoring of chlorinated and other recalcitrant compounds and emerging contaminants in various environmental media. Risk, regulatory, site management/closure and sustainability issues associated with these technologies will be discussed. Presentations will emphasize cutting edge research to address current environmental challenges, recent advances in site characterization, new developments in remediation technologies, and field applications to achieve site closure.

Additional technical information will be provided by exhibits from more than 100 companies and government agencies engaged in remediation-related activities. Seventeen short courses are scheduled as December 12, and will be conducted all-day Sunday and Tuesday afternoon.

Receptions and other meals offered throughout the Conference will afford attendees numerous opportunities to meet informally with one another. The Student & Young Professional Reception on Monday evening will enhance networking and career development opportunities for students.

The Oregon Convention Center is located within the Lloyd District and is within easy walking distance of downtown Portland. Conference attendees will find ample sightseeing, shopping and dining options for their free time in the evenings and during the Tuesday afternoon recess.

Program at a Glance

Sunday, May 31, 2020
- 8:00 a.m.–5:00 p.m. Short Courses
- 3:00–9:00 p.m. Registration Desk Open
- 6:00–9:00 p.m. Welcome Reception, Exhibits, Poster Group 1 Display

Monday, June 1, 2020
- 7:00-8:00 a.m. Continental Breakfast
- 8:30–10:30 a.m. Plenary Session
- 10:30 a.m.-12:00 p.m. General Lunch
- 12:10-4:20 p.m. Platform Presentations
- 2:30-3:00 p.m. Afternoon Beverage Break
- 4:30-6:30 p.m. Group 1 Poster Presentations and Reception

Tuesday, June 2, 2020
- 7:00-8:00 a.m. Continental Breakfast
- 10:00-11:00 a.m. Morning Beverage Break
- 8:00 a.m.-1:50 p.m. Platform Presentations
- Lunch on own, general lunch not provided
- 1:50 p.m. Technical Program Recesses
- 2:00-6:00 p.m. Short Courses

Wednesday, June 3, 2020
- 7:00-8:00 a.m. Continental Breakfast
- 9:30-10:00 a.m. Morning Beverage Break
- 8:00 a.m.-4:20 p.m. Platform Presentations
- 11:30 a.m.-1:00 p.m. General Lunch
- 2:30-3:00 p.m. Afternoon Beverage Break
- 4:30-6:30 p.m. Group 2 Poster Presentations and Reception

Thursday, June 4, 2020
- 7:00-8:00 a.m. Continental Breakfast
- 9:30-10:00 a.m. Morning Beverage Break
- 8:00 a.m.-4:20 p.m. Platform Presentations
- 11:30 a.m.-1:00 p.m. General Lunch
- 2:30-3:00 p.m. Afternoon Beverage Break
- 4:30 p.m. Closing Cocktail Reception

*All times are subject to change in the months leading up to the Conference.
Location and Schedule

All events will be held at the Oregon Convention Center (777 NE Martin Luther King Jr Blvd., Portland, OR 97232). Room blocks with group rates for Conference attendees are available at the Hyatt Regency Portland (375 NE Holladay St., Portland, OR 97232) located steps away from the Convention Center and Hotel Eastlund (1021 NE Grand Ave., Portland, OR 97232) located across the street from the Convention Center.

Exhibits, the Group 1 Poster Display, and the Welcome Reception will open Sunday, May 31, at 6:00 p.m. The technical program will be conducted Monday, June 1, through Thursday, June 4. A half-day recess will be held Tuesday afternoon, June 2. Short courses will be held all-day Sunday, May 31, and Tuesday afternoon, June 2, during the technical program recess.

Program Committee

Conference Chairs
- Steve Rosansky, PE (Battelle)
- Rick Wice, PG (Battelle)

Steering Committee
- David Becker, PG (USACE)
- Carlotta Cellucci, RG (NAVFAC)
- Rick Cramer, PG (Burns and McDonnell)
- Catalina Espino Devine, PE (Chevron)
- Damon DeYoung, PG (Battelle)
- Linda Fiedler (USEPA)
- David Freedman, Ph.D. (Clemson University)
- Rick Gillespie (Regenesis)
- Stephen Koenigsberg, Ph.D. (EN Rx)
- Michael Meyer, MS, RG, LEG, LHG (Battelle)
- Charles Newell, Ph.D., PE (GSI Environmental)
- Patty Reyes (ITRC)
- John Simon (Nathan Associates)

Exhibits, Internet Café & Learning Lab

Exhibits. Exhibit booths will be provided by more than 100 organizations that conduct remediation activities or supply equipment used in such work. Exhibits will be on display from 6:00 p.m. Sunday evening through 1:00 p.m. Thursday afternoon.

As of December 12, a few booth spaces are still available. Click here to be directed to a list of current Exhibitors and the online booth registration form.

Internet Café. Computers and charging outlets are available to participants who wish to check email during Exhibit Hall hours Sunday–Thursday in the Internet Café, located near the Learning Lab area of the Exhibit Hall.

Learning Lab. The Learning Lab will consist of hands-on demonstrations highlighting specific technologies, tools, and software. A schedule of planned demonstrations will be available in the Final Program.

See pages 87-97 for an overview of Learning Lab descriptions.

Learning Lab Sponsors. We appreciate the participation of Burns & McDonnell and Ramboll, whose contributions will be applied towards the overall cost of the Learning Lab experience.

Technical Program Overview

The technical program will be comprised of more than 1,000 platform and poster presentations in 88 sessions, along with five panel discussions. The sessions and panels are organized according to the following major topics:

- Remediation Technology Innovations
- Emerging Contaminants
- International Environmental Remediation Markets
- Characterization, Fate, and Transport
- Petroleum and Heavy Hydrocarbon Site Strategies
- Metals
- Assessing Remediation Effectiveness
- Vapor Intrusion
- Advanced Diagnostic Tools
- Addressing Challenging Site Conditions
- Fractured Rock and Complex Geology
- Technology Transfer and Stakeholder Communications
- Green and Sustainable Remediation

Platform and Poster Presentations. Platform sessions will begin Monday afternoon and conclude Thursday; poster sessions will be conducted on Monday and Wednesday evenings. Platform and poster presentations scheduled as of December 12, are listed by session on pages 16-75.
Panel Discussions. Five panel discussions will be incorporated into the technical program. Panel descriptions and moderators’ and panelists’ names appear on the pages indicated below.

- Should We Develop PFAS Ambient Levels: Why and How? (page 29)
- Perspectives, Paradigm Shifts, and Implications of Evolving Developments in PFAS Chemistry, Toxicity, Transport, and Remediation (page 41)
- Integrating Systems-Based Monitoring and Predictive Modeling into Adaptive Site Management (page 46)
- Investigating and Remediating a Major Chlorinated Solvent DNAPL Site (page 66)
- Remediation Geology, Remediation Hydrogeology, and Process-Based CSMs Support Complex Site Remediation (page 72)

See the following pages for additional information:
- Pages 14-15: Poster Sessions in each of the two poster groups.
- Pages 16-75: Titles and authors for the presentations in each session. Titles beginning with an asterisk (*) are to be presented as poster presentations.
- Pages 77-85: Short Course descriptions for the courses offered on Sunday and Tuesday.
- Page 86-97: Learning Lab descriptions for the demonstrations to be presented Monday–Thursday.

Proceedings. The proceedings will be made available online approximately 2-3 months after the Conference to registrants who paid standard industry, government, or student rates. Past years’ (2002-2014) proceedings are available on the Conference website under the Publications tab. Proceedings papers are no longer requested, however, all technical program abstracts will be included along with a PDF version of the PowerPoint presentation for most platform presentations and PDFs of some poster presentations.

Final Program & Abstract Collection. This Preliminary Program lists all presentations scheduled as of December 12. It is subject to revision (e.g., changes of presenters, withdrawals) in the months leading up to the Conference. To assist participants in planning their time while at the Conference, the following program information resources will be available online by May 18, 2020:
- PDF of Final Program
- Abstracts for all scheduled presentations, available only through the Conference mobile app

Email notifications will be sent to all who have registered and paid by May 18, 2020, providing links to the resources. A printed copy of the Final Program will be provided onsite with registration material. Because of the size of the program—five panels and more than 1,000 platform talks and poster presentations—it is strongly recommended that each participant review the online version of the Final Program and abstracts prior to the Conference to plan his or her time effectively.

Short Courses. As of December 12, there are 17 short courses scheduled for presentation. Courses will be offered on Sunday, May 31, from 8:00 a.m.-5:00 p.m., and on Tuesday afternoon, June 2, from 2:00-6:00 p.m., during the recess in the program. Courses are open to both Conference registrants and individuals who will not be attending the Conference program. Discounts apply for early registration and payment.

See pages 77-85 for short course descriptions and scheduling information.

Education Sponsor. We appreciate the participation of ITRC and their commitment to education for the benefit of the remediation community as a whole.
Meals, Breaks, & Receptions

For the convenience of Conference participants, the following meals, breaks, and light receptions will be provided on site at no additional cost to program registrants and exhibit booth staff. All food functions will be served in or near the Exhibit Hall.

Food function times are subject to change in the months leading up to the Conference and the final schedule will be available in the Final Program. If registrants wish to bring guests to meals, guest tickets can be purchased at the Conference Registration Desk; guest tickets will be priced equal to the cost incurred by the Conference for each meal.

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**Food Service Times**

Breaks in the technical program between sessions may not correspond with food service times. If you wish to attend specific food functions, please plan your schedule accordingly.

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continental Breakfast</strong></td>
<td>Monday-Thursday, 7:00–8:00 a.m.</td>
</tr>
<tr>
<td><strong>Morning Beverage Break</strong></td>
<td>Tuesday, 10:00–11:00 a.m.</td>
</tr>
<tr>
<td></td>
<td>Wednesday–Thursday, 9:30–10:00 a.m.</td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td>Monday, 10:30 a.m.–12:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Tuesday, lunch not provided.</td>
</tr>
<tr>
<td></td>
<td>Wednesday–Thursday, 11:30 a.m.–1:00 p.m.</td>
</tr>
<tr>
<td><strong>Afternoon Beverage Break</strong></td>
<td>Monday, Wednesday, and Thursday, 2:30–3:00 p.m.</td>
</tr>
<tr>
<td><strong>Welcome Reception</strong></td>
<td>Sunday, 6:00–9:00 p.m.</td>
</tr>
<tr>
<td><strong>Poster Group 1 Presentations &amp; Reception</strong></td>
<td>Monday, 4:30–6:30 p.m.</td>
</tr>
<tr>
<td><strong>Poster Group 2 Presentations &amp; Reception</strong></td>
<td>Wednesday, 4:30–6:30 p.m.</td>
</tr>
<tr>
<td><strong>Closing Cocktail Reception</strong></td>
<td>Thursday, 4:30–5:00 p.m.</td>
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</tbody>
</table>

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**Closing Reception Sponsors.** We appreciate the participation of Ivey International, Inc., Landau Associates, and Yellow Jacket Drilling Services, whose contributions will be applied towards the Closing Reception.

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**Student Participation**

University students, up through Ph.D. candidates, are encouraged to attend the Conference and will find participation valuable to their career development. In addition to the technical information gained by attending presentations and visiting exhibits, students will be able to meet and talk with environmental professionals representing a wide range of work experience and employers. Recruitment is a major focus of many participating Exhibitors and Sponsors and the Conference will provide an unprecedented opportunity for student job-seekers.

**Student Paper Competition.** Paper submissions were due October 31, 2019. The winning paper(s) will be scheduled for presentation at the Conference. Presenters will be awarded at the Plenary Session and will receive complimentary registration and a financial award to help cover travel and related costs.

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**Student Paper Winners**

Nicholas W. Johnson (University of California/USA)
*Improved Adsorbent Performance for the Treatment of 1,4-Dioxane-impacted Water by Bioaugmentation and Bioregeneration*  
(Session D3, Poster Group 1)

Hao Wang (Clemson University/USA)
*Naturally and Biologically-Mediated Abiotic Transformation of TCE in Low Permeability Formations*  
(Session A5, Platform)

Congratulations!
**Student Networking Event.** To help students get acquainted, a Student Networking Reception will be held Monday evening, June 1, following the Group 1 poster presentations. Additional details will be emailed to student registrants by May 18, 2020.

**Student Event Sponsors.** We appreciate the participation of Aspect Consulting, Haley & Aldrich, Odin Construction Solutions, and Tetra Tech, Inc., whose contributions will be applied toward the overall cost of the Student Events.

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**Program Participant Registration Required**

*No financial assistance is available to support registration or other costs of attending the Conference. All presenting authors (platform and poster), session chairs, and panel moderators/participants are expected to register and pay the applicable technical program registration fees. This policy is necessary because registration fees are the major source of funding for the Conference and a significant percentage of registrants will make presentations or chair sessions. No exceptions are made to this policy.*

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**Sponsors and Additional Sponsorship Opportunities**

As the Conference organizer and presenter, Battelle gratefully acknowledges support of the Conference Sponsors, the Learning Lab, Student Event, and Closing Reception Sponsors. Their financial contributions help defray general operating costs of planning and conducting the Conference.

Sponsorship opportunities are still available. See the Conference Sponsors & Exhibitors page for details.

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**Conference Registration**

The technical program registration fees seen to the right cover admission to all platform and poster sessions, exhibits, group lunches, receptions, daily continental breakfasts, and refreshment breaks. Each technical program registrant will also receive the proceedings, which will be available in digital form after the Conference.

**Registration Terms & Conditions.** The full list of registration terms and conditions can be found on the Conference website on the Registration page. Registration terms and conditions are subject to change without notice and are applicable to all levels of registration, including booth staff and Sponsor/Exhibitor waived and discounted registrants. No one under 18 years of age will be admitted to any Conference event unless registered as a student, valid student ID required at check-in.

**Note:** You must OPT-IN during the registration process if you wish to be included in Conference Registration Lists.

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**Payment.** Payment is required to confirm registration and registration discounts apply only to payments received by the specified dates. Checks will be accepted for registrations made through March 30, 2020. Beginning March 31, 2020, payment may be made only by major credit card. Purchase orders will not be accepted at any time. Fees are not transferable to other Battelle Conferences.

Conference information meant for attendees only (e.g., links to mobile apps, abstracts, and registration lists) will only be sent to individuals that are paid in full.

**Cancellations & Refunds.** Registration cancellations and refund requests must be received in writing on or before the “cancellation requested date” below to qualify. Refunds will be processed to the credit card used for payment. By registering for the Conference, you agree to the following registration cancellation refund policy, a $50 service fee applies to each cancelled registration: (1) cancellation requested on or before January 10, 2020, will receive 75% of the registration fee; (2) cancellation requested January 11, 2020, through March 30, 2020, will receive 50% of the registration fee; (3) after March 30, 2020, no refunds.
Photo ID Required

A valid, government-issued PHOTO ID (driver’s license/passport/student ID), that matches the name on the badge, will be required for verification upon check-in and/or to request a badge reprint for lost or forgotten badges. Only the attendee named on the badge may pick up his or her badge and registration materials.

Booth Staff, Sponsor/Exhibitor Discounted Technical Program Registration

The Organization ID associated with the company’s booth reservation will be required to register discounted sponsor/exhibitor technical registrants and booth staff. It can be found in the booth reservation confirmation email.

See the Registration page for additional details and registration links for the categories below.

Booth Staff Registration. Booth staff will be registered by the Booth Point-of-Contact. Booth staff are defined as the employees of your company who will be attending the Conference solely to work in your booth. Booth staff registration must be done online. Once a booth has been reserved, the Booth Point-of-Contact may access registrations at any time to add/update booth staff. The Participation ID of the person being registered is required. All booth staff must be registered online by May 13, 2020. Any changes or additions after that date will be assessed a $35 charge. Booth staff will be admitted to food functions and may attend the Plenary Session. Booth staff are eligible for upgraded technical program registration ($700/each) up to the maximum technical upgrade totals shown in the Exhibitor Terms and Conditions. Booth staff badges are not transferable to other individuals and may not be traded/swapped with technical program registrants to avoid technical program registration fees.

Booth staff are not eligible to attend technical sessions unless registered for the technical program. Anyone found to be attending technical sessions without the proper registration credentials will be charged a full conference technical registration fee ($1,025).

Sponsor/Exhibitor Discounted Technical Program Registration. Only those registered for the technical program will be admitted to technical sessions. Anyone making a platform or poster presentation or chairing a session must be registered for the technical program. Technical program registrants may staff the exhibit booth as needed. A certain number of booth staff, determined by booth size, are eligible for an upgraded technical program registration ($700/each) and registration must be completed online.

Attendee List Opt-in

When registering for the technical program, you must OPT-IN to be included in Conference attendee lists by checking the appropriate box on the registration form. Leaving the box unchecked will result in your name not being included in attendee lists.

Conference Venue & Hotels

The Conference technical program will be conducted at the Oregon Convention Center (OCC) and room blocks will be available at the adjacent Hyatt Regency Portland and nearby Hotel Eastlund.

The OCC is a Leadership in Energy and Environmental Design (LEED®) Platinum certified facility and has held a long-standing leadership role in green building and environmental responsible business practices. It is the only convention center in the United States to earn a Level 4 APEX/ASTM certification, standards specifically created for green meetings and events. The OCC focuses on energy reduction, diverting materials away from landfills, watershed stewardship, indoor air quality, sustainable purchasing, and expanding community engagement.

Hotel Accommodations

Room blocks with reduced group rates for Conference attendees have been secured at the Hyatt Regency Portland and Hotel Eastlund. Mention that you are attending the “Battelle Chlorinated Conference” to qualify for the group rate. Be sure to obtain a registration confirmation number and to inquire about the hotel’s payment, cancellation, and early check-out policies before making a reservation.

See the Venue & Hotels page for the group rate expiration dates, unless the blocks sell out before those dates, and links to the Hotel’s reservations pages.
Group-Rate Reservations. Reservations can be made online or by phone. Insert your arrival and departure dates and then follow the prompts to complete your reservation.

Government Reservations. A percentage of rooms will be available at the prevailing U.S. Government per diem rate (plus tax) for U.S. federal, state, and local government employees (not applicable for government contractors). Please use the applicable “Government Rate” links. Government employee ID must be presented at check-in for rate verification.

Portland

Within easy walking distance of the Convention Center, you will find restaurants, shops, and attractions in Portland’s Lloyd District, home to the Moda Center, where sporting events, concerts, and other major gatherings take place. Catch a hockey game at Veteran’s Memorial Coliseum or make a stop by the Lloyd Center Ice Rink for a spin on the ice in your free time. Unique sports bars and microbreweries populate this section of the city. Hop on the city’s public transportation system, TriMet, to visit any one of Portland’s unique neighborhood districts to fit your interests. Stay busy shopping and browsing in the Alberta Arts District, full of galleries and shops, or Old Town Chinatown, Portland’s original downtown, now home to unique shops, eateries, and gardens.

If a slower pace is more your style, visit the St. John’s District and picnic in Cathedral Park or stroll through the Nob Hill District to view the Victorian homes or take a hike in the adjoining Forest Park. With more than 200 parks within the city limits, be sure to find a tranquil spot to relax. Stop and smell the roses at the International Rose Test Garden in Washington Park where more than 10,000 rose bushes in hundreds of varieties can be seen or stop by Hoyt Arboretum, the largest in the country, where you can see 1,000+ species of trees and shrubs. With no shortage of indoor and outdoor activities, you are sure to find something to enjoy while visiting Portland. Travelportland.com

Contact Information

Program details and presenter, session chair, and panelist coordination:
Gina Melaragno (Battelle)  
chlorcon@battelle.org  
phone 614.424.7866

Sponsorship, exhibits, registration, and hotel information:
Susie Warner (The Scientific Consulting Group)  
chlorinated2020@scgcorp.com  
301.670.4990 phone  
301.670.3815 fax

Travel and Local Transportation

Air Transportation. Major air service is available into the Portland International Airport (PDX) just eight miles from the hotel.

Local Transportation. Board a light-rail train at the Convention Center MAX Station just outside the Hyatt Regency Portland to easily access PDX, Washington Park, Union Station, Pioneer Square, or Beaverton.

Parking. The Conference does not validate parking and the rates below are subject to change without notice.

- Convention Center: $12 for 4-18 hours, lesser rates available for fewer hours. Overnight parking not permitted.
The technical program will begin on Monday morning, June 1, with the Plenary Session. It will continue with the 88 breakout sessions and five panels and conclude Thursday afternoon. The breakout sessions and panels are organized into the following thematic tracks:

- **Remediation Technology Innovations**
  - Sessions A1-A10
  - Sessions B1-B9
  - Sessions C5-C8
- **Emerging Contaminants**
  - Sessions C1-C4
  - Sessions D1-D9
- **International Environmental Remediation Markets**
  - Session E1
- **Characterization, Fate, and Transport**
  - Sessions E2-E8
- **Petroleum and Heavy Hydrocarbon Site Strategies**
  - Sessions F1-F8
- **Metals**
  - Sessions F9-F11
- **Assessing Remediation Effectiveness**
  - Sessions G1-G7
- **Vapor Intrusion**
  - Sessions G8-G12
- **Advanced Diagnostic Tools**
  - Sessions H1-H4
- **Addressing Challenging Site Conditions**
  - Sessions H6-H10
- **Fractured Rock and Complex Geology**
  - Sessions I1-I5
- **Technology Transfer and Stakeholder Communications**
  - Sessions I6-I8
- **Green and Sustainable Remediation**
  - Sessions I9-I11
Dr. Rosina Bierbaum holds a BA in English, a BS in biology and a Ph.D. in ecology and evolution. She is Dean Emerita of the University of Michigan's School of Natural Resources and Environment and the Weston Chair in Natural Economics at the University of Maryland.

Her experience extends from climate science to foreign relations and international development and she served for two decades in both the legislative and executive branches of the U.S. Government. Dr. Bierbaum ran the first Environment Division of the White House Office of Science and Technology Policy as well as chaired the World Bank’s first report on climate change, the first, and only, report Congress asked for on adaptation. She chairs the Science and Technical Advisory Panel of the Global Environment Facility and serves as an Adviser to the Global Adaptation Commission. She is also a member of the National Academy of Sciences, a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the Ecological Society of America, and Sigma Xi. She has lectured on every continent and serves on the boards of the Gordon and Betty Moore Foundation, the Wildlife Conservation Society, the Federation of American Scientists, American Association for the Advancement of Science, the Environmental and Energy Study Institute, the Climate Reality Project, the Morgan Stanley Institute for Sustainable Investing, and the Tyler Prize for Environmental Achievement.

Dr. Bierbaum has received the American Geophysical Union’s Waldo Smith award for ‘extraordinary service to Geoscience’ and the Environmental Protection Agency’s Climate Protection Award.

Dr. Bierbaum’s talk will review the latest findings in climate science, including the ability to attribute observed changes in frequency and intensity of some extreme events to climate change, new evidence on sea level rise and ice melt, and shifting species and ecosystem disruption. Impacts observed to date at the almost 1°C temperature increase over pre-industrial levels will be described for different regions and sectors, including flooding, drought, fires, storm intensity, pest shifts, and agricultural productivity.

The world is not currently on a path to meet the goals of the Paris Climate Accord to keep global average temperatures “well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C”. Such levels are likely to be exceeded in the next few decades unless action is greatly accelerated.

A range of possible futures will be described. These depend on the outcomes of the climate negotiations and the pace of efforts to both mitigate or reduce emissions of greenhouse gases as well as those designed to cope with or adapt to changes already underway. Concerted efforts to move to clean energy, to preserve intact ecosystems, to design cities more sustainably, to protect people from disease and disasters, and to grow crops more efficiently will be needed.

Analyses focused on adaptation have lagged behind those on mitigation. There are significant opportunities for the private sector and local communities to help identify best practices for coping with current and future changes ranging from protecting supply chains to emergency preparedness planning. All sectors in all regions will be affected by climate change. To avoid ‘dangerous anthropogenic climate change—the goal of the Framework Convention on Climate Change—will require transformational, not incremental change in thinking, technologies, management, and action.
**Poster Group Schedule**

Poster sessions are divided into two groups for display and presentation as shown below. Presenters will be at their posters during the designated presentation times to discuss their work. Light refreshments will be provided during the poster presentations.

**Poster Group 1**  
**Display:** Sunday 6:00 p.m.–Tuesday 1:00 p.m.  
**Presentations:** Monday 4:30–6:30 p.m.

A1. Lessons Learned with In Situ Technologies  
A2. In Situ Chemical Oxidation  
A3. Monitored Natural Attenuation  
A4. New Developments, Formulations, and Innovations in Microorganisms and Electron Donors for Biodegradation  
A5. Abiotic and In Situ Biogeochemical Processes  
A6. Injectable Activated Carbon Amendments: Lessons Learned and Best Practices  
A7. Thermal Remediation Design & Best Practices  
B1. Advances in Amendment Formulations  
B2. Innovative and Optimized Amendment Delivery and Monitoring Methods  
B3. Combined Remedies and Treatment Trains  
B4. Application of Zero Valent Iron: Case Studies and Lessons Learned  
B5. Advances in Understanding Bioremediation: Processes and Novel Assessment Methods  
C1. Other Emerging Contaminants  
C2. PFAS Site Characterization  
C3. Advances in the Analysis of Per- and Polyfluorinated Alkyl Substances (PFAS)  
C4. Explosives, Perchlorate  
C5. Permeability Enhancements for In Situ Technologies  
D1. PFAS: Water Treatment Case Studies  
D2. Advances in 1,4-Dioxane Biological Treatment Technologies  
D3. 1,4-Dioxane Remediation Challenges  
E1. International Regulatory Issues and Challenges  
E2. Groundwater Modeling Advancements  
E3. High-Resolution Site Characterization (HRSC)  
E4. Incremental Sampling for Characterization  
F1. Natural Source Zone Depletion  
F2. LNAPL Recovery/Remediation Technology Transitions  
F3. In Situ Remediation of Petroleum Hydrocarbons  
F4. TPH Risk Assessment and Metabolites  
G1. Setting Cleanup Goal End Points: When Are We Done?  
G2. Estimating Cleanup Timeframes and Modeling to Support Site Closure  
G3. Optimizing Remedial Systems  
G4. Assessing Performance and Cost of Remedies  
G5. Big Data, Data Mining, and Portfolio Optimization  
H1. Environmental Forensics  
H2. Using Omic Approaches to Optimize Site Remediation  
H3. Use of Advanced Molecular Tools for Site Assessment or Remedy Performance  
H4. Compound-Specific Isotope Analysis  
I1. Managing Remediation in Fractured Rock and Karst Aquifers  
I2. Challenges and Considerations to Evaluate Technical Impracticability at Fractured Rock Sites  
I3. Remediation Geology: Geology-Focused Approach to Remediation Site Management  
I4. Depositional Environments and Stratigraphic Considerations for Remediation

The poster presentations below will be on display Sunday–Thursday near the Registration Desk.

  Bill DiGuiseppi (Jacobs/USA)

  Carlos Pachon (USEPA, Superfund/USA)
Poster Group 2
Display: Wednesday 7:00 a.m.–Thursday 12:00 p.m.
Presentations: Wednesday 4:30–6:30 p.m.

A8. Monitoring and Assessment during and after Thermal Treatment
A9. Innovations in ZVI Amendment Formulations and Applications
A10. Thermal Remediation: Case Studies and Lessons Learned
B7. Emerging Remediation Technologies
B8. Phytoremediation/Mycorrhizal Remediation and Plant Uptake
B9. Best Practices and Lessons Learned for Permeable Reactive Barriers
C6. Heat-Enhanced Remediation
C7. Electroenhanced Technologies
C8. Horizontal Wells
D4. PFAS Risk Assessment and Toxicity
D5. Pump and Treat for PFAS Remediation
D6. PFAS Fate and Transport
D7. In Situ PFAS Treatment Approaches
D8. Ex Situ PFAS Treatment Approaches
D9. PFAS and Bugs: The Search Continues
E5. Conceptual Site Models
E6. Risk Assessment Practices and Applications
E7. Improvements in Site Data Collection, Data Management, and Data Visualization
E8. Advanced Investigation Tools and Techniques
F5. Understanding and Managing Risks at LNAPL Sites
F6. Characterization and Remediation of Heavy Hydrocarbons
F7. Manufactured Gas Plants
F8. Surfactant-Enhanced Remediation
F9. Precipitation and Stabilization of Metals
F10. Managing Chromium-Contaminated Sites
F11. Mining and Uranium Site Restoration
G6. Applications of Mass Flux and Mass Discharge for Remedial Design/Optimization
G7. Assessing Remediation Effectiveness: Performance Assessment of In Situ Activated Carbon-Based Amendments
G8. Chlorinated Compound Vapor Intrusion
G9. Vapor Intrusion Risk Assessment and Site Management
G10. Advances in Vapor Intrusion Investigations
G11. Vapor Intrusion Preferential Pathways
G12. Vapor Intrusion Mitigation and Effectiveness
H5. Large, Dilute and Commingled Plume Case Studies
H6. Adaptive Site Management
H7. Surface Water/Groundwater Interactions
H8. Lessons Learned in DNAPL Source Zone Remediation
H9. Low-Permeability Zone Challenges and Case Studies
H10. Landfill Assessment and Remediation
I5. Process-Based Conceptual Site Models (CSMs) for Informing Remediation
I6. Technology Transfer and Decision Analysis Tools for Environmental Restoration Applications
I7. Practice of Risk Communication and Stakeholder Engagement
I8. Innovative Strategies and Approaches to Expedite Site Closure
I9. GSR Metrics and Resiliency Evaluations
I10. GSR Best Practices and Case Studies
I11. Impact of Climate Change and Sea Level Rise on Remediation Sites
Breakout Sessions and Panels

All presentations scheduled as of December 12, 2019, are listed below in alphabetic order by title. In each entry, the author list appears in italics, followed by the name and affiliation of the person scheduled to give the presentation. Each title beginning with an asterisk (*) is to be presented as a poster presentation.

The schedule is subject to revision (changes of presenters, withdrawals) in the months leading up to the Conference. To assist participants in planning their time at the Conference, the Final Program and abstracts will be made available approximately two weeks prior to the Conference. Everyone preregistered and paid will receive an email providing links to the resources.

A1. Lessons Learned with In Situ Technologies

Platforms Monday | Posters (*) Monday Evening
Chairs: Michelle Crimi (Clarkson University) and Kerry Sublette (University of Tulsa)

* 30 Years of Plume Containment at Air Force Plant 4. J. Woertz and J. Wolfe. Jennifer Woertz (Los Alamos Technical Associates, Inc./USA)

* An Assessment of Implementation Strategies for EISB: Is There a Right Way? D.F. Alden, G.M. Birk, and J. Roberts. David Alden (Tersus Environmental, LLC/USA)

* Biogenic Toluene and Ketone Formation at 40 ERD Sites. J.M. Tillotson and M. McCaughey. Jason Tillotson (Arcadis/USA)


Evaluating the Impact of In Situ Amendments on Aquifer Permeability. P. Erickson, K. Mahoney, S. Amick, and K. Thoreson. Paul Erickson (REGENESIS/USA)

In Situ Remediation of Source Chlorinated VOCs at an Industrial Site in Japan. M.R. Lamar, C. Franzel, H. Kamemoto, R.L. Olsen, and G. Ebert. Michael Lamar (CDM Smith, Inc./USA)

* Injection of Gaseous Carbon Dioxide to Neutralize High pH Groundwater. C.D. Hand, L.M. McGaughey, and W.M. Young. Charles Hand (Wood/USA)


* Limitations and Lessons Learned in Adjusting pH for In Situ Groundwater Remediation of VOCs and Metals. T.J. Patterson and R. Srirangam. Thomas Patterson (Roux Associates, Inc./USA)

* Methodology and Lessons Learned Conducting In Situ Bioremediation Using Emulsified Vegetable Oil in Arizona. T. Titus, J. Rackow, and M. Morales. Tom Titus (Arizona Department of Environmental Quality/USA)

* Predicting Site Biogeochemistry Influence on EVO Fouling and Injection Well Failure. A.R. Wadhawan, M. Schnobrich, and M. Hay. Amar Wadhawan (Arcadis/USA)

* Targeted In Situ Remediation of Multiple Contaminants in a Performance-Based Remediation Contract. S. Suryanarayanan, P. Srivastav, S. Watson, and R.E. Mayer. Sowmya Suryanarayanan (APTIM/USA)


Why Your In Situ Bioremediation Design Approach Won’t Work for In Situ Chemical Oxidation. F.J. Krembs, K. McDonald, M.G. Sweetenham, S. Mass, and M.R. Olson. Fritz Krembs (Trihydro Corporation/USA)


A2. In Situ Chemical Oxidation

Platforms Monday | Posters (*) Monday Evening
Chairs: Will Moody (Provectus Environmental Products, Inc.) and Brant Smith (PeroxyChem, LLC)

Achievement of Regulatory Closure at a VOC-Impacted Site Using Soil Mixing with Sodium Persulfate. M. Perlmutter and E. Flic. Mike Perlmutter (Jacobs/USA)


* = poster presentation
Denmark’s First Full-Scale Application of Combined In Situ Chemical Oxidation and Solidification/Stabilization for Remediation of a DNAPL Source Area. N.D. Durant, C. Robb, T.H. Jorgensen, L. Nissen, N.E. Bordum, and A. Toft. Neal Durant (Geosyntec Consultants/USA)

* Evaluation and Implementation of ISS-ISCO at a Dry Cleaner VI Site. J. Parker, J. Valkenburg, B. Smith, and B. Lang. Joel Parker (Hamp, Mathews and Associates/USA)

* Geophysical Monitoring of the Subsurface Distribution of ISCO Reagents in a Groundwater Remediation in Denmark. J.F. Christensen, I.H. Olesen, T.S. Bording, A.V. Christiansen, L. Bennedsen, and T.H. Jørgensen. Jørgen Fjeldsø Christensen (Region of Southern Denmark/Denmark)


* In Situ Chemical Oxidation of Chlorobenzenes in Fractured Rock. R. Evans, T. Glancey, M. Pague, and J. Moore. Richard Evans (Groundwater & Environmental Services, Inc./USA)


Lessons Learned while Injecting 100 Tons of Potassium Persulfate. A.M. Baird, D.E. Knight, and J. Lowe. Drew Baird (FRx, Inc./USA)

Practical Approaches to ISCO Delivery Promote Informed Dosing Calculations across Multiple Sites. B.R. Hoye, J.R. Hommer, and K. White. Brian Hoye (Burns & McDonnell/USA)

* Solar Thermal Activation of Persulfate for In Situ Remediation of a VOCI Soil Contamination at a Former Industry Site in Sao Paulo, Brazil. C. Heidel, K. Diesner, R. Engelhardt, P. Jacobs, P. Aquino, and J. Overgord. Patrick Jacobs (Tauw/Germany)

* Use of a Dual Oxidant Injection Scheme to Address Indeterminate DNAPL Sources. D.G. Jackson, B. Garner, J.M. Bradley, J.E. Cardoso-Neto, K. Adams, J. Rossabi, G.T. Kinsman, and J. Furr. Dennis Jackson (Savannah River National Laboratory/USA)

A3. Monitored Natural Attenuation

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Roger Anderson (TRC Companies, Inc.) and Rodrigo Coelho (GEOKLOCK)

* Evaluation of the Natural Attenuation Processes for the Organic Pollutants Plume from the Industrial Area of the Former Chemical Plant “Zachem” (Bydgoszcz, North Poland). M. Czop, E. Kret, and D. Pierry. Mariusz Czop (AGH University of Science and Technology/Poland)

Monitored Natural Attenuation for Phthalates in a Former Industrial Site. L.T. Kimura, N.V. Robles, and E.V. Freire. Lucas Takeshi Kimura (GEOKLOCK Consultoria e Engenharia Ambiental Ltda./Brazil)

* Multi-Disciplinary Approach to Demonstrate the Sustainability of MNA Processes following Source Area ISCO. M. Apfelbaum, A. Benevides, and E. Axelrod. Michael Apfelbaum (Woodard & Curran/USA)

Natural Attenuation Evaluation of Commingled CVOC and 1,4-Dioxane Plume in Fractured Bedrock Influenced by Pump and Treat. L. Zeng, A. Boodram, J. Ameye, A. Smith, B. Koto, and S. Abrams. Lingke Zeng (Langan/USA)

Natural Attenuation Rates of a NAPL-Contaminated Site with Seasonal Change of Groundwater Flow Directions. Y.S. Zhao, M. Hong, J. Dong, C.Y. Qin, and R. Zhou. Yongsheng Zhao (Jilin University/China)

Use of Novel Methods to Understand and Communicate MNA Data. M. Harkness, P. Hare, J. Vollick, C. Forman, and P. Freyer. Mark Harkness (Ramboll/USA)

A4. New Developments, Formulations, and Innovations in Microorganisms and Electron Donors for Biodegradation

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Raphi Mandelbaum (LDD Advanced Technologies, Ltd.) and J. Mark Nielsen (Ramboll)


Cyanuric Acid Hydrolase for Recreational Water Remediation. L.P. Wackett. Lawrence P. Wackett (University of Minnesota/USA)


Modified Emulsified Vegetable Oil Formulations for Site-Specific Challenges. P.M. Dombrowski, F. Hostrop, M. Lee, and D. Raymond. Paul Dombrowski (ISOTEC Remediation Technologies/USA)


Abiotic and In Situ Biogeochemical Processes

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Jeff Gamlin (Jacobs) and John Wilson (Scissortail Environmental Solutions, LLC)


* Biogeochemical Reductive Dechlorination Achieves Rapid and Sustained PCE Plume Suppression over 400 Feet from Source. J. Studer and N. Glenn. James Studer (InfraSUR, LLC/USA)


* A Combination In Situ Pilot Study Using Chemical Reduction and Biogeochemical Transformation to Treat Organochlorine Pesticides. P. Jacob, F. Nchako, S. Barker, J. Smith, and P. Hicks. Priya Jacob (AECOM/USA)


Student Paper Winner


Recent Advances in Subgrade Biogeochemical Reactors with Treatment of ~15 mg/L of 1,2-DCA to near Non-Detect Levels. C. Walecka-Hutchison, J. Gamlin, J. Strunk, R. Wenzel, R. Stuetzle, and A. Sidebottom. Claudia Walecka Hutchison (The Dow Chemical Company/USA)
A6. Injectable Activated Carbon Amendments: Lessons Learned and Best Practices

Platforms Wednesday | Posters (*) Monday Evening
Chairs: Scott Noland (Remediation Products, Inc.) and Kristen Thoreson (REGENESIS)

Achieving Lasting Success with In Situ Activated Carbon: A Five-Year Field Study. C. Brownfield, M. Friedman, B. Donovan, and B. Bremen. Christopher S. Brownfield (AECOM/USA)


* BOS 100® Successfully Treats PCE Source Areas: Lessons Learned from Remediation at an Active Facility. M. Reiter, A. Maninkovic, M. Stiller, J. Harshman, P.M. Dombrowski, M. Mazzarese, and K. O’Neal. Matt Reiter (AECOM/USA)

* Demonstrating a New Sorption and Bioamendment Combination in an Excavation. J.K. Sheldon, K. Smail, and C. Pederson. Jack Sheldon (Antea Group/USA)

Eliminating Contaminant Flux through Combined Sorption-Enhanced Anaerobic Bioremediation and In Situ Chemical Reduction Treatment in a Barrier. D. Davis, R. Moore, and E. Blodgett. Doug Davis (REGENESIS/USA)


In Situ Injection of an Activated Carbon Injectate to Degrade Carbon Tetrachloride and Degradation Products at an Oregon Site. S. Omo and M. Mazzarese. Mike Mazzarese (AST Environmental, Inc./USA)

* Lessons Learned about Activated Carbon Injections on a Site in Wyoming. T. Sorrells and J. Skogman. Tree Sorrells (Alpine Remediation, Inc./USA)

Persistence Saves the Day: Robust Characterization and Injection Techniques Lead to Successful Activated Carbon-Based PRB for Petroleum Hydrocarbons. B. Tunnicliffe and M. Mazzarese. Bruce Tunnicliffe (Vertex Environmental, Inc./Canada)

Results of Several Activated Carbon Installations. T. Sorrells and R. Davey. Tree Sorrells (Alpine Remediation, Inc./USA)


A7. Thermal Remediation Design & Best Practices

Platforms Wednesday | Posters (*) Monday Evening
Chairs: James Baldock (ERM) and Rubens Spina (GEOKLOCK)


* Direct Comparison of Competing ISTR Extraction Strategies. B.C.W. McGee and P.R. Hegele. Paul Hegele (Arcadis/Canada)


* Heat Faster and Save Energy: The Case for Rapid In Situ Thermal Remediation to Reduce Heat Losses and Costs. E. Crownover, G. Heron, and J. Seeman. Emily Crownover (TRS Group, Inc./USA)

Heating Shallow Pancakes: In Situ Thermal Treatment of Surface and Near-Surface Soils. G. Geckeler and B. Krumholz. Grant Geckeler (GEO/USA)


* = poster presentation


Laboratory- and Field-Scale Testing for Thermal Remediation: Why, Where, and How. E.L. Davis. Eva Davis (U.S. Environmental Protection Agency/USA)


Power Density: Why It Rules, and How to Maximize It. E. Crownover, G. Heron, and A. Wagner. Emily Crownover (TRS Group, Inc./USA)

* Smoldering Remediation (STAR): 10 Years from Pilot to Remedy Completion. G. Scholes, D. Major, G. Grant, D. Liefi, A. Sims, M. Auger, and L. Jo. Grant Scholes (Savron/Canada)


* Thermal Oxidation of Extracted Off-Gas to Supplement In Situ Heating. G. Geckeler, V. Burbach, and C. Morris. Grant Geckeler (GEO/USA)

* Treat Almost Anything above Grade: Avoid Transportation Risks and Liabilities. G. Heron, D. Oberle, and E. Crownover. Gorm Heron (TRS Group, Inc./USA)

The Use of Steam Propagation Tests and Thermal Modeling to Develop In Situ Thermal Remediation Design Parameters. G. Mackey, J. Dablow, M. Dawes, A. Salvador, C. Hurdle, J. Baldock, and J. Dinham. Graham Mackey (ERM/USA)

* When the Site Surprises You: How to Adjust to Unexpected Groundwater Flow. G. Heron, M. Nanista, and A. Wagner. Gorm Heron (TRS Group, Inc./USA)


* Hot Groundwater Sampling to Assess Progress during a Thermal Remedy. N. Stone, A. Bonarrego, and A. Fortune. Nikole Stone (Cascade Thermal/USA)


* Million-Dollar Numbers: Collecting and Using Data Effectively at Thermal Sites. S. Nienstedt and A. Caravella. Samuel Nienstedt (Cascade Thermal/USA)


The Thermal Remediation System Has Been Turned Off: How Will Groundwater Concentrations Respond? E.L. Davis. Eva Davis (U.S. Environmental Protection Agency/USA)

A9. Innovations in ZVI Amendment Formulations and Applications

Platforms Thursday | Posters (*) Wednesday Evening Chair: Dan Nunez (REGENESIS)

* Abiotic Destruction of Chlorinated Alkanes Using Catalyzed ZVI: Including 1,2,3-TCP, 1,2-DCP, and 1,2-DCA. J.G. Booth, N. Lapeyrouse, and C. Yestrebsky. J. Greg Booth (Woodard & Curran/USA)


* = poster presentation
Clinton Jacob (Landau Associates, Inc./USA)

Jenny Green (Landau Associates, Inc./USA)

Jan Filip (Palacký University/Czech Republic)

Dan Nunez (REGENESIS/USA)

Sailor Zhang (Shanghai Greenment Environmental Technology Co., Ltd./China)

Michael Lee (Terra Systems, Inc./USA)

Kristene Tidwell (Brown and Caldwell, Inc./USA)

Dimin Fan (Geosyntec Consultants/USA)

* Applying Electrical Resistance Heating in One Large-Scale, Low Permeable Site Contaminated by Chlorinated Compounds in China. W. Sun, Z.Y. Lyu, L. Wei, and A. Small.
Wei Sun (Beijing GeoEnviron Engineering & Technology, Inc./China)

Jason Cole (Jacobs/USA)

Electrical Resistance Heating Trials: Lessons Learned at a Site in Germany. R. Meinke, O. Kohnen, and S. van Wert.
Robert Meinke (ERM/Germany)

* Evolution of Thermal Remediation and Vapor Treatment Technology to Overcome Project Constraints in China. X. Chen, G. Geckeler, and C. Winell.
Xiaosong Chen (Geo Inc./USA)

Matt Dotto (ISOTEC/USA)

In Situ Thermal Remediation to Reduce TCE with Rapidly Increasing Water Table. S. Avritt, E. Crownover, and C. Blundy.
Susan Avritt (Wood/USA)

* In Situ versus Ex Situ Thermal Remediation of CVOCs Utilizing Electrical Resistance Heating. A. Schamber, J. Grabs, J. Bamer, and C. Thomas.
Andrew Schamber (CDM Smith/USA)

Carlos Felipe Ferreira da Silva Calderon (Geoklock Consultoria e Engenharia Ambiental Ltda./Brazil)

Xiaosong Chen (Geo Inc./USA)

Nicholas Dumaresq (McMillan-McGee Corp./Canada)

Pilot-Scale “in pile” Thermal Desorption Remediation of Soil Contaminated with Mercury and Pesticides. S. Eriksen, J. Holm, and J. Brix.
Søren Eriksen (Krüger A/S/Denmark)

* = poster presentation
Advances in Amendment Formulations B1.

Yu-Gyeong Kang (POSTECH/South Korea)

Comparative Evaluation of the Polyhydroxyalkanoates Obtained by MMC for Supporting Biological Reductive Dechlorination. N. Amanat, M.M. Rossi, F. Andreini, M. Majone, and M. Petrangeli Papini.
Neda Amanat (Sapienza University of Rome/Italy)

Hongwen Sun (Nankai University/China)

Hongwen Sun (Nankai University/China)

Michael Lee (Terra Systems, Inc./USA)

* Nano-Fe(0) Embedded in Mesoporous Carbon for Efficient Activation of Peroxydisulfate. Y.W. Wu, D.T. Yue, and X.F. Qian.
Xufang Qian (Shanghai Jiao Tong University/China)

John Houston (Clemson University/USA)

Innovative and Optimized Amendment Delivery and Monitoring Methods B2.

Platforms Monday | Posters (*) Monday Evening
Chair: Chapman Ross (Geosyntec Consultants) and William Slack (FRx, Inc.)

Advantages of Multiple Interval Oxidant Injection for Remediation of TCE. E.B. Hollifield and J.G. Byrd.
Edward B. Hollifield (Environmental Resources Management/USA)

Ondrej Lhotsky (DEKONTA a.s./Czech Republic)

Karen Campbell (U.S. Navy Facilities Engineering Command Southeast/USA)

Chapman Ross (Geosyntec Consultants/USA)

Donald Malone (Terracon/USA)

In Situ Injections in Remote Locations. T. Sorrells and R. Davey.
Tree Sorrells (Alpine Remediation, Inc./USA)

Jay Dablow (ERM/USA)
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<tr>
<th>* Innovative Spin® Injection Technology Pushes Boundaries of In Situ Remediation: Case Studies.</th>
<th>Application of Multiple Remediation Techniques to Achieve Full Site Closure Abroad.</th>
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<td>* Lessons Learned and the Future of Injection Imaging. T. Halihan and S.W. McDonald.</td>
<td>* Challenges in Remediating Sites That Have Been “Previously Remediated” with Different Remediation Approaches.</td>
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<tr>
<td>Todd Halihan (Oklahoma State University/USA)</td>
<td>S. Aluani, C. Spilborghs, E. Pujol, F. Tomiatti, G. Siqueira, N. Nascimento, and J. Mueller. Sidney Aluani (SGW Services/Brazil)</td>
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<td>Tim Johnson (Pacific Northwest National Laboratory/USA)</td>
<td>M.D. Hudock, K. Kinsella, and D.M. Winslow. Marc Hudock (GZA GeoEnvironmental/USA)</td>
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<td>David Scheer (Minnesota Pollution Control Agency/USA)</td>
<td>M. Nemecek, J. Zentmeyer, P. Tomiczek, and S. Koenigsberg. Matt Nemecek (Civil &amp; Environmental Consultants, Inc./USA)</td>
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<td>Venus Sadeghi (AECOM/USA)</td>
<td>G.D.C. Mello, A.R. Cervelin, G.N. Garcia, and F.A. Campello. Gustavo de Mello (Ramboll Environ/Brazil)</td>
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<td>Scott Potter (ARCADIS/USA)</td>
<td>A. Oka, M. Ambrusch, K. Novalis, K. DelCol, G. Iosue, S. Knoop, S. Abrams, and M. Burke. Amita Oka (Langan/USA)</td>
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<td>Paul Freyer (Ramboll/USA)</td>
<td>A. Heft, O. Miller, and R. Moore. Adam Heft (WSP/USA)</td>
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<td>Venus Sadeghi (AECOM/USA)</td>
<td>L. Honetschlägerová, R. Škarohlíd, and M. Martinec. Lenka Honetschlägerová (UCT Prague/Czech Republic)</td>
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<td>Combined Remedies and Treatment Trains</td>
<td>Electrical Resistance Heating and Bioremediation: Combined Remedy Success at the BSCSS Site, Bothell, Washington.</td>
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<td>Platforms Tuesday</td>
<td>J.R. Kane, R.M. D’Anjou, A.C. Swift, M. Dodson, and G. Sandberg. John R. Kane (Kane Environmental, Inc./USA)</td>
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<td>* = poster presentation</td>
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Long-Term Anaerobic Bioremediation of MGP Contaminants by Iron- and Sulfate-Reducing Bacteria following Combined ISCO/ISS Treatment. D.P. Cassidy and V.J. Srivastava. Daniel Cassidy (Western Michigan University/USA)


* Pilot Test in Operational Industrial Site: SVE, Air Sparging, and Ozone Injection System. D.D. Savio, D.S. Saunite, E. Freire, and T.F. Noccetti. Daniel Danezi Savio (GEOKLOCK/Brazil)


Selection of Combined Treatment Remedy Approaches Based on Site and Budget Constraints, Primary COCs and Current/Future Land Use: Three Case Studies. M. Temple, P. Kakarla, and P.M. Dombrowski. Mike Temple (In-Situ Oxidative Technologies, Inc./USA)

* Simple and Flexible Clears Efficient Path to Closure. K. Dyson, P. Randazzo, and M. Miner. Kevin Dyson (Brown and Caldwell/USA)

Surfactant Enhanced Extraction (SEE) at LNAPL- and DNAPL-Impacted Sites: Pilot- to Full-Scale Applications in Canada, United States and Europe. G. Heernaert and G.A. Ivey. George (Bud) Ivey (Ivey International, Inc./Canada)


* Dry Cleaner Groundwater Impacts Emanating from Groundwater Divide. W. Smith, R. Kondelin, and J. Rossi. William Smith (Environmental Alliance, Inc./USA)


From nZVI to S-nZVI: Lessons Learned from Field-Scale Nano-Iron Injections. D.M. O’Carroll. Denis O’Carroll (University of New South Wales/Australia)

* Full-Scale Application in Italy of EHC® Liquid Technology: Combined ISCR and ERD Treatment of an Aerobic Aquifer Impacted with Tetrachloromethane and Chloroform. M. Mueller, A. Leombruni, D. Leigh, and F. Lakhwala. Alberto Leombruni (PeroxyChem, LLC/Italy)

* Fundamental Advances in Environmental Science and Engineering from 25 Years of Research on ZVI and PRBs. P.G. Tratnyek. Paul Tratnyek (Oregon Health & Science University/USA)


Long-Term Performance Update on the 15-Year Anniversary of the First Full-Scale EHC® Injection PRB. J. Molin, A. Seech, J. Valkenburg, R. Oesterreich, and J. Son. Josephine Molin (PeroxyChem, LLC/USA)

* Optimization and Performance of Iron Amendments for In Situ Chemical and Biological Reduction. G.M. Birk and D.F. Alden. Gary Birk (Tersus Environmental, LLC/USA)

Performance Assessment of a Pilot-Scale ZVI PRB Installed with Hydraulic Fracturing. S. Fiorenza. Stephanie Fiorenza (BP/USA)

A Permeable Reactive Barrier at a Former Uranium Mill Tailings Site: The Good, the Bad, and the Future. R.H. Johnson and R. Kent. Raymond Johnson (Navarro Research and Engineering, Inc./USA)


Somersworth Superfund ZVI PRB: 19 Years of Performance Monitoring. A. Przepiora, S. O’Hara, and S. Waddley. Andrzej Przepiora (Geosyntec/Canada)

* Treatment of Chlorinated Solvents in a Multi-Zoned Aquifer with Combination of Emulsified Vegetable Oil and Zero Valent Iron. B. Yuncu, D. Jones, R. Norris, and V. Burrows. Bilgen Yuncu (Draper Aden Associates/USA)


**Platforms Wednesday | Posters (*) Monday Evening**

**Chairs:** Elizabeth Edwards (University of Toronto) and Frank Loeffler (University of Tennessee)

B5. Advances in Understanding Bioremediation: Processes and Novel Assessment Methods


Carbon and Chlorine Stable Isotope Analysis for Investigating Aerobic Degradation of Trichloroethylene in a Large-Scale Aquifer Survey. A. Gafni, Z. Ronen, A. Bernstein, and F. Gelman. Zeev Ronen (Ben Gurion University of the Negev/Israel)


* Investigating the Coexistence of *Dehalococcoides* and Etheneotrophs Using Fluorescence in Situ Hybridization. P.M. Richards and T.E. Mattes. Patrick Richards (University of Iowa/USA)

The Nature of Biofilms and Their Impact on Contaminant Remedial Actions. S.R. Burge and K. Hristovski. Scott Burge (Burge Environmental, Inc./USA)


* = poster presentation
* Redox Conditions Determine the Microbial Cobamide Pool with Implications for Bioremediation Practice. L.A. Seus, J. Yan, and F.E. Loeffler. Laurel A. Seus (EHS Support/USA)

* Unclogging Clogged EVO Injection Wells in Saline Environment. V. Hosangadi, P. Chang, B. Shaver, and M. Pound. Vitthal Hosangadi (NOREAS, Inc./USA)


Bioremediation Using High and Low Pressure Injection to Address a TCE Source Area at Kennedy Space Center, Florida. R.C. Daprato, J. Langenbach, and A. Chrest. Rebecca C. Daprato (Geosyntec Consultants/USA)


* Field Testing Reductive Dechlorination Bioaugmentation Cultures in a Low pH Groundwater Setting. L.G. Lehmicke, H. Wang, and D. Freedman. Leo Lehmicke (CO₂ and Water/USA)

* Full-Scale In Situ Bioremediation of Chlorinated Solvents and 1,4-Dioxane. L. LaPat-Polasko and G. Waters. Laurie LaPat-Polasko (Matrix New World Engineering/USA)


* In Situ Bioremediation of Chlorinated Volatile Compounds in Fractured Bedrock: Preferential Dechlorination of TCA. K. Boger and P. Castellano. Kevin Boger (TRC Companies, Inc./USA)

* In Situ Remediation of a Fractured Metamorphic Bedrock Aquifer Impacted with TCE and 1,1,1-TCA through ERD Techniques: Pilot-Scale Results. M. Chaturgan and D. Smith. Mindy Chaturgan (EWMA/USA)

* Incoming! Utilizing In Situ Bioremediation in a Commingled Plume with an Uncontrolled Source. A. Revezzo, R. Ferree, and R.L. Fimmen. Alicia Revezzo (Geosyntec Consultants/USA)

* Methane Generation under Building from EVO Injections in Shallow Groundwater. V. Hosangadi, P. Chang, B. Shaver, and M. Pound. Pamela Chang (Battelle/USA)

Optimization of a Passive Enhanced In Situ Bioremediation (EISB) Remedy by Biobarrier and Source Injection Approach. C.A. Fogas and M.P. McDonald. Christine Fogas (Ramboll/USA)

Phased Biostimulation/Bioaugmentation of a TCE DNAPL Source Area in Fractured Bedrock with Karst Features. K.A. Morris, P. Beyer, and J. Fiacco. Kevin Morris (ERM/USA)


### Emerging Remediation Technologies

#### Platforms Thursday | Posters (*) Wednesday Evening
Chair: Linda Fiedler (U.S. Environmental Protection Agency)

*S. Noland.*  
Scott Noland (Remediation Products, Inc./USA)

### Foam as a Blocking Agent to Enhance Remediation Efficiency in Heterogeneous Source Zones: Lessons from Three Field Tests.  
*O. Atteia, E. Verardo, C. Portois, N. Guiserix, and A. Joubert.*  
Olivier Atteia (Bordeaux University/France)

### In Situ Remediation of DNAPL Source and Plume at an Active Industrial Facility with Innovative Enhanced Reductive Dichlorination Technology.  
*G. Giorgio Ceriani.*  
Gabriele Giorgio Ceriani (Ejlskov A/S/Denmark)

### * Passive Anode-Cathode Technology: Boosting Microbial Benzene Biodegradation.  
Kathlyne Hyde (University of Saskatchewan/Canada)

### * Persistent Organic Pollutant Lindane Degradation by Alkaline Cold-Brew Green Tea.  
*C.-W. Wang and C. Liang.*  
Chenju Liang (National Chung Hsing University/Taiwan)

### Technology for Continuous, In Situ Production of Reactive Oxygen Species.  
Jim Mueller (Provectus Environmental Products, Inc./USA)

### * Testing of New In Situ Treatment Approaches for Contaminant Mixtures.  
*I. Demirkilani, J. Szecsody, C. Bagwell, and M. Truex.*  
Inci Demirkilani (PNL/USA)

### * There’s a Method to This Madness: Dynamic Groundwater Recirculation (DGR™).  
*M.W. Killingstad, J. Roller, J. Wahlberg, and S.T. Potter.*  
Marc Killingstad (Arcadis/USA)

### Phytoremediation/Mycoremediation and Plant Uptake

#### Platforms Thursday | Posters (*) Wednesday Evening
Chair: Tesema Chekol ( Battelle)

### * Eight Years of Commercial Use of Tree Coring as a Screening Method during Site Investigations: What Have We Achieved?  
M. Algreen, S.R. Pedersen, and K.E. Sadowski.*  
Mette Algreen (Orbicon | WSP/Denmark)

### Evaluating Native and Naturalized Plant Species for the Phytoextraction of DDT and Dieldrin at a National Park in Ontario, Canada.  
*B.A. Zeeb, R. Bergin, and A. Rutter.*  
Barbara Zeeb (Royal Military College of Canada/Canada)

### Investigation of Oregon Native Plants for Remediation of Trace Metals and Organic Pollutants in Stormwater.  
*R. Hilliard and T. Radniecki.*  
Richard Hilliard (Oregon State University/USA)

### * Performance of a 2500 Poplar Tree Phytoremediation System to Extract and Treat a Chlorinated Hydrocarbon Plume in South Central Wisconsin.  
*R.J. Rudy, W. Doucette, and B. Hutson.*  
Richard J. Rudy (RJR/USA)

### * Phytoremediation Experiences at Multiple Sites for Treatment of 1,4-Dioxane and Other Recalcitrant Compounds.  
*F.J. Krembs, K. McDonald, M.G. Sweetenham, S. Lombardo, and J. White.*  
Fritz Krembs (Trihydro Corporation/USA)

### * Phytoremediation for Treatment of Subsurface Impacts by Persistent Chlorinated Pesticides at a Site in Southern Europe.  
*P.F. Wouters, D. Göschel, A. García, and R. Álvarez-Troncoso.*  
Peter F. Wouters (Ramboll Iberia S.L./Spain)

### * Phytoremediation in Paradise: Remediation of Soil Fumigants in Hawaii.  
*G.L. Zimmerman.*  
Gary Zimmerman (Golder Associates/USA)

### * Phytotoxicity Assay to Assess Species Potential for Rhizoremediation of Petroleum Hydrocarbons: From Greenhouse to Models.  
*M.O. Eze, S.C. George, and G.C. Hose.*  
Michael O. Eze (Macquarie University/Australia)

### Sustainable Phyto-Integrated® Remediation System to Treat Chlorobenzene-Contaminated Groundwater in a Saprolite/PWR Aquifer in South Carolina.  
*E.B. Hollifield and E.G. Gatliiff.*  
Edward B. Hollifield (Environmental Resources Management/USA)

### Utilizing the Plant Microbiome and Bioaugmentation to Degrade 1,4-Dioxane and Co-Contaminants.  
Reid Simmer (University of Iowa/USA)
Best Practices and Lessons Learned for Permeable Reactive Barriers

Platforms Thursday | Posters (*) Wednesday Evening

Chairs: Bruce Henry (Parsons) and Clinton Jacob (Landau Associates, Inc.)

Pejman Rasouli (Ramboll/USA)

* Assessment and Selection of Various Technical Grades and Brands of Zero Valent Iron (ZVI) for Remediation of Tetrachloroethene (PCE) regarding the Permeable Reactive Barrier at the Rheine Site, Germany. V. Birke, R. Singh, S. Chakma, and H. Burmeier.
Volker Birke (University of Wismar/Germany)

Bench to Field: ISCO-Based Permeable Reactive Barrier at Former Wood Treatment Facility. B.A. Smith, S. Telesz, and T. Pac.
Brant Smith (PeroxyChem, LLC/USA)

Gary Simpson (AST Environmental, Inc./USA)

Craig Sandefur (REGENESIS/USA)

* Evaluating Opportunities to Increase the Effectiveness of Permeable Reactive Barriers for Biological Treatment of Nitrogen. V.L. Gonzalez, P.M. Dombrowski, and C.A. Ramsburg.
Veronica Gonzalez (Tufts University/USA)

Wouter Gevaerts (Arcadis/Belgium)

Richard Girouard (Ahtna Global, LLC/USA)

Lin Li (Tennessee State University/USA)

Andrzej Przepiora (Geosyntec/Canada)

Injectable Activated Carbon Permeable Reactive Barrier to Address Mass Flux from TCE Source Area beneath a Building. E. Blodgett, T. Beaster, A. Danielson, S. Filby Williams, and J. Tracy.
Eric Blodgett (Barr Engineering Co./USA)

Martina Bertolini (Università degli Studi di Milano/Italy)

Mark Amidon (Savannah River National Laboratory/USA)

Tracie Ahneman (Ramboll/USA)

Keith M. Gaskill (REGENESIS/USA)

Andrew Gray (ERM/Australia)

Other Emerging Contaminants

Platforms Monday | Posters (*) Monday Evening

Chairs: Alison Cupples (Michigan State University) and John Simon (Nathan Associates, Inc.)

* Alkanolamines? K.W. Quast.
Konrad William Quast (Wood/USA)

* Biological Treatment of a Contaminant Mixture including VOCs, Chlorinated Ethers BCEE and BCEM, and 1,4-Dioxane. M. Klemmer, A. Harmon, J. Forbort, R.J. Stuetzle, and R. Wenzel.
Mark Klemmer (ARCADIS/USA)
* Combating Climate-Exacerbated Harmful Algal Blooms (HABs) Using Diffusive Aeration and Mechanical Circulation. A.T. Jones. Amelia Jones (TRC/USA)


The Impact of Toxicological Uncertainties on the Regulation of Emerging Contaminants. D. Cox and H. Lanza. Doug Cox (GHD Inc./USA)

In Situ Reduction of 1,2,3-Trichloropropane in Groundwater: Advancements and Case Studies. M. Asher, S. Varadhan, E.J. Suchomel, L.Z. Kane, and S. Dworatzek. Melissa Asher (Geosyntec Consultants/USA)

Microplastic Pollution in River Water and Bed Sediment and the Associated Microbial Communities. N.L. Fahrenfeld, K. Parker, K. Bailey, K. Sipps, K. Parrish, G. Saba, R. Chant, and G. Arbuckle-Keil. Nicole Fahrenfeld (Rutgers University/USA)


* Untangling the Robust Catalytic Versatility of Soluble di-iron Monoxygenases in Initiating the Biotransformation of Legacy and Emerging Groundwater Pollutants. D. Deng, D. Pharm, F. Li, J. Antunes, and M. Li. Mengyan Li (New Jersey Institute of Technology/USA)


Panel Discussion—Monday, Track C

Should We Develop PFAS Ambient Levels: Why and How?

Moderator
Sheau-Yun (Dora) Chiang, Ph.D., PE (CDM Smith)

Panelists
Richard Spiese (Vermont Department of Environmental Conservation)
Antti Mikkonen (CDM Smith)
Jennifer Guelfo, Ph.D. (Texas Tech University)
Grant Trigger (Racer Trust)
Richard Anderson (U.S. Air Force)

Per- and polyfluoroalkyl substances (PFAS) are manmade and ubiquitous in the environment after nearly 7 decades of use and release. Local, regional, national and global detections of PFAS in different environmental media are evident and the literature verifies their persistence and mobility. With the advance of analytical techniques, PFAS can now be detected at subpart per trillion levels and even parts per quadrillion range. It is anticipated that the frequency of low-level PFAS detections will rise as more PFAS monitoring is requested by different regulatory agencies. Toxicity of PFAS is not always clear in relationship to long-term bioaccumulation of trace-level PFAS. Should all levels be considered harmful? Can any detections at a site suggest the presence of PFAS sources due to firefighting activities, manufacturing and other PFAS discharges (landfill leachate, wastewater discharges, biosolids)? If not, what is the practice to differentiate site-derived impact versus ambient levels?

Some states are proposing PFAS criteria close to or below 10 ppt in water. At such levels, detections may or may not relate to site activities. Can such low criteria lead to unnecessary remediation activities following with no clear path on site closure (i.e., achieving remedial goals lower than ambient levels)? Can acceptable PFAS ambient levels be established? The current international practice for developing PFAS background levels has been constrained by inconsistent applications of regulatory ‘background definition(s)’ for different media and the lack of published robust assessment programs.

This panel will provide interactive discussions on the range of “background” data collected to date and whether ambient levels should and can be established. The panel will also discuss the international experience of developing ambient levels, and the practices that can be considered to provide a more rigorous evaluation of PFAS ambient levels for developing remediation goals and risk management strategy.
Maureen Leahy (ERM/USA)

Maggie Radford (Jacobs/USA)

Matthew Traister (Ramboll/USA)

* Investigation of PFAS Impacts in Multiple Media at Portland International Airport (PDX), Oregon. H. Gosack and A. Reese.
Heather Gosack (Apex Companies, LLC/USA)

Jonathan Medd (Golder Associates/Australia)

* Occurrence, Distribution, Analysis, Toxicology and Remediation of Perfluorinated Pollutants in Germany. V. Birke.
Volker Birke (University of Wismar/Germany)

Mark Rigby (Parsons/USA)

Dennis Jackson (Savannah River National Laboratory/USA)

Caron Koll (Antea Group/USA)

Erin Palko (Integral Consulting, Inc./USA)

Brian Hoye (Burns & McDonnell/USA)

PFAS: Smart Characterization for an Emerging Contaminant. P.J. Curry, J. Quinnan, and M. Rossi.
Patrick Curry (Arcadis/USA)


An Updated Review of Impacts that Perfluorochemicals (PFCs) Have Had on Three New Hampshire Communities. J. Emery and D. Tinkham. James Emery (Emery & Garrett Groundwater Investigations, A Division of GZA/USA)

Voluntary/Proactive Characterization of PFAS Impacts to Groundwater at Former Marine Corps Air Stations Tustin and El Toro, California. G. Chammas. Guy Chammas (U.S. Department of the Navy/USA)


Advances in the Analysis of Per- and Polyfluorinated Alkyl Substances (PFAS)

Platforms Wednesday | Posters (*) Monday Evening Chairs: Kavitha Dasu (Battelle) and Janice Willey (U.S. Navy)


Comprehensive Analysis of PFAS-Contaminated Environmental Samples Using High-Resolution Mass Spectrometric Methods. L. Mullins and K. Dasu. Larry Mullins (Battelle/USA)


The Enrichment of PFAS and Discovery of Hydrocarbon Surfactants in Foam and the Surface Microlayer on Surface Water Impacted by AFFF. T. Schwichtenberg, J.A. Field, D. Bogdan, and C. Carignan. Trever Schwichtenberg (Oregon State University/USA)


Innovative Sampling and Analysis Techniques for Stack Sampling of PFAS Compounds in Air Emissions from Stationary Sources. W. Fritz and P. Meeter. Wesley Fritz (Weston Solutions, Inc./USA)


New Approaches for Analysis of Airborne PFAS Compounds Using PTR-MS. H. Behzadi, H. Huber, and A. Tasoglu. Harry Behzadi (RJ Lee Group/USA)

PFAS Analytical Concerns and Mitigation Strategies. T. Hill, J. Bishop, and A. Dodson. Tiffany Hill (Jacobs Engineering/USA)

PFAS Analytical Data: What Do You Have and What Does It Mean? W. Swanson. Ward Swanson (Barr Engineering Co./USA)

PFAS Data Validation: A Technical Perspective. S. Denzer and S. Cuenco. Scott Denzer (LDC, Inc./USA)


= poster presentation

* A Rapid Screening Tool to Measure Total Organofluorine in Per- and Polyfluoroalkylated Substance (PFAS)-Contaminated Media. K. Dasu and C. Cucksey. Kavitha Dasu ( Battelle/USA)

* Total Fluoride Analyses as an Effective Tool for Evaluating First and Second Generation AFFF Sources. M. Eberle, M. Edelman, E. Denly, and J. Occhialini. Michael Eberle (TRC Companies, Inc./USA)

* Understanding the Occurrence of Emerging PFAS in Water, Soil, Sediment and Fish in North America. B. Chandramouli, M.C. Hamilton, and M. Woudneh. Bharat Chandramouli (SGS AXYS/Canada)


Platforms Wednesday | Posters (*) Monday Evening
Chairs: Kevin Morris (ERM) and Christopher Jackson Ritchie (Ramboll)

C4. Explosives, Perchlorate


Degradation of Insensitive Munition Constituents in the Environment: Predicting the Products and Their Properties Using In Silico Methods. T.L. Torralba-Sanchez, P.G. Tratnyek, and E.J. Bylaska. Tiffany Torralba-Sanchez (Oregon Health & Science University/USA)

C5. Permeability Enhancements for In Situ Technologies

Platforms Wednesday | Posters (*) Monday Evening
Chairs: Kent Sorenson (CDM Smith, Inc.) and Jeana Wolters (Ramboll)

* Application of ZVI in Complex, Low Permeability Lithologies: A Large-Scale Success. R.L. Kelley, J. Liskowitz, and P. Randall. Robert Kelley (Hepure/USA)


Direct Push Jet Injection for Enhanced Treatment of Chloropicrin in Low-Permeability Soils. C.S. Martin, C.M. Ross, R.E. Scott, and C.M. Greene. Chris Martin (Geosyntec Consultants/USA)


* = poster presentation
Heat-Enhanced Remediation

Platforms Thursday | Posters (*) Wednesday Evening
Chairs: Tim Garvey (Oneida ESC Group) and Christopher Hook (Tetra Tech, Inc.)


Application of Elevated Temperatures (10 to 70°C) on ZVI PRBs for an Enhancement of CHC Degradation. A. Metzgen, A. Dahnke, and M. Ebert. Adrian Metzgen (Kiel University/Germany)


* Biological Anaerobic Degradation of VOCs Combined with Recirculated Groundwater Heating. M. Slooijer, M. de Camillis, and J. Dijk. Martin Slooijer (GreenSoil Group/Belgium)


Groundwater Temperature Increases Associated with Biodegradation of Volatile Organic Compounds at a Superfund Site. R. Thompson, J. Holden, M. Gefell, J. Goin, G. Heron, and B. Thompson. Rowan Thompson (GEI Consultants, Inc./USA)


Low Temperature ERH Pilot Study: Hydrolysis of Munitions Constituents. B. Morris, C. Thomas, M. Maxwell, C. Crane, and C. Williams. Brad Morris (TRG Group, Inc./USA)


* Thermal Light In Situ Remediation: Lessons Learned on a Dutch Chlorinated Solvent Site, Remediated by Heat-Enhanced Soil Vapor Extraction. M. van den Brand, K. de Jong, J. Reukers, and N. van Ras. Marco van den Brand (HMVT/Netherlands)

* Thermal Soil Mixing and ZVI Injection Using Large Diameter Augers at a Former Dry Cleaner. J.C. Brown and M.C. crews. Jesse Brown (Golder Associates, Inc./USA)


* = poster presentation
Eric Bergeron (Golder Associates/Canada)

Andrea Hanson (Colorado State University/USA)

Charlotte Riis (NIRAS A/S/Denmark)

Megan Leigh Altizer (Microbiome Engineering/USA)

Vojtech Stejskal (Photon Water Technology/Czech Republic)

Mark Watling (Geosyntec Consultants/Canada)

Mark Sylvester (ATS2, LLC/USA)

David B. Gent (U.S. Army Corps of Engineers Engineer Research & Development Center/USA)

Gil Elgressy (E.Elgressy/Israel)

* Reflections of Challenges and Opportunities in the Field Implementation of Electrokinetically-Delivered Amendments in Clay. D.M. O’Carroll.
Denis O’Carroll (University of New South Wales/Australia)

* Remediation of a Vinyl Chloride Dissolved-Phase Plume through a Combination of Electrokinetics and In Situ Chemical Oxidation at the Santos Port Area, Brazil. G. Setti and A.P. Queiroz.
Flavio Lima (Waterloo Brasil/Brazil)

* Air Sparging Barrier Wall with Vertical and Horizontal Air Supply. G. Alexander and T. Miller.
Gordon Alexander (Kennedy/Jenks Consultants/USA)

Michael Lubrecht (Ellingson - DTD/USA)

Maria Pena (Arcadis/USA)

Joshua Long (Equipoise Corporation/USA)

Neil Smith (CDM Smith, Inc./USA)

Kyle Carlton (Geosyntec/USA)

Horizontal SVE and Steam Injection for Source Zone Depletion in Mixed LNAPL under Active Building at Naval Air Station North Island. V. Hosangadi, P. Chang, R. Mennis, and M. Pound.
Michael Pound (Naval Facilities Engineering Command Southwest/USA)

New Perspectives on Horizontal to Vertical Well Ratios for Site Cleanup. W.R. Laton.
W. Richard Laton (Cal State Fullerton/USA)

* = poster presentation
Joseph Quinnan (Arcadis/USA)

* Soil Vapor Extraction Using a Horizontal Remediation Well to Remedy Biogenic Methane and VOCs: A 2-Year Review. S.H. Bailey and M. Pate.
Sam Hendrik Bailey (Kleinfelder/USA)

Christopher Power (University of Western Ontario/Canada)

D1. PFAS: Water Treatment Case Studies

Platforms Monday | Posters (*) Monday Evening

Chairs: Rula Anselmo Deeb (Geosyntec Consultants) and Shalene Thomas (Wood)

Kirk Moline (C.T. Male Associates/USA)

Michael Truex (Pacific Northwest National Laboratory/USA)

Kristen Musgrove (Brown and Caldwell/USA)

Beth Landale (GHD/USA)

Catherine McMillen (Aerostar SES, LLC/USA)

* Effective Strategies for Planning and Managing Risks of PFAS Contamination in Drinking Water Supplies. K.D. Hay and B.A. Martin.
Kyle Hay (Weston & Sampson, Inc./USA)

Steven Woodard (ECT2/USA)

* Novel Approach to Horizontal Vapor Mitigation, Intersecting Geology and Engineering. E. Pearson, E. Arslanian, and A. Hillman.
Erik Pearson (Ramboll/USA)

Michael Donovan (CETCO/USA)

Jurgen Buhl (Cornelsen Umwelttechnologie GmbH/Germany)

* Overview of PFAS Treatment Effectiveness from Projects Conducted in Canada, the Netherlands, and the United States. N. Robertson, R. Capelle, J. Jacangelo, A. McGrath, F. Lauzon, S. Richards, and C. Soeter.
Neil Robertson (Stantec/USA)

PFAS: Advocating for Approval of the Best Treatment Technologies in an Evolving Regulatory Climate. S.J. MacDonald, M.S. Apgar, and F.P. Wilson.
Stephen MacDonald (Fishbeck, Thompson, Carr & Huber, Inc./USA)

Maureen Leahy (ERM/USA)

Cathy Swanson (Purolite Corporation/USA)

Paula Bond (Aerostar SES, LLC/USA)

* = poster presentation
Validation of Rapid Small-Scale Column Tests (RSSCTs) to Replicate Large-Scale Systems for PFAS Adsorption.  
S.A. Grieco, A.M. Redding, and J. Roth.  
Scott Grieco (Jacobs/USA)

Aerobic Cometabolism of COCs in Continuous Flow Column Packed with Gellan-Gum Macrobeads Encapsulated with 21198 Cells and TBOS as a SRC Source.  
M. Azizian, A. Saito, L. Semprini, and M. Hyman.  
Mohammad Azizian (Oregon State University/USA)

Bioaugmentation a Developing Tool for 1,4-Dioxane Bioremediation.  
Philip Dennis (SiREM/Canada)

Bioaugmentation to Enhance In Situ Biodegradation of 1,4-Dioxane.  
Rebecca Mora (AECOM/USA)

* Characterization of a 1,4-Dioxane-Metabolizing Mixed Microbial Culture.  
Chao Zhou (Geosyntec Consultants/USA)

Cometabolism of 1,4-Dioxane and Chlorinated Hydrocarbon Mixtures Induced by Multiple Primary Substrates in a Packed Column with Groundwater Recirculation.  
Hannah Rolston (Oregon State University/USA)

Full-Scale Implementation of Propane Biosparge System for In Situ Remediation of 1,4-Dioxane in Multiple Treatment Zones.  
C.H. Bell, K. Parsons, and K. Gerber.  
Caitlin Bell (Arcadis/USA)

* The Impact of cis-Dichloroethene and Lactate on the Aerobic Biodegradation of 1,4-Dioxane.  
H. Dang and A. Cupples.  
Hongyu Dang (Michigan State University/USA)

Addition of 1,4-Dioxane Removal System to Municipal Water Treatment Plant: Pilot to Operation.  
J. Macejkovic and A. Ling.  
Julia Macejkovic (Barr Engineering Co./USA)

* Design-Build Expedites the Remediation of 1,4-Dioxane Groundwater Plume through Source Removal.  
P. Randazzo and K. Dyson.  
Peter Randazzo (Brown and Caldwell/USA)

Evaluation of Multiple Treatment Technologies for 1,4-Dioxane.  
Fritz Krembs (Trihydro Corporation/USA)

* Ex Situ Treatment of 1,4-Dioxane in Groundwater Using an Advanced Oxidation Process.  
N. Hunt, B. Thompson, D. Fuerst, N. Carabillo, and K. Bivens.  
Nathan Hunt (de maximis, inc./USA)

Field Applications Treating 1,4-Dioxane with Activated Potassium Persulfate.  
D. Bytautas, C. Letts, and V. Sadeghi.  
Dustin Bytautas (AECOM/USA)

Forensics for Assessing Commingled 1,4-Dioxane Plumes.  
B. Bond, I. Wolfe, K. Kelly, and M. Morris.  
Bob Bond (LANGAN/USA)

* = poster presentation
* In Situ Remediation of a 1,4-Dioxane Plume in a Heterogeneous Aquifer, Lessons Learned: Full-Scale Remediation with Activated Sodium Persulfate. T. Louviere and P. Hsieh. Trevor Wade Louviere (Dalton, Olmsted & Fuglevand, Inc./USA)

* ISCO Injections Utilizing Hydraulic Fracturing to Treat 1,4-Dioxane in Groundwater. K. Dyson, R. Ruhmke, K. Ramanand, and J. Seracuse. Kevin Dyson (Brown and Caldwell/USA)

Low Temperature Heat Injection for 1,4-Dioxane Source Zone Remediation. G. Alexander, B. Logan, R. Strandberg, and S. Crawford. Gordon Alexander (Kennedy/Jenks Consultants/USA)

* Multi-Tool Characterization, Delineation and Capture of a Detached, Commingled, 1,4-Dioxane and Chlorinated Ethenes Plume in Coastal Plain Deposits. C. Meyn and S. MacMillin. Charles Meyn (Brown and Caldwell/USA)

Natural Attenuation of 1,4-Dioxane: Challenges and Opportunities. D.T. Adamson, A. Danko, J. Wilson, C. Lebron, and D. Freedman. David Adamson (GSI Environmental, Inc./USA)

* Re-evaluation of Selected Remedy at a Superfund Site Impacted by 1,4-Dioxane: A Success Story Complicated by New Emerging Contaminants. L.L. Kammer, M.K. Kanarek, J.J. Soukup, and C.L. Sprague. Lisa Kammer (Wesston Solutions/USA)

* Remediation of 1,4-Dioxane via Electrical Resistance Heating. E. Crowder and L. Stauch. Emily Crownover (TRS Group, Inc./USA)

* Selecting the Most Viable Oxidant to Treat 1,4-Dioxane in Groundwater. K. Ramanand, R. Ruhmke, K.D. Dyson, and J. Seracuse. Karnam Ramanand (Brown and Caldwell/USA)

* System Design to Capture Historically Unidentified 1,4-Dioxane Plume Created by Re-Injection of Treated Discharge from an Existing TCE Remediation System. J.R. Dickson. James Dickson (CTI and Associates, Inc./USA)


* Treatment of 1,4-Dioxane to Attain Stringent Groundwater Quality Standard. N. Turner, V. Scruggs, H. Johannes, and A. Mead. Ned Turner (TLI Solutions, Inc./USA)

Untangling the Web of 1,4-Dioxane Water Treatment Technologies. C.H. Bell. Caitlin Bell (Arcadis/USA)

D4. PFAS Risk Assessment and Toxicity

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Scott Grieco (Jacobs) and Rosa Gwinn (AECOM)

* Behind the Numbers: How Understanding the Toxicology behind the Varying PFAS Criteria Improves Risk Management. D. Marquez, B. Hoye, and K. Patel-Coleman. Diana Marquez (Burns & McDonnell/USA)

* Comparative Analysis of Health-Based Screening Levels for Site Characterization of Groundwater Impacts at Various PFAS Release Sites. R. Arestides, J. Peters, and G. Sikri. Ruth Arestides (Haley & Aldrich, Inc./USA)


Impact of Soil Amendments on PFAS Bioavailability: Implications for Human Health Exposure Assessment. A.L. Juhasz and R. Stewart. Albert Juhasz (University of South Australia/Australia)


In Silico Prediction of Fate and Risk-Determining Properties of Per- and Polyfluoroalkyl Substances (PFAS). T.L. Torralba-Sanchez, P.G. Tratnyek, O. Dmytrenko, D.M. Di Toro, and E.J. Bylaska. Tiffany Torralba-Sanchez (Oregon Health & Science University/USA)

* Multi-media Distribution and Source Identification of PFAS Surrounding a Typical Landfill in China. C. Xu and X. Song. Xin Song (Chinese Academy of Sciences/China)

PFAS Uptake in Homegrown Produce. B. Selcoe, O. Henderson, and L. Lund. Barrie Selcoe (Jacobs/USA)

* Potential Human Exposure to PFAS via Consumption of Finfish and Shellfish: A National U.S. Survey. D. Bogdan, B. Ruffle, and M. Maier. Dorin Bogdan (AECOM/USA)

* Protecting Human Health from Consumption of PFOS in Deer Meat. A.R. Quintin, A.M. Rodolakis, and M. Covenev. Amy Quintin (Wood/USA)

* Risk Assessment Challenges Associated with Atmospheric Transport of PFAS. L.J. Trozzolo. Laura Trozzolo (TRC Companies, Inc./USA)


D5. Pump and Treat for PFAS Remediation

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Stewart Abrams (Langan) and Paul M. Randall (U.S. EPA)


* Deploying a “Three-Legged-Stool” Approach to Drinking Water Protection for PFAS Mitigation. R. Singer, R. Walton, and T. Gerhard. Rob Singer (Wood/USA)

GAC and Anion Exchange Resin for Treating Perfluoroalkyl Acids: The Value of Bench-Scale Testing. C.E. Schaefer, D. Nguyen, P. Ho, J. Im, and A. LeBlanc. Charles Schaefer (CDM Smith, Inc./USA)


D6. PFAS Fate and Transport

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Grant Carey (Porewater Solutions) and Maureen Leahy (ERM)

* 3M Settlement: Project 1007 PFAS Source Assessment, Fate and Transport in Interconnected Surface Water and Groundwater. R.A. Higgins and A. Tarara. Rebecca Higgins (Minnesota Pollution Control Agency/USA)

* CMC, Foaming, and Phase Behavior Properties of AFFFs: Implications for PFAS Fate and Transport. P. Sharma, T. Wanzek, E. Christie, K. Kostarelos, and J. Field. Konstantinos Kostarelos (University of Houston/USA)


* Establishment of Fate and Transport Mechanics for PFAS under Controlled Aquifer Conditions. B.P. Shedd, E.O. Weikel, L. Blaney, K. He, and D.B. Gent. Brian Shedd (U.S. Army Corps of Engineers/USA)

* Experimental and Modeling Investigations on Accumulation of PFAS at the Air and NAPL-Water Interface. M. Arshadi, L.M. Abriola, and K.D. Pennell. Masoud Arshadi (Tufts University/USA)


How Can We Determine Site-Specific Soil Remedial Goals That Are Realistic for PFAS. A. Lee, S. Corish, G. Avakian, and L. Mcleod. Amanda Lee (AECOM/Australia)

* = poster presentation
Partitioning and Storage of Per- and Polyfluoroalkyl Substances Considering Precursors and Supramolecular Assemblies in Unsaturated and Saturated Zones of Fire Training Areas. I. Ross. Ian Ross (Arcadis/United Kingdom)

Per- and Polyfluoroalkyl Substance (PFAS) Fate and Transport: Lessons Learned from a Monitoring Case Study in Sweden. G. Niarchos, F. Fagerlund, L. Ahrens, and D.B. Kleja. Georgios Niarchos (Uppsala University/Sweden)


PFAS Phase Behavior at Field-Relevant Concentrations: Interfaces, Desorption, and Colloids. C.E. Schaefer, V. Culina, D. Nguyen, E. Christie, and J.A. Field. Charles Schaefer (CDM Smith, Inc./USA)


* Retention and Transport of PFAS during Repeated 3% AFFF Applications to a Soil Profile. T. Wanzek, M. Kleber, and J. Field. Thomas Wanzek (Oregon State University/USA)

* A Robust PFAS Fate and Transport Model for a Chrome Plating Facility. J.M. Cuthbertson, J. Buzzell, B. Hoare, and D. Bogdan. John Cuthbertson (AECOM/USA)

Simulation of the Air Deposition Pathway to PFAS Groundwater Contamination. A. Janzen, E. Christianson, D. Dahlstrom, E. Edwalds, and R. Wuolo. Adam Janzen (Barr Engineering Company/USA)

* Substrate-Mediated Biotransformation and Biodefluorination of FTCAs by Actinomycetes. C. Wu, Q. Wang, H. Chen, and M. Li. Chen Wu (New Jersey Institute of Technology/USA)

* Unsaturated Zone Screening Model for PFAS Fate and Transport. A. Janzen, D. Dahlstrom, and E. Christianson. Adam Janzen (Barr Engineering Company/USA)


* Assessment of the Durability of Sorptive Remediation of Soils Contaminated with Per- and Polyfluorinated Alkyl Substances. S. Kabiri and M.J. McLaughlin. Shervin Kabiri (The University of Adelaide/Australia)

* Bench-Scale Testing of In Situ Stabilization and Solidification (ISS) on Multiple Soils Contaminated with Per- and Polyfluoroalkyl Substances (PFAS). D.P. Cassidy. Daniel Cassidy (Western Michigan University/USA)

* Bench-Scale Treatability Study Results for Treatment of PFOA and PFOS Commingled with Volatile Organic Compounds in Groundwater. L. Cook, J. Persons, S. Grieco, and D. Gustafson. Laura Cook (Jacobs/USA)

* Chemical Destruction of PFAS: Bench-Scale Treatability Results. R. Ball, A. Moore, D. Eberlé, and C. Ross. Raymond G. Ball (EnChem Engineering, Inc./USA)

* Colloidal Activated Carbon Used to Reduce PFAS and PCE Concentrations in Groundwater to below Detection Limits at a Michigan National Guard Site. P.B. Lyman and R. Moore. Ryan Moore (REGENESIS/USA)

Degradation and Mechanism of Hexafluoropropylene Oxide Dimer Acid by Thermally-Activated Persulfate. X. Song and X.Y. Ding. Xin Song (Chinese Academy of Sciences/China)


* Four-Year Results from a Full-Scale In Situ Program to Treat PFAS-Impacted Groundwater Using Colloidal Activated Carbon. R. McGregor. Rick McGregor (InSitu Remediation Services Ltd./Canada)


An In Situ Reactor to Treat PFAS-Contaminated Groundwater. M. Crimi and F. Laramay. Michelle Crimi (Clarkson University/USA)

PFAS Source Zone In Situ Stabilization as an Alternative Remedy to Excavation and Off-Site Disposal. A. Gupta, J. McDonough, D. Liles, A. Baumeister, and J.L. Davis. Ankit Gupta (Arcadis/USA)

Results from Six In Situ Pilot-Scale Tests for the Treatment of PFAS-Impacted Groundwater. R. McGregor. Rick McGregor (InSitu Remediation Services Ltd./Canada)


Platforms Thursday | Posters (*) Wednesday Evening
Chairs: Matthew Burns (WSP) and Rick Wice (Battelle)


* Comparison of PFAS Treatment Technologies: Results from Pilot- and Lab-Scale Experimentation. C. Bellona, T. Strathmann, C. Liu, C. Murray, and D. Knappe. Christopher Bellona (Colorado School of Mines/USA)

* Development and Lab-Scale Demonstration of a Sorbent Treatment Train for Optimal Removal of PAHs, PCBs, PFAs, and Heavy Metals. B. Parker, S. Simonich, J. Field, M. Babbar-Sebens, T. Radniecki, and G. Wilson. Bethany Parker (Oregon State University/USA)

* Effective Adsorption Removal of Short-Chain Polyfluoroalkyl and Perfluoroalkyl Substances (PFAS) Using Biochar. N. Liu and M. Li. Na Liu (New Jersey Institute of Technology/USA)

* Electrochemical-Based Coagulation and Foam Fractionation for PFAS Treatment. D. Chiang, H. Shi, J. Huang, S. Liang, and J. Zhou. Dora Chiang (CDM Smith, Inc./USA)


* Lab-Proven Total Destruction Methods for PFAS. L.E. Dejarme, J. Ellis, and K. Dasu. Lindy Dejarme (Battelle/USA)

Meet the New Heavy Lifter in a PFAS Treatment Train: Foam Fractionation. D. Burns and P. Murphy. David Burns (OPEC Systems/Australia)


Swellable Organosilica Adsorbents Optimized for PFAS Adsorption. P. Edmiston, K. Pike, H. Hartmann, M. Klonowski, E. Stebel, C. Hefner, and D. DeGena-Segal. Paul Edmiston (The College of Wooster/USA)

* Thermal Conductive Heating for PFAS Remediation. S. Eriksen and A. Schultz. Søren Eriksen (Krüger A/S/Denmark)

* Thermal Decomposition of PFAS in Simulated Investigation-Derived Wastes (IDW) and Possible Thermal Treatment Amendments. P.G. Koster van Groos, P. Hedman, A. Soto, and C. Condee. Paul Koster van Groos (APTIM/USA)
Panel Discussion—Thursday, Track D

Perspectives, Paradigm Shifts, and Implications of Evolving Developments in PFAS Chemistry, Toxicity, Transport, and Remediation

Moderator
John Simon (Nathan Associates, Inc.)

Panelists
Bill Digiuseppe, PG (Jacobs)
Elizabeth Denly (TRC)
Linda Hall, Ph.D. (GSI)
Beth Parker, Ph.D. (University of Guelph)
Dan Bryant, Ph.D., PG (Woodard & Curran)

This panel will discuss rapidly evolving developments in chemistry, toxicity, transport, and remediation of PFAS, with emphasis on potential implications of those developments on regulatory policy and common paradigms regarding how PFAS are managed.

This panel is an outgrowth of the PFAS Experts Symposium held in May 2019, from which the following key topics of discussion were drawn:

1. Regulatory and Policy Issues: Implications if PFAS are designated “hazardous substances” at the Federal level, including new Superfund sites, application of stringent state standards as ARARs, additional characterization and remediation at existing sites, reopening of closed sites, and cost renegotiation among PRPs. Technical impracticability waivers could play an increasingly important role in site management decisions due to strict cleanup objectives and limited remedial options that make remediation exceptionally costly or impracticable.

2. Chemistry and Analytics: Analytical methods continue to advance but significant gaps remain. Newly developed methods for environmental matrices have advantages but limitations and data quality issues must be recognized. TOP assay and TOF methods may be useful to scope the total PFAS impact and appropriate remedial designs.

3. Toxicology and Risk: “Replacement compounds” may be less toxic and biologically persistent than legacy PFAS but uncertainties remain regarding health effects, half-life, interspecies differences, and appropriate uncertainty factors. Given the thousands of PFAS that may be present in the environment, a more appropriate paradigm may be to develop toxicity criteria for groups of PFAS rather than individual PFAS.

4. Transport and Fate: Understanding transport and fate will require improved soil/rock/sediment extraction and analytical methods to quantify contaminant mass and flux, and better understanding of various source (input) conditions. Physicochemical properties and corresponding transport and fate characteristics of most PFAS are not well known, including branched and linear isomers of the same compound, interactions with co-contaminants, and extension of experimental results at concentrations in the tens of micrograms to milligram per liter range to the nanogram per liter range pertinent for PFAS.

5. Remediation Technologies and Research: Current technologies largely focus on separation (sorption, ion exchange, or sequestration) rather than destruction. Effective destructive treatment will likely require complex treatment trains due to the diversity of PFAS properties. Precursor transformation pathways for the available destructive technologies are not well understood, and incomplete mineralization can result in generation of more mobile and/or toxic products. A paradigm shift to receptor protection rather than aquifer restoration may be appropriate due to the lack of destructive technologies, large and low concentration plumes, conservative cleanup levels, and associated financial limitations.
Platforms Thursday | Posters (*) Wednesday Evening
Chairs: Laurie LaPat-Polasko (Matrix New World Engineering) and Shaily Mahendra (University of California, Los Angeles)

Michelle M. Lorah (U.S. Geological Survey/USA)

Jeff Roberts (SiREM/Canada)

* Characterizing PFAS-Degrading Microbial Communities in Environmental Samples Collected from Pristine and PFAS-Contaminated Areas across the United States. K.H. Kucharzyk, K. Dasu, L. Mullins, and V. Fulwider.
Kate Kucharzyk (Battelle/USA)

Defluorination of PFOA, PFOS, Its Intermediates, and Other Non-perfluorinated PFAS by Acidimicrobium sp. Strain A6. P.R. Jaffe and S. Huang.
Peter R. Jaffe (Princeton University/USA)

Dora Chiang (CDM Smith, Inc./USA)

Platforms Monday | Posters (*) Monday Evening
Chairs: James Feild (Wood) and Jason House (Woodard & Curran)

James Schuetz (Parsons/USA)

Gaelen Merritt (Matrix Solutions Inc./Canada)

* Constraining Conceptual Models to Understand Complex Sites and Estimate Long-Term Risks. O. Atteia and C. Portois. Olivier Atteia (Bordeaux University/France)


New Targets for Improving Contaminant Transport Model Calibration. A. Laase and J. Rumbaugh. Al Laase (Navarro Research and Engineering, Inc./USA)

* Numerical Modelling of Pollutant Migration and Groundwater Remediation in the Complex Hydrodynamical Conditions for the Industrial Waste Site of the Former “Stalowa Wola” Steelworks. E. Kret and M. Czop. Ewa Kret (AGH University of Science and Technology/Poland)


PHT-USG: A Module for Interfacing PHREEQC to USG-Transport. C.M. Mok, H. Mori, J. Park, H. Prommer, V. Post, S. Panday, and A. Laase. Sorab Panday (GSI Environmental/USA)


Strategies for Simulating the Complete Transport Pathways of Regional Scale, Atmospherically Dispersed Contaminants from Emissions Sources to Groundwater Receptors. E. Christianson, D. Dahlstrom, A. Janzen, J. Carter, and R. Wuolo. Adam Janzen (Barr Engineering Company/USA)


Platforms Tuesday | Posters (*) Monday Evening
Chairs: Angela Paolucci (Battelle) and Andrew Bullard (CDM Smith, Inc.)

* Application of High-Resolution Characterization Methods at a Fractured Rock Site to Develop a Three-Dimensional Distribution of Hydraulic Conductivity. J.N. Dougherty, T.W. Macbeth, and M.W. Hills. John Dougherty (CDM Smith Inc./USA)


* Designing a Treatment Solution Using High Density Site Characterization. M.J. Quimby and A.R. Taylor. Mark Quimby (SME/USA)


* Efficiently Implementing High-Resolution Site Characterization and Three-Dimensional Modeling to Improve Remedy Performance. J.D. Flattery and W.M. Flinchum. Jason Flattery (Cascade Environmental/USA)


* High-Resolution Characterization of a Source Area and Its Downgradient Plume to Optimize Full-Scale ERD Design. P.A. Lepczyk, M.D. Colvin, and C.A. Weber. Peter Lepczyk (Fishbeck, Inc./USA)

* = poster presentation
High-Resolution Delineation of Facility-Scale Subsurface Heterogeneity by Hydraulic and Geophysical Tomography. C.M.W. Mok, T.C.J. Yeh, and W.A. Illman. Chin Man W. Mok (GSI Environmental, Inc./USA)

* High-Resolution Site Characterization of a Complex Bedrock Setting with DNAPL. T.A. Harp. Thomas Harp (Remediation Risk Reduction, LLC/USA)


* LIF/UVOST Application for a Conceptual Site Model Refinement at an NAPL-Impacted Site in the South Region of Brazil. K. Campos and J. Vasconcellos. Kamilo Campos (Arcadis Brazil/Brazil)

* NAPL Investigation Approach Applying Geophysical Methods and the LIF/UVOST. K. Campos and V. Limeira. CAMILO CAMPOS (Arcadis Brazil/Brazil)

Redefinition of Hydrocarbon-Contaminated Soil Removal Based on High-Resolution Site Characterization Results. S. Souto, C. Malta, C. Chaves, M. Evald, G. Varela, M. Saturnino, and A.C. Corredori. Mateus Knabach Evald (FINKLER Ambiental/Brazil)


* Strategic Utilization of HRSC Subsurface Imaging Technologies. J.L. Castle and B. Courtney. Janet Castle (Eagle Synergistic/USA)


Use of Membrane Interface Probe Transects to Locate a Thin Perchloroethylene Plume in an Eloian Sand Aquifer. J. Berndt. James Berndt (August Mack Environmental/USA)

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Roger Brewer (Hawaii Department of Health) and Harry Craig (U.S. EPA)


* Challenges of Implementing ISM Soil Sampling for Human Health and Ecological Remedial Investigation at a Former Metals Refinery. S. Hellekson and J. Robinson. Stacey Hellekson (Woodard & Curran/USA)


Fake Data? The Need for Sampling Theory in Environmental Characterization and Remediation. R.C. Brewer. Roger Brewer (Hawaii Department of Health/USA)

Incremental Sampling Methodology Case Studies: Improved Characterization and Cleanup with ISM following Discrete Sample Collection. A. Bihler and J. Brodersen. Jason Brodersen (Tetra Tech Inc./USA)


Update on Soil Processing and Subsampling for Incremental Sampling Methodology. M.L. Bruce, J.L. Clausen, and W.E. Corl. Mark Bruce (Eurofins TestAmerica/USA)
E5. Conceptual Site Models

Platforms Wednesday | Posters (*) Wednesday Evening
Chairs: Joseph Good (Langan) and Victor Vanin Sewaybricker (GEOKLOCK)


* Case Study on Site Investigation and the Development of Robust Conceptual Site Models to Resolve Disputes. S. Luis, S. Dergham, N. Heller, and E. Arslanian. Steve Luis (Ramboll/USA)

* Conceptual Site Model Refinement to Support the Change of Use of a Former Industrial Site Impacted with Chlorinated Solvents. R. Mori, F. Gimenes, M. Scarance, L. Kimura, M. Nunes, and V. Vanin. Roberta Mori (GEOKLOCK/Brazil)


How to Combine Legacy Datasets with HRSC to Develop Flux-Based CSMs. R.J. Stuetzle, J. Nail, N. Welty, and M. Klemmer. Robert Stuetzle (Dow/USA)

* The Importance of CSM Verification: Implications for Source Identification, Monitoring, and Remediation. D. Livermore and A. Frankel. David Livermore (Integral Consulting, Inc./USA)


* New Tools for Developing Conceptual Site Models Using the Same Old Data. J. Fiacco, E. McLane, L. Mastera, A. Sandzen, and B. Shaver. R. Joseph Fiacco (ERM/USA)

* Non-target Chemicals as Source Area Tracers, Two Case Studies Using Freon 113 to Assist PCE/TCE/TCA Plume Delineation. S.R. Irvin and R.H. Christensen. Steven Irvin (Acuity Environmental Solutions, LLC/USA)


Three-Dimensional Visualization and Volumetric Analysis to Update the Conceptual Site Model for a Former Uranium Mill Site. R.D. Kent. Ronald D. Kent (Navarro Research and Engineering, Inc./USA)


Use of Geochemical and Hydraulic Analyses to Investigate and Confirm Counterintuitive Groundwater Migration Pathways and Discharge Areas at a Former MGP Site. J.L. Marolda, R.L. O’Neill, and S. Stucker. James Marolda (Brown and Caldwell/USA)

* Use of Geologic Modeling to Demonstrate Waste Unit Isolation from Groundwater. A. Wilson, E. Schwartz, and M. Sellwood. Amy Wilson (TRC/USA)

* The Value of Three-Dimensional Implicit Modeling to Support In Situ Remediation Design at a PCE-Contaminated Site. M. Tulich, A. Frankel, and S. Sherman. Mandy Tulich (Integral Consulting, Inc./USA)

Why the Geology of Washington and Oregon is Relevant to the Development of Dynamic CSMs. M. McCaughey, S. Potter, M. Killingstad, M. Cobb, and P. Kambhammettu. Matthew McCaughey (Arcadis/USA)

* = poster presentation
Monitoring tools for environmental soil and groundwater applications have advanced and improved the ability to measure contaminants, biogeochemical processes, and subsurface properties. However, integration of multiple types of monitoring data and interpretation to support understanding of the environmental setting, contaminant behavior, controlling features and processes, and remediation processes is still a challenge, especially at complex sites. Approaches that integrate predictive modeling with monitoring design and interpretation offer possibilities for improving interpretation for environmental management. Adaptive application of monitoring data collection and interpretation that is integrated with an overall site approach for management decisions may also improve the effectiveness of addressing complex site issues. This panel will discuss recent advancements in monitoring approaches and the remaining challenges associated with complex site applications and with managing a site for long-term stewardship and toward closure.
Thomas Allen Fewless (GHD/USA)

Karilyn Heisen (CDM Smith/USA)

**From 1-D to 4-D: The Importance of Spatiotemporal Analyses of the Subsurface and How to Leverage Your Existing Data.** E. Torres.
Eryn Torres (Geosyntec Consultants/USA)

Kyle Andrews (Dow, Inc./USA)

**Remediation 2.0: Using the Internet of Things on Remediation Projects.** N.R. Welty, J. Gallegos, and C. Hollister.
Nicklaus Welty (Arcadis/USA)

Amber Lee Vick (Arcadis US/USA)

**State of the Practice: Immersive Technologies in Environmental Remediation.** A. Yanites, N. Welty, and J. Horst.
Allison Yanites (Arcadis/USA)

Ankit Gupta (Arcadis/USA)

* Use of Dynamic Data Visualization Tools to Improve Remediation Outcomes at Well-Studied Sites. E. Jones and M. King.
Emily Jones (Floyd|Snider/USA)

James Depa (St. John-Mittelhauser and Associates/USA)

David Horne (Burns & McDonnell Engineering Co., Inc./USA)

Scott Blanchard (T&M Associates/USA)

**Platforms Thursday | Posters (*) Wednesday Evening**
Chairs: Nathan Hagelin (Wood) and John Sohl (Columbia Technologies, LLC)

Elliott Grunewald (Vista-Ciara, Inc./USA)

* Conceptual Site Model Development Using an Airborne Geophysical Program to Evaluate Hydrostratigraphy, Laramie County, Wyoming.** P.G. Ivancie and J. Abraham.
Paul Ivancie (Wood/USA)

Mette Algreen (Orbicon | WSP/Denmark)

Sam Falzone (Rutgers University Newark/USA)

* Drone Use Delivers Safety, Efficiency, and Cost Savings for Excavation.** J. Diamond and N. Welty.
Jason Diamond (Arcadis/USA)

Jonás García-Rincón (CSIRO/Australia)

* High-Resolution Passive Sampling to Characterize Heterogeneous Chlorinated Solvent Sites.** W.A. Jackson, U. Garz-Rubalcava, P. Hatzinger, G. Lavorgna, and D. Schanzle.
W. Andrew Jackson (Texas Tech University/USA)

Jesse Drummond (EA Engineering, Science, and Technology, Inc., PBC/USA)

Nick Teague (U.S. Geological Survey/USA)

** Nuclear Magnetic Resonance Geophysics for High-Resolution Site Characterization, CSM Refinement, and Remedial Design Optimization. B.D. Cross.**

Bradley Cross (ERM/USA)

* ORP Kit: A New Tool for Predicting Contaminant Degradation through Improved Reduction Potential Measurement. C.M.D. Kocur, D. Fan, P.G. Tratnyek, and R.L. Johnson. Chris Kocur (Oregon Health & Science University/USA)


* Understanding Chlorinated Solvent Attenuation within a Low Permeability Lacustrine Deposit. T.P. Justham and K. Kinsella. Tanya Justham (GZA GeoEnvironmental, Inc./USA)


* Using Electrochemical Analysis to Determine Environmental Reactivity and Response to Treatment. M.J. Bradley and P.G. Tratnyek. Miranda J. Bradley (Oregon Health and Science University/USA)


Using Microimaging to Understand Flow and Transformation Processes of Relevance to Groundwater Remediation. D. Wildenschild. Dorothe Wildenschild (Oregon State University/USA)

Using the MIP System with Preprobed and Grouted Holes to Enable DNAPL Source Delineation in Consolidated Granite Till. N. Larsson, F. Nilsson, A.G. Christensen, and E. Bergstedt. Nicklas Larsson (NIRAS/Sweden)

** Platforms Monday | Posters (*) Monday Evening**

Chair: Charles Newell (GSI Environmental, Inc.)


* Challenges and Alternatives of Measurement of NSZD Rates at Sites with Impervious Surfaces. J. Zimbron and M. Rousseau. Julio Zimbron (E-Flux/USA)

Developing the NSZD Conceptual Site Model: Benefits of a Multiple Lines of Evidence Approach for NSZD. J. Smith, S. Gaito, and B. Koons. Jonathon Smith (AECOM/USA)

* Evaluation and Demonstration of Techniques to Validate Natural Source Zone Depletion for LNAPL-Contaminated Sites. L. March, S. Moore, G. DeRuzzo, S. Rosansky, P. Kulkarni, B. Li, T. McHugh, and T. Lewis. Lauren March (Battelle/USA)

* Evaluation of In Situ Method to Determine Depth-Discrete Soil Thermal Conductivities at Multiple Sites for Thermal Monitoring of Natural Source Zone Depletion. P.R. Kulkarni, T.E. McHugh, G. Uhlir, and K.L. Walker. Poonam Kulkarni (GSI Environmental Inc./USA)


* In-Field Rapid Precipitation of Carbonate Minerals for Assessing Hydrocarbon Biodegradation Rates through Radiocarbon Apportionment. L. Reynolds and T. Palaia. Lindsay Reynolds (Jacobs/Canada)

* Integrating Natural Source Zone Depletion into Remediation Optimization at a Long-Term LNAPL Site. J. Wang, N. Durant, D. Fan, and C. Weber. James Wang (Geosyntec Consultants/USA)

* = poster presentation

* A Process-Based Approach to Natural and Enhanced Source Zone Depletion. P. Jourabchi, D. Mackay, and C. Meile. Parisa Jourabchi (ARIS Environmental Ltd./Canada)


Quantifying NSZD under Paved/Impervious Surfaces. A. Pennington, R. Ahlers, and E. Gates. Andy Pennington (Arcadis US, Inc./USA)


* Using Combined Lines of Evidence in LNAPL Source Depletion Estimates. G. DeVaull, E. Hinojosa, C. Bruce, and I. Rhodes. George DeVaull (Shell Global Solutions/USA)

Platforms Monday | Posters (*) Monday Evening
Chair: Brad Koons (AECOM)

F2. LNALP Recovery/Remediation Technology Transitions


Mining Valuable Data from Periodic LNAPL Recovery. A. Pennington, R. Ahlers, T. Duffy, and E. Gates. Andy Pennington (Arcadis US, Inc./USA)


Platforms Tuesday | Posters (*) Monday Evening
Chairs: George (Bud) Ivey (Ivey International, Inc.) and Eric J. Raes (Bio-Enhance)

F3. In Situ Remediation of Petroleum Hydrocarbons

Antarctic Soil Hydrocarbon Treatment with Fenton’s Reagent. S. Beal, A. Mossell, and J.L. Clausen. Jay Clausen (USACE ERDC-CRREL/USA)


* Carbonate is a Fickle Mistress: Tailoring Biostimulatory Solutions for Use in Cold-Region Calcareous Soils. A. Jimmo and S.D. Siciliano. Amy Jimmo (University of Saskatchewan/Canada)

Combining Slurry-Supported Soil Excavation, Air/Biosparging, and Enhanced Reductive Dechlorination to Accelerate Remediation of a Commingled Plume with LNAPL. M. Perlmutter, J. Persons, K. Rosebrook, M. Strong, and D. Williamson. Mike Perlmutter (Jacobs/USA)


* Degradation of Polychlorinated Biphenyl (PCB) Mixtures (Aroclors) and Petroleum Hydrocarbons in Contaminated Sediments with PCBs with Encapsulated Oxidoreductase Enzymes. K.H. Kucharzyk, E. Strozier, C. Peven, and T. Duong. Kate Kucharzyk (Battelle/USA)

* Engineering Design and Removal of Soil Impacted with TPH at Industrial Site under Deactivation. T.F. Noccetti, A.A. Faria, and U.F. Mourão. Talita Favaro Noccetti (Geoklock/Brazil)

* The Impact of Lead Co-contamination on Ecotoxicity and the Bacterial Community during the Bioremediation of Total Petroleum Hydrocarbon-Contaminated Soil. L.S. Khudur, E. Shahsavari, G.T. Webster, D. Nugegoda, and A.S. Ball. Leadin Khudur (RMIT University/Australia)

In Situ Chemical Oxidation (ISCO) of Total Petroleum Hydrocarbons. A.E. Fuse, A. Canale, and R. Kumamoto. Allan Edrick Fuse (GEOLOCK/Brazil)


* Remediation and Closure of LNAPL-Contaminated Site Using an Innovative Three-Step Approach from Remedial Design to In Situ Remediation. G. Giorgio Ceriani. Gabriele Giorgio Ceriani (Ejlskov A/S/Denmark)

Sequential In Situ Treatment of BTEX, MTBE, and TBA in an Unconfined Aquifer. R. McGregor and F. Vakili. Fatemeh Vakili (Dragun Corporation/USA)

* Soil and Groundwater Bioremediation Using ORC® and Organic Fertilizer at a Tidally-Influenced Site. H. Bentfield, S. Sadrpour, C. Ferrell, and R. Brenner. Heather Benfield (Tetra Tech, Inc./USA)

F4. TPH Risk Assessment and Metabolites

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Barrie Selcoe (Jacobs) and Usha Vedagiri (Wood)


The Biodegradation Continuum of Hydrocarbon Oxidation Products in Contaminated Aquifers Reveals the Transport of Persistent Biorefractory Compounds to Downgradient Receptors. D.C. Podgorski, P. Zito, K. Humpal, I.M. Cozzarelli, and B.A. Bekins. David Podgorski (University of New Orleans/USA)


* = poster presentation


Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Tom Palaia (Jacobs)

* Determine the Distribution of Hydraulic Conductivity and NAPL Contamination to Design Monitoring Wells to Accurately Evaluate Risk from Residual Petroleum NAPL. J.T. Wilson and W. McCall. John Wilson (Scissortail Environmental Solutions, LLC/USA)

* Evaluation of Partitioning in NAPL Saturation Estimates in a Heterogeneous Fine-Grained Site in Western Australia. E. Gatsios, J. García-Rincón, and J.L. Rayner. Jonás García-Rincón (CSIRO/Australia)

* LNAPL Risk Assessment at a Complex Site in São Paulo: An Innovative Tool for Risk-Based Management in Brazil. A.C. Chirmici, G. de Mello, and R.G. Salvi. Alyne Cetrangolo Chirmici (Ramboll Brazil/Brazil)

Managing Compositional-Based LNAPL Risk and Concerns at a Legacy Petroleum-Impacted Site in Phoenix, Arizona. R. Frank, T. Palaia, and V. Gamez Grijalva. Robert Frank (Jacobs/USA)

* Petroleum Constituent Cleanup Goals: The Lack of Science behind Using Tier 1 Soil Screening Levels for Protection of Groundwater. R. Ahlers. Rick Ahlers (Arcadis/USA)

Pivoting to a Risk-Based Response: Case Studies for Evaluating Risk from NAPL Mobility in Sediment. L.A. Reyenga and J.M. Hawthorne. Lisa Reyenga (GEI Consultants/USA)

Risk-Based LNAPL Management at the Former Willow Run Manufacturing Facility. B. Landale, M. Rousseau, and G. Trigger. Matthew Rousseau (GHD/Canada)

Unified Performance Assessment Metrics for NAPL Management. R. Muthu and A. Kirkman. Ranga Muthu (Parsons/USA)

F6. Characterization and Remediation of Heavy Hydrocarbons

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Duane Guilfoil (AST Environmental, Inc.) and Kyle Waldron (Marathon Petroleum Company)

Bioremediation and Chemical Oxidation to Treat Soil Contaminated with High Concentration Heavy Fraction Hydrocarbons in Taiwan. M.-H. Liu, C.-M. Hsiao, J.-M. Hung, and J. Leu. Min-Hsin Liu (Chaoyang University of Technology/Taiwan)

* In Situ Injection of Activated Carbon-Based Injectate to Reduce/Eliminate Gasoline and Diesel LNAPL at an Oregon Site. S. Omo and M. Mazzarese. Mike Mazzarese (AST Environmental, Inc./USA)

In Situ Smoldering Combustion (STAR) for the Treatment of Contaminated Soils: A Case Study at the Quendall Terminals Superfund Site. J. Cole, S. Moore, G. Grant, L. Kinsman, W. Ferguson, and K. Cerise. Jason Cole (Jacobs/USA)


Rapid Closure of a Heavy Crude Oil Site Using In Situ Bioremediation Technology in Low-Permeability Soil and Fractured Bedrock. T.A. Harp. Thomas Harp (Remediation Risk Reduction, LLC/USA)


* = poster presentation

* Identifying and Adjusting Design and Dosing to Account for Unknown Contaminant Mass when Installing Injection Wells. S.A. Wisher, M. Martin, and B. Linenfelser. Scott Wisher (Cascade Technical Services/USA)

In Situ Thermal Remediation of MGP Coal Tar and Water Gas Tar Using Conductive Heating to 100°C. C. Jaggie, A. Bonarrigo, S. Griepke, and B. Holderness. Christopher Jaggie (Cascade Thermal/USA)


Surfactant- and Heat-Enhanced Biodegradation of Soils from Former Manufactured Gas Plants. R. Sambrotto, A. Rance, and H. Sanchez. Ray Sambrotto (Allied Microbiota/USA)

* Lessons Learned from Surfactant-Enhanced Aquifer Remediation of Light and Dense NAPLs. D.F. Alden and G.M. Birk. David Alden (Tersus Environmental, LLC/USA)


Surfactant Enhanced Push-Pull Technique for In Situ Remediation of a Residual and Persistent TPH-Impacted Site in Malaga, Spain. R.G. Salvi, J. Perez, and P.F. Wouters. Julio Pérez (Ramboll Iberia S.L./Spain)


* Surfactant-Enhanced Aquifer Remediation of Coal Tar NAPL in an Alluvial Aquifer. D.K. Hirth and D. Craig. Daniel Hirth (BlueSphere Environmental Pty Ltd/Australia)


* Assessment of In Situ Chemical Fixation Technologies for Addressing High Arsenic Concentrations in Groundwater. D.S. Finney, K. Block, D. Williamson, and S. Coladonato. David S. Finney (Jacobs/USA)

* Combined Remedial Approach Based on Geochemical Stabilization of Copper in a Source Area and Dissolved-Phase Groundwater Plume. L. Hellerich and N. Hastings. Lucas Hellerich (Woodard & Curran/USA)

* = poster presentation


* Gravel Bed Reactors: Semi-Passive Water Treatment of Metals and Inorganics. S. Mancini, R.E. James, and E. Cox. Silvia Mancini (Geosyntec Consultants, Inc./Canada)

In Situ Remediation of Hexavalent Chromium: From Fungicide to Fruit Juice. C.W. Lenker, A. Ayysaswami, and J. Batista. Carl Lenker (Tetra Tech, Inc./USA)

In Situ Treatment of Mercury in a High Sulfate, Tidally Affected Aquifer. L. Coulibaly, K. Shiroodi, A. Seech, and D. Leigh. Alan Seech (PeroxyChem, LLC/USA)


* Remediation as Resource Recovery: Opportunities in the Copperbelt Region of Zambia. P. Chisala, C. Switzer, and J. Renshaw. Precious Chisala (University of Strathclyde/Scotland)

Seeking Solutions for Groundwater Arsenic Contamination in a Coastal Industrial Site (Southern Italy): Lab Experiments Prior to Field Trial. M. Barbieri, S. Passaretti, M. Petitta, C. Sbarbati, A. Barron, J. Sun, H. Prommer, B. Bostick, N. Colombani, M. Mastrocicco, and Y. Zheng. Marco Petitta (Università La Sapienza di Roma/Italy)

* Solidification-Stabilization of Lead and Tungsten in Firing Ranges. A. Karachalios. Antonis (Tony) Karachalios (Tetra Tech/USA)

* Stormwater Treatment of Heavy Metals, PCBs, PAHs, and PFAS through Adsorption Columns. T. Radniecki, K. Rodman and C. Kanalos. Kelly Rodman (Oregon State University/USA)


F10. Managing Chromium-Contaminated Sites

Platforms Thursday | Posters (*) Wednesday Evening
Chairs: Sandip Chattopadhyay (U.S. Environmental Protection Agency) and Bruce Sass (Geosyntec Consultants, Inc.)

* Adapting Treatment to Optimize Capture of a Hexavalent Chromium Plume in Perched Aquifer with a Discontinuous Silt Layer. P. Hsieh and T. Gray. Patrick Hsieh (Dalton Olmsted & Fugelvand, Inc./USA)

* Chemical Reduction of Hexavalent Chromium at One of the World’s Largest Former Chromite Ore Processing Facilities. J. Xiong, Y. Wu, C. Wang, and L. Kessel. John Xiong (Haley & Aldrich, Inc./USA)

Evolution of In Situ Biological, In Situ Biogeochemical and Abiotic Pilot Studies for Treatment of a Hexavalent Chromium Source Area. S. Brubaker, G. Ng, T. Simpkin, R. Barber, A. Darpinian, E. Hauber, S. Nelson, and K. Flynn. Sarah Brubaker (Jacobs/USA)


* = poster presentation
Remediation of Hexavalent Chromium in Groundwater Using In Situ Techniques in Five Countries. R.L. Olsen. Roger Olsen (CDM Smith Inc./USA)

* Removal of Chromium in Clay Soil by Oxidative Washing Remediation. J. Song, J. Wang, and J. Lu. Jun Lu (Hefei University of Technology/USA)

Strategies for Applying Remediation Technologies for Hexavalent Chromium in Soil and Groundwater. L. Hellerich. Lucas Hellerich (Woodard & Curran/USA)

* Supplemental Injection Program Targeting the Residual Cr(VI) Impacts in Bedrock and Saproilte/Bedrock Transition Zones Using Calcium Polysulfide (CaSx). Y. Kunukcu, N.M. Rabah, and J. Oliva. Yasemin Kunukcu (TRC Companies/USA)

Platforms Thursday | Posters (*) Wednesday Evening Chairs: Al Laase (Navarro Research and Engineering, Inc.) and Herb Levine (U.S. Environmental Protection Agency)


Evaluating Ongoing Contaminant Sources at a Former Uranium Mill Site: Is a 100-Year Natural Flushing Timeframe Reasonable? R.H. Johnson, R. Kent, and A.D. Tigar. Raymond Johnson (Navarro Research and Engineering, Inc./USA)


ISR Restoration Methods and Applicability to Groundwater Remediation at Abandoned Uranium Mills. B. Hendricks, P. Lemke, S. Bakken, and E. Tiepel. Bridgette Hendricks (Golder Associates Inc./USA)

* Necessary Geochemical Data for a Uranium Reactive Transport Model to Simulate Cleanup Timeframes and Achieve Site Closure at the Monticello, Utah, CERCLA Site. R.H. Johnson, R. Kent, A. Reynolds, and J. Nyman. Raymond Johnson (Navarro Research and Engineering, Inc./USA)


* Reconstructing Historical Three-Dimensional Plume Capture and Remedy Performance at a Former Uranium Mill Site. M.M. Morse, P.C. Schillig, R. Kent, P. Lemke, and A. Laase. Michael S. Morse (Navarro Research & Engineering, Inc./USA)

* Uranium Dose and Risk Modeling Using RESRAD-OFFSITE. R. Hupfer, C. Drummond, E. Granapragasam, and C. Yu. Ryan Hupfer (Drummond Carpenter, PLLC/USA)

Uranium Remediation Chemistry and Implementation Approaches. H. Emerson, J.E. Szecsody, and M.J. Truex. Michael Truex (Pacific Northwest National Laboratory/USA)

G1. Setting Cleanup Goal End Points: When Are We Done?
Platforms Monday | Posters (*) Monday Evening Chairs: Matthew Alexander (Texas A&M University-Kingsville) and Ronnie Britto (Tetra Tech, Inc.)

* Defining Cleanup Goals Based on DNAPL Mobility in Soil. M. Palmer, K. Hewlett, L. Stauch, and P. Joyce. Lynette Stauch (TRS Group, Inc./USA)

* = poster presentation
* Defining Success for In Situ Thermal Remediation with NAPL Mass beyond the Limits of Treatment. R. Boyd, D. Warren, C. Blundy, E. Crownover, and K. Novello. Daniel Warren (TRC Companies, Inc./USA)

Calibration of a Matrix Diffusion Model for Optimization of Remedial Design in a Saprolite Aquifer. M. Friedman, M. Zenker, E. Morgan, and W. Doucette. Michelle Friedman (AECOM/USA)


Large Diffuse Plume Alternative Approach to Pump and Treat /MCLs and Meeting the New EPA Accelerated Closure Directives: A Sustainable Plume Management Approach Using the Arizona WQARF Model. S.P. Zachary and E. Pigati. Scott Zachary (Haley & Aldrich, Inc./USA)

* Modeling Depletion of Mixed NAPLs to Evaluate Risk to Groundwater and Remediation Timeframe. R.K. Sillan. Randall Sillan (AECOM/USA)

Large Diffuse Plume Alternative Approach to Pump and Treat /MCLs and Meeting the New EPA Accelerated Closure Directives: A Sustainable Plume Management Approach Using the Arizona WQARF Model. S.P. Zachary and E. Pigati. Scott Zachary (Haley & Aldrich, Inc./USA)

* Modeling the Variability in Remedy Complete Attainment Due to Variable Groundwater Conditions. M.L. Alexander. Matthew Alexander (Texas A&M University-Kingsville/USA)

Using Multiple Lines of Evidence to Determine Success When Applying In Situ Thermal Remediation. A. Wagner, J. van Rossum, T. Warner, M. van den Brand, and H. Boden. Amy Wagner (TRS Europe/Netherlands)

* Using the Past to Redefine the Present: A Site-Specific Approach to Evaluating Background Soil Conditions. T.D. Johnson, S.A. Theriault, and A.B. West. Tonia Johnson (Barr Engineering Co./USA)

* A Pedagogic Tool to Test Remediation Efficiency and Compare Different Techniques and Options. O. Atteia and G. Cohen. Olivier Atteia (Bordeaux University/France)


* Successful Site Closure Where Residual Contamination Remains, by Applying Mass Flux. C. O’Farrell and S.A. Richards. Sarah Richards (Coffey/Australia)


* = poster presentation
Optimizing Remedial Systems

Platforms Tuesday | Posters (*) Monday Evening
Chairs: David Becker (U.S. Army Corps of Engineers) and Lucas Hellerich (Woodard & Curran)


* Innovative Pre-Design Characterization, Treatability Studies and Pilot Program to Redirect Remediation Strategy for Cr(VI) and TCE via a Liability Transfer Program at a Superfund Site: Part I. B.J. Lazar, Y. Kunukcu, and N.M. Rabah. Brendan Lazar (TRC Companies, Inc./USA)

* Optimization of cVOC Corrective Action Selection over 35 years. J.A. Ross, B. Kramer, J.E. Cardoso-Neto, D.G. Jackson, and K.M. Adams. Jeffrey Ross (Savannah River Nuclear Solutions, LLC/USA)


* A Project Facelift: Reevaluating the Project Strategy and Implementing Practical Cost-Saving Solutions. P.G. Robertson, S. Hatz, M. Burns, and C. Myers. Pamela Robertson (WSP/USA)


* Remedial System Operation and Maintenance is Not Cruise Control. A. Stark, B. Caldwell, and R. McCarthy. Alexandra Stark (EnSafe Inc./USA)

* Remediation System Optimization: A Life-cycle Process. S. Madabhushi and J. Waldrop. Sriram Madabhushi (Booz Allen Hamilton/USA)


* Successful Application of Long-Term Monitoring Optimization. E. Huntley, G. Rieger, C. Myers, and M. Gentoso. Erin Huntley (WSP/USA)

* Using Machine-Learning Algorithms to Accelerate Pump and Treat Options Analysis. N.M. DeNovio, J. Moreno, and W.L. Fowler. Nicole M. DeNovio (Golder Associates/USA)

Assessing Performance and Cost of Remedies

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Dirk Pohlmann (Bay West LLC) and George Walters (U.S. Air Force)

* Avoiding a cis-DCE Stall during the ERD of PCE DNAPL in Highly Weathered Shale via Biostimulation Alone. K.C. Armstrong and G. Bell. Kent Armstrong (TerraStryke Products, LLC/USA)

* Benefits of Sustainability Assessment and Implementation in Soil Vapor Extraction Projects. M. Pehlivan. Mehmet Pehlivan (Bays Environmental Remediation Management/USA)

Building a Robust Geochemical Model to Evaluate and Manage a Large, Dilute, Commingled Plume. K. Leslie, T. Macbeth, E. Ehret, J. Dougherty, M. Gamache, T. Cook, and M. Hills. Karla Leslie (CDM Smith/USA)


Keys to Success from 20 Years of Optimization. M. Barba, J. Horin, and J. Santillan. Michael Barba (Noblis/USA)

* = poster presentation
**Long-Term Limitations and Problems That Need to be Resolved during the Remediation of Chlorinated Compounds Present in Soil Gases and Soil/Groundwater Source Areas.** E.A. Council and S.M. Council.
Edward Augustus Council (Advanced Geologic Sciences, LLC/USA)

**Long-Term Trends and Site Dynamics Post ERD Injection at a VOC-Contaminated Site in Monterey, California.** A.J. Halmstad and A. Frankel.
Andrew Halmstad (Integral Consulting, Inc./USA)

Robert Kelley (Hepure/USA)

Remediation of Four Large RDX and TCE Groundwater Plumes: Optimization Efforts and Lessons Learned from 20 Years of Pump and Treat System Operation and Recent High-Resolution Source Area Characterization Results. F.E. Bales, J.R. L’Ecuyer, B.J. Brink, and M.J. Boughan.
Frank Bales (U.S. Army Corps of Engineers/USA)

Understanding a Site’s Conceptual Site Model to Prolong the Life Expectancy of an In Situ ZVI PRB. P.J. Palko and D. Schnell.
Deborah Schnell (GeoSierra Environmental, Inc./USA)

Julie Konzuk (Geosyntec Consultants/Canada)

Anna Harrington (Azimuth1/USA)

Rosialine Marques Roedel (CETREL SA/Brazil)

**Data Science: A New Approach for the Use of High-Resolution Tools.** A.F. Pessoa and V.V. Sewaybricker.
Atila Ferreira Pessoa (Geoklock/Brazil)

**Developments in Data Handling for Improvement of Site Remediation Operations and Project Financial Controls.** M.E. Packard and M. Palmer.
Mark Packard (ddms, inc./USA)

Harnessing the Power of Big Datasets to Optimize Bioremediation. D. Taggart, K. Clark, and S. Rosolina.
Dora Taggart (Microbial Insights, Inc./USA)

**Lessons Learned from the Implementation of an Automated Cloud-Based Big Data Decision Support System.** J.M. Hawthorne.
J. Michael Hawthorne (GEI Consultants, Inc./USA)

Mining Your Natural Attenuation Data with a Neural Network: Predicting Future Performance. P. Favara and J. Butner.
Paul Favara (Jacobs/USA)

No, We Don’t Have Remediation Blockchain: Separating Hyperbole from Reality in Digital Transformation. S. Burnell, N. Welty, M. Dupre, and J. Horst.
Shawn Burnell (Arcadis U.S, Inc./USA)

Halfdan Sckerl (Central Denmark Region/Denmark)

Chris Johnson (Pacific Northwest National Laboratory/USA)

Todd Kremmin (Jacobs/USA)

Jonathan Roller (ARCADIS/USA)

**Evaluation of Benzene Mass Discharge Using the Transect Method to Support Remediation System Shutdowns.** S. Stromberg and K. Waldron.
Scott Stromberg (Orion Environmental, Inc./USA)

* = poster presentation


* High-Resolution Site Characterization and 3-D Visualization and Analysis to Help Identify Potential Remedial Alternatives at a Superfund Site. K.R. Schuldt. Kristi Schuldt (Tetra Tech/USA)


G8. Chlorinated Compound Vapor Intrusion

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Michael Pound (Naval Facilities Engineering Command Southwest) and Thomas Szocinski (Land Science)

* Assessment of Risk from Chlorinated Hydrocarbon Vapor Intrusion above a Fractured Rock Aquifer, Melbourne, Australia. N. Woodford, K. Teague, and S.A. Richards. Sarah Richards (Coffey/Australia)


* Challenges of Conducting Complex Environmental Site Investigation with Sensitive Receptors to CVOC Contamination. G.D.C. Mello, P. Aronchi, J.R. Cury, and M.H. Roldan. Gustavo de Mello (Ramboll Environ/Brazil)

Crossing the Lines: How Multiple Lines of Evidence Helped and Hinder Evaluating Chlorinated Solvent VI in an Impacted Neighborhood. D.Y. Marquez and B.T. Kistner. Diana Marquez (Burns & McDonnell/USA)


* = poster presentation
* Innovative Design/Build to Address Soil Vapor to Indoor Air Threat. F.W. Blickle.
Frederick W. Blickle (Horizon Environmental Consultants, Inc./USA)

* Multi-Faceted Approach to Vapor Intrusion Assessment of Industrial Building: Differentiating Indoor Air Sources and Vapor Intrusion Pathways. J.H. Sanborn and D. Shea.
Jennifer Sanborn (Sanborn, Head & Associates, Inc./USA)

* Multiple Lines of Evidence in a Vapor Intrusion Pathway Investigation at a Large Former Manufacturing Building: Reducing the Mitigation Footprint. B. Schwie, E. Blodgett, and J. Bankston.
Brad Schwie (Barr Engineering Company/USA)

Trine Skov Jepsen (Dansk Miljørådgivning AS/Denmark)

Seeing through the Fog: Making VI Risk Decisions in the Presence of Indoor Air Sources. C. Regan and J. Hancock.
Catherine Regan (ERM/USA)

* Stakeholder Engagement with a Personal Approach: A Large-Scale Vapor Intrusion Assessment Success Story. S. Ramsden, S. Gaffin, E. Blodgett, and M. Sands.
Sara Ramsden (Barr Engineering/USA)

Jay Snyder (EA Engineering, Science, and Technology, Inc., PBC/USA)

G9. Vapor Intrusion Risk Assessment and Site Management

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Donna Caldwell (U.S. Navy) and Christopher Glenn (LANGAN)

Richard Kapuscinski (U.S. Environmental Protection Agency /USA)

Analysis of Carbon Tetrachloride in Ambient Air within the San Francisco Bay Region. J. Schaettle, S. Reinis, and J.F. Ludlow.
Jessica Schaettle (LANGAN/USA)

Harvinder Singh (AECOM/USA)

Matthew Lahvis (Shell Global Solutions/USA)

Jessica Yeager (Geosyntec Consultants/USA)

Maggie Radford (Jacobs/USA)

Incorporating Vapor Intrusion into Human Health Risk Assessments. L. Lund, J. Lowe, and M. Bedan.
Loren Lund (Jacobs/USA)

Shannon Thompson (212 Environmental Consulting, LLC/USA)

Julio Yasbek Reia (ANTEA Group/Brazil)

Karen Campbell (U.S. Navy Facilities Engineering Command Southeast/USA)

Amy Quintin (Wood/USA)

Using Radon and Thoron to Determine Attenuation Factors and Locate Entry Points in Vapor Intrusion Assessments. A. Miller.
Anthony W. Miller (Gannett Fleming, Inc./USA)

* Using U.S. EPA's PVISCREEN to Derive Vertical Screening Distance Criteria for Lead Scavengers (1,2-DCA and EDB). H. Luo, R. Kolhatkar, C. Gaule, and J. Watterson.
Hong (Emma) Luo (Chevron/USA)

* Vapor Intrusion: Where We’ve Been and Where We’re Going. M.N. Wacksman.
Mitch Wacksman (ARCADIS/USA)

* = poster presentation
**G10. Advances in Vapor Intrusion Investigations**

 Platforms Thursday | Posters (*) Wednesday Evening  
 Chairs: Elie H. Haddad (Haley & Aldrich, Inc.) and Blayne Hartman (Hartman Environmental Geoscience)

Laurent C. Levy (Jacobs/USA)

Keri Hallberg (Jacobs/USA)

Evaluating the Potential for Mercury Vapor Intrusion. N. Wanner. 
Nate Wanner (Cox-Colvin & Associates, Inc./USA)

Laurent C. Levy (Jacobs/USA)

Overcoming Shortcomings of Traditional Vapor Intrusion Sampling Approaches via Continuous Automated Monitoring and Response. B. Hartman, M.L. Kram, and C. Frescura. 
Blayne Hartman (Hartman Environmental Geoscience/USA)

* Passive Sampling for BTEX in Roadside Air and Implications for Vapor Intrusion Studies. B. Pautler, H. Groenevelt, T. McAlary, and R. Healy. 
Brent Pautler (SiREM Laboratory/Canada)

Michael Meyer (Battelle/USA)

* Post-Remedy Vapor Intrusion Evaluation for a Superfund Site in California. R.O. Devany, M.L. Stallard, and A. Verce. 
Anja Verce (Weiss Associates/USA)

Bart Eklund (AECOM/USA)

Keri Hallberg (Jacobs/USA)

Karen Gruebel (EKI Environment & Water, Inc./USA)

**G11. Vapor Intrusion Preferential Pathways**

 Platforms Thursday | Posters (*) Wednesday Evening  
 Chairs: Paul Ecker (EES Environmental Consulting, Inc.) and Lisa Goode (Geosyntec Consultants)

John Russell (Douglas Partners Pty Ltd/Australia)

Identification of Preferential Vapor Intrusion Pathways: Lessons Learned from Sun Devil Manor. C. Holton and T. McAlary. 
Chase Holton (Geosyntec Consultants, Inc./USA)

* The Importance of Sanitary Sewers as the Expected Preferential Pathway in Vapor Intrusion Evaluations. C.A. Cox. 
Craig Cox (Cox-Colvin & Associates, Inc./USA)

* Use of Temporal-Spatial Continuous Monitoring Data to Isolate Vapor Intrusion Entry Points and Assess VOC Exposure Dynamics. B.M. Kahl. 
Brian Kahl (Farallon Consulting, LLC/USA)

Richard Rago (Haley & Aldrich, Inc./USA)

Using Real-Time Data to Evaluate the Sewer Gas to Indoor Air Pathway. A.P. Friedrich and A. Wallace. 
Aaron Friedrich (ERM/USA)

Jay Clausen (USACE ERDC-CRREL/USA)

Nate Wanner (Cox-Colvin & Associates, Inc./USA)

* = poster presentation
Kristen Thoreson (REGENESIS/USA)

Sigrida Reinis (LANGAN/USA)

Peter Grant (EPRO/USA)

Rebecca Oliver (Geosyntec Consultants/USA)

Nadira Najib (Langan/USA)

Richard Rago (Haley & Aldrich, Inc./USA)

Deepa Gandhi (EKI Environment & Water, Inc./USA)

Brian Kistner (Burns & McDonnell Engineering Company, Inc./USA)

Carlo DiTullio (Arcadis/USA)

Lina Akiko Araki (GEOLOCK/Brazil)

Paul Nicholson (Geosyntec Consultants/Canada)

* Older Residential Homes: Sub-Slab Depressurization Lessons Learned for Successful Mitigation. C. Regan.
Catherine Regan (ERM/USA)

Keri Hallberg (Jacobs/USA)

Mark Quimby (SME/USA)

* VOC’s Vapor Intrusion: Practical Case of Site Management. J. Rheinbold, A. Borie, J. Senechaud, and M. Morlay.
Jerome Rheinbold (COLAS Environment/Canada)

Mike Burcham (Geosyntec Consultants/USA)

*S = poster presentation
**Environmental Forensics**

Platforms Monday | Posters (*) Monday Evening
Chair: Dora Taggart (Microbial Insights, Inc.)

*C* assays to derive degradation rates in support of MNA. M. Burns, P. Robertson, and C. Myers. Matthew Burns (WSP/USA)

Advancements in the development of nuclear magnetic resonance (NMR) as a forensics tool. D. Fallaise, J. Longstaffe, J.S. Konzuk, C. Cheyne, E.E. Mack, and B. Pautler. Brent Pautler (SiREM Laboratory/Canada)

Application of diagnostic tools to evaluate remediation performance at two petroleum hydrocarbon-contaminated sites. K. Sra, R. Kolhatkar, and E. Daniels. Kammy Sra (Chevron Energy Technology Company/USA)

* Application of selective reaction monitoring (SRM) proteomics to quantify reductive dehalogenase peptides (RDases) in microbial consortium SDC-9. K.H. Kucharzyk, J. Meisel, L. Mullins, M. Michalsen, P.B. Hatzinger, F.E. Loeffler, F. Kara Murdoch, J.T. Wilson, and J. Istok. Kate Kucharzyk (Battelle/USA)

* Challenges with petroleum spill characterization. R. Ruffolo. Ralph Ruffolo (Ontario Ministry of the Environment and Climate Change/Canada)

Compound-specific isotope analysis data visualization methods. S. Rosolina and D. Taggart. Sam Rosolina (Microbial Insights, Inc./USA)

* CSIA forensics for remediation. P.W. McLoughlin. Patrick McLoughlin (Pace Analytical/USA)

* Identifying origins of chlorinated organics during land-based and sediment investigation: Finding that silver bullet. R.J. Vitale. Rock Vitale (Environmental Standards, Inc./USA)

* Modelling study in support of forensics investigations. L.C. Boutin and A. Niazi. Louis-Charles Boutin (Matrix Solutions Inc./Canada)

Using qPCR assays for oxygenase enzymes to predict rate constants for cometabolism of TCE in aerobic groundwater. J.T. Wilson, B. Wilson, D. Taggart, B. Baldwin, D. Freedman, and J. Mills, IV. John Wilson (Scissortail Environmental Solutions, LLC/USA)

**Using Omic Approaches to Optimize Site Remediation**

Platforms Monday | Posters (*) Monday Evening
Chairs: Kate Kucharzyk (Battelle) and Mandy Michalsen (U.S. Army Corps of Engineers)

* Assessment of methyl tert-butyl ether (MTBE) degradation using metagenomics and metaproteomics. S. Fiorenza, K.H. Kucharzyk, S. Lummus, and J. Nyvall. Stephanie Fiorenza (BP/USA)


* Evaluating RDX- and HMX-biodegrading populations during bioremediation of highly-impacted soils. T.W. Macbeth, J. Wright, and R. Lamendella. Tamzen Macbeth (CDM Smith/USA)

* Fluorescent activity-based labeling of monoxygenases associated with the cometabolic transformation of contaminants of concern by *Rhodococcus rhodochrous* ATCC 21198. L. Semprini, K. Krippaehne, R. Murnane, A. Belessio, P. Celorie, M. Hyman, and W. Chen. Lewis Semprini (Oregon State University/USA)

From (bio)markers to maps: How metaomics may change our view of microbial pathways in the subsurface. S.K. De Long and K. Rossmassler. Susan De Long (Colorado State University/USA)

The future of metabolomics in environmental investigation. D. Taggart, S.R. Campagna, F.E. Loeffler, A.L. May, and S. Rosolina. Dora Taggart (Microbial Insights, Inc./USA)


* Microbial population dynamics during bioaugmentation of chlorinated ethene-contaminated sites. K. Motomura, N. Okutsu, T. Kikuchi, and T. Shiotani. Kei Motomura (Kurita Water Industries Ltd./Japan)

* = poster presentation
Casey Brown (Microbial Insights, Inc./USA)

Jeff Gamlin (Jacobs/USA)

Shawn Campagna (University of Tennessee/USA)

Platforms Tuesday | Posters (*) Monday Evening
Chair: Paul Hatzinger (APTIM)

Advances in Bio-Trap Samplers for Environmental Site Diagnostics. K. Clark, D. Taggart, and K. Sublette.
Kate Clark (Microbial Insights, Inc./USA)

* Anaerobic Remediation of BTEX. P. Santos, D. Alden, and G. Birk.
Paul Santos (Talon LPE/USA)

Kate Kucharzyk (Battelle/USA)

Francisco Barajas-Rodriguez (AECOM/USA)

Petr Kozubek (ENACON s.r.o./Czech Republic)

Eleanor Jennings (Parsons Corporation/USA)

Fadime Kara Murdoch (University of Tennessee, Knoxville/USA)

Frank Loeffler (University of Tennessee/USA)

H4. Compound-Specific Isotope Analysis

Platforms Tuesday | Posters (*) Monday Evening
Chair: Patrick McLoughlin (Pace Analytical)

Daniel Segal (Chevron/USA)

Orfan Shouakar-Stash (Isotope Tracer Technologies, Inc./Canada)

* Carbon Isotope Evidence of Abiotic and Biological Degradation of 1,2-Dibromoethane (EDB) in Field Samples. P.G. Koster van Groos, P.B. Hatzinger, G. Lavorgna, T. Kuder, and R.P. Philip.
Paul Koster van Groos (APTIM/USA)

Philip Dennis (SiREM/Canada)

Patrick McLoughlin (Pace Analytical/USA)

Elizabeth Phillips (University of Toronto/Canada)

Flavio Lima (Waterloo Brasil/Brazil)

Alex West (Barr Engineering Co./USA)

* = poster presentation
The Reliability of CSIA as One MLE in Differentiating an Indoor Source from Vapor Intrusion. S. Dergham, E. Pearson, C. Serlin, D. Rowe, and B. Hartman. Safaa Dergham (Ramboll/USA)

Site Monitoring: A Deep Dive into Compound Specific Isotope Analysis Data. S. Rosolina, D. Taggart, and M. Burns. Sam Rosolina (Microbial Insights Inc./USA)

Using Compound-Specific Isotope Analysis to Demonstrate Additional Sources and Natural Attenuation of CVOCs in Groundwater. J.A. Kowalkoski and S.S. Redding. Justin A. Kowalkoski (Roux Associates, Inc./USA)

Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Diana Cutt (U.S. Environmental Protection Agency) and Scott Wilson (REGENESIS)


* Bench-Scale Biodegradation of 1,2,3-Trichloropropane from a Dilute Aquifer Using a Dehalogenimonas-Containing Bioaugmentation Culture. M. Pompliano and S. Dworatzek. Michael Pompliano (Matrix Design Group/USA)

* Chlorinated Solvent Release: A Case Study. S. Manley. Stuart Manley (GHD/USA)


* Evaluation of a Sustainable Cometabolic Biobarrier to Treat Large Dilute Chlorinated VOC Groundwater Plumes. D.R. Lippincott, G.M. Lavorgna, B. McInturff, and J.F. Begley. David Lippincott (APTIM/USA)

Excavation, Groundwater Extraction, In Situ Bioremediation, and In Situ Chemical Oxidation to Treat Large Commingled CVOC Plumes. R.E. Mayer, J. Koelsch, K. Chambers, and M. Gunderson. Robert Mayer (APTIM Federal Services/USA)


Improved Plume and Source Characterization Highlights Challenges with Large Dilute Plume Remediation and Leads to Improved Remedies. I. Bowen, S. Garcia, M. Storck, and A. Baird. Ian Bowen (U.S. Environmental Protection Agency/USA)


Positive Trends Downgradient of In Situ Enhanced Bioremediation of PCE. E.S. Mysona and G. Ulrich. Eric S. Mysona (Parsons/USA)


Successful Use of Liquid-Phase Carbon for Groundwater Remediation at Two Superfund Sites. B. Thompson, T. Majer, J. McCusker, K. Sorenson, J. Holden, and M. Gefell. Bruce Thompson (de maximis, inc./USA)

Treatment of a New Jersey CVOC Plume in Urban Geology with Combined Remedy Approach. J.P. Chiappetta and A. Miller. Joe Chiappetta (Castleton Environmental/USA)


* Using High-Resolution Site Characterization (HRSC) and Three-Dimensional Data Visualization to Untangle Commingled Plumes. J.C. Ruf. Jason Ruf (S2C2, Inc./USA)

* = poster presentation
**Adaptive Site Management for a 115-Acre Chlorinated Solvent Plume with Two Separate Source Areas at Kennedy Space Center, Florida.** A. Chrest, R.C. Daprato, M. Burcham, and J. Langenbach. Anne M. Chrest (NASA Kennedy Space Center/USA)

**Adaptive Decision Framework for Selecting a Remedy for DNAPL Remediation.** S. Ohannessian, C. Ota, T. Macbeth, and M. Fattahipour. Sharon Ohannessian (NAVFAC Southwest/USA)

* Adaptive Remedial Design at a Former Smelter Superfund Site Results in Increased Green and Sustainable Remediation Opportunities. D.P. Earhart and S.L. Shelton. Daniel Earhart (Burns & McDonnell/USA)


* ERH Operations under Active Auto Repair Shop. L. Stauch, J. Root, W. Carroll, and J. Harrington. Lynette Stauch (TRG Group, Inc./USA)

* Investing in Data Visualization to Develop Adaptive Site Management Strategies to Streamline Site Closure at a U.S. EPA Superfund Site. J.C. Ruf and J. Orris. Jason Ruf (S2C2, Inc./USA)


* Remediation of Cr(VI)-Impacted Groundwater to Drinking Water Standards. E. Mantor, K. Houston, and F. Lenzo. Erik Mantor (Arcadis U.S., Inc./USA)

**Surface Water/Groundwater Interactions**

* 3-D Model of Surface Water as a Guiding Tool for Environmental Monitoring. T.F. Noccetti, D.D. Savio, and V.S. Ambrogi. Talita Favaro Noccetti (Geoklock/Brazil)


* Evaluation of Modeled Infiltration from Retention Ponds to Affect an Air Sparge/Soil Vapor Extraction Remediation System. K. Pasternak and J. Coll. Kevin Pasternak (ATC Group Services/USA)


* = poster presentation
Katy Lindstrom (Barr Engineering Co./USA)

Mishal Al-Johar (Arcadis-U.S., Inc./USA)

James Peale (Geosyntec Consultants/USA)

* Using Stream Geochemistry to Determine Groundwater/Surface Water Interactions at a Former Uranium/Vanadium Mill Site. A. Reynolds.
Allison Reynolds (Navarro Research and Engineering, Inc./USA)

Panel Discussion—Thursday, Track H
Investigating and Remediating a Major Chlorinated Solvent DNAPL Site
Moderator
Bruce Thompson (de maximis, inc.)

Panelists
Bernard Kueper, Ph.D., P.Eng., FNGWA (Queen's University)
Gorm Heron, Ph.D. (TRS Group)
Julie Sueker, Ph.D., PH, PE (ARCADIS)
Jeffrey Holden, PE, LSP, LEP (GEI Consultants)
Karen Lumino (U.S. EPA)—tentative

This panel will address the evolution and application of “state-of-the-art” during 25 years of investigation and remediation at the Solvents Recovery Service of New England, Inc. Superfund Site. Significant themes to be discussed include:

1. DNAPL site concepts, including avoiding NAPL zone expansion during site work, using multiple lines of evidence for source zone delineation, understanding and using bedrock structure and hydraulics, evaluating the effects of matrix diffusion, and the utility of models;
2. implementing in situ thermal remediation and assessing effects of post-treatment "residual" heat;
3. application of monitored natural attenuation to a complex, multicomponent groundwater plume;
4. optimizing long-term O&M and adaptive management to address PFAS; and,
5. effective regulatory oversight and coordination.

* = poster presentation

H8. Lessons Learned in DNAPL Source Zone Remediation

Platforms Thursday | Posters (*) Wednesday Evening
Chairs: Heather Rectanus (Geosyntec Consultants)

* Applying Electrical Resistance Heating at a Large-Scale, Low Permeability, Chlorinated Solvent-Impacted Site in China. Z. Lyu, W. Sun, L. Wei, and D. Small.
Zhengyong Lyu (Beijing GeoEnviron Engineering & Technology, Inc./China)

* Challenges and Successes of Source Zone Remediation and Groundwater Cleanup in a Heterogeneous Fluvial/Alluvial System. L.M. Smith, W. Irons, J.G. Booth, and E. Cooper.
L. Maile Smith (GSI Environmental/USA)

Leah MacKinnon (Geosyntec Consultants, Inc./Canada)

* Counting the Nines: Orders of Magnitude Reductions and Sub-PPB Targets on a Large Chlorinated Solvent Plume in Northern Italy. J. Birnstingl, P. Goria, and M. Carboni.
Jeremy Birnstingl (REGENESIS/United Kingdom)

Courtney Savoie (Maul Foster & Alongi, Inc./USA)

Todd Kremmin (Jacobs/USA)

* Evolving In Situ Bioremediation of a Former TCE Vapor Degreaser Source. C.L. Jacob and C.B. Kimmel.
Clinton Jacob (Landau Associates, Inc./USA)

* Field-Scale Demonstration of Enhanced DNAPL Dissolution during Bioremediation. A.D. Fure.
Adrian Fure (Haley & Aldrich, Inc./USA)

Stephen Dankevy (British Columbia Government/Canada)

Martin Schmidt (EHS Support/USA)

* The Value of Real-Time Data Evaluation in DNAPL Source Removal. A. Sellers, S. Maihofer, and J. Hartley. Sara Maihofer (Jacobs Engineering/USA)

Optimizing the Conceptual Site Model for an In Situ Reagent Emplacement to Treat and Control Back Diffusion of Chlorinated Solvents in a Heterogenous Aquifer. J. D’Addona, C. Savage, R. Moore, and D. Davis. John D’Addona (Environmental Consulting & Technology, Inc./USA)

Combining In Situ Chemical Reduction and Big Diameter Vertical Soil Drill as an Alternative Solution for Thermal on a Complex Site Impacted by Chlorinated Solvents (Sao Paulo, Brazil). S. Aluani, C. Spilborghs, E. Pujol, F. Tomiatti, G. Siqueira, N. Nascimento, and J. Mueller. Sidney Aluani (SGW Services/Brazil)

* Pneumatically-Enhanced Injections for Combined In Situ Chemical Reduction/Enhanced In Situ Bioremediation/Bioaugmentation. T. Tyler, B. Moran, and A. Alvaro. Edward (Ted) Tyler (Kleinfelder/USA)

Low-Permeability Zone Challenges and Case Studies


* Ex Situ Treatment of 345,000 Tonnes of Clay Soils Impacted by CVOCs Using Novel Technologies. M. Cadotte and J. Paquin. Myriam Cadotte (Sanexen Services Environnementaux/Canada)


* Application of Remote Telemetry Instrumentation to Evaluate Above Grade and Subgrade Drainage System Performance of an Inter-tidal Zone Superfund Landfill. J.R. Dickson and P. Gbolo. James Dickson (CTI and Associates, Inc./USA)

* Low-Pressure Delivery of Augmentation Agent to PCE-Contaminated Low Permeable Aquifer. P. Thomson, D. Erickson, and M. Zaluski. Patrick Thomson (Water & Environmental Technologies/USA)


* Mitigate Long-Term Back-Diffusion from Low-K Unit with Horizontal ISCO Barriers. H. Huang, D. Kistner, D. Baird, D. Knight, and J. Cibrik. He Huang (AECOM/USA)

Landfill Assessment and Remediation

* Addressing Groundwater-Surface Water Considerations at a Closed Landfill in Michigan. F.W. Blickle. Frederick W. Blickle (Horizon Environmental Consultants, Inc./USA)


* = poster presentation
In Situ Treatment of Landfill to Remove 200,000 Pounds of Contaminants in Less Than One Year. G. Geckeler, V. Burbach, and C. Morris.
Grant Geckeler (GEO/USA)

Thomas Drachenberg (Parsons Corporation/USA)

* Investigation and Remediation of Nitrates under Title 27: A Case Study at an Operating Landfill. E. Schwartz and A. Wilson.
Elizabeth Schwartz (Entera Geoscience, Inc./USA)

Sigrida Reinis (LANGAN/USA)

* Statistical Analysis as Line of Evidence for the Assessment of Vapor Intrusion in Residential Area over Landfill. A.F. Pessoa and L.A. Araki.
Atila Ferreira Pessoa (Geoklock/Brazil)

* Using a 3-D Visualization-Centered Approach to Accelerate a Landfill Cleanup. J. Jackson.
Jonah Jackson (Environmental Standards, Inc./USA)

Fractured Crystalline Bedrock: Is Thermal an Option or Are We Wrong? N. Ploug, S. Griepke, and J. Holm.
Niels Ploug (Krüger A/S/Denmark)

Scott Wisher (Cascade Technical Services/USA)

Paul Dombrowski (ISOTEC Remediation Technologies/USA)

* A Silver Lining DOES Exist for Heavy Metals Remediation at Fractured Bedrock Sites. L.G. Kessel.
Lowell Kessel (C.E.R.E.S. Corporation/USA)

* Strategy to Transition a Dilute TCE Plume at a Bedrock Site from Active In Situ Biotreatment Mode to Monitored Natural Attenuation. K. Ramanand, C. Milone, and P. Randazzo.
Karnam Ramanand (Brown and Caldwell/USA)

Alexander E. Marr (Ramboll US Corporation/USA)

Bonani Langan (Wood/USA)

Technical and Regulatory Approaches for Cleanup of Contaminated Groundwater at Test Area North at the INL. P. Johansen, M. Roddy, and N. Badrov.
Pete Johansen (Idaho DEQ/USA)

* Transitioning from Pump-and-Treat to ISCO Recirculation and MNA in a Fractured Bedrock Aquifer Impacted by TCE. D. Williamson, S. Borchert, and P. Jones.
Dean Williamson (Jacobs/USA)

* Transitioning from Pump-and-Treat to Sustainable Combined Remedies in a Fractured Bedrock Aquifer Impacted by PCE and PCBs. D. Williamson and M. Perlmutter.
Dean Williamson (Jacobs/USA)
Platforms Monday | Posters (*) Monday Evening
Chairs: David S. Lipson (HRS Water Consultants, Inc.) and Bernard Kueper (Queen's University)

* Could There Be DNAPL? Lines of Evidence in Fractured Bedrock. C. Gurr and J. Dougherty.
Chris Gurr (CDM Smith, Inc./USA)

Michael Cobb (Arcadis/USA)

Jeffrey Hale (Kleinfelder/USA)

Neven Kresic (Woodard and Curran/USA)

Christian Soares Nogueira (Worley/Brazil)

Robert D. Mutch (Mutch Associates, LLC/USA)

William Slack (FRx, Inc./USA)

Site Characterization for Remediation in Fractured Rock Settings. K. Novakowski.
Kent Novakowski (Queen's University/Canada)

Judith Leclair (Brown and Caldwell/USA)

TI Waivers in Rock? After You Target the Source Zone. G. Heron and J. Cummings.
Gorm Heron (TRS Group, Inc./USA)

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Rick Cramer (Burns & McDonnell) and J. Mark Stapleton (Noblis)

Katharine Carr (AECOM/USA)

Colin Plank (Burns & McDonnell/USA)

Murray Einarson (Haley & Aldrich, Inc./USA)

Correlating the Permeability of Specific Fracture Sets to Regional Tectonic Stresses: A Case Study from the Jurutatuba Industrial Area, Sao Paulo, Brazil. C. Payne and M. Einarson.
Charles Payne (Haley & Aldrich, Inc./USA)

D. Scott Pittenger (Norfolk Southern/USA)

* If You Miss It by a Foot, You Miss It by a Mile: The Use of Multiple Lines of Evidence to Optimize Fractured Bedrock Remediation. T.H. Darby, J.A. Quinnan, and J. Franz.
Thomas Darby (Arcadis/USA)

* Improving Remedial Outcomes: Lessons Learned from Pre-Application Assessments at 50 Sites. C. Sandefur and C. Lee.
Craig Sandefur (REGENESIS/USA)

Thomas Darby (Arcadis/USA)

Ryan Samuels (AECOM/USA)
Predicting the Feasibility of Groundwater Remediation Strategies from Depositional Systems Analysis. M.R. Shultz and C.P. Plank. Mike Shultz (Burns & McDonnell/USA)


Tools for Improving the Consideration of Geology in CSMs to Support Remediation. J.E. Rice and C. Pachon. Jim Rice (ICF/USA)

Using 3-D Visualization to Optimize Remediation Design in Complex Geologic Environments. C.S. Martin and C.M. Ross. Chris Martin (Geosyntec Consultants/USA)

I4. Depositional Environments and Stratigraphic Considerations for Remediation

Platforms Tuesday | Posters (*) Monday Evening
Chairs: Damon DeYoung (Battelle) and John Gillespie (U.S. Air Force)

* Characterizing Chlorinated Ethene Sources and Transport in a Complex Fractured Rock Aquifer Impacting Twin Cities Area Municipal Supply. D. Scheer. David Scheer (Minnesota Pollution Control Agency/USA)

Complexity and Heterogeneity in Previously Glaciated Settings: Hydrogeological Implications. E. Arnaud and T. Harvey. Emmanuelle Arnaud (University of Guelph/Canada)

* Correlating NMR and Gamma Logging to Hydraulic Testing Results for Detailed Aquifer Characterization of the Navajo Sandstone at a Former Uranium Mill Site. P.C. Schillig, M.S. Morse, R.D. Kent, P. Lemke, and A. Laase. Peter Schillig (Navarro Research & Engineering, Inc./USA)


* Geologic Controls on Vadose Zone Transport in Alluvial Settings. C.S. Alger and C. Steedman. Christopher Alger (Terraphase Engineering, Inc./USA)

Optimizing the Level of Detail in Geologic Interpretations. J.P. Brandenburg and M.D. Einarson. J.P. Brandenburg (Haley & Aldrich, Inc./USA)


* Role of Depositional Environments and Stratigraphy in Developing a Successful Remediation Strategy. T. Champion. Tom Champion (AECOM/USA)

Role of Sequence Stratigraphy in Remediation Geology: An Example from the Puchack Well Field Superfund Site, New Jersey. J. Sadeque and J. Rice. Junaid Sadeque (AECOM/USA)

* Stratigraphic Sequencing and Refinement of the Conceptual Site Model to Optimize an Existing Pump and Treat System. E.B. Dieck, R.E. Lees, and B. Bond. Eric Dieck (LANGAN/USA)


Platforms Wednesday | Posters (*) Wednesday Evening

Chairs: Beth L. Parker (University of Guelph) and Robert Stuetzle (Dow)

Conceptual Site Model for a Complex Mixed-Composition NAPL Site in Fractured Sedimentary Rock under Hydraulic Control. J.J. Frederick, P.R. Trudell, and K.J. Goldstein.
Paul R. Trudell (Louis Berger/WSP/USA)

Connectivity and Self-Organization of Heterogeneity: Lessons Learned about Transport and Remediation.
G.E. Fogg.
Graham Fogg (University of California at Davis/USA)

Christopher R. Maxwell (Stantec Consulting Services, Inc./USA)

Allan Horneman (Arcadis/USA)

* High Resolution Geological Modelling for Risk Assessment of Large Complex Landfill Sites at Hedeland, Denmark. K.E.S. Klint and B.M. Olsen.
Knud Erik Klint (Geo/Denmark)

High-Resolution Characterization of a Fractured Dolostone Municipal Aquifer to Create a Refined 3-D Conceptual Site Model with Hydrogeologic Units.
C. Skinner, B.L. Parker, P. Pehme, and J. Harman.
Chrystyn Skinner (University of Guelph/Canada)

Karla Brasaemle (TechLaw, Inc./USA)

Carlos Maldaner (G360 Institute for Groundwater Research, University of Guelph/Canada)

David Collins (Stantec/USA)

* Unraveling Complexity through Fate and Transport Numerical Simulations in a Tidally-Influenced Heterogenous, Multi-System, Density Driven Regime.
J.W. Schuetz, R.J. Stuetzle, and R.R. Wenzel.
James Schuetz (Parsons/USA)

Martin Schmidt (EHS Support/USA)

* Using Calibration Boreholes and Head Profiles to Develop Conceptual Site Models in Fractured Sedimentary Bedrock.
J. Fiacco, L. Mastera, J. Mark, and E. McLane.
R. Joseph Fiacco (ERM/USA)

Lucas Ribeiro (Jacobs/Canada)

J. Foster, W. Pence, M. Annable, J. Langenbach, A. Brey, and A. Ramsey.
Rachel Klinger (Geosyntec Consultants/USA)

* Unraveling Complexity through Fate and Transport Numerical Simulations in a Tidally-Influenced Heterogenous, Multi-System, Density Driven Regime.
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J. Foster, W. Pence, M. Annable, J. Langenbach, A. Brey, and A. Ramsey.
Rachel Klinger (Geosyntec Consultants/USA)

* = poster presentation
Panel Discussion—Wednesday, Track I

Remediation Geology, Remediation Hydrogeology, and Process-Based CSMs to Support Complex Site Remediation

Moderators
Rick Cramer (Burns & McDonnell)
Beth Parker (University of Guelph)

Panelists
Barbara Bekins (USGS)
Sophia Lee (NAVFAC EXWC)
Herb Levine (U.S. EPA, Region IX)
Jim Strunk (Dow Chemical)
John Wilson (Scissortail Environmental Solutions, LLC)

This panel will explore the relationship between geology, hydrogeology, process-based conceptual site models (CSMs), and remediation with a focus on strategic management of complex contaminated sites. Remediation geology is a recently developed workflow that emphasizes analyzing existing geologic data using facies analysis and sequence stratigraphic techniques to create more accurate three-dimensional geologic models of the subsurface. Remediation hydrogeology builds on the remediation geology workflow by hydrologically calibrating the robust geologic frameworks using high-resolution hydrologic datasets (e.g., hydraulic head, groundwater velocity, contaminant, and hydrogeochemistry profiles). These hydrologically-calibrated geologic frameworks enhance the assignment of groundwater flow and contaminant transport parameters throughout the three-dimensional volumes of interest, allowing for robust representation of advective and diffusive transport and interactions influencing contaminant behavior, i.e., process-based CSMs.

Some topics for discussion include:

- Review of the “Geologic Truths” from last year’s remediation geology panel.
- What do we need to know, when do we need to know it?
- What geology-related issues impede remediation?
  - Have you hydraulically (and hydrochemically) calibrated your geology or geologically (K, mineralogy, etc.) calibrated your groundwater hydrology?
- Matching the remedy to the geology and hydrogeology architecture (3-D spatial geometry)
- Do you know what processes are most strongly influencing (or desired changes to) site conditions?
- How do you match the scope and level of effort to the problem?
- Example of “golden spike wells” for highly complex aquifer analysis (what is the role of high-resolution data sets).
- How does hydrogeology inform the geologic model, and vice versa?

I6. Technology Transfer and Decision Analysis Tools for Environmental Restoration Applications

Platforms Wednesday | Posters (*) Wednesday Evening
Chairs: Patricia Reyes (Interstate Technology and Regulatory Council/ECOS) and Cannon Silver (CDM Smith, Inc.)

Applying Decision Support Tool to Facilitate Stakeholder Consensus on Remedial Technology Selection. C.F. Silver and T.W. Macbeth.
Cannon Silver (CDM Smith, Inc./USA)

Paul Favara (Jacobs/USA)

James Feild (Wood/USA)

* = poster presentation

* Lessons Learned in a 28-year Span of Technology Transfers. D. Taggart, S. Rosolina, and K. Clark. Dora Taggart (Microbial Insights, Inc./USA)

* Merging the Use of Mobile Form Technology and Data Analytics Dashboards to Create Efficiency and Accuracy during Investigation and Remediation of PFAS at Residential Properties. Y. Rappaport and C. Hillman. Yoav Rappaport (Parsons Corporation/USA)


* SERDP and ESTCP Technology Transfer. M. Unger. Marvin Unger (Noblis, Inc./USA)

* Use of Monte-Carlo Analysis to Evaluate Remedy Costs for Chlorinated Solvent Sites. J. Berndt. James Berndt (August Mack Environmental/USA)


* When Flying under the Radar Isn’t an Option: Effective Stakeholder Engagement Practices to Reduce Non-Technical Risks. C. Davis, P. Rusten, and J. Vaillancourt. Patty Rusten (Environmental Resources Management/USA)

Bioengineering as a Solution for Conflicting Site Cleanup and Windmill Constructions. K. Cottrell, L. Soos, and M. Wichman. Kenneth J. Cottrell (HydroGeologic, Inc./USA)

* Applying In Situ Thermal Remediation in a Complex Setting with Multiple Stakeholders. K. Cottrell, L. Soos, and M. Wichman. Kenneth J. Cottrell (HydroGeologic, Inc./USA)


Platforms Wednesday | Posters (*) Wednesday Evening Chairs: Melissa Harclerode (CDM Smith, Inc.) and Lisa McIntosh (Woodard & Curran)

Platforms Thursday | Posters (*) Wednesday Evening Chairs: Michael Singletary (U.S. Navy) and Ryan Wymore (CDM Smith, Inc.)

* Adaptive Remediation at a Complex Fractured Bedrock Site in the UK: Containment to Source Treatment. C. Couves, J. Baldock, S. Tillotson, and M. Eversman. Colette Couves (ERM/United Kingdom)

* = poster presentation

Application of Integrated Remedial Approaches to Address an Off-Site 4,000-foot 1,2-DCA Plume under Developed Properties. B. Vanderglas, D. Griffiths, R. Wenzel, R. Stuetzle, and B. Wilkinson. Brian R. Vanderglas (Parsons Corporation/USA)


* Comprehensive Closure Strategy by Removing RCRA Listing and Enhancing the Site’s Natural Dechlorination Processes. K. Ramanand, M.B. Krishnayya, J. Warburton, and J. Seracuse. Karnam Ramanand (Brown and Caldwell/USA)


The Use of Adaptive Management and High-Resolution Site Characterization to Advance Closure at a Superfund Site. R.A. Wymore, N. Smith, T. Macbeth, and M. Smith. Ryan Wymore (CDM Smith, Inc./USA)

* When is Mass Removal Enough: Remediation of a Chlorinated VOC Plume with DNAPL Source. T. Louviere, P. Hsieh, and N. Gray. Trevor Wade Louviere (Dalton, Olmsted & Fuglevand, Inc./USA)


* Putting Sustainability Metrics to Adaptive Site Management Practices. B. Collins, M. Louth, and D. Cleland. Betsy Collins (Jacobs/USA)

* Quantitative Analysis of Stakeholder Perceptions of Contaminated Area Management in Brazil. R.M. Aguiar and M. Gabriel. Rizia Aguiar (CETREL SA/Brazil)

**SURE**: A New Multi-Criteria Tool for Sustainability Assessment in Contaminated Land Risk Management and Remediation. J. Laitinen and G.L. Søndergaard. Jarno Laitinen (Ramboll/Finland)


Version 1 to Version 3.1: Lessons Learned from a Decade of SiteWise™ Use. B. Collins, K. Brickman, and P. Favara. Betsy Collins (Jacobs/USA)

I9. GSR Metrics and Resiliency Evaluations

Platforms Thursday | Posters (*) Wednesday Evening

Chairs: Paul Favara (Jacobs) and Richard L. Raymond, Jr. (Terra Systems, Inc.)

* = poster presentation
Debunking Myths about Sustainable Remediation. 
J.W.N. Smith and C.L. Bruce. 
Jonathan Smith (Shell Global Solutions/Netherlands)

Gerlinde Wolf (AECOM/USA)

James Dickson (CTI and Associates, Inc./USA)

Christopher Jackson Ritchie (Ramboll/USA)

James Bays (Jacobs/USA)

Bing-Nan Wang (SINOTECH Environmental Technology, Ltd./Taiwan)

Song Jin (University of Wyoming/USA)

Impact of Climate Change and Sea Level Rise on Remediation Sites

Platforms Thursday | Posters (*) Wednesday Evening 
Chairs: Thomas K. O’Neill (New Jersey Department of Environmental Protection) and Thomas Potter (Massachusetts Department of Environmental Protection)

Steven Giese (Brown and Caldwell/USA)

Climate Change Analysis of Remedies for Terrestrial Operable Units at Naval Base Kitsap Bremerton, Bremerton, WA. J. Gryzenia, S. McKnight, B. Mintz, G.T. Burgess, and J. Vandever. 
Steve McKnight (AECOM/USA)

* Climate Change and Cleanup: Potential Impacts to Washington State’s Contaminated Sites. C.E. Asher. 
Chance Asher (Washington State Department of Ecology/USA)

Katerina Tsitonaki (Orbicon | WSP/Denmark)

Remedy Resiliency to Extreme Weather Events. R.I. Thun. 
Roy Thun (GHD/USA)

Cathy Rockwell (Woodard & Curran/USA)

Sustainable Remediation at the Intersection of Climate Variability and Contaminated Site Management. K.A. Morris, V. Kolluru, and W. Schew. 
Kevin Morris (ERM/USA)

* = poster presentation
SHORT COURSES
Short Course Schedule

The link to register for a Short Course can be found on the Short Courses page on the Conference website.

Sunday, May 31, 8:00 a.m.-5:00 p.m. (all-day)
- ITRC: Managing PFAS Contamination at Your Site
- Applications of Stable Isotopes in Contaminant Remediation and Forensics
- * Use of Molecular and Genomic Tools for Understanding and Managing Environmental Processes

Sunday, May 31, 8:00 a.m.-12:00 noon (half-day)
- Application of Aerobic Vinyl Chloride Oxidation Processes in Contaminated Groundwater Remediation Strategies
- Delineating Subsurface Heterogeneity by Hydraulic Tomography for Effective Remediation and Monitoring
- ITRC: Optimizing Injection Strategies and In Situ Remediation Performance
- Hydrogeochemistry Made Easy for Applied Site Investigation and Remediation
- Unmanned Aerial Vehicles for Site Assessment and Characterization

Sunday, May 31, 1:00-5:00 p.m. (half-day)
- Assessing and Addressing Potential Preferential Pathways for Vapor Intrusion
- Effective Application of Multiple ITRC Guidance Documents to Hydrocarbon Sites
- Practical High-Pressure Injection: Preparation, Tools, Design, Distribution, and Evaluation Illustrated by Case Studies
- ITRC: Implementing Advanced Site Characterization Tools
- Remediation of Contaminant Mass in Low-Permeability Materials

Tuesday, June 2, 2:00-6:00 p.m. (half-day)
- ITRC: The Emerging Contaminant 1,4-Dioxane
- ITRC: Risk Communication, an Emerging Contaminants Focus

*Indicates a “laptop-required” course.
**ITRC: Managing PFAS Contamination at Your Site**

**Instructors:** Kate Emma Schlosser (New Hampshire Department of Environmental Services), Sandra Goodrow (New Jersey Department of Environmental Protection), Jennifer Field (Oregon State University), Dora Chiang (CDM Smith), Rula Deeb (Geosyntec), Stewart Abrams (Langan Engineering), Jason Conder (Geosyntec), and Mel Harclerode (CDM Smith)

**Objective:** The course will provide an overview of PFAS in the environment and the key elements for characterizing and managing PFAS-impacted sites. Case studies will be presented that demonstrate how each of these elements can be applied in the site-specific projects. The training will incorporate interactive learning experience with classroom exercise and Q&A sessions for reinforcing these course learning objectives.

**Overview:** PFAS, comprising diverse groups of fluorinated chemicals (3000+ in the global market), have been widely used since the 1950s in various military and industrial applications and consumer products. PFAS are not biodegradable and are relatively soluble in the environment. Their manufacturing and uses, without proper PFAS management and pollution controls, have made them nearly ubiquitous in the environment. Their unique characteristics also make this class of contaminants difficult to treat. In 2017-2018, the Interstate Technology & Regulatory Council (ITRC) developed six fact sheets that provide an overview on PFAS nomenclature and physical/chemical properties; sources and uses; regulatory trends; site characterization (including sampling and lab methods); fate and transport; treatment technologies; and aqueous film-forming foam (AFFF). The team is also developing a PFAS risk communications tool box and a more in-depth report on PFAS. The course will provide an overview of PFAS in the environment and the key elements for characterizing and managing PFAS-impacted sites. Attendees will be able to:

- Understand the essential knowledge on PFAS sources, uses and occurrence
- Recognize the unique aspects of PFAS sampling, analysis and data accuracy
- Develop an understanding of PFAS fate and transport
- Establish basic knowledge of PFAS uptake and bioaccumulations associated with different ecological and human receptors, and their potential toxic effects based on today's state of the science
- Evaluate treatment technologies ranging from commercially available separation and binding technologies to destruction technologies under development. Design considerations and performance evaluation will be presented for those technologies that are proven and demonstrated.

Laptops are **not required** for this course.

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**Applications of Stable Isotopes in Contaminant Remediation and Forensics**

**Instructors:** Paul Hatzinger (APTIM), R. Paul Philp (University of Oklahoma), and Paul Koster van Groos (APTIM)

**Objective:** The goal of this course is to expose environmental scientists, engineers and regulators to the use of stable isotopes as an analytical tool for monitoring the fate of a variety of different contaminants in natural environments. The application of this approach as a forensic tool to discern the origin of specific contaminants will also be covered.

**Overview:** Stable isotope analysis has emerged as a powerful analytical tool to detect, understand, and quantify biological and abiotic transformation of contaminants, including chlorinated solvents, propellants, explosives, metals, and fuel additives, among others. This technique should not be thought of as a stand-alone approach, but one that should be integrated with more conventional assessment methods. This short course will cover the basics of stable isotope analysis and provide theoretical and real-world examples of how stable isotope data can be used to help document natural attenuation and active remediation of a variety of contaminants. Recent developments in stable isotope analysis, such as the utilization of multiple isotopes to discern dominant pollutant degradation mechanisms and the application of alternative techniques, such as ICP-MS, to measure select isotopes will be discussed. Limitations of stable isotope analysis for evaluating pollutant fate will also be covered. A second main area of application for stable isotopes is forensics. This approach is relevant for materials that have both natural and synthetic sources (e.g., perchlorate and nitrate), as well as synthetic chemicals with different manufacturing or degradation histories, leading them to become isotopically distinct (e.g., chlorinated solvents). The course will examine the current state of the art in forensic evaluation of contaminants, with a specific focus on perchlorate, and distinguishing sources of chlorinated solvents during vapor intrusion studies.

Laptops are **not required** for this course.
Use of Molecular and Genomic Tools for Understanding and Managing Environmental Processes

Instructors: Philip Dennis (SiREM), Duane Graves (Geosyntec Consultants), Peter Guerra (Wood PLC), Rebecca Reiss (New Mexico Tech [Retired]), Andrea Rocha (Geosyntec Consultants), Jacques Smith (Geosyntec Consultants)

Objective: The objective of this course is to explain the molecular and genomic diagnostic tools used to investigate environmental microbiomics, providing easy to understand descriptions of currently available molecular-based tools for environmental engineers and scientists, demystifying the perceived “barrier to entry” to using and interpreting gene and genome-based techniques. The course will focus on two topics: how molecular and genomic tools can provide opportunities for environmental management and engineered remedial solutions that are unobtainable using more conventional analytical methods by providing examples of specific environmental challenges, and the potential and challenges for these methods to become standardized tools for environmental professionals.

Overview: The field of environmental microbiomics is rapidly enabling increased understanding of the interplay of microbial communities and the environment. This practice area is widely applicable, including the development of predictive models and optimizing beneficial activities in virtually any microbial system. Molecular and genomic tools are uniquely beneficial in biogeochemical stabilization of metals, monitored natural attenuation (MNA) and characterizing critical shifts in microbial populations directly related to biogeochemical reactivity and enhanced bioremediation. The methods are also applied to engineered systems, such as wastewater treatment, and for detecting surface water/groundwater interactions. Environmental microbiomic research can capture microbial community signatures that impact (or are impacted by) water quality, remediation performance, process outputs, amendment addition and other operational parameters. This is accomplished by augmenting standard whole-cell microbiological techniques with the isolation and investigation of the genetic material (i.e., DNA) from in situ microbial communities. The specific molecular or genomic strategy is dictated by the project objectives/budget and can include approaches such as polymerase chain reaction (PCR)-based screening, microarrays, next generation sequencing (i.e., 16S rRNA gene and 18S rRNA gene sequencing), and shotgun metagenomic sequencing. Each of these approaches provides differing levels of understanding of the potential metabolic capability of keystone species and/or microbial communities and functional genes. During the course, participants will be provided with the current practical use of gene and genome-based technologies, recent advances, and their limitations. Case studies will be used to demonstrate where these techniques provided diagnostic information that led to a better understanding of specific environments/scenarios, thereby guiding decision making. Participants will ultimately gain a better understanding of these technologies, how they provide enhanced understanding of the fine balance between microbial populations and environmental conditions and how they can be used to optimize remedy performance.

Laptops are required for this course.

Application of Aerobic Vinyl Chloride Oxidation Processes in Contaminated Groundwater Remediation Strategies

Instructors: Timothy Mattes (University of Iowa) and Patrick Richards (University of Iowa)

Objective: Attendees will gain a basic understanding of the physiology and genetics of aerobic vinyl chloride (VC) oxidizing bacteria and their occurrence and activity in contaminated groundwater. Attendees will also learn about the technologies used for tracking VC-oxidizing bacteria in the environment and how to interpret this information in the context of both active and monitored natural attenuation remediation strategies. An opportunity for discussion of specific site strategies will be provided.

Overview: Enhanced anaerobic bioremediation is a popular approach to clean up of chlorinated solvent-contaminated sites (usually involving groundwater contamination). The remediation goal is to convert the original solvent (e.g., PCE and/or TCE) into environmentally benign products (i.e., ethene). However, reductive dechlorination processes alone have the potential to accumulate significant amounts of VC. VC accumulation problems can be solved by adding more dechlorinating microorganisms via bioaugmentation and/or adding more electron donor to enhance reduction of VC to ethene. An alternative strategy that supports anaerobic reductive dechlorination processes is to account for the possibility that aerobic VC-oxidizing bacteria can contribute to attenuation of DCEs, and VC in contaminated groundwater, even under geochemical conditions that may appear to be anaerobic. By understanding the occurrence and activity of VC-oxidizing bacteria in groundwater systems, remediation professionals may be able to design more effective and more precise remediation strategies. This could include savings on electron donor additions and developing strategies that enhance the activity of VC-oxidizers rather than relying on a purely anaerobic bioremediation strategy.

Laptops are not required for this course.
**Sunday, May 31**  
8:00 a.m.-12:00 p.m.  

**Delineating Subsurface Heterogeneity by Hydraulic Tomography for Effective Remediation and Monitoring**

**Instructors:** Chin Man W. Mok (GSI Environmental, Inc.) and Walter Illman (University of Waterloo)

**Objective:** The course will present an overview of hydraulic tomography for high-resolution site characterization, its application to remediation and monitoring, and implementation considerations. The potential audience includes remediation managers, regulators, and environmental professionals with needs for high-resolution site characterization.

**Overview:** Inaccurate or inadequate delineation of groundwater flow fields at appropriate resolution has resulted in poor remediation performance at many recalcitrant sites with complex hydrogeology. Characterizing such sites by conventional methods is often difficult and expensive. Hydraulic tomography (HT) is a cost-effective high-resolution site characterization technique for delineating the spatial distributions of hydraulic conductivity (K) and storativity, which is critical for better management of contaminated groundwater sites. HT involves conducting a series of aquifer pumping tests by perturbing the hydraulic stresses in the subsurface differently in each test, which is analogous to hydraulically scanning the subsurface from many different angles. The complete data sets of observed hydraulic head responses over a well network are jointly analyzed. This short course will provide an overview of the technology, illustrate the data collection and analysis processes, present case studies at local- and facility-scale sites, and provide implementation and applicability evaluation guidance. In addition, this presentation will discuss HT applications to remediation reliability evaluation and optimization.

Laptops are not required for this course.

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**Sunday, May 31**  
8:00 a.m.-12:00 p.m.  

**ITRC: Optimizing Injection Strategies and In Situ Remediation Performance**

**Instructors:** Tamzen Macbeth (CDM Smith), Elizabeth Rhine (Geosyntec Consultants), David Scheer (Minnesota Pollution Control Agency), and Amy Wilson (TRC Companies Inc.)

**Objective:** The ITRC Optimizing Injection Strategies and In Situ Remediation Performance Technical Regulatory Guidance document will be presented. The document and training will guide remediation practitioners through the design and implementation of successful in situ remedies, how to quickly identify and diagnose poor performance, and the optimization of under-performing remedies. The audience includes state and federal regulators, environmental professionals, and stakeholders.

**Overview:** In situ chemical and biological treatment technologies are effective when amendments are successfully emplaced in contact with the contaminant mass. The leading causes of ineffective remedy performance are failure to adequately characterize the site, failure to account for contaminant mass storage in low permeability zones, and failure to effectively distribute amendments in low permeability materials. The focus of this short course is on remedial design characterization and the application of in situ technologies where biological and/or chemical amendments are distributed in the subsurface to treat targeted contaminant mass in porous media and fractured rock. Emphasis is given to understanding: 1. geologic and hydrogeochemical data needs (i.e., remedial design characterization); 2. spatial distribution of contaminant mass storage in low permeability material; 3. developing emplacement strategies to improve amendment distribution; 4. iterative and adaptive refinement of amendment selection, dose, and delivery; 5. performance metrics necessary for successful in situ remediation programs; 6. recognizing when to transition to monitored natural attenuation or an alternate remedy, which may require additional treatability or pilot testing; and 7. regulatory perspectives and community considerations. The course will illustrate design and optimization approaches with case studies, and will review commonly encountered field and design issues and resolutions.

Laptops are not required for this course.

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**Sunday, May 31**  
8:00 a.m.-12:00 p.m.  

**Hydrogeochemistry Made Easy for Applied Site Investigation and Remediation**

**Instructor:** George (Bud) Ivey (Ivey International, Inc.)

**Objective:** The course will present an easy to comprehend, visually driven model for understanding the technical aspects of hydrogeological contaminant chemical behavior as this pertains to conceptual site models, site investigation of vapor intrusion, soil, and groundwater investigation and improving in situ and ex situ site remediation strategies.

**Overview:** The course will introduce attendees to a new and easy to use set of hydrogeological and chemical principles to better understand and predict vapor, soil and groundwater contaminant behavior on sites. This is achieved through a visually driven and interactive hands-on presentation format in which attendees learn: water is not
H₂O but a cluster, an easy rule to predict the solubility of all contaminants, the simple cause of contaminant sorption (i.e., absorption and adsorption), that soil textures and forest density models have much in common to understand contaminant movement (transmissivity) in soil, bedrock and groundwater hydrogeological settings, and how these understandings can aid practitioners to complete better site investigations and remediation action plans. Even attendees with limited chemistry, microbiology, geology and/or hydrogeology experience will learn a new set of applied principles to easily predict the behavior of contaminants in soil, sediment, bedrock, and groundwater regimes, including water solubility, sorption potential, and how to potentially improve physical, biological and chemical availability for in situ or ex situ remediation strategies. The course will challenge conventional understandings (models) of what water and organic contaminants are, and provide three simple tools to predict their behavior in soil, bedrock and groundwater environments. In doing so, this simplifies many of the highly technical contaminant hydrogeology principles by allowing attendees a better understanding of why some contaminants dissolve in water while others do not, and why some absorb or adsorb to soil while others do not, why some more quickly than others, and why some contaminants express limited “availability” for remediation, while others do not. Attendees will leave the workshop with an applied ability to predict contaminant behavior as it affects environmental site investigation and remediation.

Laptops are not required for this course.

Sunday, May 31
8:00 a.m.-12:00 p.m.

Unmanned Aerial Vehicles for Site Assessment and Characterization

Instructor: William Stiteler (Arcadis)

Objective: This course will familiarize the student with environmental and risk assessment applications of unmanned aerial vehicles (UAVs,) and will provide an overview of the regulations governing their commercial use. A photogrammetry dataset will be provided for the students to process using 3DR Sitescan online with temporary accounts under the Arcadis-North America license.

Overview: The use of UAVs has expanded dramatically in recent years. This course will introduce remediation, assessment, and site characterization applications of this tool. Topics will include the analysis of imagery from various types of sensors, including multispectral and thermal cameras, as well as photogrammetric measurements, magnetometer analysis, and the use of UAVs for sampling the physical environment (water, vapor, etc.). The regulatory landscape governing the commercial use of UAVs will also be covered, as well as the range of available platforms and UAV tools. The course is intended for students with limited background in the use of UAVs, who wish to begin using them, or who want to learn about considerations when hiring a contractor for UAV work.

If time and conditions permit and venue permissions secured, students will have the opportunity to fly a small UAV.

Laptops are not required for this course.

Sunday, May 31
1:00-5:00 p.m.

Assessing and Addressing Potential Preferential Pathways for Vapor Intrusion

Instructors: Lila Beckley (GSI Environmental, Inc.), Thomas McHugh (GSI Environmental, Inc.), Kelly Pennell (University of Kentucky), Gina M. Plantz (Haley & Aldrich, Inc.), and Richard Rago (Haley & Aldrich, Inc.)

Objective: The course will provide comprehensive instruction on preferential pathway vapor transport considerations, with the objective that attendees will become familiar with lines of evidence for appropriately screening vapor intrusion sites with potential preferential pathways, application of sampling and analytical methods, and techniques for corrective mitigation. The course will also include a summary of a decade of case studies.

Overview: Vapor intrusion (VI) is defined as the migration of vapor-forming chemicals from sources in soil and groundwater into the indoor air of occupied buildings. In varying levels of detail, over two decades of regulatory VI guidance documents generally describe a conceptual model of VI that includes vapor-phase partitioning, diffusive transport from saturated and unsaturated vapor sources in the vadose zone, and advective and convective transport into buildings. More recently, updates include an emphasis for the investigator to also evaluate the potential for preferential pathways in VI assessments. However, there is a lack of information detailing a conceptual model of vapor transport via this pathway and correspondingly little or no guidance on how to assess preferential pathways. Accordingly, preferential pathway assessments are not currently being investigated in a consistent manner, if conducted at all. This technical course provides comprehensive instruction on preferential pathway vapor transport considerations, with the objective that attendees will become familiar with lines of evidence for appropriately screening VI sites with potential preferential pathways. Course attendees will gain an understanding of what types of subsurface conduits most commonly serve as VI preferential pathways and what sites are at greatest risk for preferential pathway VI. A preferential pathway conceptual site model will be described, including commonly identified preferential pathway contaminant entry points, vapor
transport within preferential pathways, and vapor transport from preferential pathways into buildings. Also covered are applications of sampling and analytical methods and techniques for corrective mitigation. In addition, the course will present real-life case study sites with preferential pathway VI and successful mitigation.

Laptops are not required for this course.

Sunday, May 31  
1:00-5:00 p.m.

Effective Application of Multiple ITRC Guidance Documents to Hydrocarbon Sites

Instructors: Andrew Kirkman (BP), Matthew Lahvis (Shell Global Solutions), Laura Trozzolo (TRC), and Diana Marquez (Burns & McDonnell)

Objective: The course will provide real-world case examples of technical elements identified in each of ITRC’s petroleum-related guidance documents (Total Petroleum Hydrocarbon [TPH] Risk, Light, Nonaqueous Phase Liquid [LNAPL], Petroleum Vapor Intrusion [PVI]), giving course attendees a stream-lined, high-level review and understanding of how to support technically-sound, risk-based decisions integrating these ITRC documents when assessing their own hydrocarbon sites.

Overview: Hydrocarbon-impacted sites are subject to regulations and guidance directed at petroleum vapor intrusion, total petroleum hydrocarbons in soil, and LNAPL. However, these regulations do not always acknowledge the interrelated nature of these concerns. ITRC has published guidance over the past five years to provide guidance related to each concern; however, practical integration of the concepts in each of the three guidance documents is necessary to provide a comprehensive evaluation at most petroleum hydrocarbon sites. The course will provide a high-level review of concepts presented in ITRC’s hydrocarbon-related guidance. The course invites audience participation in navigating case study examples of typical scenarios encountered at hydrocarbon sites addressing:

- Concepts of maximum extent practicable, LNAPL transmissivity, and natural source zone depletion (NSZD) to manage TPH risks.
- Risk assessment/management at former hydrocarbon sites undergoing redevelopment/land use change.
- Comprehensive conceptual site model (CSM) development to satisfy elements of all three ITRC guidance documents.

Real-world examples will illustrate how ITRC’s documents overlap in providing guidance and represent actual questions/concerns from regulators and practitioners. When all three ITRC documents are reviewed together, they can provide a beneficial roadmap to guide practitioners through successful assessment and identifying closure pathways for their own projects.

Laptops are not required for this course.

Sunday, May 31  
1:00-5:00 p.m.

Practical High-Pressure Injection: Preparation, Tools, Design, Distribution, and Evaluation Illustrated by Case Studies

Instructors: Scott Noland (Remediation Products, Inc.), Ryan Oesterreich, (Arcadis), Deborah Schnell, (GeoSierra Environmental, Inc.), and Edward Winner (Division of Waste Management Commonwealth of Kentucky)

Objective: Course participation will help attendees such as managers, regulators, and consultants make informed decisions when they plan, direct, and evaluate high-pressure injections. The course will discuss tool selection, injection techniques, and the proper applications of the same under various site conditions and with multiple amendment types, and it will describe and illustrate the same using case studies.

Overview: In situ remediation by injections of amendments has bloomed into a common practice over the last 25 years. Unfortunately, advancements in technology, techniques, and equipment, as well as knowledge of what works versus what does not work have not been effectively communicated to remediation professionals. Many misconceptions exist regarding pumps, injection tooling, flow rate, injection point grid spacing, injection pressure, how injectate moves in the subsurface, how to monitor and evaluate amendment distribution during and after injections are completed, and, finally, what quality assurance/quality control measures can be implemented and performed in the field to ensure the best outcome. This course will provide a needed, in-depth understanding of high-pressure injection, primarily in the overburden, but also in the bedrock. The course is designed to enable participants to evaluate injection work plans and to specify equipment and injection techniques best suited to a particular remediation effort. It will assist field personnel in detecting and diagnosing problems and in critically evaluating and implementing measures to overcome them. Finally, the course will address post-injection evaluation of amendment distribution and appropriate laboratory testing to monitor performance. Topics will be systematically discussed in detail during the class and illustrated using case studies. The didactic approach will be partially problem based.
A core, significant concept will be presented after which a problem from a case study will be presented. The participants will then be encouraged to solve the problem, identify the error, or oversight, to which the core concept is relevant. The purpose is to ensure that the participants recall and remember lessons many years after the course is completed.

Laptops are not required for this course.

**Sunday, May 31**
1:00-5:00 p.m.

**ITRC: Implementing Advanced Site Characterization Tools**

**Instructor:** Edward Winner (Division of Waste Management Commonwealth of Kentucky)

**Objective:** To encourage the use of advanced site characterization tools (ASCTs) in the areas of direct sensing, surface geophysics, borehole geophysics, and remote sensing and to improve the participant's ability to appropriately select and apply ASCTs. Within this objective is the introduction to the ITRC’s ASCT document, website, and training videos.

**Overview:** The course will cover four types of tools: direct-sensing tools, downhole-geophysical tools, surface-geophysical tools, and remote-sensing tools. Specific information for the appropriate application of the tools as well as the technical limitations of each tool will be discussed. Direct-sensing tools measure a parameter of interest through direct contact or precise, discrete sampling. Several of these tools are advanced into the subsurface to obtain logs of lithology or the permeability of soils or unconsolidated formations. Some tools provide logs about the presence and level of volatile organic compounds while others are used to provide information about the presence of non-aqueous phase liquids. Tools can also be combined to provide sensors for both contaminant detection and lithologic identification in one device. The course will present multiple such tools and outline their best use. Borehole and surface geophysics tools measurement contrasts in the physical properties of different materials (through active or passive detection methods), differences that are then used to infer or estimate parameters of interest. For example, contrasts observed in gamma radiation can be used to infer changes in lithology while changes in temperature in a borehole can be used to infer groundwater flow direction and velocity. Surface geophysical methods are non-intrusive and used to evaluate the subsurface over large areas. For example, electrical resistivity can be used to identify the location and contour of the bedrock surface through the overlying soil. The course will illustrate the values of these tools and offer application advice. The rising availability of inexpensive, small drones has opened new opportunities for particular types of remote sensing and has spurred the development of new technologies applicable to site characterization activities. The course will outline available technologies for such drones and their operating parameters.

Laptops are not required for this course.

Sunday, May 31
1:00-5:00 p.m.

**Remediation of Contaminant Mass in Low-Permeability Materials**

**Instructors:** David B. Gent (U.S. Army Corps of Engineers Engineer Research & Development Center), Steffen Griepke (Cascade Thermal), William Slack (FRx, Inc.), Eric J. Tollefsrud (Geosyntec Consultants), and James Wang (Geosyntec Consultants)

**Objective:** The course will provide information specifically related to remediation in low-permeability materials (e.g., clay and fractured rock), including modeling and conceptual site model development for remedial design, as well as remediation technologies suitable for such challenging materials. The potential audience includes environmental site/program managers, regulators, and remediation practitioners.

**Overview:** Topics related to challenges and benefits of remediating contaminant sources in low-permeability materials, including development of conceptual site models (CSMs) supporting remedial design, as well as processes and applications of several in situ remediation technologies particularly suitable for these challenging materials will be covered. The life-cycle of a CSM demands iterative improvement of understanding as the project proceeds, based on systematic procedures. Data gap assessment and uncertainty analysis are the structural elements in the life-cycle of a CSM, and proper management of these CSM elements is particularly challenging and critical for sites with low-permeability zones. We will examine some pitfalls in evolution of the CSM life-cycle and present examples of CSMs that have been developed to meet the design, implementation and performance assessment of increasingly sophisticated remedial technologies. The CSM discussions will have particular focus on fractured bedrock as a low-permeability medium. Various environmental fracturing technologies have been demonstrated to effectively facilitate in situ remediation of low-permeability materials. The mechanisms, techniques, and applications of environmental fracturing, including the current spectrum of proppant materials, fracture emplacement methodologies, and remedial applications will be discussed. An in-depth explanation of several thermal technologies, including thermal conductive heating (TCH), steam-enhanced extraction (SEE), and electrical resistance heating (ERH),
that are often considered as effective alternatives for low-permeability materials and bedrock will be provided. Remedial design approaches and tools, as well as guidelines for evaluating strengths and weaknesses of each technology with considerations of challenging site conditions will be considered. Electrokinetic (EK) transport of remediation amendments in the subsurface relies on ion migration and electroosmosis, which are electrochemical mechanisms relatively independent of soil’s hydraulic conductivity. Therefore, EK transport can achieve effective distribution of select amendments in low-permeability and heterogeneous subsurface formations. The fundamentals of EK technology, its engineering implementation, and example projects will be presented.

Laptops are not required for this course.

Tuesday, June 2
2:00-6:00 p.m.

ITRC: The Emerging Contaminant, 1,4-Dioxane

Instructors: Gladys Liehr (Florida Department of Health), Heather Barbare (Colorado Department of Public Health & Environment), Bill Diguiseppi (Jacobs), and Dave Adamson (GSI)

Objective: The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition working to advance the use of innovative environmental technologies and approaches. The ITRC 1,4-dioxane (1,4DX) team is comprised of subject matter experts from public and private sectors who are collaborating to produce factsheets, a technical document, as well as training on the complex subject of 1,4DX. The objective is to provide an overview of 1,4DX, the challenges associated with this set of emerging contaminants, and best practices in addressing them.

Overview: Characterization of 1,4DX sites poses challenges on several fronts. First, 1,4DX is not detected using standard volatile organic compound analytical methods, therefore most solvent sites are unaware of the high likelihood of impacts from this compound. Second, there are no field screening methods (e.g., photoionization detector) that are appropriate for assessing the level of contamination at a site without fixed laboratory analysis. This leads to slow progress in investigation because of analytical turnaround times. Third, lab analytical methods are plagued by the difficulty in separating the DX from the water samples due to its miscibility and low Henry’s Law coefficient. As a result, method detection limits are often too high to meet the low standards, especially the subpart per billion standards being promulgated in some states. Fourth, 1,4DX’s miscibility and low sorption to organic matter in soils leads to very high mobility. Plumes as long as 7 miles have been documented. This poses challenges for sites late in their lifecycle where outer wells have been abandoned and may need to be re-drilled to understand the nature and extent of 1,4DX, which can easily be present above standards at greater distances than the host chlorinated solvent from which it was released. The compound is not treated well by traditional groundwater treatment commonly (and cost effectively) applied at chlorinated solvent sites, such as carbon adsorption, air stripping, zero-valent iron chemical reduction, and anaerobic bio-stimulation. Therefore, at contaminated sites where 1,4DX is newly discovered, existing remedies will need to be supplemented or replaced and, at newly discovered sites, the selection of treatment technologies will be driven by the presence of 1,4DX. The course, led by 1,4-DX experts from state agencies and the private sector, will provide guidance on characterizing and managing 1,4-DX contamination. The training will also incorporate interactive learning with classroom exercise and Q&A sessions for reinforcing these course learning objectives.

Laptops are not required for this course.

Tuesday, June 2
2:00-6:00 p.m.

ITRC: Risk Communication, an Emerging Contaminants Focus

Instructors: Jessika Cohen (Oregon Dept. of Environmental Quality), Melissa Harclerode (CDM Smith, Inc.), and Lisa McIntosh (Woodard & Curran)

Objective: The course will provide practitioners with resources and tools to perform effective, meaningful risk communication for stakeholders impacted by environmental contamination, with a focus on the emerging contaminants poly- and per-fluoroalkyl substances (PFAS) and 1,4-dioxane. Regulators, site managers, facility owners, consultants, technology developers, and other stakeholders will all benefit from the short course instruction.

Overview: In 2017, the Interstate Technology and Regulatory Council (ITRC) assembled a team of over 300 PFAS experts from industry, academia, state and federal agencies, consulting, and the U.S. Departments of Defense and Energy. This team developed the upcoming PFAS technical guidance chapter on risk communication and, in collaboration with other ITRC teams, a risk communication toolkit for environmental issues and concerns. The ITRC Risk Communications Toolkit includes a brief overview of risk communication, walks through the steps in developing a communication plan, presents an overview of risk communication concepts, applies these principles in case studies, and includes various tools to facilitate risk communication plan development. The training will begin with a brief overview of risk communication basics, discussion on risk communication challenges at emerging contaminant cleanup sites, and an introduction to risk communication planning tools. This introductory material
will be followed by an overview of PFAS in Oregon and a case study presented by the State of Oregon Department of Environmental Quality, including lessons learned. The second portion of the course is formatted as a breakout session for participants to draft a risk communication plan for an emerging contaminant site. The instruction portion of the course will walk through the elements of a risk communication plan, pausing at each step to provide a working session for participants to: profile the issue; set Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) goals and objectives; identify communities and constraints; perform a community and stakeholder assessment; identify messages; and select communication engagement tools. The short course will close with information on risk communication strategy implementation, evaluation, and follow-up.

Laptops are not required for this course.
Learning Lab Schedule

The Learning Lab, located in the Exhibit Hall, will consist of hands-on demonstrations highlighting specific technologies, tools, and software. A schedule of the planned demonstrations as of December 12, 2019, can be seen below.

Monday, June 1

- 12:35-1:00 p.m.: 3-D Visualization and Analysis Software Demonstration
  Instructor: Thomas Cook (CDM Smith, Inc.)
  Objective: This Learning Lab will demonstrate the innovative use of 3-D visualization and analysis (3DVA) software to support the evaluation and remediation of contaminated soil, groundwater, and sediment.
  Description: Through the innovative use of 3DVA software, complex contaminated soil and groundwater remediation challenges can be resolved faster and less expensively than ever before. By incorporating all available site data into a 3DVA model, the project team is able to explore and evaluate the distribution of contamination in the subsurface to support the evaluation of the nature and extent of contamination and other activities such as remedial investigations, contaminant transport evaluations, feasibility studies and remedial design. The latest 3DVA software enables the entire project team to explore the 3-D model on their own by using either public-domain viewer software or a web browser. The desktop viewer software tools and web browser provide unprecedented access to the entire 3-D (and sometimes 4-D) datasets for project geologists, engineers, risk assessors, and decision makers to evaluate the various contaminant distribution scenarios. In addition

- 1:25-1:50 p.m.: SiteWise™: An Interactive Crash Course on Its Uses and Capabilities
- 2:15-2:40 p.m.: Remote Data Monitoring and Management for Environmental and Remediation Applications
- 3:05-3:30 p.m.: Proven Active Soil Gas Sampling Techniques for Efficient Site Characterization, Vapor Intrusion Investigation and Mitigation
- 3:55-4:20 p.m.: UV-Transparent Wells for Nondestructive Monitoring of LNAPL Distribution in the Ground Using HRSC Optical Techniques

Tuesday, June 2

- 10:05-10:30 a.m.: SOCRATES: A Web-Based Application for Environmental Data Analytics
- 10:55-11:20 a.m.: Harnessing Native Bacteria for Live In Situ Monitoring and Assessment
- 11:45 a.m.-12:10 p.m.: In Situ Remediation Optimization Calculators and Matrix: Manifolding, Radius of Influence, Chlorinated Solvent Technology
- 12:35-1:00 p.m.: 3-D Printing for Advanced Conceptual Site Models

Wednesday, June 3

- 8:25-8:50 a.m.: Automated Remote Continuous Vapor Intrusion Monitoring and Response: Streamlining Deployment Logistics
- 9:15-9:40 a.m.: Use of Magnetic Susceptibility to Map Amendment Distribution in the Subsurface
- 10:05-10:30 a.m.: Digital in the Field: Mobile and Augmented Reality Solutions for Data Collection, Quality, and Safety
- 10:55-11:20 a.m.: The Application of Indicators and Tracers for Vapor Intrusion Sampling Strategies with a Scale Building
- 11:45 a.m.-12:10 p.m.: Lab-Proven Total Destruction Methods for PFAS
- 12:35-1:00 p.m.: Defining Appropriate Application Scale to Improve In Situ Remedial Outcomes
- 1:25-1:50 p.m.: ENFOS: Artificial Intelligence and Enterprise Remediation Management System
- 2:15-2:40 p.m.: PFAS-Predict™: Demonstration of a Groundwater Transport Model for PFAS
- 3:05-3:30 p.m.: New Perspectives in the Use of Horizontal Wells for Site Assessment and Remediation
- 3:55-4:20 p.m.: Documenting In Situ Reactive Mineral Formation Using the Min-Trap™: A New Monitoring Well-Based Sampling Tool

Thursday, June 4

- 8:25-8:50 a.m.: Furthering Hydrologic Characterization by Visual Mapping of Injection Data
- 9:15-9:40 a.m.: Immobilization of PFAS in Soil: As Easy as Baking a Cake!
- 10:05-10:30 a.m.: The Optical Image Profiler (OIP) for Detection and Assessment of Fluorescent NAPLs by Direct Push Methods
- 10:55-11:20 a.m.: Groundwater Profiling with the GWP 1.75
- 11:45 a.m.-12:10 p.m.: Pathway to Remediation Success: Next-Generation Approach to Complex Contaminated Sites
- 12:35-1:00 p.m.: Decision Support Tools for Geophysical Method Selection and Go/No-Go Determinations

Monday, June 1

12:35-1:00 p.m.

3-D Visualization and Analysis Software Demonstration

Instructor: Thomas Cook (CDM Smith, Inc.)

Objective: This Learning Lab will demonstrate the innovative use of 3-D visualization and analysis (3DVA) software to support the evaluation and remediation of contaminated soil, groundwater, and sediment.

Description: Through the innovative use of 3DVA software, complex contaminated soil and groundwater remediation challenges can be resolved faster and less expensively than ever before. By incorporating all available site data into a 3DVA model, the project team is able to explore and evaluate the distribution of contamination in the subsurface to support the evaluation of the nature and extent of contamination and other activities such as remedial investigations, contaminant transport evaluations, feasibility studies and remedial design. The latest 3DVA software enables the entire project team to explore the 3-D model on their own by using either public-domain viewer software or a web browser. The desktop viewer software tools and web browser provide unprecedented access to the entire 3-D (and sometimes 4-D) datasets for project geologists, engineers, risk assessors, and decision makers to evaluate the various contaminant distribution scenarios. In addition
to internal use, the 3DVA software provides unparalleled presentation visuals for sharing site results and project team conclusions with the client, regulators, and the public. 3DVA software can also be used to help make better remedial design decisions and then present the design to project stakeholders in order to quickly reach consensus on site cleanup decisions. This Learning Lab will demonstrate some of the latest features of the 3DVA software tools using real-world site examples with an emphasis on demonstrating how the use of the 3DVA software enabled the project team to resolve complex contaminant challenges by effectively incorporating all available site data including lithology, analytical results, historic reports and cross sections, and borehole and surface geophysics into a comprehensive 3-D conceptual site model.

**Monday, June 1**
1:25-1:50 p.m.

**SiteWise™: An Interactive Crash Course on Its Uses and Capabilities**

**Instructors:** Jason McNew (EA Engineering, Science, and Technology, Inc., PBC) and Betsy Collins (Jacobs)

**Objective:** Attendees will be given an introduction on the use of SiteWise™ for calculating green and sustainable remediation (GSR) metrics in an interactive setting. Inexperienced practitioners will gain an understanding of SiteWise™ capabilities with common roadblocks encountered while experienced practitioners will learn new tips and tricks and have an opportunity to have their questions answered.

**Description:** One goal of the Sustainable Remediation Forum (SURF) is to promote the use of tools for evaluating GSR metrics associated with investigation and remedial activities. Of the tools publicly available, SiteWise™ is a common tool used by practitioners. SiteWise™ is a free, spreadsheet-based software developed by Battelle, the U.S. Navy, and the U.S. Army Corps of Engineers that calculates GSR metrics based on user inputs. SURF provided a webinar on the use of SiteWise™ in 2019 and this Learning Lab serves as another opportunity to educate practitioners on the availability and use of the software. Common examples of metrics included within SiteWise™ include greenhouse gas emissions (both on site and off site), fuel usage, and water usage. This Learning Lab will offer a demonstration of the software, from initial setup through project input and evaluation of resulting metrics. The instructors, both SURF Board Members, will demonstrate how to initiate a project and identify the various user inputs. The various categories of user inputs will be discussed and examples of common inputs will be presented. Additional information provided will include a quick review of look-up tables and data sources. Potential roadblocks and common mistakes that users may encounter will be identified. The Learning Lab will provide the users with an introductory understanding of the software capabilities to set the users up for success. Version 3.2 of the software will be utilized.

**Monday, June 1**
2:15-2:40 p.m.

**Remote Data Monitoring and Management for Environmental and Remediation Applications**

**Instructor:** Adam Hobson (In-Situ)

**Objective:** Participants will learn about recent advancements in telemetry and data management technologies that make it easier to collect data remotely, vastly expand cellular and satellite coverage, enable secure, long-term deployments through efficient power usage, and enhance the utility of the data through custom alarms and advanced analysis and management tools. For anyone who currently uses telemetry to collect water monitoring data or has avoided it because they perceive it to be difficult to use, this presentation will show them how the latest developments in environmental data transfer and management are applicable to their work.

**Description:** When most environmental and remediation professionals think of telemetry, they think complicated, expensive, and unnecessary. However, recent advances in wireless data collection and data management services have changed the game. Remote monitoring and data management is now easier and cheaper and can improve data quality while facilitating rapid decision making and reducing project costs. Learn about the latest data collection and management technologies and how they’re relevant to your applications.

**Monday, June 1**
3:05-3:30 p.m.

**Proven Active Soil Gas Sampling Techniques for Efficient Site Characterization, Vapor Intrusion Investigation, and Mitigation**

**Instructors:** Laurie Chilcote (Cox-Colvin & Associates, Inc.) and Craig Cox (Cox-Colvin & Associates, Inc.)

**Objective:** The 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 characterisation studies, the assessment of vapor intrusion potential, and the effectiveness of vapor (VOC and radon) mitigation systems. New technology provides the ability to test below vapor barriers.
Distributions in the ground. Such data density is very useful in characterizing detailed contaminant such as laser induced fluorescence (LIF), have proven critical decision points during the site lifetime. Logs using optical HRSC methods, enabling such surveys at will describe a nondestructive technique to survey boring building the LNAPL conceptual site model. This presentation will demonstrate the use of such locations, and how these surveys can shed light into the factors that affect LNAPL redistribution in the ground upon groundwater level and contaminant mass loading changes. The session will also show how these factors translate into free LNAPL thickness at a traditional monitoring well.

Tuesday, June 2
10:05-10:30 a.m.

SOCRATES: A Web-Based Application for Environmental Data Analytics

Instructor: Chris Johnson (Pacific Northwest National Laboratory)

Objective: This Learning Lab will provide a hands-on demonstration of the web-based SOCRATES software for data-driven analytics for environmental restoration sites. Using Hanford data as an example, attendees will learn how web-based tools can be used to evaluate water level data, plume dynamics, remediation systems, monitoring systems, and remotely-sensed data. Environmental professionals and site managers will benefit from this Learning Lab demonstrating the ease of access to analytics relevant to site decision-making.

Monday, June 1
3:55-4:20 p.m.

UV-Transparent Wells for Nondestructive Monitoring of LNAPL Distribution in the Ground Using HRSC Optical Techniques

Instructor: Julio Zimbron (E-Flux)

Objective: High-resolution site characterization (HRSC) tools provide detailed mapping of contaminant distributions in the ground, and detailed context information about formation features that are often heterogeneous in nature. These features have made HRSC tools very useful in building the LNAPL conceptual site model. This presentation will describe a nondestructive technique to survey boring logs using optical HRSC methods, enabling such surveys at critical decision points during the site lifetime.

Description: Ultraviolet (UV)-based surveying methods, such as laser induced fluorescence (LIF), have proven very useful in characterizing detailed contaminant distributions in the ground. Such data density is very useful in understanding LNAPL mobility, risk, and the needs of remedies at LNAPL-contaminated sites. However, these tools are normally only available on a one-time basis, due to the destructive nature of these surveys. Bored locations are normally plugged or turned into traditional monitoring wells, making the availability of such HRSC tools limited. E-Flux has developed a simple technique to transform a bored location surveyed into a monitoring port that can be repeatedly surveyed using HRSC UV-based techniques. This presentation will demonstrate the use of such locations, and how these surveys can shed light into the factors that affect LNAPL redistribution in the ground upon groundwater level and contaminant mass loading changes. The session will also show how these factors translate into free LNAPL thickness at a traditional monitoring well.
Tuesday, June 2
10:55-11:20 a.m.

Harnessing Native Bacteria for Live In Situ Monitoring and Assessment

Instructors: Megan Leigh Altizer (Microbiome Engineering) and Tim Vogel (Microbiome Engineering)

Objective: This Learning Lab will demonstrate the rapid response rate and high sensitivity of the native soil microbial community, including anode respiring bacteria, to environmental perturbations and show how this microbe can be harnessed in lieu of many traditional monitoring strategies.

Description: Advanced microbiology tools like next generation sequencing are often used in site investigations or remedies to tell us what bacteria are present and with what metabolic functions. The structure of the soil microbiome is used to infer functionality and form hypotheses about what might be occurring in situ. It is also possible to harness the soil microbiome in real time to give continuous, live updates about reactions occurring in the subsurface. This dynamic system relies on common and ubiquitous microbes like anode respiring and fermentative bacteria. Fermentative bacteria consume contaminants or additives like petroleum hydrocarbons or lactate to produce acetate. The acetate, in turn, is consumed by anode respiring bacteria, which, when part of an engineered biosensor, generate electricity. This electrical signal is a then live and continuous representation of organic carbon concentrations in situ. As remediation of petroleum hydrocarbon progresses, the electrical signal will steadily decrease. As required substrates for chlorinated solvent remediation flow through the groundwater, the electrical signal will increase. By harnessing the native soil microbial community to deliver real-time, continuous information about site conditions, decision makers can take quick action to improve the outcome of site treatment. This Learning Lab will show how the native soil microbiome can be used in a biosensor to deliver real-time information about organic carbon concentrations by demonstrating the changes in electrical signal that occur with addition of different organic carbon compounds to our biosensor setup and how interpretation of the signal may vary in different applications and how decision-makers can best utilize this technology to achieve the best results.

Tuesday, June 2
12:35-1:00 p.m.

3-D Printing for Advanced Conceptual Site Models

Instructors: Chapman Ross (Geosyntec Consultants) and Chris Martin (Geosyntec Consultants)

Objective: This Learning Lab will introduce 3-D printing technology to conference attendees and present an overview of how this novel tool can be used to visualize environmental data. Participants will have an opportunity for hands-on interaction with several 3-D printed models representing a variety of potential applications.

Description: 3-D printing is a powerful tool for creating physical models of structures that exist solely in digital form. The use of software tools to visualize digital 3-D models is becoming increasingly common, and 3-D printing is a unique and innovative way to build on this technology by facilitating hands-on interaction with environmental data. Over the last ten years, the cost of desktop 3-D printers has decreased significantly, while the options for low-cost printers expand each year, presenting new potential applications of this tool. 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 model. The 3-D model file is then “sliced” using specialized software to generate the 3-D printer tool path for each layer of the model. The printer uses this input...
Automated Remote Continuous Vapor Intrusion Monitoring and Response: Streamlining Deployment Logistics

Instructor: Mark Kram (Groundswell Technologies, Inc.)

Objective: Participants will learn how to deploy VaporSafe™ continuous automated vapor concentration and pressure monitoring to rapidly identify and confirm indoor sources of trichloroethylene (TCE) and other volatile organic compounds (VOCs), determine whether vapor intrusion is occurring, identify vapor entry locations and preferential pathways, and prevent acute toxic exposures via automated response. Participants (site managers and regulators) will become familiar with field logistical requirements, learn how to set up system components, access and navigate the web dashboard, set automated response criteria, and interpret observations.

Description: The continuous automated monitoring system is comprised of a customized laboratory-grade analytical instrument equipped with various detectors for rapidly measuring TCE, tetrachloroethylene (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 16 locations as far as 300 m from the analyzer, evaluation of spatial and temporal concentration dynamics, measurement of pressure differential and climatic data, and efficient remote data management of the hundreds of data points collected each day via Cloud-based automated data-processing, visualization, alerting, and response. The approach incorporates automated calibration runs and delivery of status reports. Data patterns generated result in the ability for site managers to quickly move to the next phase in the vapor intrusion risk management process (e.g., identify/expand correlations with natural and anthropogenic factors, determine reasonable maximum exposure concentration and risk, obtain site closure, design and confirm surgical mitigation approaches, and rapidly assess large neighborhoods, etc.). The approach is also ideal for remediation performance monitoring (e.g., preventing fugitive VOC and methane emissions during thermal and amendment applications) and for triggering actions when treatment components are depleted or require adjustment. Continuous automated monitoring and response represents a comprehensive and cost-effective risk characterization and prevention option for consultants, responsible parties and the regulatory community.

Wednesday, June 3
8:25-8:50 a.m.

Use of Magnetic Susceptibility to Map Amendment Distribution in the Subsurface

Instructors: Mark Harkness (Ramboll) and Paul Freyer (Ramboll)

Objective: This Learning Lab will demonstrate the use of magnetic susceptibility (MS) to measure amendment distribution in the subsurface, including an overview of the MS measurement technique and a “hands-on” demonstration of how MS can be applied in the field using synthetic soil cores and a hand-held MS sensor. The demonstration is appropriate for regulators, project managers, scientists and engineers, and field personnel.

Description: Achieving good distribution of amendments in the subsurface is critical to effective remediation. However, amendment distribution is not measured in many remedial applications because of the time and efforts required to gather the information and difficulty in differentiating amendments from the soil matrix. This problem is solved for amendments containing zero-valent Iron (ZVI) by use of MS, which measures iron via its strong MS signal. EHC© is one such amendment that contains micro-scale iron mixed with a plant-based organic carbon. The method has now been used to measure the distribution of EHC© in subsurface soil at a half dozen sites in a number of different soil matrices and was recently applied to determine the radius of influence of an EHC© injection program in shallow overburden soil in upstate New York. The MS meter and hand-held sensor are commercially available and can be rented for short-term use for field measurements. The MS measurements are fast, easy, and quantitative. For example, a two-person field team can measure a 5-foot plastic-lined soil core in about the same time it takes the drillers to secure the sample. The Learning Lab will include an overview of the MS measurement technique, along with a “hands-on” demonstration of how MS can be applied in the field using synthetic soil cores and a hand-held MS sensor.
Wednesday, June 3
10:05-10:30 a.m.

Digital in the Field: Mobile and Augmented Reality Solutions for Data Collection, Quality, and Safety

Instructors: Allison Yanites (Arcadis) and Nicklaus Welty (Arcadis)

Objective: To give an overview and hands-on demonstration of digital tools that can be applied today in the field, and the value realized from implementation of digital field solutions. A broad audience of project managers, technical staff, site managers, and regulators will leave with new digital solutions they can use for data collection, quality, and safety.

Description: Attendees will learn how to apply digital tools in the field to simplify decision-making, reduce costs, improve health and safety, and connect stakeholders with a hands-on demonstration of tools for (1) digital data collection, (2) on-site data visualization, and (3) hands-free communication. Digital data collection tools for recording field observations, forms, and 360-degree reality capture will be demonstrated. These tools allow creation of detail-rich virtual site models available in almost real time to remote project teams. On-site augmented reality data visualization tools will be demonstrated that transform the way we see and interact with existing environmental data in the field. The course will also show how to view geospatial environmental data like plume footprints, excavation zones, or property lines with global positioning system (GPS) on mobile devices and in augmented reality. Hands-free live-stream video-conference calls that can link staff at remote field sites with experts back in the office will be demonstrated. The video feed can be marked up and edited in real time to communicate change, resolve questions quickly, oversee tasks, and complete health and safety audits with a remote team in a highly visual and interactive way. The insights and efficiencies generated from electronic data capture, mobile applications, and remote assistance communication result in a more efficient organization.

Wednesday, June 3
10:25-11:20 a.m.

The Application of Indicators and Tracers for Vapor Intrusion Sampling Strategies with a Scale Building

Instructors: Laurent C. Levy (Jacobs), Loren Lund (Jacobs), Christopher Lutes (Jacobs), and Benjamin F. Thomson (Jacobs)

Objective: Monitoring low-cost indicators and tracers (I&T), such as differential temperature, differential pressure, and radon, has been suggested as a way to improve the representativeness of vapor intrusion (VI) sampling data by targeting sampling times on the basis of the I&T information. This Learning Lab will illustrate how I&T devices can be installed and provide a better understanding of VI concepts using a “dollhouse” scale model.

Description: The scale building is anticipated to have a realistic envelope and will serve to illustrate concepts driving VI. Innocuous materials will be used to help visualize airflow. The Learning Lab will show how to install devices such as: low-cost temperature data loggers; differential pressure data loggers/micromanometers; and consumer-grade radon detectors. As further illustration for these concepts, PowerPoint slides and/or a poster will provide examples for data processing, including: sampling time selection (including automated options); selection for sampling of rooms/structures most vulnerable to VI; mitigation system effectiveness verification, etc. After some introductory remarks, the audience will be able to view the inside of a “dollhouse” and the subslab space below it (through plexiglass), as vapor flow is generated and drawn up into the house advectively through a preferential pathway (a simulated crack in the dollhouse foundation). An ordinary floor fan will be used to simulate wind effects. A computer screen will be used to illustrate how differential temperature and differential pressure data are acquired in real time to track forces driving vapor flow.

Wednesday, June 3
11:45 a.m.-12:10 p.m.

Lab-Proven Total Destruction Methods for PFAS

Instructor: Jeffrey L. Ellis (Battelle Memorial Institute)

Objective: To demonstrate the parallel development of destruction technologies for PFAS using PFOA and PFOS as test materials prepared at the part per million levels in water.

Description: PFAS are man-made fluorinated chemicals with widespread application as performance chemicals in areas such as industrial (mist suppressant on chrome plating, cabling materials, construction, and roofing), and automobile (car paint, wiper blades, and aqueous foam forming films [AFFF]), and surface treatments including food-related, apparel, household, and personal care. The unique properties of PFAS make them persistent in the environment, thus making them the new emergent contaminants and many of them are of unknown toxicity, human health effects, and fate/transport in the environment. Realizing the unfilled need to destroy PFAS without producing harmful byproducts, Battelle is investing internal research and development dollars to explore destruction of PFAS exploiting various chemical reactions, known and available today. These chemical reactions included oxidation, abstraction, hydration, and insertion, all resulting in reduction of the PFAS into fundamental inorganic molecules that are benign to humans, fauna and flora, the
environment, and the whole world of ecology. Five different methods of PFAS destruction were proven in the laboratory: one method involves removal of PFAS as intact molecules from contaminated environments, and the four others are complete destruction of PFAS in the matrix they are found. To ensure reproducible and successful execution of this work, detailed test plans were written containing objectives, test strategies, test parameters and resources required for testing, schedule, and deliverables. Due to intellectual property considerations, the exact nature of the destruction technologies deployed and detailed results cannot be disclosed in this description but will be discussed during presentation of this work. The destruction efficiency (DE) of 99%+ has been observed in this work for both PFOA and PFOS as a mixture. In one case, 99.999999% (8 log destruction) destruction was achieved for both compounds. Evaluation of the DE was determined by noting the concentration of the starting PFOA and PFOS mixture and analyzing for their presence in the treated matrix using a well-established LC/MS/MS method with published method detection limit of 30 parts per trillion. To verify the extent of destruction, two sample preparations were made: 1) analysis of sample as received, and 2) solid phase extraction was conducted to concentrate PFOA and PFOS as well as their degradation products 250 times. The first and second preparations yielded non-detect for PFOA and PFOS and degradation products. Optimization of the methods of destruction was performed and will continually be followed through to achieve higher DE values on technologies that have not yielded destruction above 99%. The technology that yielded 8 log destruction will be applied to matrices other than water. The results of the optimization will be included in the presentation.

Wednesday, June 3
12:35-1:00 p.m.

Defining Appropriate Application Scale to Improve In Situ Remedial Outcomes

Instructors: Craig Sandefur (REGENESIS) and Chris Lee (REGENESIS)

Objective: To inform remedial designers and practitioners about the use of appropriate materials and methods to more accurately design successful in situ remediation programs. Underpinned by the emerging concepts of remediation geology, this demonstration will focus on the notion of heterogeneity and scale as a significant driver of remedial outcomes. Further discussion will include how ignoring this factor often leads to below average or underperformance.

Description: This demonstration will focus on determining the appropriate remediation scale within a site’s target treatment zone (TTZ) using a set of field assessment steps shown to improve existing design assumptions prior to application. The main reason for performing a pre-application remedial assessment step is to help define the appropriate remedial scale (e.g., lateral size, vertical thickness, hydraulic conductivity) at a level of detail that provides sufficient insight into remedial reagent quantity, application and TTZ accommodation rates and volumes necessary for successful outcomes. This demonstration uses a combination of field-based assessment methods and analysis to provide significant insights into design and injection method selection prior to application. Implementing these methods has resulted in demonstrated improvements in remedial performance outcomes. The primary focus of this demonstration will be on the use of practical methods to identify those aquifer characteristics that matter most. Identification of these aquifer characteristics can be accomplished using traditional geologic field methods and simple analysis methods. Although basic in nature, these methods provide significant insight into remedial design and application programs that are not generally available through previous field efforts. Specifically, this demonstration will focus on documentation and analysis of TTZ methods that directly improve remedial outcomes at over 50 in situ project sites. Attendees will learn:

- Why the scale of in situ remediation programs should closely match the sedimentary scale present within the TTZ
- How passive flux meter results can be leveraged to improve remedial outcomes
- Use of simple analysis methods to derive better groundwater velocities and the underlying contaminant flux
- Why modest changes in groundwater velocity estimations impact the design and outcomes of in situ reactive zones
- Which pre-application remedial assessment methods tend to have the greatest impact on successful outcomes.

Wednesday, June 3
1:25-1:50 p.m.

ENFOS: Artificial Intelligence and Enterprise Remediation Management System

Instructor: Roger Well (ENFOS, Inc.)

Objective: To explain how an enterprise remediation management information system can be used by corporations and governmental entities to predict, manage, and control environmental costs and true cost drivers. The audience that will benefit most are remediation team leaders, remediation professionals, and environmental consultants supporting them.
**Description:** ENFOS is the only web-based enterprise class software platform designed to manage the nuances and complexities of environmental remediation and liability management. ENFOS is used by the federal government, multi-national corporations, and organizations responsible for managing a portfolio of contaminated sites. The enterprise technology to be showcased includes new research and development results from the ENFOS Machine Learning Initiative. This initiative uses built-up data from thousands of remediation projects to predict future cleanup costs and to identify site attributes and risk triggers through natural language algorithms derived from years of documents, spreadsheets, and other relic electronic files through time by consultants, regulators, and other stakeholders.

**Wednesday, June 3**
**2:15-2:40 p.m.**

**PFAS-Predict™: Demonstration of a Groundwater Transport Model for PFAS**

**Instructor:** Joel R. Sminchak (Battelle)

**Objective:** To demonstrate the PFAS-Predict™ groundwater transport model. The high mobility of PFAS in the environment presents challenges for traditional groundwater transport models. In addition, the fate and transport parameters for PFAS are not well-defined. Consequently, modeling options are needed to simulate behavior of PFAS in groundwater, evaluate remediation methods, and predict the exposure pathways.

**Description:** PFAS-Predict™ is a groundwater transport model developed by Battelle to specifically simulate the groundwater transport of PFAS chemicals. The transport model is compatible with industry standard MODFLOW groundwater flow output. The PFAS-Predict™ transport code is based on the concept that dispersion in porous media includes a degree of randomness, which is especially pertinent for PFAS mobility in groundwater. The model features advection, dispersion, degradation, diffusion, sorption (first and second order, linear, Lagmuir, Freundlich), and multiple source release options (slug, continuous, disperse). The PFAS-Predict™ model can also simulate backward particle tracking to evaluate likely PFAS source locations. In this lab, a demonstration of PFAS-Predict™ will be presented outlining input parameters, model test run, model calibration, and model applications. Input Parameters - PFAS chemical properties, pertinent aquifer properties, source zone parameters were integrated into the PFAS input process. The input deck provides a ready list of the key parameters necessary to evaluate PFAS transport in groundwater. The model input was developed to address key items related to PFAS like polarity behavior, aquifer clay content, and disperse sources. In the demonstration, a PFAS-Predict™ simulation will be run showing the linkage to a MODFLOW groundwater flow model, definition of chemical properties, input of aquifer properties, and source zone parameters. The scenario has multiple PFAS sources released within a multi-layer aquifer. In the demonstration, the PFAS-Predict™ model run will be calibrated to PFAS plume site data via a general calibration to total PFOA+PFOS. The simulation calibration exhibits the variable spreading in groundwater seen in PFAS plumes. The model framework provides an option to develop empirical models tailored to PFAS groundwater plumes. The PFAS-Predict™ groundwater transport model may be used to support site characterization, risk assessment, exposure studies, and design/evaluate remedial actions. Data processing schemes were developed to port data to Virtual Reality and EarthVision 3-D visualization programs. The model complements Battelle’s PFAS analytical, toxicology, risk characterization, and remediation capabilities.

**Wednesday, June 3**
**3:05-3:30 p.m.**

**New Perspectives in the Use of Horizontal Wells for Site Assessment and Remediation**

**Instructors:** Stephen Koenigsberg (EN Rx, Inc.), Erik Piatt (EN Rx, Inc.), and Lance Robinson (EN Rx, Inc.)

**Objective:** Important new developments in deploying horizontal well systems for site assessment and remediation are now available in the environmental industry. Illuminating these options will largely benefit, and in significant ways, professionals who are responsible for resolving contaminated site issues.

**Description:** Remediation technologies can sometimes be established, but are not prevalent, for a variety of reasons; however, creative economics and process improvements can drive new applications and levels of acceptance. This is what is happening with the deployment of nested, segmented horizontal wells for site assessment and remediation. In essence, decreasing costs and “greater systems flexibility,” are two factors that have brought about a resurgence of horizontal well systems and specifically the nested, segmented designs. The latter is specifically tied to moving away from monolithic single well systems, which present certain complications for sampling and treatment. Horizontal well site profiling, with nested, segmented well systems, brings additional accuracy to assessment - especially those challenged by access issues (e.g., the built environment, secure locations, property interferences). It also provides more directed treatment operations with surgical precision. Further, conceptual site models can be significantly enhanced with better information on the presence of contamination and, depending on the situation, provide economic advantages in remedy deployment. Finally, this technological advancement creates a new paradigm in contrast, or rather as an adjunct, to vertical profiling and high-resolution site characterization. It opens up a new strategic approach that can be called...
high-resolution contaminant distribution, with discretized data sets that illuminate the full scope of site impacts. Vertebræ™ Systems are one option to deploying the advantages cited and have a smaller and more compact design with shorter drilling setback requirements providing economic incentives. Also, an important feature for any horizontal well system, such as Vertebræ, is that one horizontal unit can be the equivalent of about a dozen vertical wells, depending on variable site conditions; guidance software will be demonstrated. Specialty applications for vapor intrusion mitigation and leak detection at active storage/distribution operations will also be discussed.

Wednesday, June 3
3:55-4:20 p.m.

Documenting In Situ Reactive Mineral Formation Using the Min-Trap™: A New Monitoring Well-Based Sampling Tool

Instructor: Dora Taggart (Microbial Insights, Inc.)

Objective: Participants will gain a practical understanding of how and when to use an innovative new tool called the Min-Trap™ to assess in situ reactive mineral formation. The presentation will introduce the technology, explain how Min-Traps™ can be adapted for different applications, provide practical guidance on deployment and sampling techniques, summarize available analytical methods, and showcase data from field applications.

Description: In situ remediation strategies for chlorinated solvents are increasingly being designed to harness the reducing power stored in reactive minerals to facilitate abiotic contaminant transformation. In addition, many in situ treatment approaches for metal contaminants rely on the sequestration of the target contaminant within a precipitated mineral phase. However, cost-effective tools to evaluate and document these treatment processes in field applications are currently limited. While the analytical techniques to characterize reactive minerals are well developed, collection of samples to evaluate in situ mineral formation means costly drilling is required. A simple and cost-effective approach for the collection of samples to directly confirm the formation of these reactive minerals in situ without the need for drilling is needed. A novel approach to monitoring the formation of reactive minerals has been developed that provides direct evidence of reactive mineral formation within an aquifer matrix without the need for drilling. The Mineral Trap (or Min-Trap™) is a passive sampling device that is deployed within a conventional monitoring well. Porous medium contained within the Min-Trap™ provides a carrier substrate upon which target minerals can form passively. Analysis of the solid phase media within the Min-Trap™ through chemical, microscopic, or spectroscopic means gives direct evidence of the formation of target minerals in situ while avoiding the challenges associated with traditional drilling-based sampling techniques. This low cost, monitoring well-based approach is a significant addition to the monitoring toolbox, with which practitioners can document reactive mineral formation in situ and obtain conclusive data to evaluate degradation capacity, support remedy optimization, and/or facilitate natural attenuation evaluations.

Thursday, June 4
8:25-8:50 a.m.

Furthering Hydrologic Characterization by Visual Mapping of Injection Data

Instructors: Doug Davis (REGENESIS) and Andrew Kavanagh (REGENESIS)

Objective: This course will showcase the use of largely unexplored yet abundant data collected during in situ remediation projects to greatly enhance the understanding of site hydraulic conditions, and thereby achieve a successful remedy and a more rapid site closure. The audience that would benefit most from the material is remediation practitioners, site managers, and remediation design engineers.

Description: Among remediation practitioners it is a known truth: there isn’t sufficient understanding of the hydrology before implementing a remediation project. However, there is a largely unexplored yet abundant data mine collected during in situ remediation projects that can greatly enhance the understanding of hydraulic conditions. When used properly in conjunction with an adaptive remediation approach, a successful remedy and a more rapid site closure can be assured. One of the common methods employed for the injection of remediation fluids is pumping through drilling rods advanced by a direct push rig. When done correctly, flow rates, pressure responses and applied volumes are recorded for a given vertical interval as fluids are injected. Through the relationship between an applied pumping (i.e., flow) rate and the formation pressure response, a relative permeability can be derived for a given volume or, unit of treatment. These permeability units can then be plotted, and visual enhancement applied to create a cross-sectional picture of the subsurface hydrological architecture. When viewed in real time during injection, these pictures are a useful aid in properly directing remedial fluids to the target contaminant flux zones. Once completed, they can often greatly enhance the hydraulic understanding at a project site due to the density of data that are often collected during injection. A case study will be presented to demonstrate how this approach was used to overcome a challenging heterogeneous environment during installation of a permeable reactive barrier utilizing a liquid activated carbon substrate to cut off migration of chlorinated solvents from an industrial facility into a residential area. This led to a more optimal directing of remedial fluids, a better understanding of the more discrete nature of the permeable channels and a successful remedy implementation. The site
is in the performance monitoring stage and is currently on track for closure.

**Thursday, June 4**  
9:15-9:40 a.m.  

**Immobilization of PFAS in Soil: As Easy as Baking a Cake!**  

**Instructor:** Richard Stewart (Ziltek Pty., Ltd.)  

**Objective:** The audience will learn how to immobilize PFAS in soil using a “cooking show” style demonstration to show the simplicity of the process. Anyone involved in PFAS soil remediation will benefit from the demonstration including consultants, remediation practitioners, site owners, government bodies and regulators.

**Description:** Leaching of PFAS from contaminated soil can lead to health and environmental harm through transfer into groundwater, surface water and drinking water sources. A number of commercial adsorbents have been shown to bind up or immobilize PFAS in soil to prevent leaching. Soil immobilization is a simple process, which involves adding adsorbents at between 1% and 3% by weight, mixing with the addition of water, and waiting 24 hours for fixation to occur. The demonstration will use a ‘cooking show style’ platform to show how easy the process is. A mixed media approach will also use PowerPoint to demonstrate the scale-up process based on full-scale case studies from Sweden and Australia. The full-scale treatment process will be presented in an easy to follow step-by-step presentation showing all aspects of the process from the preprocessing of soils to the final validation sampling procedures. Data will also be presented from independent studies conducted by Airport Authorities and Universities that show the long-term stability and sustainability of the binding reaction. Soil immobilization is a popular remediation choice for PFAS-contaminated soil because many traditional remediation approaches are either not feasible, or are uneconomical, due to the inherent stability of the PFAS chemistry.

**Thursday, June 4**  
10:05-10:30 a.m.  

**The Optical Image Profiler (OIP) for Detection and Assessment of Fluorescent NAPLs by Direct Push Methods**  

**Instructors:** Wesley McCall (Geoprobe Systems), Thomas Christy (Geoprobe Systems), Dan Pipp (Geoprobe Systems), and Ben Jaster (Geoprobe Systems)  

**Objective:** Operation of the OIP probe and system will be conducted during the lab with data and images of fluorescent products/wastes presented onscreen. The user-friendly log viewing software will be demonstrated to share real-world OIP log results and interpretation.

**Description:** The OIP is a new direct push logging tool developed by Geoprobe Systems® that enables the operator to detect fluorescent nonaqueous phase liquids (NAPLs) in soils and many unconsolidated formations. A sapphire window on the side of the probe and an ultraviolet (275nm) light emitting diode (UV LED) inside the probe illuminate the formation through the window. The OIP-UV system is used for the detection of common petroleum fuels (e.g., gasoline, diesel). A CMOS camera mounted behind the window captures images of fluorescence at 30 frames per second. The images are displayed onscreen in real time as the probe is advanced at 2 cm/sec into the formation. One image of fluorescence is saved to file every 0.05 ft (~15 mm) of log depth. The software analyzes each image to determine the area of fluorescence detected. A log of the area of fluorescence is plotted versus depth. The probe also contains a visible light (VIS) LED. The operator may halt probe advancement at any time to sequentially capture still images of UV-induced fluorescence and a visible light image for formation texture and color. The OIHPT is equipped with an electrical conductivity array and a hydraulic profiling tool (HPT) sensor to help define lithology and assess potential migration pathways. Additionally, an OIP-Green probe uses a green (520 nm) wavelength laser diode to induce fluorescence of coal tar, creosote and some heavy fuels. The log viewing software allows the investigator to plot the graphical logs versus depth and also to view all of the images captured while logging. The viewing software will be used to review and evaluate OIP and OIHPT logs obtained from selected field sites.

**Thursday, June 4**  
10:55-11:20 a.m.  

**Groundwater Profiling with the GWP 1.75**  

**Instructors:** Thomas Christy (Geoprobe Systems, Inc.), Janet Castle (Eagle Synergistic), and Wesley McCall (Geoprobe Systems, Inc.)  

**Objective:** This lab will introduce you to the new GWP 1.75 groundwater profiling tool developed by Geoprobe Systems®. This tool is designed to obtain groundwater samples from multiple depth intervals in a single push. This learning lab will review profiler design, construction and field operation. The various pumps that can be used to perform sampling with this tool also will be reviewed. Examples of field use and guidelines for successful groundwater profiling will be presented.

**Description:** This groundwater profiling tool is designed...
with 20 screened ports over a 4-inch vertical interval on the probe body. Clean water is injected through the ports at a rate of approximately 500 mL/min as the probe is advanced into unconsolidated materials with direct push methods. This profiler is driven with 1.75-inch diameter probe rods using a GH60 series, or smaller hammer. The Geoprobe® HPT controller provides injection flow and monitors flow rate. An HPT pressure sensor is installed in line, up hole, to provide a log of injection pressure versus depth. The model FI6000 Field Instrument provides digital data output to a laptop computer with acquisition software. A log of pressure and flow versus depth is used to define permeable zones where groundwater can be effectively purged with the down-hole pump. Probe advancement is halted at selected sampling intervals and injection flow is turned off. An actuator is installed on top of the rods to run the downhole reciprocating pump. Flow rates are primarily controlled by local formation permeability but also influenced by depth. Flow rates exceeding 300 mL/min can be achieved at depths up to 60 ft in permeable materials. The profiler has been used at depths of up to 140 ft with flow rate in the range of 100 mL/min to sample for volatile organic contaminants.

Thursday, June 4
11:45 a.m.-12:10 p.m.

Pathway to Remediation Success: Next-Generation Approach to Complex Contaminated Sites

Instructors: Rick Cramer (Burns & McDonnell), John Hesemann (Burns & McDonnell), and Beth L. Parker (University of Guelph)

Objective: The emerging practices of remediation geology, remediation hydrogeology, and process-based conceptual site model (CSM) development will be explored to demonstrate how they address the challenges and uncertainties associated with complex contaminated sites, resulting in improved outcomes. The recommended audience is scientists, engineers, regulators, and site managers.

Description: The primary technical challenge encountered at complex contaminated sites is the uncertainty related to the subsurface. This Learning Lab will tap into the expertise of thought leading researchers and practitioners in the developing areas of remediation geology, remediation hydrogeology, and complex site remediation. It will demonstrate how developing a data-driven, environmental sequence stratigraphy (ESS)-based subsurface framework is critical to the development of a process-based CSM and how these components iteratively “inform” each other to significantly reduce the uncertainty of the subsurface at heterogeneous, complex contaminated sites. Real-world case studies will be presented to actively engage the audience in selecting tools and developing workflows to achieve remediation objectives at complex sites. Actual remediation results will be used to demonstrate the value of the process-based CSM throughout the remediation project life cycle.

Thursday, June 4
12:35-1:10 p.m.

Decision Support Tools for Geophysical Method Selection and Go/No-Go Determinations

Instructor: Frederick Day-Lewis (U.S. Geological Survey [USGS])

Objective: To provide an overview of two public-domain software tools to support decisions around the use of geophysical methods for site characterization and monitoring. The target audience includes site managers, regulators, and users of geophysical information, not geophysicists.

Description: This Learning Lab will provide an overview of two USGS spreadsheet-based tools to support decisions around the use of geophysical methods for site characterization and monitoring. The use of the Fractured Rock Geophysical Toolbox Method Selection Tool (FRGT-MST) and the Scenario Evaluator for Electrical Resistivity (SEER) will be demonstrated for participants, including a step-by-step walkthrough of the workflow for each tool. The presentation and software demonstrations will underscore best practices for method selection and how to assess—prior to field campaigns—whether a specific geophysical method is likely to ‘work’ for a given problem and site. Although the tools are standalone, the presentation will briefly overview the Enviro Wiki pages for geophysical methods and geophysical case studies.
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The flagship product is the Vertebrae™ Segmented Horizontal Well System which offers greater flexibility in assessment and treatment of sites and features the ability to overcome access issues (e.g., the built environment, secure locations, property interferences). Vertebrae™ Systems are smaller and more compact in design offering other advantages in cost and deployment; one example being a shorter drilling setback requirement. An important feature for any horizontal well system, such as Vertebrae™, is that one horizontal unit can be the equivalent of about a dozen vertical wells, depending on variable site conditions (software available). Specialty applications include use in sub slab depressurization, or as a preventative measure for leak detection in active storage/distribution operations.

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<td>7:00 a.m.–7:00 p.m.</td>
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