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13th Environmental Risk Management Workshop

Data Driven Decision Making

June 11-12, 2024

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Dear Attendees,

Welcome to the 13th Annual AIPG Michigan Section Environmental Risk Management Workshop! This year's theme, "Data-Driven Decision Making," is at the core of the work we do, emphasizing the essential role of data in making informed decisions about the risks contaminants pose to public health and the environment.

As environmental professionals, we are tasked with making decisions every day that affect the health and welfare of people and the environment. To do this effectively, we need quality data that is appropriate for the decisions we make. Over the years, we have made significant advancements in our understanding of the behavior of contaminants, their fate and transport, and their effects on human health and the environment. As we navigate the Age of Big Data, our ability to collect, manage, and analyze data has become critical, enabling us to make informed and defensible decisions.

The importance of repeatable, reproduceable, and replicable data in the scientific process cannot be overstated. Visualizing data to effectively communicate outcomes and guide decision-making has become the standard in our field. Furthermore, partnerships are crucial in making informed decisions. By collaborating and sharing knowledge, we can enhance our abilities to protect public health and the environment and manage risks from environmental contamination.

We received an impressive number of abstracts for this year's workshop, and the selection committee faced the challenging task of narrowing down the submissions. We have curated a conference program that showcases exemplary cases of data-driven decision-making in various areas, including remediation, emerging contaminants, ISM/CSM, data collection and analysis, and artificial intelligence and modeling.

We hope you find the content of this workshop beneficial and that it enhances your ability to make data-driven decisions. Our community of professionals shares a common goal, and we greatly appreciate your support, participation, and commitment to furthering your professional development. Together, we strive to protect public health and the environment.

Thank you for being part of this knowledge-sharing and partnership-building event. AIPG is the gold standard in geoscience professionalism, and your involvement helps us maintain and elevate this standard.

Sara K. Pearson, CPG

AIPG Michigan Section Workshop Chair


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TECHNICAL SESSION SCHEDULE

TUESDAY - JUNE 11, 2024

7:30 AM – 9:20 AM — **WORKSHOP REGISTRATION & ROOM CHECK-IN**

9:30 AM — Opening Remarks & Keynote Speaker Introduction

9:40 AM – 10:30 AM — **Keynote - ESRI Project Delivery for the Redevelopment of Buick City, Flint, Michigan**
Kevin Brown and Kevin Lund, CPG, (Mannik Smith Group); Grant Trigger, (Racer Trust); Mark Quimby (Ashley Capital)

10:40 AM – 11:00 AM — **Groundwater Containment Infiltration Study**
Joe Ruiz and Katie Frey, PG (Weston Solutions, Inc.)

11:20 AM – 11:50 AM — **A Decision-Making framework to Expand the Understanding of Microplastics in Stormwater and Soil**
Mala Hettiarachchi, PE, PhD (Environmental Resources Group)

12:00 PM – 12:50 PM — **LUNCH**

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BREAKOUT SESSIONS

SESSION A Data Collection & Analysis	SESSION B ISM/CSM	SESSION C Data Collection & Analysis/AI
1:00 PM – 1:40 PM **Part 201 Site Risk Assessment and Prioritization** Sam Baushke, PE (Geosyntec), and Dave Bandlow (EGLE)	**Incremental Sampling Methodology (ISM)/Multi-Increment® Sampling: "A Plain English Guide to Improving Data Quality for Decision Making"** Terry Obal, PhD (Metiri Group)	**Digital Data Collection Tools Aid in Creation of Conceptual Site Model (Part 1)** Christopher Tort and Tom Kinney, CPG (GHD)
1:45 PM – 2:15 PM **Using Collected Site Data to Formulate a "Contained-Out" Waste Characterization Plan and Remediate a Former Dry Cleaner Site** Nick Rogers (WSP)	**Incremental Sampling of Urban Fill: Factors for Success** Steve Zayko, PE, CPG, Abigail Varner (Hamp Mathews & Asociates, Inc.), and April Hehir and Chris Christensen, CPG (EGLE)	**ERH Remediation of VOCs and Issuance of a Certificate of Completion (Part 2)** Tom Kinney, CPG (GHD)

2:25 PM – 3:05 PM — **Networking Break - Sponsored by - Weston Solutions**

3:00 PM – 3:40 PM **Petroleum NAPL Characterization Using Multiple Lines of Evidence** Nick Swiger, PE, CPG and Chris Christensen, CPG (EGLE)	**How Much is Too Much? Sampling Density in Stratified Sediment Bedforms for Estimating Surface-Area Weighed Average Concentrations** Evan Thomas, PE (WSP)	**Artificial Intelligence and Machine Learning in Examination and Processing of Environmental Remediation Data** Barry Harding, CPG (AECOM)
3:45 PM – 4:25 PM **Improvements in the development of the conceptual site model (CSM) from NSZD and HRSC data for impactful decisions on your NAPL-contaminated site** Julio Zimbron, PhD (E-Flux)	**DQO Data Collection for Developing a Conceptual Site Model** Steve Zayko, PE, CPG and Abigail Varner (Hamp Mathews & Associates)	**Application of multi-class machine learning for source classification of PFAS in environmental water samples** Jason Lagowski, CPG (Brown and Caldwell)

4:25 PM — **Closing Remarks**

4:30 PM – 5:20 PM — ***EVENING BREAK - Check-in at local hotel, Shuttle Service Available***

5:30 PM – 6:20 PM — **DINNER (bar open)**

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6:30 PM – 7:50 PM — **TECHNICAL DEMONSTRATIONS/INFORMAL Q&A**
Vapor Pin Sampling: Active and Passive Sampling - *Vapor Pin*
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8:00 PM – 12:00 AM — **SOCIAL EVENT** — **LIVE MUSIC, OPEN BAR, BONFIRES, Shuttle Transportation to Hotels**

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Live music ends @11PM

Last Call for Shuttle Service to Hotels

TECHNICAL SESSION SCHEDULE

WEDNESDAY - JUNE 12, 2024

	SESSION A Data Collection & Analysis	SESSION B Emerging Contaminants	SESSION C Remediation
7:15 AM	**Breakfast**		
7:20 AM 7:50 AM			
8:00 AM 8:50 AM	**Morning Coffee & Networking**		
9:00 AM 9:10 AM 9:20 AM 9:30 AM	**Equilibrium Passive Sampling of Bioavailable Hydrophobic Organic Compounds at Sediment Sites: Advantages for Decision Makers using the Shiawassee River as a Case Study** Cameron Myshok (Geosyntec), Mary Schafer (EGLE), and Brent Pautler, PhD (SIREM)	**Using a Digital CSM to Expedite Workflow for DoD PFAS Site Investigations** Patrick Curry (Arcadis)	**Groundwater Plume Analytics® - Tools for Using Your Site Data to Better Assess Remediation Effectiveness and Plume Stability** Joe Ricker, PE (WSP)
9:40 AM 9:45 AM 9:55 AM 10:05 AM 10:15 AM	**GWQS Achieved in Fractured Bedrock at a TCE Release Site in the Passaic Formation** Bill Brab, CPG (AST Environmental)	**Data Driven Remedial Investigation Strategies at an Orphaned Plating Facility** Tom Brubaker (Global Remediation Technologies)	**Horizontal Injection Wells for Offsite In-Situ Remediation of Chlorinated Solvents Beneath an Active Manufacturing Facility** Kate Villars, PE and Ryan Fimmen, PhD (Geosyntec)
10:25 AM	**MORNING BREAK**		
10:35 AM 10:45 AM 10:55 AM 11:05 AM	**A GSI Compliance Approach to Demonstrate Protection of Surface Water from a Chlorinated Solvents Plume Beneath an Extensive Wetland System** Peter Lepczyk, CPG and Bailey Hannah (Fishbeck)	**Colloidal Activated Carbon (PFAS) Barrier Commissioning - Fine-Tune Adjustment and Performance Optimization Supported by Computer Modelling at a Michigan Site** Keith Gaskill, LPG (Regenesis)	**Don't Inject Blind: Using HRSC Tools and 3D Modeling to Create Targeted Injection Plans** Jim Depa (Jacob & Hefner Associates)
11:15 AM 11:20 AM 11:30 AM 11:40 AM 11:50 AM	**Cost-Effective Data Collection and Visualization Strategies to Bolster Confidence in Decision Making** Darby Litz, EIT, PG (TRC Companies)	**Advancements in Analytical Techniques to Demonstrate Successful Destruction of PFAS** Taryn McKnight (Eurofins)	**Advances in Phytoremediation for Sustainable Nature-Based Treatment for Contaminated Ground Water Removal and In-situ Degradation** Renee Murphy (Intrinsyx Environmental)
12:00 PM	**LUNCH Sponsored by - Barr Engineering**		
	SESSION A: Modeling		
1:00 PM 1:10 PM 1:20 PM 1:30 PM	**Using Geospatial Analysis to Optimize Monitoring Networks** Adam Janzen, PE (Barr Engineering)	**A More Comprehensive Analysis of PFAS in Landfill Leachate, What to Expect as Regulations Develop** Taryn McKnight (Eurofins)	**Managing High Frequency O&M Data for In-Situ Remediation System Performance Optimization** Kyle Amonette (TRC Companies)
1:40 PM 1:45 PM 1:55 PM 2:05 PM 2:15 PM	**Using Conditional Simulation Modeling for Estimating Contaminated Sediment Remediation Volumes** Dan Peabody, (EGLE) and John Kern, (Kern Statistical Services)	**High Dimensional Data Analysis and Visualization to Demonstrate Compliance** Alex Eklund (TRC Companies)	**Biogeochemical Reduction Processes and What You Need to Know** Lowell Kessel, PG (CERES Remediation Products)
2:25 PM 2:35 PM 2:45 PM	**AFTERNOON BREAK - ICE CREAM SOCIAL** **Sponsored by - Michigan Basin Geological Society**		
2:55 PM 3:05 PM 3:15 PM 3:25 PM 3:35 PM 3:45 PM	**Data Driven Decisions in Brownfield Redevelopment** Carrie Geyer, Ryan Londrigan, and Nick Swiger, PE, CPG (EGLE)		
3:55 PM 4:05 PM 4:15 PM	**Closing Remarks - Day 2** **Raffle Drawing**		

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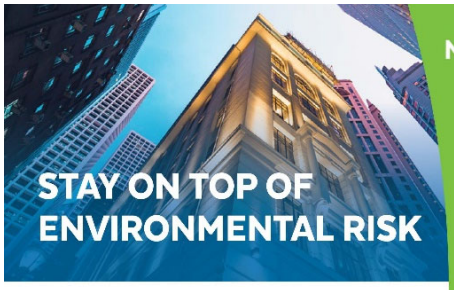

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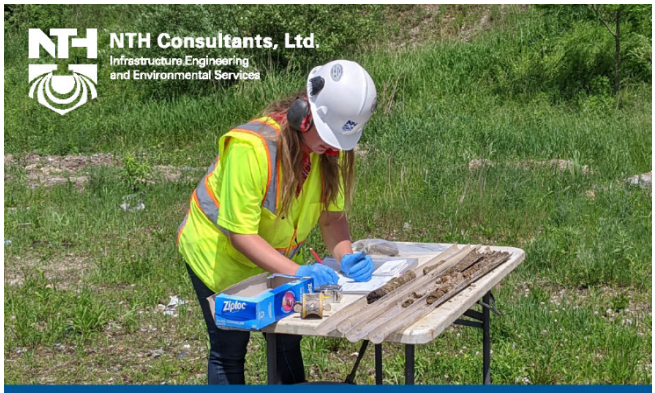

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PLENARY SESSIONS

Welcome and Keynote

ESRI Project Delivery for the Redevelopment of Buick City, Flint Michigan: A Case Study – Part I: Preparing for the Sale; Part II: After the Closing, Site Development Planning

Presenters: Kevin Brown (Mannik Smith Group); Grant Trigger (RACER TRUST), and Mark Quimby (Ashley Capital)

Both site closure and safe redevelopment is achieved by leveraging Geographic Information System (GIS) technology to effectively manage and collaborate, leading to sustainable and transformative urban revitalization of Buick City in Flint, Michigan.

When faced with unique challenges, such as risk management/due care planning, infrastructure planning, stakeholder engagement and incorporation of historic RCRA Corrective Actions decisions, the visualizing the information is paramount.

To apply the GIS technology to visualize the information it starts with setting requirements for gathering and scoping, through data acquisition and integration, to application development and deployment. The ESRI Project Delivery was the platform selected to streamline project management, data collection, analysis, and visualization.

The data preparation and planning was key to data integration, standardization, and quality assurance in ensuring successful implementation of ESRI Project Delivery to visualize this data. A challenge that was overcome was the integration of stakeholders work from CAD platforms using various ESRI tools, including ArcGIS Pro and ArcGIS Online to facilitate collaboration, decision-making, and communication among project teams. ESRI Project Delivery fostered cross-functional coordination, enabling seamless integration of GIS technology into existing workflows of the stakeholders allowing engineering development decisions, preparations of recorded deed restrictions, consolidating geotechnical and environmental data, improved data collection decisions, accessibility to stakeholders, enhanced stakeholder engagement and cost savings through efficient project management and streamlined workflows.

Presenters: Kevin Brown is a GIS Specialist and Project Manager with MSG, as an environmental Scientist, Kevin specializes in developing a visualization schema using GIS data to visualize the clients' data using various ESRI tools, including ArcGIS Pro and ArcGIS Online.

Grant R. Trigger, PE is Michigan Cleanup Manager for RACER Trust, directing all aspects of site investigations; design and implementation of remedial project work; and integrating remedial project work with redevelopment activities at 36 former General Motors commercial and industrial properties in Michigan. He is a professional engineer, environmental attorney, and adjunct professor of Law at the University of Detroit School of Law, and has over 40 years of experience in waste water management, environmental remediation, natural resources management and brownfield redevelopment. Mr. Trigger serves on the Environmental Rules Review Committee within the Michigan Department of Environment, Great Lakes and Energy and served on the Great Lakes Compact Council and Regional Body from 2011 to 2018.

Mark Quimby is a Development Manager with Ashley Capital, one of the largest privately held industrial real estate firms in the USA. He leverages 17 years spent as an environmental consultant specializing in brownfield redevelopment and vapor intrusion to solve site development risk challenges on contaminated land. He specializes in understanding and navigating the complex interplay between regulations, environmental and geotechnical conditions, incentive procurement and management, site planning, and the implementation of remediation and construction activities.

Groundwater Containment Infiltration Study

Presenters: Joe Ruiz and Katy Frey (Weston Solutions, Inc.)

This presentation discusses the extensive investigation of groundwater infiltration into an enclosed containment cell. As part of a complex remedy negotiation at a former chemical facility, groundwater within 30-acres of impacted soil was required to be contained and removed at a rate exceeding infiltration. Following completion of the containment cell construction and start of the groundwater extraction system, the infiltration rate was determined to be significantly higher than anticipated (around one order of magnitude). In order to comply with the remedial requirements, the increased infiltration needed to be investigated and either resolved or the groundwater extraction rate would need to be increased.

The setting of the property is in an urban area that was developed into usable land by filling on top of a lakebed. The former shoreline extends past the area where the containment cell was constructed. The geology consists of a fill layer (15-30 feet thick) overlaying glacial deposits (isolated silt/sand stringers) overlaying dolomite bedrock. The site has three water bearing zones – shallow (within fill), intermediate (within native), and deep (bedrock). The containment cell was constructed using a soil-bentonite mixture with a target conductivity of 1E-7 centimeters per second.

The various phases of investigation included a comprehensive utility search, permeability testing of the asphalt cap, using data loggers to provide high frequency of measurements (groundwater levels, temperature), nested wells in the various water-bearing units to investigate upward/downward gradients, paired wells on opposite sides of the slurry wall, pump tests, and high-resolution mapping of the slurry wall surface.

A water balance was developed to evaluate the flow into and out of the for the containment cell. This was followed by development of a MODFLOW model to simulate groundwater conditions under various scenarios such as no action, limited groundwater extraction rate increases, elimination of minor infiltration sources, and various targeted pumping schemes. The MODFLOW model was also used to assess future risk of groundwater contaminate migration and potential impacts to previously remediated areas.

Following the comprehensive data collection efforts and evaluation, the decision was made to dramatically increase the flow rate of the groundwater extraction system. The next phase of evaluation was to determine the most effective way to extract groundwater – collection trench, extraction well field, large diameter wells, or other collection methods.

Presenters: Joe Ruiz has over 23 years of environmental engineering and project/program management experience. His experience includes investigations, remediations, and remediation system operations and maintenance for various municipal, state, federal, and private clients. Mr. Ruiz has worked on various regulatory programs throughout the US and is currently Weston's Program Manager for the State of Michigan clients. Mr. Ruiz lives in Ann Arbor and splits time between his home office and an office in Okemos.

Kathryne (Katie). Frey, PG has over 15 years of environmental experience and is a licensed PG in Illinois, Kansas, and Delaware. Her experience includes Phase I ESAs, data management/GIS, and has been primarily focused on complex geologic/hydrogeologic site investigations and remediations throughout the Midwest and in California. Ms. Frey works out of Weston's Lincolnshire, Illinois office and is the National Practice Lead for Weston's Geosciences Practice ultimately overseeing 125+ geologists and scientists.

A Decision-Making framework to Expand the Understanding of Microplastics in Stormwater and Soil

Presenter: Mala C. Hettiarachchi, PhD, PE., (Environmental Resources Group)

Microplastics (MPs) are widespread, persistent, and pervasive pollutants. They represent a vast array of solid particles originating from various sources such as the degradation of larger plastic items, polymer-based paints such as road markings, textile fibers, tire wear particles, polymer encapsulation of fertilizers, infill materials of artificial turfs, waste management facilities, and biosolid land application. A massive number of MPs is believed to be present in soil. However, the quantitative estimates on the MPs in soil and their impact on soil properties and the soil ecosystem is limited. Stormwater transports MPs from these terrestrial sources into the aquatic environment. A large faction of MPs in soil could be carried into the aquatic environment via stormwater. Some recent estimates suggest that stormwater contributes over 40% of MPs to the aquatic environment. Therefore, quantitative emissions estimates of MPs via stormwater is also crucial in treating the MPs before they enter the aquatic environment.

Therefore, a study has been conducted to examine MPs in soil to advocate for a robust decision-making framework to effectively comprehend and tackle MP pollution. This study evaluates the emission of MPs via biosolid land application and waste disposal facilities to the soil and the emission of MPs from soil to the stormwater. Leveraging data from biosolid land application, the current evaluation employs linear regressions to develop relationships between MPs and critical parameters such as oxygen uptake rate, solids, and volatile solids in biosolids. Furthermore, soil properties like pH, total phosphorus, and nitrates are examined in correlation with plastic content. The study also investigates large plastic litter emissions in the vicinity of waste management facilities to develop estimates of MPs to the soil.

Utilizing land use statistics and visual observations, this study aims to provide a comprehensive understanding of MP loading from soil to the receiving waters through stormwater runoff. Using hydrograph data of the land application periods, quantitative estimates of MP discharges during storm events have been developed. In addition, this study evaluates the large plastic litter emissions in select areas related to waste management facilities at storm events. Visual observations and counting were used to determine the macroplastic distribution. The results provided insight into the MP loading to receiving water via stormwater runoff. Also, it emphasizes the pivotal role of stormwater in transporting MPs and importance of the implementation of stormwater treatment methods to capture MPs prior to discharging into receiving water bodies.

Presenter Biography: Mala C. Hettiarachchi, PhD, PE is a Senior Engineer at Environmental Resources Group and an Assistant Professor (part-time) at Wayne State University. Mala views source control as the most appropriate and sustainable solution in reducing plastic and microplastic pollution. She has been conducting public outreach activities in Michigan on this topic since 2016. Mala has created a volunteer non-profit organization named "Freshwater Conservancy" in 2022 with the goal and mission of "Spread the word and protect freshwater from plastic pollution."

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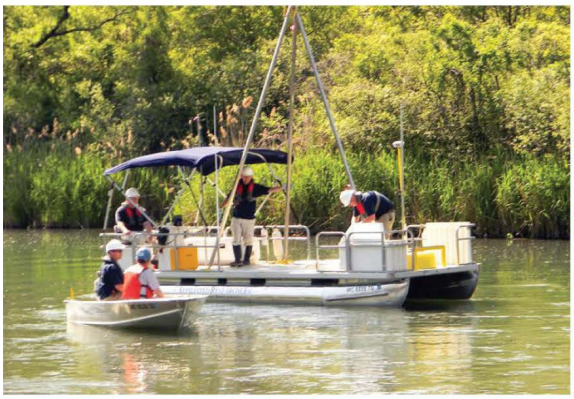

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TUESDAY

SESSION A

Data Collection & Analysis

Part 201 Site Risk Assessment and Prioritization

Presenters: Sam Baushke, GIT (Geosyntec) and Dave Bandlow (EGLE)

The Remediation and Redevelopment Division (RRD) of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) manages an extensive portfolio of properties under Michigan's Natural Resources and Environmental Protection Act. Within the Remediation Information Data Exchange (RIDE) database, the assignment of a "risk condition" to each site is crucial for RRD to prioritize and address areas of heightened environmental concern.

This project addresses the challenge of a substantial backlog in assigning accurate risk conditions, particularly for locations currently labeled as "Risks Not Determined." Due to limited staff and resources, this backlog persisted across over 11,000 regulated facilities.

The primary objective of the Risk Condition Data Cleanup project, initiated in February 2023, is to streamline and expedite the classification process. Leveraging the Indefinite Scope-Indefinite Delivery (ISID) contract, the project engages contractors to assess available information and assign appropriate risk conditions, thereby reducing the prevalence of "Risks Not Determined."

During a ten-month period, over 5,000 Part 201 facilities were classified. The reviews were conducted using existing data and information uploaded by EGLE and assigning an appropriate risk condition in the RIDE database based on an analysis of the data using a modified version of form EQP4469 for Part 213 locations, based on the risk-based corrective action process. Specifically, relevant correspondence and site reports, such as Baseline Environmental Assessments, Phase I and Phase II Environmental Site Assessments, and documentations of due care compliance were reviewed to evaluate and assess the potential risks for human health, safety, welfare, environment, and sensitive receptors. Facilities are classified as follows:

- Risks Present and Immediate;
- Risks Present and Requires Action in the Short-term (present to two years);
- Risks Present and Requires Action in the Long-term (greater than two years);
- Risks Controlled Interim;
- Risks Controlled Final; or
- Inadequate Data to Assign Risk.

This effort is expected to aid the RRD in the prioritization of sites for compliance and state-funding purposes. The RIDE database can easily be queried for risk classifications. As the project continues, the state will have a better understanding of the range of risks and priority of facilities across the state.

Presenter Biography: Sam Baushke has 17 years of experience investigating and remediating sites with impacted soil gas, groundwater, and soil on behalf of manufacturers, public institutions, and fuel clients. With a career grounded in fieldwork, Sam offers intimate knowledge of the capabilities and limitations of investigation techniques and remediation systems, using this knowledge to inform his project management. Sam focuses on chlorinated solvents, petroleum, and PFAS and was on the teams that developed ITRC guidance for vapor intrusion mitigation and LNAPL. Recently, Sam joined the local brownfield redevelopment authority, and is developing a stronger working relationship with EGLE on the Premcor and other projects.

Mr. Bandlow is the Database Specialist for the Remediation Information Data Exchange (RIDE) database, which is managed by the Michigan Department of Environment, Great Lakes and Energy, Remediation and Redevelopment Division (EGLE, RRD). Prior to becoming the RIDE Database Specialist, he worked for RRD in the Grand Rapids District Office as a Project Manager and a Supervisor. Before joining EGLE, Mr. Bandlow worked for a consulting firm performing environmental site evaluations, risk assessment, remediation, and regulatory compliance. In total, Mr. Bandlow has nearly 20 years of experience in the environmental regulatory field. He has an associate degree in civil engineering from Ferris State University and a bachelor’s degree in environmental engineering from Michigan Technological University.

Using Collected Site Data to Formulate a “Contained-Out” Waste Characterization Plan and Remediate a Former Dry Cleaner Site

Presenter: Nick Rogers (WSP)

Tetrachloroethylene (PCE) was used historically and released to the environment at a former dry-cleaning facility (Site) in Ann Arbor, Michigan. The dry cleaner operated from the 1940s until September of 2021. Known releases of PCE to the ground occurred to the north and northwest of the Site building. However, the extent of PCE impacts in soil, soil vapor and groundwater collected by others suggested that additional releases of PCE may have occurred at the Site of at other potentially properties in the area. The Site is located in a mixed use residential, historic, business district. Adjacent properties include single and multi-family residential properties.

WSP and EGLE performed supplemental investigations at the Site between 2017 and 2020 that included a ground penetrating radar (GPR) survey, and soil and high-resolution vertical aquifer profile (VAP) sampling. WSP also used compound specific isotope analyses (CSIA) to evaluate the potential for other offsite sources of PCE and related daughter products and performed focused, receptor-based sampling. GPR and soil borings mapped the subsurface topography of a shallow (7-8 feet below grade) sandy silt unit that produces locally perched conditions. PCE in soil collected from below the Site building (e.g., near sumps of the dry-cleaning machinery) and on adjacent properties exceeded soil saturation concentration screening levels to depths of up to 17 feet below grade. VAP sampling (Waterloo APS) of groundwater in perched lenses on top of and within the silt enhanced the conceptual site model (CSM) understanding of historical gravity driven product migration, pooling, and infiltration. CSIA results failed to identify a smoking gun offsite source, instead suggesting that observed PCE contamination and isotopic trends could be explained from multiple releases at the Site over time.

Soil heterogeneity and gross contamination of F-listed waste below the Site building presented significant source remediation challenges. EGLE worked with the Site property owner to successfully demolish the Site building in 2021 to expedite cleanup and property redevelopment. Handling of material generated during the remediation of F-Listed waste incurs significant costs. At this former dry-cleaning facility, WSP collected various Site data to successfully execute a contained-out characterization plan that distinguished F-Listed “release”-related waste (hazardous handling) from relatively low-level residual impacts (non-hazardous handling). Based on the collected data and the updated CSM, the contained-out investigation reduced the volume of soil requiring hazardous material handling by approximately 60%. WSP and EGLE completed benchtop studies and is remediating the Site using mechanically mixed in-situ chemical oxidation (ISCO; sodium persulfate) and Portland cement in-situ stabilization methods.

Presenter Biography: Nick Rogers is an Assistant Vice President/Project Manager - Geology at WSP with over 20 years of site characterization and remediation experience at contaminated Sites across Michigan and the Midwest. His primary areas of expertise include: planning and implementation of large scale drilling and river sampling programs, remedial investigation drilling techniques; remediation systems operations and maintenance and remediation of dry cleaner sites. Nick earned a Bachelor of Science degree (Geology, 1999) from Calvin University.

Nick is married with two children and lives in Chelsea, Michigan. He is volunteer board member and Referee Assignor for the Chelsea Soccer Club youth program. Nick is also active in his son’s Boy Scout Troop (Troop 425) in Chelsea as the Committee Chair. Nick enjoys camping, kayaking, paddle boarding and water skiing.

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Petroleum NAPL Characterization Using Multiple Lines of Evidence

Presenters: Nick Swiger, PE, CPG and Chris Christensen, CPG (EGLE)

"The Michigan Department of Environment, Great Lakes, and Energy (EGLE), Remediation and Redevelopment Division (RRD) revised and reissued guidance on the characterization and management of petroleum non-aqueous phase liquids (NAPL) in June of 2023. The goal of the guidance document is to clarify expectations required by statutes (both Part 201 and Part 213) to move a site towards closure, clarify the delineation and characterization goals of the NAPL, and to utilize of a multiple line of evidence (MLE) approach for NAPL.

The MLE approach for NAPL allows for a more comprehensive and data driven approach towards the characterization of NAPL; however, can introduce some complexities when some of the lines of evidence may conflict. When the regulated community and EGLE are working on a moving the sites toward closure it is imperative that all site decision makers are on the same page. A brief review of the guidance document including the statutory requirements for moving the site toward closure will help the audience knows how we can get to that goal of closure.

In addition, the common lines of evidence will be reviewed and the considerations and limitations of each of the lines of evidence must be discussed to enable all parties the knowledge on how to handle sites when you have conflicting lines of evidence.

Finally, a review of the characterization practices commonly used to delineate and determine the state/presence of the NAPL (residual, mobile, migration) is needed to allow for everyone to use the best data for site evaluations. Site considerations that should be evaluated for each state/occurrence of NAPL will ensure the sites are being appropriately evaluated and managed.

A case study or two will be presented with conflicting lines of evidence and will be discussed from the perspective of EGLE on how the department would evaluate the site.

Nick Swiger, PE, CPG is a professional engineer and certified professional geologist. He is educated as a geologist and engineer with a focus on remedial design and innovative treatment approaches. His work interests are varied including emerging contaminants as well as non-aqueous phase liquids, petroleum hydrocarbons, and inorganic contaminants.

Chris Christensen, CPG is an Environmental Hydrogeologist with the Michigan Department of Environment, Great Lakes and Energy (EGLE), Remediation and Redevelopment Division (RRD), Technical Support Unit out of the Grand Rapids District since 1992. Chris works on both Leaking Underground Storage Tank sites as well as chlorinated solvent and surficial soil contamination sites. He is on RRD Technical Teams related to Incremental Sampling, Non-Aqueous Phase Liquids, Risk-based Corrective Action and Groundwater Modeling. He has advocated for Incremental Sampling use in Michigan since 2011 and contributed as a member of the ITRC ISM-2 team. Chris has a BS in Geology from Michigan State University and a MS in Hydrogeology from Western Michigan University.

Improvements in the Development of the Conceptual Site Model (CSM) From NSZD and HRSC Data for Impactful Decisions on Your NAPL-Contaminated Site

Presenter: Julio Zimbron, PhD (E-Flux)

The management of non-aqueous phase liquids (NAPL) contaminated sites has changed drastically in the last decade. This has occurred due to improvements in the conceptual site model (CSM), based on scientific developments and techniques related to contaminant fate and transport. Two major, groundbreaking developments are mostly responsible for this paradigm shift in the conceptual site model: i) site-specific field rate measurements of contaminant degradation are easily accessible, for both petroleum and chlorinated compounds, with the resulting rates being sometimes higher than the removal rate of active remedies, and ii) high resolution site characterization (HRSC) tools allow collection of high-density data that enable understanding contaminant distribution and migration at levels not available before. This talk will describe new, state of the art developments in these relatively new concepts and offer examples of how these technical developments result in data-based, more effective CSM. This is a two-part talk, 1) the use of soil respirometry techniques to measure field rates of contaminant degradation, and 2) multi-phase transport factors resulting in the soil redistribution of contaminants and recent developments in the use of non-destructive fluorescence-based high-resolution site characterization tools used for field measurements.

Presenter Biography: Dr. Julio Zimbron is a researcher and inventor of one of the main methods used to measure NSZD rates. He is a recognized expert in contaminant natural source-zone depletion. His work is featured in different publications, and he presents multiple times a year at national and international conferences.

TUESDAY

SESSION B

ISM/CSM

Incremental Sampling Methodology (ISM)/Multi-Increment® Sampling: "A Plain English Guide to Improving Data Quality for Decision Making”

Presenter: Terry Obal, PhD (Metiri Group)

Incremental Sampling Methodology (ISM) or Multi-increment® Sampling (MIS) is a technique used in environmental sampling to assess and manage environmental site assessments, remediation projects, and risk assessments. The primary goal of ISM is to improve the accuracy and representativeness of sampling, and by extension the laboratory data, by reducing sampling error and variability. Adhering to ISM protocols helps to improve data reliability and reduce uncertainties, allowing the environmental stakeholder to make more informed decisions about the extent and nature of contamination at a given site.

This methodology is commonly employed when dealing with contaminated sites, where the pollutants are not evenly distributed throughout a site. ISM provides a statistically supported suite of planning, sampling, sample preparation, and subsampling techniques that addresses heterogeneous soil contamination, increases sample representativeness, and reduces data variability.

Having a clear understanding of basic ISM concepts and their utility in both field sampling and laboratory subsampling activities, including the key advantages and limitations to the technique, will equip the environmental practitioner with important tools for developing and executing sampling and analysis programs that reduce cost, increase data confidence, and improve decision making.

Learning Objectives:

This presentation will:

- Review principles of measurement uncertainty in laboratory test results
- Provide a “plain English” explanation of incremental sampling methodology in the field and the laboratory
- Demonstrate how ISM protocols reduce data variability and provide for field samples and laboratory test results that are more representative of the site

Presenter Biography: Terry Obal, PhD is the Chief Science Officer for Metiri Group. Terry’s mission is to shape and implement Metiri's scientific strategy across the laboratory network. This mandate is achieved through the development, validation and commercialization of new methods and processes at Metiri Group companies, and providing technical representation, consultative support and expert opinions for Metiri clients and key environmental stakeholders.

Having over 35 years of experience in analytical chemistry, laboratory management and environmental chemical consulting with expertise in site assessment and remediation, water and wastewater treatment, emerging contaminants and quality assurance, Dr. Obal is frequently called upon to provide scientific input and expertise. He holds B.Sc., M.Sc., and Ph.D. degrees in chemistry, and is a Chartered Chemist (C.Chem.) through the Association of the Chemical Profession of Ontario (ACPO).

Incremental Sampling of Urban Fill: Factors for Success

Presenters & Co-Authors: Stephen Zayko, CPG, Abigail Varner, and April Hehir (Hamp Mathews & Associates, Inc.; Chris Christensen, CPG (EGLE-RRD)

Urban areas are plagued with remnants of their historic past. Prior to best management practices for handling of waste material from former structures, common practice was to utilize the waste material as a source of fill. This fill material containing soil and non-native materials has been termed urban fill. Urban fill commonly includes, but is not limited to, bricks, concrete, slag, and asphalt. Characterizing the nature and extent of contaminants in urban fill is challenging, and essentially impractical due to the randomly dispersed nature of contaminants in urban fill soil.

Incremental Sampling Methodology (ISM) can provide statistically valid estimates of the mean contaminant concentration for a specified volume/area of urban fill. The totality of contaminants in dispersed fill can be evaluated utilizing ISM for risk-based decision making and safe redevelopment of urban properties. Critical to successful ISM sampling for urban fill soil is the development of decision unit (DU) areas. DUs are site-specific and typically represent the smallest area/volume of soil/urban fill about which a decision will be made. The area, and location of DUs is often based upon the current receptor exposure environment, the physical settings, and origin/type of contaminant compounds. Factors such as the conceptual site model, characteristics of the urban fill, identification of complete exposure pathways, and consideration of the exposure assumptions of the risk-based soil direct contact criteria are critical components for developing the DUs and ISM data collection strategy. Analytical results from ISM sampling require careful review and interpretation with consideration of exposure and risk assumptions implicit to the risk-based criteria.

This presentation will provide several case study examples where data quality objectives were evaluated with ISM to make decisions regarding the direct contact exposure pathway in urban residential areas.

Presenters: Steve. Zayko is a Senior Engineer that has nearly 30 years of experience completing projects in over 30 states, nine EPA regions, and six countries. He specializes in Vapor Intrusion, Remediation System Design, Statistical Analysis, Computer Modeling, and Risk Assessment. Mr. Zayko is currently a sub-group leader for the Interstate Technology Regulatory Council (ITRC), Environmental Data Management (EDM) Team, Data Exchange subgroup. Since 2016, he has been a member of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Response Activity Review Panel. In 2014, Mr. Zayko participated in the Michigan Criteria Stakeholder's Advisory Group to assist with planned updates to generic cleanup criteria. Mr. Zayko was a member of the Rapid Response Environmental Site Support team for BP Deepwater Horizon (MC252) Incident in the Gulf of Mexico and was also a member of the Enbridge Line 6B release response team in Marshall, Michigan. His current work activities involve volatilization to indoor air pathway assessment and mitigation at sites containing chlorinated volatile organic compounds (CVOCs) and/or petroleum volatile organic compounds (PVOCs). Throughout his career, Mr. Zayko has consistently used the United States Environmental Protection Agency (USEPA) Data Quality Objectives (DQO) process for collecting and evaluating data to develop Conceptual Site Models (CSMs) used to direct and support project decisions.

April Hehir serves as a Senior Project Manager at the Hamp, Mathews, & Associates (HMA) Grayling, Michigan office. Her formal training is in engineering. Her multi-disciplinary training includes biology, chemistry, and geology, with 20 years of experience in the environmental field. This background, along with her experience in field research and site assessments, provides a solid framework for her activities with HMA. April's responsibilities include project management, due diligence specialist, brownfield redevelopment, asbestos surveys, lead assessment surveys, vapor intrusion assessments, storm water inspections, project logistics, remedial site investigations, various types of environmental sampling and waste characterization, potable well sampling, and oversight of monitoring well installations, excavation oversight, and remediation system installations and oversight. April serves on the Crawford and Roscommon County Brownfield Redevelopment Authorities, serves as the Chair of the City of Grayling Planning and Zoning Commission, and Chair of Maple Forest Township Board of Review.

Chris Christensen, CPG is an Environmental Hydrogeologist with the Michigan Department of Environment, Great Lakes and Energy (EGLE), Remediation and Redevelopment Division (RRD), Technical Support Unit out of the Grand Rapids District since 1992. Chris works on both Leaking Underground Storage Tank sites as well as chlorinated solvent and surficial soil contamination sites. He is on RRD Technical Teams related to Incremental Sampling, Non-Aqueous Phase Liquids, Risk-based Corrective Action and Groundwater Modeling. He has advocated for Incremental Sampling use in Michigan since 2011 and contributed as a member of the ITRC ISM-2 team. Chris has a BS in Geology from Michigan State University and a MS in Hydrogeology from Western Michigan University.

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- Emergency Planning
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- Vapor Intrusion Assessment and Mitigation
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How Much is Too Much? Sampling Density in Stratified Sediment Bedforms for Estimating Surface-Area Weighed Average Concentrations

Presenter & Co-Authors: Evan Thomas, Jerry Eykholt, Joe Abid, Greg Horstmeier, and Cynthia Draper (WSP)

Supplemental Remedial Investigations and Feasibility Studies (SRI/FS) are being conducted for Operable Unit 5 (OU5) of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund site. OU5 encompasses approximately 80 miles of the Kalamazoo River in Kalamazoo and Allegan Counties, Michigan. OU5 is divided into seven areas. Sediment sampling for the SRI/FS has been completed for Area 5, a 9.1-mile stretch of the Kalamazoo River from the Trowbridge Dam to the Allegan City Dam. To efficiently cover this large reach of river, an innovative and cost-effective stratified, random sampling design was developed based on results of field reconnaissance. The sampling design provided an appropriate sample density while reducing potential data gaps that would likely arise with more traditional approaches. Sample results were used to develop surface-area weighted average concentrations (SWACs) which relate to fish exposures and tissue recovery time projections performed as part of the FS. The objectives of this study were to evaluate the sediment sampling results and to assess the value of the optimized stratified sample design using river bedforms.

The sample design was based on the CSM developed as part of two field reconnaissance activities. Reconnaissance activities included collection of high resolution topographic/bathymetric data, sediment thickness, sediment particle size distributions, and polychlorinated biphenyl (PCB) concentrations in standardized depth intervals in a limited number of sediment cores. Sediment bedform classifications (e.g., point bar, pool, riffles) were mapped within the channelized portion of Area 5 using the topographic/bathymetric surface and geomorphological/fluvial properties. The bedforms were grouped into two categories based on multivariate statistical evaluations (e.g., hierarchical cluster analysis, multivariate analysis of variance [MANOVA]) of the physical data collected during field reconnaissance. Group 1 bedforms (145.7 acres) consisted of high-energy environments with coarser gradations and thinner sediment, while Group 2 (75.6 acres) bedforms were in depositional environments with finer gradations and thicker sediment. A total of 244 Reconnaissance and Phase I cores were collected in the channelized section of Area 5, with 97 in Group 1 bedforms and 147 in Group 2 bedforms. Sample densities were determined based on observed PCB variability within each bedform group plus additional samples as a safety factor. A sensitivity evaluation on the SWAC and 95% upper confidence limit (UCL) was performed to test if fewer samples could be collected in the future to arrive at the same SWAC.

Results of the Phase I sampling further confirmed the CSM established during reconnaissance. Evaluation of PCB concentration distributions by sediment bedform group showed two dramatically different populations. While bedform groups were defined by physical characteristics, PCB concentrations in Group 2 bedforms were typically greater and more variable than those in Group 1. SWACs and UCLs were calculated using the bedform groups for three geomorphologically defined river sections. The sensitivity analysis showed that in general reasonable estimates of SWAC and UCL could be estimated with 40% fewer samples such that large safety factors on the sample count are not necessary. SWACs and UCLs developed based on bedform classification will be compared to remedial goals in the FS.

Presenter Biography: Evan Thomas is an Environmental Engineer with 13 years of experience supporting and managing multifaceted contaminated sediment and groundwater remediation sites for state, federal, and commercial industrial clients. As project manager, Mr. Thomas has led multidisciplinary teams tackling complex environmental issues at high-profile sites in Wisconsin and the Great Lakes region. Specifically, Mr. Thomas is the active project manager for two of the largest Areas of the Kalamazoo River Superfund Site and has been involved in contaminated sediment remediation work on the river for 10+ years through Remedial Investigation, Feasibility Study, Remedial Design, and Remedial Action. Mr. Thomas's technical expertise lies with designing statistically robust sample designs, the development of 2D and 3D geostatistical models of contamination and visualizing complex geospatial data and site features.

DQO Data Collection for Developing a Conceptual Site Model

Presenters & Co-Authors: Stephen Zayko and Abigail Varner (Hamp Matthew & Associates

Decisions for compliance at a Michigan Part 201 Facility or a Part 213 Site (facility hereafter) require an owner/responsible party to collect representative, reliable, and repeatable data to construct the facility conceptual site model (CSM). The United States Environmental Protection Agency (USEPA) data quality objective (DQO) process is integral to making data driven decisions. The DQO process helps to ensure that quality data is obtained for development of a facility CSM. A CSM is continually refined and updated for use in decision making as new data are gathered.

In today's world, environmental professionals often implicitly use the DQO process even if it is not explicitly followed. The seven steps of the USEPA DQO process will be re-visited to illustrate its importance as a systematic tool for collection of any and all data that needs to be representative, reliable, and repeatable. If the DQO process is followed when collecting information for the CSM, then the assembly of the CSM will be more efficient and useful for making project decisions.

The data required for a facility CSM are directly proportional to the complexity of facility. Using the DQO process is beneficial regardless of the amount and type of data required to develop a CSM. Two real world site examples will be compared and contrasted to draw out the key points.

Presenter: Steve. Zayko is a Senior Engineer that has nearly 30 years of experience completing projects in over 30 states, nine EPA regions, and six countries. He specializes in Vapor Intrusion, Remediation System Design, Statistical Analysis, Computer Modeling, and Risk Assessment. Mr. Zayko is currently a sub-group leader for the Interstate Technology Regulatory Council (ITRC), Environmental Data Management (EDM) Team, Data Exchange subgroup. Since 2016, he has been a member of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Response Activity Review Panel. In 2014, Mr. Zayko participated in the Michigan Criteria Stakeholder's Advisory Group to assist with planned updates to generic cleanup criteria. Mr. Zayko was a member of the Rapid Response Environmental Site Support team for BP Deepwater Horizon (MC252) Incident in the Gulf of Mexico and was also a member of the Enbridge Line 6B release response team in Marshall, Michigan. His current work activities involve volatilization to indoor air pathway assessment and mitigation at sites containing chlorinated volatile organic compounds (CVOCs) and/or petroleum volatile organic compounds (PVOCs). Throughout his career, Mr. Zayko has consistently used the United States Environmental Protection Agency (USEPA) Data Quality Objectives (DQO) process for collecting and evaluating data to develop Conceptual Site Models (CSMs) used to direct and support project decisions.

TUESDAY

SESSION C

Data Collection & Analysis/AI

Digital Data Collection Tools Aid in Creation of Conceptual Site Model (Part 1)

Presenters & Co-Authors: Christopher Tort, Thomas Kinney, CPG, and Elise Graff (GHD)

This is **Part 1** of the presentation for this project. Part 1 focuses on the site characterization of the site though data collection tools to create a comprehensive conceptual site model (CSM), which was relied upon to develop a remediation work plan. Part 2 focuses on remediation and closure of the site.

The Site is a former manufacturing facility and encompasses approximately 148 acres. The primary building was 2 million square feet. The manufacturing operations spanned approximately 55 years between 1957 and 2012. The manufacturing facility was demolished in 2017. The site needed to be characterized and remediated to achieve a risk-based closure for property reuse and redevelopment, with land-use restrictions.

The geological depositional environment of the site consisted of glacial outwash and a groundwater divide. Remedial investigations (RIs) were completed using traditional soil and groundwater sampling along with extensive membrane interface probe (MIP)/hydraulic profiling tool (HPT) and laser induced fluorescence (LIF). MIP/HPT and LIF borings were completed in a grid pattern within the manufacturing building and select areas of concern throughout the property. Following MIP/HPT and LIF investigations a series of soil borings, monitoring wells, and soil gas probes were installed targeting specific areas that were identified within the MIP/HPT and LIF investigations. Several geophysical surveys were conducted across the site as an additional tool to use for monitoring well placement.

Through the different methods utilized to characterize the site, light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) were identified in addition to chlorinated volatile organic compounds (cVOCs) and 1,4-dioxane in NAPL, soil, groundwater, and soil gas. Data was collected from the multiple tools and modeled into 3D and 4D models that helped define areas for further investigation/characterization and ultimately areas and volumes for remediation.

The use of digital tools helped to create a comprehensive CSM which led to the creation of a remediation work plan and ultimately site closure and redevelopment of the site.

Presenter Biography: Christopher Tort is a Senior Project Manager/Geologist with GHD Services Inc. located in the Farmington Hills, Michigan office. Christopher has over 15 years of experience within environmental consulting focusing on managing environmental investigation/remediation and due diligence projects. Christopher has worked on a wide variety of due diligence, compliance and remediation projects and has experience coordinating and managing projects ranging from small due diligence assessments to large-scale investigations and remediation. Environmental investigation and remediation experience includes facility closure investigations, UST removal and closure investigations, landfill monitoring, environmental compliance, RCRA corrective action activities and field support associated with soil, groundwater, free product, and soil gas sample collection.

ERH Remediation of VOCs and Issuance of a Certificate of Completion (Part 2)

Presenters & Co-Authors: Thomas Kinney, CPG, Elise Graff (GHD), and Christopher Tort

This is **Part 2** of the presentation for this project. Part 2 focuses on remediation and closure. Part 1 provides the site characterization.

The Site is a former manufacturing facility and encompasses approximately 148 acres. The primary building was 2 million square feet. The manufacturing operations spanned approximately 55 years between 1957 and 2012. The manufacturing facility was demolished in 2017. The site needed to be characterized and remediated to achieve a risk-based closure for property reuse and redevelopment, with land-use restrictions.

Following completion of the remedial investigation (RI), a remediation work plan was prepared using data from the RI and results of a risk assessment. The objectives of the work plan were to remove non aqueous phase liquid (NAPL), reduce source area concentrations, prevent human exposure, and prevent off-site migration of the contaminants of concern (COCs).

The objectives of the remediation work plan were met by excavating shallow impacted soils and completing dewatering activities near the property boundary and by implementing a robust electrical resistivity heating (ERH) program in the larger heavily impacted areas of the site.

Once remediation objectives had been met, closure activities were implemented to obtain a Certificate of Completion from the Indiana Department of Environmental Management (IDEM). Closure activities included quarterly monitoring for two years to document the remediation was effective and off-site migration was not taking place. Additionally, following completion of remediation, manmade preferential pathways were eliminated by bulkheading applicable storm and sanitary sewers to prevent contaminant migration to potential off-site receptors. Monitoring documented that the bulkheading and other site engineering controls put in place had effectively controlled off-site migration of COCs.

Digital data collection and analysis helped provide an accurate conceptual site model, assist with the selection and implementation of the remedy, and document the effectiveness of the remediation and closure activities. Digital tools along with traditional approaches helped meet the client’s goals in a cost effective, timely manner. A Certificate of Completion has been obtained from IDEM, the property has been sold, and the property is currently undergoing redevelopment.

Presenter Biography: Tom Kinney is an Associate and Senior Geologist with GHD located in the Farmington Hills, Michigan office. Tom has 40 years of hydrogeologic/environmental consulting experience. Tom has experience managing portfolios and individual projects that include remedial investigations, risk assessments, feasibility studies, design and implementation of site remedies, and negotiating with regulators to obtain closures/no further action designations. Tom has extensive experience with vapor intrusion assessments and VI mitigation.

Artificial Intelligence and Machine Learning in Examination and Processing of Environmental Remediation Data

Presenter: Barry Harding, CPG (AECOM)

Recently, use of Artificial Intelligence (AI) has increased exponentially in several industries due to improved computing platforms and the wide-spread availability of both customizable software packages, internet platforms and pre-packaged applications such as various versions of ChatGPT OpenAI. Society has entered into a deep learning phase of AI where computer-aided system are often better versed in pattern recognitions, rapid collation and assessment of large data-sets such as for forensic examination of environmental data. It has been estimated the computer powers using AI double every six months.

AECOM will present up to three case study examples where AI was (1) successfully used for analysis and predictive modeling of molecular biological tools used to help support an evaluation of natural attenuation of a petroleum plume, (2) use of ChatGPT to aid in the design of a bench-scale irrigation system for assessment of plant growth in a phytoremediation project, and (3) use of AI to quantify image metadata and pattern recognition of fungal growth in support of a nature-based contaminant sensor.

Project hurdles, adaptive strategies, and lessons-learned will be presented with speculative “crystal ball” thoughts on the future use of AI and how it might change the environmental industry.

Presenter Biography: Barry Harding is a technical director with AECOM. He has been a consultant for 35 years and is known for his creative and collaborative spirit and he continues to lose to computer programs with better memories of the Sicilian Defense and other chess tactics.

Application of multi-class machine learning for source classification of PFAS in environmental water samples

Presenter and Co-Authors: Jason Lagowski[1], Andrew Safulko[2], Greg Coyle[3], Tohern C. G. Kibbey[4], Denis M. O'Carroll[5]

PFAS is increasingly being found throughout the natural and built environment. The ability to adequately differentiate potential sources of the PFAS is an important step toward the development of effective remediation strategies. The application of supervised multi-class machine learning was recently demonstrated using a blind test to identify AFFF and non-AFFF sources in aqueous environmental samples based solely on composition. In this context, the application of machine learning relies on algorithms trained to identify patterns within large and diverse data sets. With proper maintenance, the accuracy of machine learning algorithms can improve over time with the addition of more information and training data. The blind test consisted of 252 authentic samples from various sites, in addition to manufactured samples to test the algorithms' ability to identify and reject artificial samples. The training data set was comprised of over 13,000 samples from a diverse range of sites and served as the basis for training the algorithm to classify the unknown samples. The results of the test show that supervised machine learning is a capable tool for the classification of unknown PFAS samples based on their respective composition. The blind test demonstrated that the method could identify similarities between unknown sample origins as well as identify outliers/artificial data and therefore can be used to assist in the development of effective remedial strategies.

Presenter Biography: Jason Lagowski has over thirty-four (34) years of professional environmental experience both domestically and internationally delivering a wide range of projects. Since 2015, He has been specializing in emerging contaminants including PFAS, working to develop and commercialize new and innovative treatment solutions for impacted media. He currently holds the title of Sr. Client Services Manager and Managing Hydrogeologist for Brown and Caldwell and serves as the Private Sector PFAS lead. In this role he was responsible for the growth and technical execution of Site Investigation, Remediation and Solid Waste (SIR/SW) projects for the business. Mr. Lagowski is a current member of the MPART Citizens Advisory Work Group leadership team and sitting member for the PA201 Response Activity Review Panel. Mr. Lagowski has been a CPG for more than fifteen (15) years and is an active member of the AIPG Michigan Section. He currently holds the position of Treasurer on the Section Executive Committee, as well as is a member of AIPG's National DEI panel.

Notes:

1. Brown and Caldwell, Detroit, Michigan
2. Brown and Caldwell, Lakewood, Colorado
3. Brown and Caldwell, Andover, Massachusetts
4. School of Civil Engineering and Environmental Science, University of Oklahoma
5. School of Civil and Environmental Engineering Water Research Center, University of New South Wales, Sydney NSW Australia

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TUESDAY

EVENING FIELD DEMONSTRATIONS

Field Demonstrations/Question and Answer Session

VaporPin: The Best of Both Worlds: Active and Passive Sampling – Objective: Participants will learn how they can take an active grab sample while a passive sampler is installed. They will also see how they can take pressure readings while the passive sampler is installed.

Description: The Vapor Pin® is a small sub-slab vapor port that is installed in minutes using commonly available hand tools (hammer drill, drill bits, and dead blow hammer). Once installed, the Vapor Pin® can be securely covered, making it suitable for multiple sampling events, or simply used to gather data during a single event. The fact that Vapor Pin® is installed in a rapid, yet minimally intrusive manner, allows practitioners to cost-effectively gather high resolution active soil gas data sets and now passive soil gas sets. This increased site coverage provides a better understanding of the spatial variability beneath sites. When used with screening tools, such as multi-gas meters or photoionization detectors (PIDs), areas of interest such as hot spots and preferential pathways can be quickly identified and targeted for analytical sampling. They are also used for continuous monitoring of differential pressure and vapor concentration. A major advantage the Vapor Pin® over other sub-slab vapor ports is that a leak-proof seal between the port and the concrete is formed immediately by the silicon sleeve that covers its outer edge. Recent enhancements to the Vapor Pin® allow it to connect to a variety of sampling devices through a barb fitting, Swagelok® compression fitting, or quick connect valve. As a result, the Vapor Pin® can quickly and reliably connect to a wide variety of vapor screening instruments, evacuated canisters, bottle vacs, absorbent tubes, manometers, portables GC/MSs, and other sensors. In addition, a variety of attachments have been developed to allow for the collection of soil gas samples at greater depths and to isolate VOC-impacted slabs. The Vapor Pin® Insert is being specified in drawings and projects across the US and is used to facilitate the collection of soil gas samples and pressure measurements beneath engineered vapor intrusion barriers.

Eco-Rental Solutions, LLC – Customizable Remote Air Monitoring Stations: Background: Air monitoring for a variety of pollutants, including particulate matter (dust) and volatile organic compounds (VOCs), is increasingly required on a host of remediation sites, especially those where soil is being disturbed. While the regulatory requirements for this type of monitoring varies by state, the national trend is headed in the direction of requiring more and more air monitoring on remediation sites of all scopes and sizes.

Method: Eco-Rental Solutions provides a customizable, modular air monitoring system that is easy to use, compact, mobile, and rugged. Optional telemetry via an Aethair Thiamis modem allows for connection to a variety of instruments contained within the station, including dust monitors, photoionization detectors (PIDs), multi-gas detectors and weather stations. Data collected and transmitted via telemetry includes battery life and is centralized to one web-based platform that allows for remote data viewing in real-time, action level alerts, and data to be displayed and analyzed in a variety of formats.

WEDNESDAY (AM)

SESSION A

Data Collection & Analysis

Equilibrium Passive Sampling of Bioavailable Hydrophobic Organic Compounds at Sediment Sites: Advantages for Decision Makers using the Shiawassee River as a Case Study

Presenters & Co-Authors: Cameron Myshok (Geosyntec), Brent Pautler (SiREM), and Mary Schafer, Nick Shorkey, and Justin Connor (EGLE)

Equilibrium passive sampling devices (PSDs) made out of low-density polyethene or polydimethylsiloxane present many advantages over conventional sampling methods for quantifying the bioavailable concentration (C_{free}) of hydrophobic organic compounds (HOC) such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs) and organochlorine pesticides (OCPs) in sediment porewater and surface water as it enables collecting representative, depth discrete data without the need for large volume aqueous samples or sacrificing detection limits. Measuring bioavailable contaminants with PSDs provides a better measure of actual toxicity and mobility for environmental receptors and improves toxicity estimation compared to conventional sampling methods (e.g., porewater extraction, whole water grab sampling).

A large site located on the Shiawassee River in Howell, MI which served as a manufacturing facility since 1964, discharged wastes into lagoons, drainage ditches, and adjacent river/wetlands between 1969 and 1977, and resulted in elevated concentrations of PCBs being detected downstream in fish, soils & sediments, and floodplain areas. In 2001, it was added to the National Priorities List with soil & sediment excavation and monitored natural recovery chosen as the remedy. After three source removal excavations, successive caged fish studies performed in 2004 and 2011 suggest an ongoing source of bioavailable PCBs. The 2019 Five-Year Review determined that the ongoing remedy was not protective or meeting the long-term cleanup goals set forth and additional response actions may be required. Therefore, this site serves as an excellent candidate for implementing PSDs for monitoring and decision-making.

In 2020, surface water SP3™ samplers (a polyethylene PSD) were deployed in the Shiawassee River at several historic caged fish locations to determine PCB C_{free} levels. A follow-up state-led field deployment of porewater and surface water SP3™ pairs at nine locations was conducted in 2023 to assess progress. Results indicate PCB C_{free} levels remain elevated and may even be increasing, providing further evidence that the selected remedy may not be performing as anticipated.

The objectives of the ongoing work are to deploy additional SP3™ samplers in summer 2024 to determine PCB C_{free} levels in surface water and pore water at 20 locations upstream and downstream of the site and to correlate the results with co-deployed caged fish studies, as well as recent SP3™, sediment, fish tissue, and surface water grab sample data in order to evaluate the performance of the selected remedy at the site. The long-term goal will be to propose a long-term PSD-only monitoring strategy to be implemented every three to five years. A reduced number of locations is anticipated once site-specific correlations with various media have been better established.

Presenters: Cameron M. Myshok is a Staff professional with Geosyntec Consultants in Detroit, Michigan. He has experience conducting site investigations with a focus on vapor intrusion and groundwater quality. In addition, he has experience with performing geochemical modeling to support work at coal combustion residual (CCR) units. For his MASc. in Water Resources Engineering he simulated a chlorinated solvent plume in a fractured bedrock aquifer threatening a municipal supply well in Guelph, Ontario.

Brent G. Pautler, Ph.D. is an environmental chemist specializing in passive sampling, analytical chemistry, and monitoring of emerging contaminants. Dr. Pautler completed his PhD research in development of spectroscopic techniques to characterize natural organic matter, transitioning into passive sampling product development and management at SiREM. He provides technical oversight, research and development, project management and supervision of all chemistry and passive sampling services.

Mary B. Schafer is Senior Project Manager with 32 years of experience in Michigan's Superfund Section. Her project management experiences include capping and monitoring dump areas-including stamp sands, characterizing and monitoring chlorinated compounds in groundwater at historic manufacturing sites, dump sites, and plating facilities, overseeing groundwater extraction and treatment systems, implementing long term monitoring efforts at various sites, and assessing PCBs at the Kalamazoo and Shiawassee River sites.

GWQS Achieved in Fractured Bedrock at a TCE Release Site in the Passaic Formation

Presenter: Bill Brab, CPG, (AST Environmental)

Background/Objectives. Trap & Treat® BOS 100® was injected in fractured, shale bedrock at a corporate site in New Jersey in 2017. An unknown TCE discharge was discovered in groundwater testing in 1992, and over the course of 20 years several remedial actions were completed including soil removal. In 2016, a Remedial Investigation Report (RIR) was completed and the Trap & Treat® Approach was recommended to update the existing Conceptual Site Model (CSM) before applying a focused BOS 100® injection program in 2018 with post-injection monitoring conducted quarterly. The Classification Exception Area /Well Restriction Area (CEA/WRA) was lifted in 2020 and the site was granted a No Further Action (NFA) status, after achieving New Jersey Ground Water Quality Standards (GWQS) only 25 months post-injection.

Approach/Activities. The site was in a grassy area abutted by woods at a corporate campus. Previously, three other AOCs onsite were managed and closed using excavation and removal of overburden soils; afterwards, chlorinated solvent impacts were not above limits in overburden soils. This injection effort focused on treating groundwater in bedrock. The Area of Interest encompassed ~3,500 $ft^2$and was situated in the Passaic Formation, which consists of reddish-brown argillaceous shale with localized sandstone/siltstone interbedding. Depth to water occurs at ~10 ft below ground surface (ft-bgs), and the impacted groundwater interval was from ~10 to 60 ft-bgs. The contaminants of concern (COCs) were TCE and 1,1-DCE, and the project objective for both constituents in groundwater was 1 ug/L.

A key to bedrock remediation is to not focus solely on highly transmissive zones. The smaller aperture fracture networks and overlying weathered bedrock habitually contain more residual contaminant mass than more transmissive features. Being able to access, isolate, and treat these zones is key to success at difficult fractured rock sites, and many sites require a combination of methods due to dissimilar properties between the less consolidated and consolidated units.

A Transition Zone (TZ) of partially weathered rock was present from 10 to 25 ft-bgs that prevented the use of standard direct push equipment (DPT) to reach and isolate this interval for assessment and treatment. TZ remediation consisted of utilizing RPI's GeoTAP™ Method; this methodology was developed to gain access to challenging geologies and first involves pre-drilling to the desired depth using sonic, air rotary, or hollow-stem augers (HSA). The evacuated borehole is then backfilled with hydrated bentonite chips or pellets to seal the bore wall, and a DPT rig can then push through the bentonite column to reach the desired injection depth intervals without compromising the bore seal. Remediation slurries or fluids are then injected through the bentonite. This technique has been used successfully on more than 30 project sites across the country, accessing depths as great as 180 ft-bgs.

Bedrock characterization and injection points (BC/IPs) were installed with air rotary/HSA in the competent lithology. Casing was installed from ground surface to 15 ft-bgs and the vertical interval of interest was left uncased so borehole geophysical tooling and discrete interval (18 in.) sampling with a straddle packer could be conducted. Finally, the bedrock zone remediation implementation used a custom straddle packer (18 in. interval) to deliver BOS 100® slurries pumped from a unique bedrock injection unit with accessible flow rates ranging from 50 to 250 gallons per minute and pressure up to 3,000 psi.

Results/Lessons Learned. The focus of this presentation will be to showcase recent improvements to techniques and approaches to access contaminant impacts in transition zones/saprolite/epikarst and consolidated lithologies for characterization in-situ remediation. This site-specific case study will illustrate the development of quantified, high-density CSMs using high-density, discrete groundwater sampling for quantitative lab analysis, which provides for surgical and aggressive in-situ remediation techniques that install requisite in-situ treatment product precisely where it is needed.

Presenter Biography: Bill Brab, CPG has been on the AST team since 2011 as a Senior Remediation Geologist and is based in Midway, Kentucky. He manages most of the projects in Kentucky and Tennessee for the company. Bill received his BS degree in Geology from the University of Kentucky. Bill is a long-standing member of the American Institute of Professional Geologists (AIPG) and currently holds the Treasurer Executive Office position for the Kentucky Section. He is also an active board delegate on the Kentucky Board of Registration for Professional Geologists, which manages and oversees licensure within the commonwealth. He was drawn to AST because of their commitment to closing sites quickly and using sound science to maximize efficiency, rather than operating under a framework that promotes stagnation and keeps properties in purgatory for decades.

A GSI Compliance Approach to Demonstrate Protection of Surface Water from a Chlorinated Solvents Plume Beneath an Extensive Wetland System

Presenters & Co-Authors: Peter Lepczyk and Bailey Hannah (Fishbeck)

Investigative and remedial activities are being performed to address chlorinated solvent releases and other contamination at a legacy site in Michigan used for the manufacture of military equipment. Groundwater in a portion of the site has been documented to migrate toward a creek and extensive wetland system (creek/wetland). A groundwater/surface water interface (GSI) monitoring well network was previously established with well screens intersecting the lower portion of the aquifer, where past vertical aquifer profiling has demonstrated the highest concentrations of volatile organic compounds (VOCs). In 2019, an investigation was implemented using a membrane interface probe/hydraulic profiling tool (MiHPT) to provide high-resolution site characterization data adjacent to and beneath the creek/wetland to better understand the fate and transport of VOCs as they migrate from the lower portion of the aquifer upward through the wetland sediments and into surface water. The MiHPT work within the wetland system was conducted using an amphibious direct push drill rig.

The MIHPT investigation findings resulted in a reinterpretation of the conceptual site model (CSM), suggesting that that high concentration VOC impacts are present primarily in the lower portion of the aquifer above the basal clay in both the upland area and outer portion of the wetland. However, beneath the creek/wetland, it was inferred that VOCs attenuate (via the reductive dechlorination pathway) as they migrate upward through the highly reduced wetland sediments, such that concentrations may meet applicable cleanup criteria at the GSI.

During 2023, to enable long-term groundwater monitoring necessary to demonstrate compliance with the GSI pathway, a network of alternative monitoring points (AMPs) was established within the creek/wetland in accordance with Michigan Department of Environment, Great Lakes, and Energy (EGLE) Remediation and Redevelopment Division (RRD) guidance updated in April 2018. The AMP network is comprised of 10 wells installed in the upper portion of the aquifer directly beneath organic-rich sediment along with five deeper wells installed within the lower portion of the aquifer. The majority of the AMPs were installed with an amphibious direct push drill rig. The sampling points were constructed of 21-inch-long, 5/16-inch-diameter, double woven, stainless-steel wire screens. Collocated surface water monitoring devices were installed at all locations. The AMP wells and surface water monitoring devices were constructed such that they could be sampled from the upland area; this was achieved by extending tubing from the sampling/well points to an accessible location along the border of the creek/wetland. The horizontal tubing runs were placed inside of conduit and terminated in an upland well vault.

To date, the key findings from this study include: confirmation that the high concentration VOC impacts are positioned within the lower portion of the aquifer; only low to non-detectable VOC concentrations are present in the upper portion of the aquifer; surface water is not impacted; and distinct geochemical differences are present between the groundwater and surface water. These findings support the transition from the legacy GSI monitoring network to a network comprised of AMPs. This will be used in conjunction with a mixing zone-based determination to demonstrate GSI compliance in accordance with the 2018 RRD GSI guidance.

Presenters: Peter Lepczyk has approximately 25 years of experience in the design and implementation of hydrogeological and remedial investigations. He is currently a senior hydrogeologist at Fishbeck. Peter has worked in a variety of geological settings and much of his career has focused on investigating and remediating complex sites impacted with chlorinated solvents. Peter holds a BS in Geology from Hope College and an MS in Environmental Geosciences from Michigan State University.

Bailey Hannah has approximately five years of experience in environmental remediation, hydrogeology, and groundwater surface water interactions. She is currently a hydrogeologist at Fishbeck. In her role at Fishbeck, she focuses on hydrogeological and remedial investigations, groundwater flow and transport models, the performance of soil and groundwater sampling, as well as drilling oversight. She has been involved with many projects for various municipalities and private clients during her time with Fishbeck. Bailey holds a BS in Environmental Studies and Sustainability and an MS in Environmental Geosciences from Michigan State University.

Cost-Effective Data Collection and Visualization Strategies to Bolster Confidence in Decision Making

Presenter: Darby Litz, EIT, PG (TRC)

Data driven decision making is critical throughout the life cycle of environmental projects, from initial site conceptual model development to site closure and demonstration of risk management. Technological advances in both environmental data collection methods and data management and visualization tools allow for cost-effective gathering and evaluation of large volumes of data. A thoughtful strategy for data collection, evaluation, and presentation can significantly strengthen understanding of site conditions and provide relevant stakeholders with a clear and transparent view of environmental data, ultimately boosting confidence in decision making relative to compliance efforts. TRC will share examples of where innovative data collection methods, including advanced sensors and technologies for real-time data collection, were used to support conceptual site model refinement.

One example is where TRC used a real-time vapor intrusion monitoring approach (VaporSafe™) to better understand the variability of TCE in indoor air as well as the potential effect of preferential pathways and variable pressure on vapor intrusion. Data were used to identify encroachment locations and an indoor air source unrelated to historical operations (brake degreasing in an area of the plant where the current tenants are operating a garage). Additionally, TRC could document how atmospheric pressure, wind speed, and site operations (air compressor) affected indoor air concentrations. These data have allowed TRC to recommend targeted, cost-effective modifications to the existing structure and sub-slab ventilation system to address those areas with lingering vapor intrusion concerns.

Another example is where a pressure transducer study was designed and deployed to better understand a complex and dynamic hydrogeological system. Water elevation data from the transducers and a nearby staff gauge were collected and visualized through a series of Power BI dashboards to better understand trends and anomalies to corroborate prior results and shore up assertions regarding groundwater compliance status. An interactive dashboard allows rapid answers to questions without creating additional visualizations to view the data from a different perspective.

These approaches allow for a more comprehensive understanding of dynamic environmental systems and can be used to help identify influences from other sources, evaluate the feasibility of remediation technologies, and support remedy selection and attainment of closure standards.

Presenter Biography: Darby Litz EIT, PG (IN, KY), is a Senior Hydrogeologist/Data Analyst at TRC with over 18 years of experience in solving engineering and remediation challenges for a variety of projects throughout the Midwest. She is a leader in TRC's quality network with expertise in data management, RCRA Corrective Action, site characterization, coal-combustion residuals (CCR), and complex remediation. She has significant experience in developing RCRA-compliant groundwater monitoring and statistical evaluation programs that integrate data management tools to enhance data interpretations and conceptual site model development. She earned her B.S. in Geologic Engineering from Michigan Technological University and M.S. in Hydrogeology from Clemson University.

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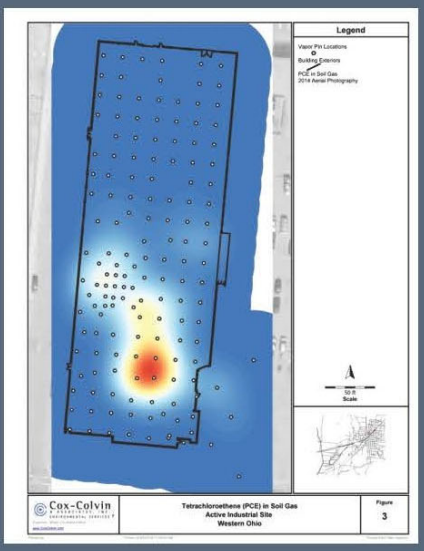

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WEDNESDAY (PM)

SESSION A

Modeling

Using Geospatial Analysis to Optimize Monitoring Networks

Presenter: Adam Janzen, PE (Barr Engineering Co.)

Geospatial analysis is based on the spatial relationships between nearby data points. These relationships are not accounted for in a traditional statistical analysis. A key concept is the variogram, which is a model of variability as a function of distance between pairs of data points. The variogram can be used by itself to inform the selection of an appropriate sample spacing but is most commonly used as an input to kriging. Kriging is a popular method for interpolating surfaces (or volumes) from point data. It is less well-known that the kriging algorithm also uses the variogram to calculate the error of estimation associated with each interpolated value. The resulting error of estimation map can be a powerful tool for optimizing future data collection, provided that an appropriate variogram model has been developed from existing site data.

A geospatial analysis can be used to optimize a monitoring program by providing a quantitative basis for identifying the most beneficial sampling locations. Geospatial analysis can be used to guide the selection of new sampling locations that will provide the most value to the project or, conversely, to identify existing sampling locations where monitoring could be discontinued because the data are redundant. For the latter case, substantial cost savings may be realized by removing redundant locations from long-term monitoring, especially for sites with many monitoring locations and frequent sampling. In either case, the results of the geospatial analysis support informed decision making and wise allocation of resources.

Presenter Biography: Adam Janzen, PE is a senior environmental engineer at Barr Engineering Co. and works remotely from a home office in Columbus, Ohio. He has used geospatial analyses to help clients optimize monitoring networks and uses geospatial methods frequently in his primary role as a groundwater flow modeler. He was one of the trainers for the Interstate Regulatory and Technology Council's (ITRC) "Geospatial Analysis for Optimization at Environmental Sites" web-based training and was a contributing author to the companion ITRC GRO-1 guidance document. Adam earned a bachelor's degree in civil and environmental engineering from the University of Illinois at Urbana-Champaign and a master's degree in civil and environmental engineering from Princeton University.

Using Conditional Simulation Modeling for Estimating Contaminated Sediment Remediation Volumes

Presenters & Co-Authors: Dan Peabody (EGLE) and John Kern (Kern Statistical Services)

Recent empirical evidence has shown that utilizing preliminary or incomplete site investigations to develop contaminant magnitude and extent estimates at sediment sites can underestimate remedial extents and material volumes. At one site, the volume of sediment material identified for removal grew from 19,500 cubic yards (yd^3) at the preliminary investigation stage, to approximately 65,000 yd^3 at the design investigation stage, and finally to more than 130,000 yd^3 at the construction stage. Such errors in remedial extent/volume estimates inevitably lead to project cost overruns that complicate, if not inhibit, an effective site closure as the amount of remaining remediation funds become more limited and previously unidentified contamination continues to be found.

Accurate remedial volume estimates require understanding the lateral and vertical extent of contamination, the remedial footprint, as well as dredging depths. While accuracy of the remedial footprint is largely a function of sample density and variability of contaminant concentrations, accuracy in the vertical extent (i.e. depth of contamination) is more complex because concentration variability is convolved with potential biases due to physical limitations of collecting sediment with coring devices. In studying the effects of these types of lateral and vertical errors, it becomes obvious that tools are needed to propagate the uncertainty in a two- or three-dimensional contaminant mapping into the subsequent uncertainty in lateral extent, volume, and cost. Relationships between mapping uncertainties and these parameters are generally nonlinear and there are no simple equations for estimating uncertainty bounds on volume and cost due to uncertainties in mapping.

Conditional simulation was developed for estimating mining production parameters from uncertain deposit mapping. This process is applicable to site remediation problems as they are essentially contaminant mining. Conditional simulation is a resampling method for generating multiple equally likely maps or three-dimensional representations of the contaminant distribution over a fine grid of locations within the study area. Each equally likely set reproduces the statistical distribution and spatial correlation of the samples and interpolates the concentrations at sample locations. Application of volume and cost estimates to each equally likely contaminant distribution provides a set of equally likely estimates of volume and cost from which uncertainties in these parameters can be anticipated. This approach is generally applicable for developing uncertainty bounds on parameters that would be biased due to the smoothing effects of other interpolation methods. This work illustrates the application by example using conditional simulation to estimate uncertainty distribution of remedial footprint area and volume and for designing an infill sampling program for remedial design.

Presenters: Dan Peabody serves as an Environmental Quality Analyst in the Michigan Department of Environment, Great Lakes, and Energy's Remediation and Redevelopment Division. In this role, Dan acts as the state's project manager for the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site. Prior to this role, he served as a geologist for the EGLE Geological Services Unit, responsible for managing, developing, and marketing the unit's marine program, as well as performing numerous hydrographic, sediment quality, and marine geophysical surveys on rivers, in-land lakes, and in near-shore Great Lakes environments throughout the state. Before joining EGLE, Dan worked as an environmental consultant for a private firm. He holds a Bachelor of Science degree in Geology from Western Michigan University, with postgraduate study in contaminant hydrogeology.

Dr. John Kern is the owner of and lead statistician for Kern Statistical Services, Inc. In this role, John provides statistical and geostatistical consulting for some of the nation's most challenging environmental and ecological projects. He is dedicated to promoting state of the science decision making through innovative statistical practices in design and implementation of environmental, ecological and wildlife management studies. His efforts at sites have focused on study design, site characterization, risk assessment, wildlife impact assessment, database management, data analysis, and statistical methods development. Dr. Kern holds a Bachelor of Science degree in Applied Mathematics from Lake Superior State University, a Master of Science in Applied Mathematics from Montana State University-Bozeman, and he holds a Doctor of Philosophy in Statistics from the University of Wyoming.

WEDNESDAY

SESSION B

Emerging Contaminants

Using a Digital CSM to Expedite Workflow for DoD PFAS Site Investigations

Presenters & Co-Authors: Patrick Curry, PG, Allison Yanites, and Oran Day, PE (Arcadis)

Background/Objectives: Over the last several years, the United States Department of Defense (DoD) has begun a large effort to assess current per- and polyfluoroalkyl substances (PFAS) liability associated with hundreds of sites across multiple armed forces. The traditional DoD site investigation process includes numerous stakeholders with long dead periods created by the interim reporting and review process. The typical period of performance for a complex PFAS investigation can stretch three to five years, and due to uncertainty, PFAS investigations will require multiple phases of work before sites are ready for remediation. Although the slow pace may seem inevitable at sites of this scale and complexity, an adaptive investigation approach with streamlined data processing and web-based dashboards – a digital conceptual site model (CSM) - can engage stakeholders, reduce dead periods, and streamline the interim reporting process.

Approach/Activities: Integrated digital processes and real-time data management allows project teams to better manage their data, plan adaptive steps faster, reduce lifecycle investigation costs, and facilitate more efficient discussions with both clients and regulators. Access to data helps stakeholders reach consensus quickly and can reduce (or eliminate) interim reporting. For the Phase 1 Buckley Space Force Base (SFB) PFAS Remedial Investigation (RI), staff collected data using tablets and the team uploaded field and analytical data to a common database connected to interactive geospatial maps and analytical dashboards. A single web portal for the digital CSM was made accessible to all stakeholders and included a GIS map, analytical dashboard, digital document library, and interactive 3D model that together presented the project status, evolving digital CSM, and remaining data gaps. The Buckley SFB RI included three primary mobilizations: prescriptive, adaptive, and monitoring. The prescriptive phase included known impacts that required initial characterization. The adaptive phase built on the prescriptive with step-outs to complete delineation. The monitoring phase included the installation of final monitoring wells based on results of the prescriptive and adaptive phases of work. Each phase was separated by an interim review period that relied on the digital CSM for data management.

Results/Lessons Learned: Prior to each phase of work, the various components of the digital CSM provided updated results for stakeholders to help illustrate the CSM, highlight data gaps, and outline the planned scope of work. Between each phase of work, rather than technical memoranda requiring stakeholder review, status meetings were used to review the digital CSM collectively and reach consensus prior to the next phase of work. Data analysis relied on the digital CSM for reference, and once the investigation activities were complete, the same database used to build the digital CSM was used as the basis for all required RI report attachments. Stakeholder feedback on the digital CSM has been positive and the Buckley SFB RI was completed within the three-year period of performance.

Presenter Biography: Patrick Curry is a Technical Expert/Associate Vice president at Arcadis and has spent the past two decades focused on site investigation and CSM development. He serves as Technical Director and oversees a variety of large-scale investigation projects and currently leads the Arcadis North America Site Investigation practice.

Data Driven Remedial Investigation Strategies at an Orphaned Plating Facility

Presenter & Co-Authors: Tom Brubaker, (Global Remediation Technologies, Inc.), Zachary McCurley and Martha Thompson (EGLE)

An expanded site investigation at an orphaned former plating facility in Jackson, Michigan, was prompted by the documented occurrence of numerous soil and groundwater impacts, combined with the proximity of potentially sensitive receptors, including surface water and municipal water supply wells, and poorly understood hydrogeologic conditions. GRT was retained by EGLE-RRD in 2023 to review limited previous site data, prepare a preliminary Conceptual Site Model, and conduct a follow-up assessment of identified data gaps.

The site is bounded by the Grand River on one side, and on the other side by a municipal well field for the City of Jackson. The well field includes a total of twelve high-capacity water supply wells completed in the underlying Marshall Sandstone, with exposed open borehole intervals typically located at 75 to 380 feet below grade. Available on-site data indicate impacts to surface and groundwater, river sediment, and soil, from up to ten discrete source areas. Recent testing by others identified on-site PFAS (PFOS > 11,000 ng/L) in shallow groundwater, and additional detections and/or criteria exceedances of CVOCs, SVOCs, PCBs, cyanide, and metals in near-surface soils and/or groundwater. Testing performed by MPART, and a consultant for the City of Jackson, detected low-level PFAS concentrations in four (4) of the adjacent municipal water supply wells. The hydraulic gradient(s) and associated impact migration directions at the site are undefined, while gradient/migration pathways directed toward the river, toward the well field, or vertically downward, are considered possible. Although up to 60 feet of unconsolidated surficial deposits are reportedly present at the site, previous site investigation activities did not include continuous soil sampling and were only completed to a maximum depth of 35 feet, and thus the site geologic materials and any geologic controls on impact migration have not been fully characterized.

Initial investigation strategies included a series of perimeter soil borings completed with continuous soil logging down to the top of the bedrock to characterize the unconsolidated geologic materials. Perimeter locations were chosen to assess any significant geologic variations present at the site, and to minimize potential carry-down of contamination in uncharacterized source area locations. Clustered monitoring wells were installed at multiple depths at the perimeter investigation locations to evaluate vertical and horizontal hydraulic gradients and to assess the potential impact migration pathways in the site groundwater. Given the potential for temporal variation in hydraulic heads and associated gradients, due to varying water withdrawal conditions in the nearby well field and other factors, water level transducers with dataloggers were installed in the site monitoring wells to document the range of hydraulic head variation, if any, and to aid in identifying the dominant hydraulic head and gradient trends needed to assess impact migration.

Sample results and hydraulic head data obtained from the clustered monitoring wells are being used to guide the next phases of investigation. Likely outcomes include prioritization of source area investigations, improved targeting/placement of investigation borings at individual source areas in both surficial deposits and the underlying bedrock aquifer and added guidance for implementing a GSI study to evaluate the extent of impacts venting into the Grand River.

Presenter Biography: Tom Brubaker serves Global Remediation Technologies, Inc. as a geologist and project manager. He leads and supports remedial investigations at a variety of EGLE-RRD Sites in Michigan that contain industrial solvents, petroleum, metals or PFAS contaminants in either unconsolidated deposits or bedrock settings. Mr. Brubaker has worked in the environmental geosciences industry for eight years.

Colloidal Activated Carbon (PFAS) Barrier Commissioning - Fine-Tune Adjustment and Performance Optimization Supported by Computer Modelling at a Michigan Site

Presenter: Keith Gaskill, LPG (Regenesis)

"Background/Objectives. The in-situ application of colloidal activated carbon (CAC) in a reactive barrier configuration is now an established remediation strategy for reducing risk posed by PFAS contaminated groundwater. Computer modelling provides a valuable design tool enabling contaminant flux, dynamic transfer between aquifer compartments, and competitive interactions between PFAS species for activated carbon sorption sites to be quantified. Post application monitoring data allow the model to be further calibrated and refined. Its use may then be extended through other project phases. Deviation of field performance data from the modelled trajectory may be observed at certain points within a barrier. This exposes zones that may require engineering attention. Pre-installation design modelling and post-installation model-supported adjustment is analogous to design and commissioning of mechanical systems such as hydraulic containment installations. This presentation provides an illustration of the model-supported commissioning process drawing from a case study of a midwestern PFAS site.

Approach/Activities. A former fire training area at a Michigan site was impacted with PFAS contamination. The plume was travelling radially from a central location within an oxbow of a moderately-sized river. A CAC barrier was installed in 2019 to stop migration of the PFAS plume into the river. The PlumeForce™ modelling software was used to interrogate the post application data. Initial input estimates of governing aquifer parameter values were adjusted based on field data to calibrate the model to the measured performance observations. Example overlay graphs of modelled trends and observed data are presented for time-series and individual sampling event data sets. These were used for communication with the client and for informing appropriate commissioning and optimization adjustments. Deviation of performance from the design trajectory was noted in two areas of the barrier. These were rectified as commissioning adjustments.

Results/Lessons Learned. Overall agreement between trendlines predicted by the PlumeForce™ software and observed performance data was high. (Average r2 =0.90; range 0.51 – 1.00). This is despite the natural variability characteristic of a real-world data set that would reduce the r2 coefficient even if the trendline were perfect. The quantitative synthesis of advection, retardation and equilibratory dialog between aqueous, CAC-sorbed, natural organic carbon-sorbed and low-transmissivity zone compartments is adequate to describe the data set. The modelling revealed three distinct performance phases that become more pronounced as distance from the barrier increases – a lag, a principal fast decline and a residual slower decline. Model calibration to performance data and subsequent model interrogation allowed PFAS fate and transport at the site to be better understood and informed predictions of performance timing and extent. In addition, the approach exposed areas where commissioning adjustments were warranted and enabled modelled explorations of potential adjustments to determine the optimum engineering course. Model-supported post-application analysis provides a powerful tool to improve understanding, projection and inform commissioning of PFAS barriers. The engineering control and management capabilities afforded are key predictors of project success."

Presenter Biography: Mr. Gaskill has worked as a scientist for over 23 years in the environmental industry. He has performed project tasks such as site investigations for a variety of property management and property sales issues; UST/AST investigation and removal; petroleum pipeline and bulk storage response and remediation, site investigation/remediation at drycleaner facilities across the United States; computer modeling of groundwater systems and geochemical fate and transport; hydrological and hydrogeological assessments, passive flux meter data analysis, mechanical remediation system conceptual design and implementation; pilot testing and remediation feasibility studies; expert witness services; extensive site investigation and delineation studies using traditional and TRIAD methodology; various types of hydrogeologic testing such as slug testing and pump testing; operation and data management of Membrane Interface Probe (MIP) and mobile lab technologies; management of multiple sites for major oil companies, drycleaners, and miscellaneous industry. Mr. Gaskill has focused on high data density and high-resolution data analysis and conceptual site model production. He has designed and implemented in-situ remediation plans for more than 15 years. As a Senior Design Specialist at Regenesis, Mr. Gaskill has been providing site specific remediation plans as well as expert technical support and advancement of remediation application technology specifically in carbon based products and treatment of CVOC and PFAS contamination.

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Advancements in Analytical Techniques to Demonstrate Successful Destruction of PFAS

Presenter: Taryn McKnight (Eurofins Environment Testing)

Conventional analytical methodologies for measuring PFAS have historically been accompanied by a series of compromises in terms of sensitivity, selectivity, and capturing the whole PFAS picture. In terms of site investigation these limitations have generally been accepted, provided that specific PFAS compounds and reporting limits are met to compare to regulatory standards. However, as the investment in destructive technologies grows, it is imperative to be able to demonstrate successful mineralization of all PFAS components being destroyed.

Conventional methods can measure a discrete list of anionic compounds, ranging from C4-14, on the order of 80+ PFAS analytes with sensitivity in the parts per trillion range. Many additional PFAS are not determined as discrete compounds for a myriad of reasons: the sample collection procedures, the sample preparation method, the analytical technology applied, and the lack of analytical reference standards.

There are methods which aim to capture non-discrete PFAS mass such as Total Organic Fluorine (TOF) by combustion ion chromatography (CIC). The U.S. EPA has published OTM-45 for the collection and analysis of semivolatile PFAS from source air emissions and is in the process of finalizing OTM-50 for the collection and analysis of ultra-short chain and volatile PFAS that are the suspected products of incomplete destruction from source air emissions. Utilizing a Quadrupole Time-of-Flight mass spectrometer (LC-QTOF-MS), we can conduct a Non-Target Analysis (NTA) to attempt to identify what the PFAS “dark matter” is comprised of and what we might be missing but this is not a quantitative tool. All these analytical methods aim to close the mass balance, but each are susceptible to certain limitations.

A combination of tools, along with certain method modifications, can improve assessments of complete PFAS mineralization but the science is still evolving. This research lessens the gap between varied approaches through method development and makes clear where improvements are still needed. Method development has been conducted to improve the isolation of organic fluorine from inorganic fluorine in gas phase extracts, allowing for a more accurate total organic fluorine measurement in gas phase samples. When biphasic end products are produced, such as pyrolysis oil from the pyrolysis treatment technology, method development has been conducted to improve extraction efficiency from both phases, leading to a more accurate representation of destruction efficiency. EPA led and Eurofins supported, method development to improve recoveries from EPA’s method OTM-45 is in progress and these data will be available to include in the discussion in June. Through these method development efforts, Eurofins has determined that existing methodologies for measuring inorganic fluorine are insufficient to support a mass balance for PFAS. Without method development efforts to address this gap, it is important to be aware of this limitation when developing an analytical plan to assess destruction technologies and interpretation of the data.

Presenter Biography: Taryn McKnight, PFAS Practice Leader for Eurofins, has more than 20 years of experience in the environmental testing industry. As one of the company’s subject matter experts on PFAS, Ms. McKnight contributes to multiple agency workgroups to address PFAS challenges, including co-chair of the NGWA subcommittee to develop PFAS Sampling Guidance and a PFAS Forensics White Paper. With her expertise she provides technical guidance to clients in setting up programs to achieve their site-specific objectives, and to agencies with understanding their data usability considerations.

A More Comprehensive Analysis of PFAS in Landfill Leachate, What to Expect as Regulations Develop

Presenter: Taryn McKnight (Eurofins Environment Testing)

With the latest version of EPA's national wastewater discharge standards, Plan 15 calls for updating standards in its landfill category. This decision was based off evidence that leachate from effluent Subtitle D landfills can discharge PFAS to surface waters and POTWs. It is not yet clear when the new rules will take effect or how the guidelines will be established.

In 2022, the EPA initiated a study of wastewater from the organic chemicals and plastics category, which for the first time included the collection of Adsorbable Organic Fluorine (AOF) data. These data represent the potential presence of untargeted PFAS in these samples and will be used to inform future effluent limitation guidelines (ELGs). It is unknown whether the EPA will continue to collect AOF data for other categories including landfills, but a recent study revealing a 30% conversion rate of precursors to targeted PFAS, suggests there is value in capturing untargeted PFAS (Chen et al, 2022).

As the investigation of landfill leachate matures and discharge guidelines are established, there is growing interest in understanding the true mass or composition of PFAS in this matrix. Given the complexity of a landfill, it is also critical to understand what potential there is for a high or low bias when applying proxy measurements such as AOF or TOP Assay. To better understand what measure of utility there is when applying various targeted and non-targeted tools to landfill leachate, samples were analyzed for an expansive list of semivolatile and volatile PFAS, the TOP Assay procedure, and AOF. With these data we have a more comprehensive characterization of landfill leachate and ultimately what may be required to provide treatment or comply with government regulations. We see how the various techniques can complement each other or where they fall short of certain objectives.

The results show that when a limited target list of analytes is applied, such as the 40 compounds from EPA's Draft 1633 method, key PFAS constituents may be missed. Although the TOP Assay and AOF methods both aim to capture the unknown mass of PFAS that may be present in a sample, these methods may tell a different story in landfill leachate. When targeted results indicate the presence of many PFAS compounds and at higher concentrations, these data align with a notable conversion of precursors in the TOP Assay as well as a significant measurement of total organic fluorine. However, when the targeted results indicate the presence of very few PFAS compounds at lower concentrations, these data tend to align with a minimal conversion of precursors in the TOP Assay but not always with a significant measurement of total organic fluorine. This research demonstrates what utility there is when applying these various analytical tools to landfill leachate and some of the limitations when interpreting proxy data.

Presenter Biography: Taryn McKnight, PFAS Practice Leader for Eurofins, has more than 20 years of experience in the environmental testing industry. As one of the company's subject matter experts on PFAS, Ms. McKnight contributes to multiple agency workgroups to address PFAS challenges, including co-chair of the NGWA subcommittee to develop PFAS Sampling Guidance and a PFAS Forensics White Paper. With her expertise she provides technical guidance to clients in setting up programs to achieve their site-specific objectives, and to agencies with understanding their data usability considerations.

High Dimensional Data Analysis and Visualization to Demonstrate Compliance

Presenter: Alex Eklund (TRC)

Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are powerful statistical techniques that can be used to evaluate high dimensional groundwater data generated in a variety of sites including waste disposal and management facilities, sites of environmental contamination, and sites where PFAS are being characterized. These techniques are particularly useful in assessing unanticipated changes in groundwater quality and distinguishing sources of groundwater contamination.

PCA and LDA methods offer several benefits in the analysis and interpretation of data over traditional analysis techniques through: 1) dimensionality reduction and visualization, reducing the dimensionality of the dataset to more easily visualize and make correlations in the data; 2) dominant pattern identification, revealing which variables are the dominant factors influencing groundwater quality differences; 3) noise reduction, focusing on the significant components to identify meaningful patterns and relationships; and 4) multivariate analysis, where the relationships among multiple variables are taken into account simultaneously. The multivariate analysis capability is a key benefit for groundwater analysis as it accounts for the interdependencies among various parameters (e.g., pH, chemical concentrations, temperature) that affect water quality, particularly for large-volume datasets.

PCA has been gaining popularity as an analysis tool in the environmental world, with more regulatory agencies becoming aware of the method and utilizing it themselves. Additionally, the number of academic articles containing PCA has substantially increased in the past five years compared to previous decades. With increased acceptance and adoption of PCA and LDA, care must be taken to understand and properly explain the applicable use cases and findings of the analyses so that incorrect conclusions are not made. When used correctly, these methods provide quantitative analysis to aid in making more informed decisions and developing effective strategies for groundwater management and remediation. TRC's project experience with direct application of these statistical techniques to real-world situations has provided valuable insights for groundwater characterization efforts, such as evaluating the potential influence of identified source material on groundwater quality.

Presenter Biography: Alex Eklund is a Data Analyst at TRC with experience in the management, visualization, and statistical analysis of environmental data. He is a prominent member of TRC's Center of Research Expertise (CORE) data management and assessment team (DMAT) where he leads the implementation of interactive dashboards and high frequency data collection and visualization. Alex also has proficiency with statistical analysis, is an active member of TRC's Statistical Analysis of Environmental Data CORE team and has presented on the use of principal component analysis and linear discriminant analysis. Alex earned his B.S. in Environmental Science and M.S. in Data Science and Business Analytics from Wayne State University.

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SESSION C

REMEDIATION

Groundwater Plume Analytics® - Tools for Using Your Site Data to Better Assess Remediation Effectiveness and Plume Stability

Presenters & Co-Author: Joe Ricker, PE and Timothy Goist, PG (WSP)

Groundwater Plume Analytics® (GPA) tools are innovative, data-driven evaluation techniques to reliably identify and effectively communicate meaningful patterns in groundwater data. GPA tools oftentimes lead to beneficial project outcomes including cessation or optimization of remediation systems, demonstrating natural attenuation, optimizing monitoring programs, and/or risk-based site closure. GPA tools may also identify areas where remedial enhancements or targeted source remediation may be needed to expedite plume stabilization and a path to closure.

The published Ricker Plume Stability Method® is a unique and publicly available method of evaluating plume stability that overcomes limitations posed by conventional well-by-well analysis techniques. The Ricker Method® calculates plume stability metrics of plume area, average concentration, mass, and center of mass. The method synthesizes empirical and routinely collected data (e.g., depth to water, depth to product, low flow water quality parameters, groundwater analytical results etc.) to generate outputs that can be used to further dissect and evaluate dissolved plumes over time and provide a powerful data-driven tool to evaluate remedy effectiveness. Outputs from the Ricker Method® can be used with other innovative plume diagnostic tools such as the Spatial Change Indicator™ (SCI) analysis and Well Sufficiency Analysis (WSA) to further evaluate and communicate groundwater plume dynamics. The SCI™ evaluation shows sequential spatial changes in the plume over time. The WSA tool is used to assess how many monitoring wells can be removed from a monitoring well network while continuing to maintain plume analysis integrity. When considering a reduction to a groundwater monitoring well network, it is essential to take a data-driven approach to achieve optimization of the network. The reductions are designed using mathematical and statistical procedures that allow for reduction in monitoring program costs while retaining the ability to understand long-term groundwater plume behavior.

Successful use of GPA tools will be illustrated at two case study sites. At an existing chemical manufacturing site, GPA tools were used to demonstrate remedial success from an offsite extraction system that had been operated for 24 years. Traditional data evaluation techniques suggested that the plume had reduced by 35 percent, but the GPA tools demonstrated that the dissolved plume mass had decreased by more than 99 percent and the outcome provided a much better understanding of remediation progress to project stakeholders. At a bulk petroleum storage facility, GPA tools were used to demonstrate remedial success from four independent remediation systems that operated at the site over a 20-year period. Based on the GPA results, each of the systems was terminated and evaluated further using GPA tools to confirm acceptable post-shutdown plume behavior. The site has transitioned to monitored natural attenuation (MNA) and the WSA tool was used to optimize the long-term monitoring program, which resulted in a 40% reduction in wells sampled and a 50% reduction in monitoring frequency. Overall success not only included a significant reduction in remediation costs, but also significant reductions in carbon footprint and other sustainable remediation metrics (greenhouse gas emissions, nuisance noise, health & safety risk, etc.).

Presenter Biography: Mr. Ricker has more than 29 years of experience and is a subject matter expert in groundwater data analytics. He is the author of the Ricker Method® Plume Stability Analysis and is co-author for three U.S. patents related to groundwater data analytics. Mr. Ricker is a licensed Professional Engineer in 28 states including Michigan. He received a B.S. in Civil Engineering from Rose-Hulman Institute of Technology and a M.S. in Civil Engineering from the University of Memphis.

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Horizontal Injection Wells for Offsite In-Situ Remediation of Chlorinated Solvents Beneath an Active Manufacturing Facility

Presenters & Co-Authors: Kate Villars, P.E., Ryan Fimmen, PhD, Rob Ferree, CPG, and Kyle Carlton, PG (Geosyntec Consultants)

Historical manufacturing operations within an industrial area of a major Mid-western city resulted in an extensive chlorinated solvent plume spanning multiple city blocks which eventually migrated beneath residential areas. Pilot testing indicated enhanced reductive dechlorination could be supported through injection of emulsified vegetable oil (EVO) into the target source areas and would significantly improve groundwater conditions.

Portions of the chlorinated solvent plume source area were located beneath a new manufacturing facility constructed with a thick concrete foundation, sensitive machining equipment, and multiple subsurface utilities resulting in inaccessibility of the target areas for traditional vertical injection methods. Additionally, downgradient target areas for injection were located beneath multiple utilities and ground mounted transformers.

To access the target areas beneath the manufacturing facility and utilities, Geosyntec designed three horizontal injection wells to inject EVO and inoculation with KB-1® for in-situ remediation of chlorinated volatile organic compounds (cVOCs).

Key factors considered in the design of the horizontal injection wells included:

- Custom slotted well screen design for even distribution of EVO to target areas
- Screen lengths ranging from 145 feet to 175 feet
- Borehole planning beneath the facility, a four-lane road, and 72-inch diameter sewer
- Target injection elevation of approximately 10 feet below the average groundwater level
- Horizontal well materials: flexible but strong (HDPE)
- HDD installation method: entry-exit design vs single ended methods

Due to challenging site conditions including limited HDD rig setup areas, restricted offsite access, and unconsolidated loose soils (gravelly sand and non-native sandy fill material), the Geosyntec and the HDD installation team utilized two different types of HDD well installation. One horizontal injection well targeting the downgradient plume beneath numerous public and private utilities was installed using entry-exit methodology. The HDD boring was conducted with an entry and exit point, and the horizontal well materials were pulled into the subsurface. The two other horizontal wells were installed with single-ended methodology enabling installation of the well materials to target locations within the gravelly sand beneath the manufacturing facility without the need for an exit location, which prevented site disturbance of the offsite manufacturing facility.

Injection of EVO through the horizontal wells commenced shortly after installation and approximately 277,000 gallons of 3% EVO solution were successfully injected at flow rates of approximately 25 gallons per minute per well. The custom screen design of the horizontal wells effectively distributed the EVO to target areas beneath the surface obstructions at the desired elevations.

Presenters: Kate Villars is a Senior Engineer with Geosyntec Consultants in the Columbus, Ohio office with over nine years of environmental consulting experience. Their experience is in environmental site investigation, short term response or interim action planning and implementation, site remedial planning, and remedy implementation across Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and state voluntary program sites. Kate's primary interest is in in-situ remedial technologies such as the enhanced reductive dechlorination presented here with experience spanning in situ chemical reduction, in-situ soil mixing, and phosphate-induced lead immobilization.

Dr. Ryan Fimmen is a Principal Scientist at Geosyntec Consultants with over 18 years of experience as an environmental consultant providing consulting services in the fields of remediation of soils, sediments, and groundwater; contaminant fate and transformation; and research and development of environmental remedial technologies. He has provided litigation support and export report preparation for disputes related to sites with both inorganic (metals and fertilizers) and chlorinated solvent constituents. He serves as a subject matter expert for the application of advanced site investigation techniques such as geochemical modeling, isotopic evaluations, and novel approaches for aquifer characterization.

Don’t Inject Blind: Using HRSC Tools and 3D Modeling to Create Targeted Injection Plans

Presenter: Jim Depa (Jacob and Hefner Associates)

Introduction: According to the USEPA Superfund Remedy Report published in January 2023, in-situ treatment remedies are the most popular form of active treatment on sites with impacted groundwater. Further, both bioremediation and chemical treatment are the most widely implemented form of in-situ treatment and are typically applied using injection techniques.

However, many in-situ injection projects still rely solely on monitoring well data to design the remedy. Overreliance on this type of data can be problematic since monitoring wells typically provide concentration data that is weighted by the different hydraulic conductivities of the soils within the screened interval. Additionally, typical monitoring well data tells us nothing about the vertical or hydrogeologic distribution of the impacts.

These issues can be solved using both high resolution data collection tools and 3D statistical modeling technology. By combining these tools and technologies, targeted injection plans can be created to optimize an injection strategy.

Approach/Activities: Using both Visual Basic programming language in Excel and Earth Volumetric Studio (EVS) by C-Tech, targeted injection plans were created at three sites from different high resolution data sets: Groundwater Analytical Data from Discrete Samples, Membrane Interface Probe (MIP) Data; and Optical Image Profiler (OIP) Data.

The data were first statistically interpolated in 3D to define the horizontal and vertical extent of the impacts at different concentration levels. Then, the coordinates of the impacts were exported to Excel so that the locations of the injection wells could be optimized at any desired spacing. Finally, using a few simple Python scripts, cross section maps were automatically created to visualize injection depths at every injection well location.

Results/Lessons Learned: The injection plans offered a far better solution for targeting the subsurface impacts than using monitoring well data alone, and because automation technology was implemented (using pre-built applications in EVS, Visual Basic, and Python scripts) the plans were produced efficiently and economically. Additionally, based on feedback from the clients and stakeholders, the plans could be easily modified to target any concentration level or geologic unit, or if cost was driver, a target number of injection wells or linear feet of injection.

Presenter Biography: Mr. Depa is a geologist and senior project manager at Jacob and Hefner Associates, Inc. He is a 2005 graduate from the University of Illinois with degrees in Geology and Geographic Information Sciences (GIS). He has more than 18 years of experience in the environmental consulting field and specializes in creating 3D statistical models to assess complex sites. He has created data deliverables on over 320 environmental investigation projects in 42 states, from routine 3D visuals to multi-million-dollar design remedies.

Specifically, Mr. Depa has helped design over a half dozen thermal remediation systems, calculated the in-situ contaminant mass in soil from one of the largest gasoline spills in United States history, and provided exhibits for three environmental lawsuits.

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Advances in Phytoremediation for Sustainable Nature-Based Treatment for Contaminated Ground Water Removal and In-situ Degradation

Presenter: Renee Murphy (Intrinsyx Environmental)

Background: In 2014, Intrinsyx Environmental collaborated with NASA to introduce endophytic bacteria from Dr. Sharon Doty with hybrid poplar trees to address TCE groundwater contamination at the MEW Superfund site (Doty et al., 2017 ES&T). During the last seven years, the first pilot on the MEW site expanded to a full-scale solution, and there are now more than 30 endophyte-assisted phytoremediation deployments on Superfunds, state-mandated clean-ups, and Fortune 500 redevelopment sites across the U.S. Endophyte-enhanced tolerance and appropriate tree selection of unique varieties are newly discovered keys to successful phytoremediation on polluted sites with phytotoxic concentrations of both organic and inorganic constituents.

Approach: This presentation covers data from full-scale phyto-remediation projects currently deployed and lessons learned from utilizing Endophyte-Assisted Phytoremediation System (EAPS) technology. These synergistic bioremediation tools and innovative techniques have been deployed to address several classes of pollutants, including chlorinated VOCs, petroleum hydrocarbons and 1,4-Dioxane alone and in mixed wastes. Data will be shared from several active remediation installations where grass, tree and plant species have been inoculated with endophytes identified and characterized by Dr. Doty. Data and lessons learned will be highlighted from contaminated sites in Southern California where EAPS is currently installed to treat chlorinated solvents (PCE/TCE/DCE) and 1,4-Dioxane in groundwater. Furthermore, the presentation will discuss the sustainable and cost effective benefits to utilizing this technology with a focus on environmental justice.

Lessons Learned: We have learned many lessons along the way, including additional confirmation that endophytes contribute to phytoremediation success and improved plant establishment, in-planta degradation, and enhanced source-zone depletion rates. Data suggests that endophytes are the key factor in plant establishment on sites with phytotoxic concentrations of petroleum hydrocarbons or chlorinated solvents. EAPS now represents a standalone treatment for mitigating contaminant migration and in-situ degradation of soil and groundwater contaminants.

Presenter Biography: Renee Murphy is an environmental scientist and Director of Sales for Intrinsyx Environmental. Renee has a master's in plant science/agriculture from Cal Poly Pomona and a bachelors in business from University of Southern California. Renee incorporates her native plant knowledge and agronomic background developing nature based sustainable solutions for contamination and drought impacted sites using endophyte assisted phytotechnology.

Renee has assisted in key installations of groundwater, soil and phytoremediation methods across the state that have been regulator approved and allowed for shut off of mechanical systems. Renee has served as a project manager on sites with a focus on ecological restoration, establishing native plants on exposed playa at the Salton Sea and other drought, fire-impacted sites.

As an educator about the advances in phytoremediation, Renee has presented to NASA Ames Green Team, Sustainable Silicon Valley, a panelist speaker for the International Water Holdings Corporation Conferences across the Southwest, Alaska Forum for the Environment, National Brownfields Training Conference, and was an international keynote speaker at NICOLA.org 2022 Resiliency, Nature & Climate Solutions in South Africa.

Renee serves her community through outreach programs as a speaker and workshop instructor for the California Native Plant Society, teaching native plant propagation.

Managing High Frequency O&M Data for In-Situ Remediation System Performance Optimization

Presenter: Kyle Amonette (TRC)

Complex groundwater remediation programs usually involve collecting substantial amounts of high frequency telemetry and performance data. Project teams can often overlook the enormous benefit of managing this data in a database. By leveraging the power and capabilities of advanced data management systems and strategies, we can ensure better outcomes for all project stakeholders by allowing project teams to store, manage, visualize, and report various telemetry parameters effectively and efficiently.

Oftentimes the Operation and Maintenance (O&M) systems used for remediation projects are difficult to interact with, and any internal reporting tools they may have can be limited. Without a thoughtful data management strategy, these system limitations can create a significant amount of additional work for the project team as they must deal with not only handling the data, but also figuring out ways to get any insights from the performance metrics. An additional downside is that the identification of any issues with the performance or operation of these systems is delayed, as the team is usually only able to review this data infrequently, meaning it can sometimes be weeks, if not months between check-ins.

Software such as the EQuIS Live module for the EQuIS database allow the storage and management of high frequency telemetry data for remediation projects. O&M data can be pulled automatically, or on a schedule, to ensure that the data in the system is up to date, allowing for visualization and reporting in a structured and efficient manner. Data visualizations, such as time-series plots on EQuIS Enterprise dashboards, provide the project team with access to a variety of information about the key performance parameters of the system (pump speed, run times, tank levels, etc.) O&M data can then be tied to groundwater quality data as well, giving a better picture of how effectively the system is operating. Additionally, the project team can query telemetry data from the database to support regulatory and client reporting obligations, providing a significant amount of cost savings compared to having a member of the staff manually compile all the data. By leveraging the capabilities of the EQuIS ecosystem, TRC has been able to significantly increase our capacity to both monitor system conditions and give teams access to not only up-to the minute data, but historical data as well for remediation system performance evaluation and optimization.

Presenter Biography: Kyle Amonette is a Database Administrator in TRC's Ann Arbor, MI office with over five years of experience in the management, visualization, and collection of environmental data. He is also a member of TRC's Center of Research Expertise (CORE) Data Management and Assessment Team (DMAT) where he leads the Mobile Data Collection and Report Standardization and Automation subgroups. He earned his B.S. in Geography from Ball State University.

Biogeochemical Reduction Processes and What You Need to Know

Presenter: Lowell Kessel, PG (CERES Remediation Products)

Background: The engineering of biogeochemical reduction (BGCR) remediation involves the utilization of microorganisms to transform and reduce contaminants in the environment. Critical components in this process include: electron donors, microorganisms (anthropogenic or bioaugmented), nutrients, terminal electron acceptors, pH buffers, oxygen scavengers, and chemical reducing agents. The successful engineering of biogeochemical reduction remediation requires a comprehensive understanding of these chemical components and their interactions.

Design Components: The key to in-situ BGCR design relies on known site specific hydrogeologic parameters and biogeochemical conditions collected from the site during conceptual site model (CSM) development that influence the requisite formulation of combined remediation amendments (iron, sulfate, carbon, buffer, etc.). Additional challenges include the emplacement of the reagents (i.e. utilizing mixtures of soluble, colloidal, and granular reagents in sandy, silty, clay, and fractured rock site conditions). From the CSM, (1) stratigraphy highlights fate and transport limitations, (2) porosity and permeability of lithologic units highlight preferred reagent physical properties and preferred injection method leading to optimized areal extent/distribution, (3) biogeochemistry of the target treatment areas emphasis reagent selection (e.g. soluble, colloidal, granular, fast acting vs slow acting and proppants) to manage long term performance and minimize repeat injections. Together those three legs of the design are complemented with a compatible sheer thinning fluid system to maintain reagent mixture heterogeneity during injectate propagation that will minimize uneven distribution of reagents to higher conductivity lithologies and maintain injection lens thickness for improved conductivity and limited proppant embedment.

Outcome: Site managers relying primarily on site hydrogeological and biogeochemical data for BGCR design leads to increased areal distribution of injected reagents resulting in more effective intersection of preferential pathways with higher conductivities, expedited reduction in contaminant flux from stored residual mass, rapid reduction of dissolved phase plume and orders of magnitude reduction in time of remediation and site closure.

Presenter Biography: Mr. Kessel is President of CERES Remediation Products, an international chemical manufacturer and supplier of remediation products. Mr. Kessel is a specialist in remediation technologies with work experience at multinational environmental engineering consulting firms and many environmental technology developers since 1998. Mr. Kessel has supported many projects as a technical lead in characterization and or remediation design overseen by state and federal agencies in the United States, Australia, Brazil, including other countries in South and Central America, and now working in China. Additionally, Mr. Kessel provides expert services for governmental environmental departments and agencies and to private industry. Mr. Kessel is a registered professional Geologist in the U.S. and holds a Bachelors and Masters in Geological Sciences and a Master of Business Administration, each from the University of California.

WEDNESDAY

Brownfield Redevelopment

Data Driven Decisions in Brownfield Redevelopment

Presenters & Co-Authors: Carrie Geyer and Ryan Londrigan (EGLE)

Michigan's industrial legacy is the perfect backdrop for one of the most robust and impactful Brownfield programs in the nation. Beginning with the passage of legislation in 1988, Michigan has provided funding in a variety of ways to address the redevelopment of brownfield properties. EGLE's Brownfield program continues to evolve in response to the changing landscape and that includes utilizing more data driven decisions to address the safe reuse of contaminated properties.

This session will look at EGLE's funding tools and discuss how data plays into funding decisions. It will also discuss how EGLE's brownfield site assessment (BSA) program can assist in gathering data and some new ways that risks are being evaluated on brownfield projects.

Case studies will be used to show where the application of strategies such as incremental sampling and the use of the dispersed vapor source guidance impacted the work needed to assure that the property was safe for the proposed reuse.

Presenters: Carrie Geyer has been a member of the Department of Environment, Great Lakes, and Energy's (EGLE) Brownfield Redevelopment team for nearly 20 years, first as a Brownfield Coordinator and now as the Program Manager. She has worked with consultants, developers, and local units of government throughout the state to support local projects with brownfield incentives. Carrie is also active in the national brownfield arena, where she served as chair of the ASTSWMO Brownfield Focus Group.

Ryan Londrigan is the Supervisor of the EGLE Brownfield Redevelopment Unit, assisting brownfield coordinators and communities find solutions to redevelopment challenges. Prior to joining EGLE in 2016, Ryan spent several years in environmental consulting, serving clients throughout Michigan and managing diverse environmental programs. He utilizes this background to provide perspective for communities and developers with technical, financial, and regulatory redevelopment matters. Ryan holds a B.S. in Natural Resource Ecology from the University of Michigan.

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