FRC 2017 Technical Agenda

Day One, Thursday, Dec. 7, 2017

Opening Session

9:00: **A Word from the Chair**
Jim Langenbach, PE, BCEE, Senior Principal, Geosyntec Consultants, Titusville

Keynote Address: Guest speaker to be announced

9:30: **Environmental Consulting at Brownfield Sites is (Much, Much) More than Just Contamination Assessment and Remediation: Strategies for Limiting Professional Liability, Increasing Client Profitability and Improving Redevelopment Outcomes**
Michael Goldstein, Esq., Managing Partner, The Goldstein Environmental Law Firm PA, Miami

In a brownfields context, consider the typical contamination discovery-reporting-assessment-remediation-NFA model historically marketed by environmental consultants to responsible parties fully disrupted. Clients taking on these types of sites for redevelopment are now demanding a more non-linear suite of services that emphasize evaluating incremental construction costs associated with properly managing contaminated media, obtaining regulatory agency approvals to properly manage contaminated media during construction, and actually managing contaminated media properly during construction to maintain pre-acquisition defenses to state and federal liability on the one hand while simultaneously limiting exposure to third-party liability claims from neighbors and adjacent property owners on the other. These services can also encompass tapping into federal and state redevelopment and rehabilitation incentive programs to subsidize incremental construction costs and create even greater insulation from legal liability. This presentation will suggest a "unified theory" of environmental redevelopment consulting with the intent of providing those in attendance with the knowledge, tools and resources necessary to offer a more robust and relevant suite of services to an ever-expanding pool of potential clients in the brownfields marketplace. At the same time, the presentation will highlight emerging topics of professional malpractice and strategies for improving the quality and efficacy of consultant interactions with state and local regulatory agency officials. Areas of focus in this regard will include the relationship between stormwater system design and contaminated media, the plans and reports that regulators are now requiring to allow for on-site grading of affected soils and relocation and processing of solid waste materials, non-statutory environmental criteria applicable to construction dewatering effluent, monitoring and management of airborne contaminants, proper selection of engineering control options and early-stage planning for environmental deed restrictions. In addition, a concise and detailed summary of federal and state financial incentives available to subsidize rehabilitation and redevelopment activities will be presented with recommendations regarding how to timely and efficiently coordinate with other client-retained development professionals to maximize economic subsidy opportunities.

10:00 30-Minute Break

Session 2: Innovative Assessment and Remediation Strategies

10:30 **Using a Bottom-Up Approach to Develop a Sustainable Remediation Technology: Theory and Practice**
Paul Favara, PE, Global Practice Director – Liability and Remediation, CH2M, Gainesville

In the ramp-up to integrating sustainability into remediation, a key industry focus area has been to reduce the environmental footprint of treatment processes. In-situ treatment processes involving injection of treatment reagents for chlorinated organics and fuel-related contaminants are considered inherently sustainable since they typically don't require continuous use of energy to provide effective treatment. However, a closer inspection of the burdens related to some remediation reagents shows there is room for improvement. For example, embedded energy and water used in some remediation reagents can be significant. By understanding these environmental burdens and using a bottom-up approach for using sustainable thinking to improve remediation technology, it is possible to improve sustainability profile of the technology while decreasing life-cycle costs. A solar/wind-powered subgrade biogeochemical reactor is a unique in-situ technology for treatment of contaminant source areas and groundwater plume hot spots. SBGRs have been used to treat chlorinated volatile organic compounds and fuel-related contaminants in soil and groundwater; and treatment of other contaminants continues to be evaluated. SBGRs consist of the following common elements: 1) excavation of contaminated source area soils, 2) backfill of the excavation with gravel and SBGR amendments tailored to the contaminant(s) of concern, and 3) installation of a solar- or wind-powered pumping system

to recirculate groundwater through the SBGR for treatment. For enhanced reductive dechlorination approaches at CVOC sites, SBGR treatment media have contained various types of organic mulch, new or recycled vegetable oil, iron pyrite or magnetite sands. For fuel-related sites, SBGR treatment media have included recycled gypsum products for sulfate-enhanced degradation. Use of locally sourced farm and tree byproducts, reclaimed construction materials, along with off-grid groundwater pumping, creates a low-cost, lowmaintenance and sustainable remediation solution. This presentation will provide an overview of the theory behind SBGR, discuss the sustainability attributes of the technology and provide examples of how this flexible remediation technology can be applied to address different site challenges.

10:50 **The Application of Engineered Phytotechnology for Remedial System Optimization and Ultimate Site Closure of a Complex 1,4-Dioxane Site in Sarasota**

P. James Linton, Principal, Geosyntec, Clearwater

Groundwater at a former manufacturing facility was contaminated with chlorinated volatile organic compounds, the emerging contaminant 1,4-dioxane and arsenic resulting from historic activities. Complex conditions making site cleanup challenging included a complex lithology, a residual source area, and coalescing, on- and off-site dissolved-phase plumes. An ineffective pump-and-treat system was operated by others for 12 years, and an additional 25 additional years of costly O&M was anticipated to obtain closure. Geosyntec planned and conducted high-resolution site investigation activities to refine the conceptual site model and prepared a focused feasibility study for remedial optimization. Investigation tools included vertical lithology and groundwater profiling, pump testing and groundwater flow modeling. The results indicated that the shallow surficial aquifer, the upper 15 feet, was characterized by sands, silty sand/sandy silt with layers of shells and lithified zones, and clay comparable to coastal Central Florida. A 1,4-dioxane/CVOC source area was identified within the fine-grained soils that was slowly back-diffusing into the permeable zones of the SA, resulting in an approximately three-acre dissolved-phase plume in the shallow. The FFS was finalized as a remedial action plan that met the requirements of Chapter 62-780, F.A.C. The final remedy included an impermeable barrier to isolate the 1,4-dioxane source area; innovative, engineered phytotechnology using native species for COC reduction and hydraulic containment; and long-term monitoring for the dissolved plumes.The RAP was implemented and by the second growing season, results demonstrated that the phytotechnology system had captured groundwater flow through hydraulic containment, and groundwater concentrations had decreased by two orders of magnitude. Geosyntec obtained DEP approval to shut down and decommission the P&T system and implement an optimized groundwater monitoring program specific to the phytoremediation design. By the fourth growing season, Geosyntec demonstrated that 1,4-dioxane within the isolation area had decreased to concentrations slightly above the GCTL and that the other plumes were stable and/or shrinking. Based on these results, Geosyntec successfully negotiated DEP approval for no further action with conditions.

11:10 **Demonstrating Plume Stability to Support Risk-Based Closure**

Ed Meyers, PG, Environmental Manager, UCPM Environmental LLC, Orlando

In 1997, Universal City Property Management purchased approximately 2,000 acres of property in the Orlando I-Drive tourist district area. Due to historical operations at the site, 46 solid waste management units and areas of concern were identified at the facility. Soil and groundwater contamination was identified at 17 SWMU/AOCs. UCPM has implemented corrective measures at each of the impacted SWMUs. All impacted soils have been removed from the facility. Groundwater treatment technologies have included excavation, air sparge, chemical oxidation and bioremediation. Eight sites have been closed without conditions and five sites have been closed with conditions. To date, over 800 acres of the facility have been redeveloped including the expansion of the Orange County Convention Center, and construction of two hotels, a golf course, shopping center and two apartment/condominium complexes. To support redevelopment of the impacted property and adjacent land parcels, UCPM performed a preliminary facility-wide risk assessment to evaluate future land use based on current and predicted groundwater contaminant concentrations. Risk assessment activities included development of alternative cleanup target levels associated with several possible development scenarios including commercial and residential use, onsite utility workers, short and long-term construction projects and vapor intrusion thresholds. Following contaminant reduction to acceptable levels, UCPM completed post active remediation monitoring to confirm that contaminant concentrations remain below cleanup target level criteria and remnant groundwater plumes remain stable. UCPM used several techniques to demonstrate that remnant groundwater plumes are stable and contained onsite.These techniques included analysis of groundwater contamination plume maps, groundwater contaminant trend analysis, Bichlor modeling, analysis of stable isotope data, and MAROS and Mann Kendal statistical analysis.This presentation will provide a summary of how UCPM has evaluated plume stability to support site closure

11:30 **Leveraging the Commercial Use of Drones on Military Installations for Environmental Site Cleanup**

Frank McInturff, PE, Principal, EnSafe Inc., Jacksonville

Brent Klavon, Director of Commercial Drones, Aviation Systems Engineering Co., Jacksonville

Although much of the technology evolution behind small unmanned aerial systems, or drones, has been driven by the U.S. Department of Defense's strategic defense initiatives, it is the emerging commercial applications of drones that has driven new regulations and business use cases for imagery collection, data analysis, visualization and management. Learn how we charted the path for the first commercial drone use on U.S. Navy installations for the Navy Facilities Engineering Command Southeast's environmental cleanup sites. This project included the use of multiple drone aircraft, optical and LiDAR imagery

collection, ground control, various post data analysis/visualizations and development of an ESRI ArcGIS Portal web application. The project included the data acquisition of high resolution imagery, real-world topographic mapping, stock pile volume analysis, and conceptual site model development with 3D views.

12:00 ***Day One Luncheon*** *Sponsored by* ***Advanced Environmental Laboratories***

Session 3: Emerging Contaminants of Concern: PFAS

1:00 **Chemical Properties, Uses and Sources, and Risks Associated with PFAs**
Brian Moore, PE, Principal, GHD Services Inc., Tampa

Perfluoroalkyl and polyfluoroalkyl substances are a family of manufactured chemicals that do not occur naturally in the environment. Perfluorooctane sulfonate and perfluorooctanoic acid are two of the most well-known and are contaminants of emerging concern. They have been identified in the environmental at several known and suspected contaminated sites. These chemicals are not traditional industrial pollutants and they are not commonly monitored or measured. They have the potential to enter the environment and cause known or suspected adverse ecological and human health effects. PFAS have hydrophobic and hydrophilic ends, and repel oil and water. This presentation will provide background information on the chemical properties, uses and sources, and risks associated with PFAS. The presentation will also detail existing environmental quality guidelines and some of the challenges associated with assessment and remediation of PFAS in the environment. PFAS analysis can be complicated because of cross contamination, analytical limitations and inconsistencies in methodologies. Similarly, PFAS are extremely recalcitrant to degradation or destruction, which complicates the remediation process. The presentation will also provide examples of remedial approaches for PFAS cleanup.

1:30 **Perluoroalkyl and Polyfluoroalkyl Substances: Treatment Options for Soil and Groundwater**
Gary Birk, PE, Managing Partner, Tersus Environmental, Wake Forest, NC

Perfluoroalkyl and polyfluoroalkyl substances are surfactants, polymers and other substances that are widely distributed across the higher trophic levels and are found in air, soil and groundwater at sites across the U.S. For decades, they have been used in hundreds of industrial applications and consumer products such as carpeting, apparels, upholstery, food paper wrappings and metal plating. Surfactant applications used heavily in the military include aqueous film-forming foams used to extinguish fires involving highly flammable liquids. The toxicity, mobility and bioaccumulation potential of PFAS pose potential adverse effects for the environment and human health. PFAS have been found at very low levels both in the environment and in the blood samples of the general U.S. population. To provide a margin of protection from a lifetime of exposure to perfluorooctanoic acid and perfluorooctyl sulfonate from drinking water, EPA established the health advisory levels at 70 parts per trillion. PFAS are fluorinated organic compounds in which the hydrogen atoms of the hydrocarbon skeleton are substituted fully or partially by fluorine atoms. In view of the strong covalent bond between the fluorine and the carbon atoms, these compounds are considered non-degradable and they persist in the environment. Practitioners have difficulty remediating these compounds at a reasonable cost because PFAS are extremely resistant to thermal, chemical and biological degradation processes. The current state of the practice for addressing highly concentrated source zones, mitigate mass flux of impacts to aquifers or PFAS in extracted water includes the use of granular activated carbon. Unfortunately, GAC is only a temporary solution as it is effective at removing only a portion of PFAS from groundwater. This is due to GAC's low binding capacity for PFOS as compared to nonpolar organic hydrocarbons and the low effective removal of shorter chain perfluoroalkyl acids, the daughter products resulting from biotransformation of polyfluorinated precursor compounds. As the PFAS family of compounds includes anions, cations and zwitterions, new sorbent media are being developed to remove both long and short chain PFAS that combine hydrophobic interactions with electrostatic interactions. Liquid surface-active reagents are also being developed for use as an initial pretreatment. In the pretreatment phase, dissolved PFAS are precipitated as micro-flocs by metering the liquid active compound into a stirring tank. With removal efficiencies of 96 to 98 percent, the precipitants can be concentrated to a very high degree, the life of sorbent media is significantly extended. This constitutes a considerably more sustainable approach. The presentation will include results and lessons learned from the latest laboratory and field implementation for the treatment of PFAS-impacted soil and groundwater. The presentation will also provide an update on advances in point-of-entry systems.

2:00 **Pilot Testing of Removal of Perluoroalkyl and Polyfluoroalkyl Substances from Fire Training Site Soils**
William Kerfoot, PhD, Principal, Kerfoot Technologies Inc., Mashpee, MA

Perfluoroalkyl compounds have been used with fire-fighting foams and are found adsorbed in soils from the sites. Rainwater leaches the compounds downward when porous, sandy soils dominate resulting in vadose zone and saturated soil contamination. The soils also contain the remnants of the fuels which were ignited and subjected to elevated temperatures. A series of tests were conducted on example contaminated soils with different delivery methods using peroxide-activated nanobubble ozone slurries. Formation of the slurry above ground, followed by injection through slotted screens into the contaminated soil, showed PFOS and PFOA removal of 98.5 and 92.3%, respectively, within a two-day long exposure. Fluorotelomer sulfonates of two isotopes, 6:2 and 8:2, showed removal efficiencies over 98% when monitoring aqueous fractions. Formation of the slurry in ground from special nanoporous stainless-steel laminar Spargepoints® appeared to increase the rate of removal from adsorbed soil fractions. A rise in fluoride concentration, proportional with the decomposition of 85% of PFOS, the most abundant PFAS,

was graphed during 72 hours of injection. Acidity rise, often observed due to formation of dilute hydrofluoric and carbonic acids, was controlled by use of slightly alkaline peroxide, yielding final pHs between 6.4 and 7.4. Different from chloride, residual fluoride concentrations, ranging up to .75 mg/L, gradually disappeared from groundwater solution.

2:30 **In-Situ Containment of PFAS Using Colloidal Activated Carbon**
Chad Northington, PE, Southeast District Technical Manager, Regenesis, Tallahassee

With the increasing awareness to the widespread contamination associated with PFOA, PFOS and other PFAS compounds, there is an established need for new and lower cost treatment options that can address the large dilute plumes that these contaminants commonly form. At the present time, the accepted remediation method is to use pump and treat systems equipped with activated carbon. The costs associated with running these systems and replacing the carbon can be quite high. For that reason, the ability to implement an in-situ barrier of activated carbon that can cutoff and contain these plumes for many years with a single application affords a beneficial means to decrease or avoid the operating and maintenance costs in the existing aboveground systems. This presentation examines the use of a colloidal activated carbon that readily distributes within the subsurface, providing a method for injecting an in-situ barrier of activated carbon for PFAS treatment. Laboratory batch studies were conducted to measure the relative adsorption of PFOS, PFOA, PFHpA and PFBS with a distributable form of colloidal activated carbon. Results of these studies demonstrated that a field relevant dose of the colloidal activated carbon could reduce 100 mg/L of each PFAS compound tested by at least 99.9% and the relative adsorption followed in the order: PFOS > PFOA > PFHpA > PFBS, as has been observed with other activated carbons. In these experiments PFOS and PFOA were reduced to below the 2016 revised EPA health advisory limits of 70 ng/L.

3:00 30-Minute Break

Concurrent Sessions

Session 4A: Speed Talks

3:30

1) **Green Remediation Alternative**
   Nesmar Mora, Environmental Engineer, Royal Consulting Services, Longwood
2) **Post Remediation Performance and Aquifer pH**
   Brad Elkins, MS, PG, Technical Sales & Support, EOS Remediation LLC, Raleigh, NC
3) **Horizontal Well Used for Coal Ash Basin Dewatering**
   David Bardsley, PG, Geologist, Directed Technologies Drilling Inc., Bellefonte, PA
4) **Sustainable and Cost-Effective Destruction of Chlorinated Alkane-Alkene Contaminants via Biostimulation and Enhanced Reductive Dechlorination**
   Kent Armstrong, President, TerraStryke Products LLC, Andover, NH
5) **Tools for Monitoring Contaminant Biodegradation when Combined with Colloidal Activated Carbon**
   Chad Northington, PE, Southeast District Technical Manager, Regenesis, Tallahassee
6) **Filling Data Gaps with Horizontal Wells**
   Lance Robinson, PE, Chief Technology Officer, EN Rx Inc., Parrish
7) **Successful Large-Scale Remediation Projects Using a Variety of Emplacement of Amendments Techniques and Operational Procedures**
   Robert Kelley, PhD, Client Solution Manager-East, Cascade Technical Services, Midland, NC
8) **Klozur One: A Built-In Soluble Activator with Klozur SP**
   Patrick Hicks, PhD, SE Regional Technical Sales Manager, PeroxyChem, Philadelphia, PA
9) **Time-Tested Advantages of Horizontal Wells**
   Mike Sequino, Senior Vice President, Directional Technologies Inc., Miramar Beach
10) **ISM to Delineate Soil for a Solid Waste Landfill Cell Expansion**
    John Meade, Senior Account Executive, TestAmerica, Pensacola

Session 4B: Applications of In-Situ Assessment and Remedial Strategies

3:30 **Unusual Dichloroethylene Isomer Ratios and External Nitrate Input Help Decipher In-Situ Pilot Test Outcomes**
Mark Culbreth, PG, Principal Scientist, ECT Inc., Tampa

This case study represents an interesting example where outcomes from a field pilot test of an in-situ groundwater treatment technology strayed significantly from expectations. Careful review of pilot test performance assessment data, leveraged by insights obtained from a bench-scale treatability study, led to identification of subsurface features the awareness of which avoided a misleading summary conclusion that the treatment technology was incompatible with the remedial goal. The pilot test involved a shallow injection zone and a deeper injection zone within a variably weathered limestone harbouring a TCE and

DCE groundwater plume. Natural biodegradation was slowly degrading the TCE to DCE but mineralization was not apparent. The pilot goal was to test biogeochemical reductive dechlorination, or BiRD, to accelerate remediation. A bench treatability study demonstrated in-situ biogenic ferrous sulphide production and TCE and DCE transformation without VC production. A reagent formulation identified from the bench study was the basis for 7,425 liters of reagent solution pressure injected into each zone. The central monitoring well in the shallow zone did not respond to injection—even after nine months. The central monitoring well in the deep zone did not immediately respond but eventually injectate components were detected due primarily to diffusion and TCE and DCE concentrations declined without VC production. This was perplexing given that the central monitoring well screens were only 4.6 meters from multiple injection well screens. In depth analysis identified rapidly rising nitrate concentrations and high trans-1,2 DCE to cis-1,2 DCE ratios as two quite unusual site features that led to the conclusions that 1) injectate emplacement was highly preferential to the detriment of treatment at the central monitoring wells, 2) in-situ biogenic ferrous sulphide production with complete dechlorination treatment did occur in the limestone but native partial dechlorination of TCE was also stimulated, and 3) nitrate originating from a previously unknown overlying sewer leak was preventing the shallow zone near the central monitoring well from transitioning into deep reducing conditions necessary for sulphate reduction, a prerequisite to BiRD.

4:00 **Pilot Test Evaluation of Aerobic Co-Metabolic Strategy to Degrade Low Concentrations of Vinyl Chloride**
Eric Kramer, PE, Senior Project Engineer, and Janna Hall, EI, Environmental Engineer; APTIM, Winter Garden

Aptim Environmental & Infrastructure, formerly known as CB&I Environmental & Infrastructure, performed a six-month pilot test to evaluate the effectiveness of utilizing an in-situ aerobic cometabolic bioremediation pathway to reduce low concentrations of vinyl chloride at a former circuit board manufacturing facility in Palm Bay, FL. Low concentrations of less chlorinated compounds such as VC are difficult to biologically degrade through the enhanced reductive dechlorination process. However, VC has been shown to degrade under aerobic conditions by both direct aerobic and cometabolic degradation mechanisms. The pilot test design extracted groundwater from a recovery well and infused the influent with oxygen, alkane gas (ethane) and nutrients before re-injecting to the aquifer by means of two injection wells. An array of eight monitoring points downgradient of the injection wells provided sampling locations to track the pilot test effectiveness. The field parameters monitored included pH, temperature, dissolved oxygen and ORP, while groundwater samples were periodically collected for analysis of volatile organic compounds, dissolved gases (methane, ethane, ethene), and Census analysis (qPCR for SMMO, PPO, EtnC and EtnE). Groundwater quality monitoring results indicated increases in ethene, DO and oxidase enzyme cell density with decreases in VC, methane, iron, ammonia, pH, and ORP, which are indicative of microbial activity and oxidation in the deep aquifer. Overall reductions in VC concentrations experienced 66 to 88 percent reduction from the aerobic cometabolic bioremediation strategy.

4:30 **Innovative Site Assessment Methods for Soil and Groundwater at Winter Haven Drycleaning Facility**
Brian Moore, PE, Principal, GHD Services Inc., Tampa

The House of Clean drycleaning facility operated in Winter Haven, FL. In the late 1990s, the facility was deemed eligible for cleanup through the Florida Drycleaning Solvent Cleanup Program. GHD conducted initial site assessment activities in 2006 and identified the presence of tetrachloroethene impacts to soil and groundwater beneath the site. Groundwater impacts were identified to depths over 50 feet and the groundwater plume extended over 1,500 feet downgradient. Following successful design and implementation of soil vapor extraction, the groundwater plume attenuated to levels below GCTLs in less than 10 years. This presentation details results of the site assessment and the innovative methods used to assess both soil and groundwater impacts. The presentation will also provide an overview of the approach to SVE, which involved the use of nested SVE wells to treat shallow sands along with the underlying sandy clay. Finally, the presentation will detail the optimization strategies used during active remediation and natural attenuation monitoring that resulted in groundwater attenuating to levels below GCTLs without measurable reductive dechlorination.

Day One adjourns

FRC Reception *Sponsored by **Pace Analytical Services***

FLORIDA REMEDIATION CONFERENCE

Day Two, Friday, Dec. 8, 2017

Concurrent Sessions

Session 5A: Young Professionals

9:00 **Viewing Young Professionals as Positive Additions to the Environmental Remediation Workforce**
Jilian Drenning, Env. Specialist II; Max Levine, Env. Specialist II; and Matthew Pabich, Env. Specialist II
Florida Department of Health - Polk County, Lakeland

Hiring young professionals into a specialized and dynamic field such as environmental remediation can be a risk to any business, agency or organization. Business owners or hiring managers may be hesitant to consider hiring green personnel with limited or no experience due to the investment of resources required to train these employees. As young professionals, the goal of our presentation is to encourage seasoned industry professionals to view young professionals as a positive addition to the field of environmental remediation. Young professionals can bring unique insight, skills and abilities to the table. To illustrate this, we will provide a brief example of how young professionals were able to promote positive change and revitalize the Florida Department of Health in Polk County – Petroleum Cleanup Program, a DEP-PRP local program. Until recently the program suffered from a lack of organization, staffing shortages and low moral. A major part of the "active remediation" and recent success of our program has been the hiring of new and diverse staff members, including young professionals. Lastly, we will leave you with a few key considerations to keep in mind when building your workforce and planning for the future of environmental remediation.

9:15 **Thermal Soil Mixing and ZVI Injection Using Large Diameter Augers at a Former Dry Cleaner**
Matt Crews, PE, Senior Project Engineer, Golder Associates Inc., Jacksonville

Tetrachloroethene was released into the subsurface at a site located in Jacksonville, FL, during drycleaning activities over a period of approximately 20 years. The suspected source areas include a former UST that may have contained spent solvents, a floor drain, the former drycleaning machine and a former supply well that provided water for drycleaning operations. Site assessment activities reported chlorinated solvent contamination in soil and groundwater to a depth of approximately 65 feet below ground surface. A fine-grained sand is present from land surface to a depth of approximately 60 feet. A low permeability clay layer is present below this depth and appears to have prevented further vertical migration of contamination. Solvent contamination in the vadose zone soils appear to have been either removed during the UST closure excavations or during soil vapor extraction operations. Previous remedial methods for treating the contaminated groundwater have been largely unsuccessful due to the likely presence of DNAPL at varying depths within the saturated soils. The objective of this remedy is to remove the remaining adsorbed, soluble and potential DNAPL contaminant mass located in the source areas. Funding for this technology is being provided by the Florida Department of Environmental Protection's Drycleaning Solvent Cleanup Program. Golder will be using FECC Corp.'s chlorinated source contamination removal technology with thermal treatment followed by injection of zero-valent iron to remove adsorbed, soluble and potential DNAPL contaminant mass in the source area. This remedial approach uses an eight-foot large diameter auger and thermal soil mixing to quickly remove the majority of the chlorinated solvent mass followed by injection and mixing of ZVI into the heated soil and groundwater. The ZVI continues to remove residual chlorinated solvents long after the thermal treatment. The columns would extend to a depth of approximately 65 feet to make sure chlorinated solvents sitting on top of the clay are effectively treated. The treatment technology consists of the following major elements: soil mixing using the eight-foot diameter LDA; in-situ thermal treatment using a combination of hot air and steam; a vapor collection system that recovers the volatilized contaminants, steam, and hot air in a surface shroud under an applied vacuum; a data acquisition and recording system for real-time system monitoring and contaminant removal data; an off-gas conditioning system; a recovered liquid and vapor contaminant treatment system; and a ZVI mixing and injection system. Field activities are scheduled to commence in the fall of 2017. Golder will present the results of the source removal activities, including the final number and depth of the LDA locations; the treatment area; system operating parameters, such as the steam/hot air injection flow rates and temperatures, shroud temperature, and volatized vapor extraction flow rates; effluent vapor and liquid concentrations; the estimated mass of contaminants removed, as determined by the DAR system outputs; and the amount of ZVI applied per location. Golder will also present on the advantages of using this technology over other industry accepted remedial methods for chlorinated solvent contamination

9:30 **The Effect of Sodium Persulfate Solution on Direct Push Drilling Rods**

Kyle Clarke, Redox Tech LLC, Downers Grove, IL

Sodium persulfate, a robust oxidant used in environmental remediation, can cause corrosion to metal and damage to direct push drilling rods during injection activities in the field. This corrosion can lead to difficulties while injecting as well as equipment loss during injection activities. The purpose of this study was to evaluate corrosion rates caused by sodium persulfate solution on direct push field equipment over certain periods of time. Steel samples of sections of direct push rods shaped as small cylinders and obtained from Geoprobe Systems® were used in this study. Two different types of samples were provided. Standard steel used to make their probe rods and "hardened" steel that is used on the ends and threads of their probe rods. The samples were exposed to varying concentrations of sodium persulfate solution over various time intervals. To evaluate corrosion rates, samples were removed at specific time intervals and physical properties like length, width, annular thickness and, most importantly, mass were measured. Temperature and pH of the solutions were also measured. Additionally, in order to simulate base-activated sodium persulfate—one of the most common methods used when working with this oxidant—varying concentrations of sodium hydroxide solution were also added when performing the tests. Samples were either immersed in a "bath" of solution or placed in a flow through cell where sodium persulfate solution was pumped to simulate injection activities in the field. Sodium persulfate solution, at all concentrations tested, caused significant corrosion of the samples. The relationship between concentration of sodium persulfate, amount of base activator and corrosion rates of the samples will be explored in this presentation.

9:45 **Using Real-time Data Monitoring During Large Diameter Auger Drilling with Steam and Zero-Valent Iron Injection to Enhance Source Zone Mass Removal**

Zachary Munger, PhD, Hydrogeologist, Geosyntec Consultants, Titusville

Treatment efficiency and effectiveness are the premium attributes of aggressive remediation efforts. After developing a conceptual site model and performing a remedial alternatives evaluation for a site impacted with chlorinated volatile organic compounds, Geosyntec recommended using large diameter auger drilling with steam and zero-valent iron injection to rapidly eliminate the source zone and facilitate a transition to natural attenuation. The remedial technology involves using the auger to simultaneously mix the subsurface and introduce hot air/steam to promote thermal volatilization and stripping of CVOCs from soil and groundwater, followed by injection of ZVI as a polishing step to provide treatment of residual CVOCs. To focus the LDA/Steam/ZVI treatment in the depths and areas with the greatest CVOC mass, Geosyntec developed and implemented a treatment protocol in which the number of treatment passes, ZVI injection quantity, and the addition of step-out borings were based on real-time data, including off-gas CVOC concentrations. During the three months of LDA/Steam/ZVI implementation, 500 pounds of tetrachloroethylene were remediated with most of the recovered mass being removed from two low hydraulic conductivity layers. Approximately 370,000 pounds of ZVI were injected to treat residual CVOCs. Post-processing of the real-time data was performed to calculate the CVOC mass removed from each treatment boring and to visually present the distribution of mass recovered throughout the treatment area. Utilizing real-time data collection and an adaptive treatment protocol enabled Geosyntec to immediately respond to remediation performance and carefully focus efforts to maximize treatment efficiency and effectiveness.

10:00 **Optimizing the Performance of ZVI for In-Situ Remediation: Effect of particle size and surface composition**

James Harvey, Engineering Manager, OnMaterials, Escondido, CA

Zero valent iron is a powerful reductant used to decontaminate soil and groundwater containing halogenated hydrocarbons and other toxic contaminants. Zero valent iron products have widely different sizes and compositions, and remediation performance is highly dependent on material characteristics including include particle size, composition and surface modifications. This work investigated the ability of several variations of iron to degrade aqueous phase perchloroethylene, trichloroethylene and chloroform. Dry powders that were studied included sub-micrometer powder, carbonyl iron and screened commodity iron ranging in size from 600 mesh to 50 mesh. Colloidal products that were studied included OnMaterials Z-Loy™ MicroMetal, a zero valent iron suspended in glycerol, and Z-Loy™ AquaMetal ZVI, a zero valent iron suspended in water. Z-Loy™ PRB, an aqueous suspension of microscale iron was also evaluated. Surface modified products include small additions of palladium and iron sulfide that were deposited onto the surface of Z-Loy™ AquaMetal ZVI and Z-Loy™ PRB. Reactivity was evaluated by adding 2 g/L of colloidal products and 10 to 50 g/L of commodity microscale products to closed bottles. Composition was measured using headspace gas and a gas chromatograph with an ECD detector. Pseudo first order kinetic resulted with correlation coefficients generally greater than 0.99. The study indicated that for chlorinated ethenes, particle size had a modest effect of reactions kinetics. Surface modification had a much more dramatic effect, particularly for sulfidized colloidal products. These products exhibited pseudo-first order rate constants 30-50 times greater than dry commodity products. For chlorinated methanes, surface modifications had a smaller effect on degradation rates.

10:15 **Advancements in Data Visualization Techniques: 3D Conceptual Site Models and Time-Lapse Animation**

Jim Depa, 3D Visualization Group Manager, St. John-Mittelhauser & Associates, Downers Grove, IL

The objective of this project was to create a 3D visualization and animation from soil and groundwater analytical results involving spills of perchloroethylene at a dry cleaner site in order to thoroughly understand and quantify the subsurface soil and groundwater contamination; design a cost-effective soil and groundwater remediation solution; and demonstrate the efficiency,

timing and effectiveness of the remediation. Soil and groundwater analytical results, collected from multiple subsurface investigations at an active dry cleaner, were statistically analyzed, modeled and visualized using C-Tech's Earth Volumetric Studio. EVS uses mathematical kriging to interpolate a 3D field of data from a set of known points, typically soil and groundwater sample results. EVS was also used to interpolate analytical data between the soil and groundwater sampling events. The modeled data was used to create 3D conceptual site models of the soil contamination and groundwater plume, as well as a time lapse animation of the soil and groundwater remediation. The 3D conceptual site models successfully identified the source areas of the contamination, quantified the amount of PCE contamination in both soil and groundwater and assisted in the design of the remediation systems used to remove the contamination. Additionally, the time-lapse animation demonstrated how effectively the soil vapor extraction system removed the PCE in the soil and how quickly the biological injections remediated the groundwater in the source areas.

Session 5B: Petroleum Remediation: Case Studies

9:00 **Use of Multiple EN Rx Innovative Technologies to Remediate an Off-Site Plume**

Richard Roberts, PE, Senior Engineer, Earth Systems, Jacksonville Beach

The petroleum remediation site discussed in this presentation posed multiple challenges. The plume was deep and elongate and was moving rapidly downgradient. The impacts had migrated off-site beneath an adjacent Publix shopping center parking lot, and Publix would not approve a design that involved extensive construction on their property. The site was not part of a DEP-funded program and the insurance company was insistent that the cost of cleanup be minimized. Earth Systems overcame these obstacles using a variety of innovative techniques. To gain access to the Publix property, Earth Systems teamed with EN Rx Inc. to install horizontal vertebrae wells beneath the parking lot. Each Vertebrae well was approximately 25 feet deep, 400 feet long and contained multiple screened zones. Remediation was accomplished by in-situ chemical oxidation using EN Rx's proprietary blend of hydrogen peroxide, sodium hydroxide, a catalyst called Synergist and water. The oxidant was disbursed into the Vertebrae wells continuously over several months using a solar-powered FOCISmicro system. EN Rx agreed to conduct the cleanup under a Performance-Based Cleanup contract, so the cost was negotiated up-front and agreed upon by the insurance company. Although the end-point of the PBC contract was to remediate the site until all impacts were below natural attenuation default concentrations, the levels declined below groundwater cleanup target levels within six quarters of system operation. The site was transferred to post-remedial action monitoring in November, 2016, and all sampled wells have remained below GCTLs for two quarters of PARM.

9:20 **Utilizing Multiple Methods to Remediate Groundwater in Heterogeneous Soils - Three Florida Case Studies**

Lee Bienkowski, PhD, PG, Senior Geologist, Ellis & Associates Inc., Jacksonville

Heterogeneous soils add complexity to remediating petroleum constituents in groundwater. Mechanical methods such as air sparge/soil vapor extraction are often successful in removing dissolved volatile hydrocarbons from groundwater in sandy soils. However, when sand is interbedded with clay, the clay can serve as a reservoir for contaminants, causing concentrations to rebound once mechanical remediation is discontinued. A sequence of multiple remediation methods may be required to complete site rehabilitation. Numerous remediation methods are available that claim to be effective for remediating hydrocarbons in heterogeneous soils, but there are few unbiased published case studies. The purpose of this study is to determine if any of the methods tested at the three case study sites was effective alone at remediating groundwater in interbedded sand and clay. The three sites selected for this case study are Don Hodge Auto Service, 7-Eleven Eustis, and Giovanni B Corp. All three sites are located in Central Florida, are underlain by layers of sand and clay, and have been impacted by dissolved volatile constituents in groundwater. The author conducted research on all three sites to determine the effectiveness of the various remedial methods in reducing contaminant concentrations. Included in the study were the impact of the sequential remedial methods on dissolved concentrations and correlating the time to cleanup with the amount of clay present in the impacted zone. All three sites were first remediated by mechanical means and experienced rebound of contaminant concentrations once the mechanical remedial method ceased operations. The mechanical methods were followed by a sequence of injections of nutrients and microbes, and chemicals such as calcium oxyhydroxide, hydrogen peroxide and sodium persulfate. In most cases, these injections were followed by a reduction of contaminant levels but multiple injection events were typically required to prevent eventual rebound. Two injection events were sufficient to bring the Giovanni B Corp. site to closure, which had the lowest amount of clay in the impacted zone. 7-Eleven Eustis required two injection events combined with six years of nutrient-enhanced biosparge to bring concentrations down to natural attenuation levels. The long-term effectiveness of the injection of hydrogen peroxide, surfactants and nutrients at Don Hodge Auto Service will be determined by future sampling events. There appears to be a correlation between the thickness of clay in the impacted zone and the difficulty of achieving permanent contaminant concentration reductions. Many methods appear to have some effect but there is no one remedial method that will complete the restoration of a site with significant clay with a single application. Multiple methods that flush contaminants from the clay layers appear to have the greatest impact on BTEX concentrations in heterogeneous soils.

9:40 **Does Plume Stop Work in Florida?**
Wm. Gordon Dean, PE, President, Advanced Environmental Technologies LLC, Tallahassee

This presentation provides practical application notes and initial results from a petroleum site in Florida. The site is located in Perry, Taylor County, FL, and the work was awarded under an Innovative Technology pay-for-performance solicitation by the Florida Department of Environmental Protection's Petroleum Restoration Program. The innovative technologies used were Regenox, ORC Advanced and PlumeStop. All of these are proprietary technologies manufactured by Regenesis. Site constraints included a previous source removal using large diameter augers that covered the site with approximately 15 feet of flowable fill, aboveground utilities and underground utilities. The Regenox was applied first to reduce the contaminant concentrations, followed approximately 45 days later by PlumeStop and ORC Advanced. Application issues encountered included the lithology, well design and daylighting of the chemicals. Analytical results from the baseline sampling, post-Regenox/pre-PlumeStop sampling, and the first quarter post-PlumeStop sampling will be provided and discussed.

10:00 **Innovative Petroleum Contamination Remediation Ozone Sparge Corrective Actions Dixie County, FL**
Ronald Sanzi, Senior Project Manager, and Richard Carman, Corporate Director of Environmental Services
Universal Engineering Sciences Inc., Orlando

From 2011 through 2013, Universal Engineering Sciences was retained to initiate remediation services for a petroleum release at a boat marina located on the Suwannee River in Dixie County, FL. The facility operated a 10,000-gallon gasoline aboveground storage tank and a 4,000-gallon diesel AST. A critical issue involved with this project was the potential migration of the dissolved-phased contamination into the river. The water table depth fluctuated between one and four feet daily. Plume migration from the saturated zone at the boat ramp into the river was the primary concern. Based upon the unusual site configuration and general hydrogeological challenges, Universal chose to apply the best remedial solution to fit the site parameters and existing contaminant concentrations, which was ozone sparge. Ozone is a chemical oxidant that destroys chemicals of concern in situ without the use of pump and treat, soil vapor extraction and other common intrusive technologies. Universal completed soil source removal, site assessment and free product recovery prior to implementing ozone sparge. A key component of the design was the installation of horizontal sparge lines as opposed to the standard vertical sparge points commonly used. Universal installed eight, two-inch diameter horizontal sparge lines in a "fan" configuration that spanned the width and depth of the contaminant plume. The horizontal sparge lines were designed to treat the dissolved contaminants in the water table and smear zone impacted soil. The ozone system provided an output of three pounds of ozone per day and was supplemented by add-on sparge air. Universal constructed a manifold system where the eight horizontal sparge lines were linked to the ozone unit by stainless steel Teflon®-buffered solenoid valves. The entire system was connected to a control panel that directed all system activities. The system was run at bio-sparge pressures and flow so that SVE was not necessary. The initial laboratory results for benzene in two key monitoring wells exceeded 100 micrograms per liter. After operating the system for seven months, benzene was not detected above one mg/L. The system design and operation was successful and Universal obtained a site rehabilitation completion order for the client.

10:20 **Bioremediation Approaches and Tools for Benzene Remediation Under Anaerobic Conditions**
Jeff Roberts, MSc, Senior Manager, SiREM, Guelph, Ontario, Canada

Benzene, toluene, ethyl benzene, xylene and other aromatic hydrocarbons typically degrade faster under aerobic conditions than anaerobic conditions. When hydrocarbon-contaminated aquifers are predominantly anaerobic, aerobic bioremediation is not always feasible and anaerobic bioremediation approaches become favorable. Biostimulation and bioaugmentation with anaerobic BTEX-degrading microorganisms may be required for effective remediation at anaerobic hydrocarbon contaminated sites. To address this need, anaerobic cultures capable of complete degradation of benzene toluene and xylene have been developed at the University of Toronto. These cultures have been characterized and key microorganisms have been identified. SiREM, the University of Toronto and Federated Cooperatives Ltd. are currently engaged in a three-year research project to advance anaerobic benzene degradation from the lab to the field, funded in part by Genome Canada and the Province of Ontario. The objectives of the project include scale-up of an anaerobic benzene culture to field volumes, demonstrating its effectiveness for bioaugmentation in treatability studies and field tests. This benzene-degrading culture is currently being assessed in microcosms constructed with materials from hydrocarbon contaminated sites. Information generated will include inoculum density requirements, degradation rates and the range of geochemical conditions required for optimal performance of the culture, and will be used to design field trials. Molecular genetic tools to quantify and track key microbes and functional genes involved in benzene degradation are also being developed. These tools will allow in-situ assessment and monitoring of enhanced bioremediation applications

10:40 20-Minute Break

Session 6A: Thermal Technologies and Complex Strategies

11:00 **Source Zone Treatment of CVOCs to Protect Local Groundwater - The Alaric Superfund Site, Tampa, FL**

Chris Thomas, Senior Project Manager, TRS Group, Longview WA

The historical site owners and tenant at this site used chemical degreasers to clean metal. The mishandling of chemicals led to the underlying soil and groundwater contamination at the site. Site investigations showed the presence of DNAPL and groundwater contamination spread over an area of about five acres. In the early 2000s, chemical oxidation was attempted to remediate soil and groundwater but proved unsuccessful. Environmental Restoration LLC selected TRS Group under an EPA Region 4 ERRS contract to perform in-situ thermal remediation of the CVOCs in soil using electrical resistance heating. ERH is an in-situ thermal process for the remedial treatment of VOCs in both soil and groundwater. The remedial design was solely for the source area and volume of 6,218 ft^2 and 15,500 yd^3, respectively. The remedial treatment objective was to remediate soil in the ERH treatment area and within the saturated zone from 5 to 67 feet below ground surface to 1 mg/kg for tetrachloroethene. Construction of the treatment system began in October, 2016. The site-specific ERH system includes 29 electrodes co-located with vapor recovery wells. A unique design challenge was constructing and operating the ERH system beneath a portion of an existing building. Due to the building design and height restrictions, exterior angled electrodes were installed to target impacts beneath the building. The treatment system became operational in March, 2017. Confirmation soil sampling in late July showed all the results in the treatment area achieved the cleanup objective. However, to further polish the remaining contaminants, the client requested continued operations through August. Background on the site and remediation timelines will be presented as well as design details, implementation and results of the ERH source removal.

11:20 **Complex Sites and Recalcitrant Compounds: Combining Thermal Technologies for More Efficient Remediation Efforts**

Robert D'Anjou, MSc, PhD, Assistant Technical Director, Global Remediation Solutions, Longview, WA

With the onset of improved technology and understanding, sites of increasing complexity and difficulty are coming into the realm of possibility as potential remediation sites. However, these complex sites require smarter, more informed remediation strategies. This presentation will discuss several complex sites where creative remediation system designs permitted successful remediation and will take a closer look at combining multiple in-situ thermal remediation technologies in order to optimize treatment on sites that would have otherwise been near impossible to clean. Steam-enhanced extraction, electrical resistance heating and in-situ thermal desorption represent the three major ISTR technologies available in the marketplace today. Each technology offers a unique method of energy transfer and heat propagation in the subsurface and performs optimally under differing subsurface conditions. This duscussion will present multiple projects where ISTR technologies were combined to effectively mitigate impacts from varying hydrogeologic conditions, subsurface geologies, complex co-solvated and co-mingled contaminant plumes, and intricate site features by taking advantage of the strengths of each individual technology. The presentation will also discuss theoretical site conditions that warrant the use of different ISTR technologies, or combinations of technologies, the advantages of each treatment strategy, and how to effectively optimize in-situ treatment systems under each scenario to maximize system efficacy and minimize overall project costs.

11:40 **Complex Site Assessment and Remediation of DNAPL, LNAPL, PCBs, Arsenic, Lead; Large Diameter Auger Source Removal; Conventional Source Removal and Off-Site Challenges**

Matt McClure, PE, Environmental Engineer, JEA, Jacksonville

Matthew Hampton, Senior Project Geologist, Golder Associates Inc. Jacksonville

On-site DNAPL, LNAPL, PCBs, arsenic and lead impacts along with off-site arsenic impacts were identified during the site assessment at a former electrical equipment service facility in Jacksonville, FL. Given the complexity of conditions identified in the site assessment report, a feasibility study was performed to evaluate potential remedial alternatives. The Florida Department of Environmental Protection approved the feasibility study including the proposed phased remedial strategy. To address DNAPL impacts, a DNAPL source removal system consisting of a multi-phase extraction system, a soil vapor extraction system and a thermal conductive heating system was installed. Conventional and large diameter auger excavation techniques were used to excavate a total of 10,280 tons of non-Toxic Substance Control Act-regulated and 4,486 tons of TSCA-regulated soil for off-site disposal. This was combined with engineering and institutional controls to minimize risks of direct exposure to soil. Based on groundwater sampling results obtained after soil removal, no active groundwater remediation was warranted and the site moved into post-active remediation monitoring for groundwater. Off-site arsenic soil impacts were further delineated and discussions with off-site property owners about a remedial approach is currently underway. Golder Associates Inc. and JEA will present details of installation and operation of the DNAPL source removal system, on-site source removal, the PARM program, and challenges associated with liability and access for off-site impacts.

Session 6B: Enhanced In-Situ Remediation Applications

11:00 **Surfactant Use for Enhancing Performance of Chemical Oxidation Remediation**
Dan Socci, Chief Executive Officer, EthicalChem, South Windsor, CT

Remedial approaches using chemical oxidation deliver aqueous phase oxidant treatment fluids into the contaminated subsurface. These approaches are limited to addressing contamination in the groundwater while hydrophobic contaminants remain sorbed to soil. This remaining soil-sorbed contamination will in time transfer to the aqueous phase after the chemical oxidation treatment is completed, causing groundwater contaminant concentrations to increase, resulting in what is referred to as "contaminant rebound". Rebound is typically addressed with multiple rounds of follow-up chemical oxidation treatments. Contaminant sorption limits the availability of contaminants to the aqueous phase oxidant. Using a combined oxidant-surfactant solution, liberation of the sorbed hydrophobic contaminants and emulsification into to the aqueous phase as small particles with increased surface area available for reactions with the oxidants can significantly improve soil and groundwater remediation. This presentation will discuss independent third party comparative research by the University of Madrid on the performance of combined surfactant and oxidant versus oxidant alone treatment of contaminated soil. Additionally, field case studies on successful implementation of S-ISCO® , Surfactant-Enhanced In-Situ Chemical Oxidation, will be discussed.

11:20 **Optimizing In-Situ Remediation Amendments Using Innovative Surfactant System Formulations**
David Alden, PE, Technical Associate, Tersus Environmental, Wake Forest, NC

Surfactants, polymers and solvents are key chemicals in designing products that are injected during groundwater remediation activities. Although these ingredients should all be compatible with health and environmental requirements, their function varies according to each technology's objective. For example, practitioners have concluded that NAPL solubilization with surfactants was a necessary first step in the mobilization process and that surfactant concentration, up to a point, was generally proportional to performance. When, rather than NAPL recovery, its destruction is pursued, surfactants aid in creating complex water-ZVI suspensions in oil continuum or to disperse solids or non-water soluble amendments, such as vegetable oils, sands, iron or activated carbon into aquifers. Technology developed at the University of Oklahoma, originally focused for enhanced oil recovery at petroleum reservoirs and subsequently adapted to the environmental arena, can lower the IFT sufficiently to allow physical mobilization of residual LNAPL with the limited production of thermodynamically stable emulsions. This talk will focus on the use of artfully formulated surfactant blends that reduce solubilization and simply allow LNAPLs in saturated soils to become mobile. Surfactant studies targeted to specific technology objectives has allowed the group to formulate surfactant packages that allow field technicians to create their own EVOs in the field while significantly reducing droplet size, lowering overall costs and carbon footprint by procuring oils locally. The presentation will include results and lessons learned from innovative surfactant formulations as well as the latest field implementation where selecting an optimized surfactant blend minimized required flush water for NAPL recovery and costs for produced effluent fluids treatment from sites in the U.S. and South America.

11:40 **Using Groundwater Recirculation for Enhanced Reductive Dechlorination at an Active Manufacturing Facility**
Eric Bueltel, PE, Technical Director, ETEC LLC, Washougal, WA

The use of substrates for enhanced reductive dechlorination has been widespread with varying degrees of effectiveness. Typical applications of substrates are performed using direct-push injections. Limitations of the direct-push application method include using many injection points throughout the plume for product application, inability to contact contaminated areas underneath surface structures and incapability to make real-time changes to the treatment. To overcome the limitations of direct-push substrate injections, specialized groundwater recirculation equipment, the ISD™ system, delivering the soluble, nutrient-amended substrate CarBstrate™ was used for chlorinated solvent remediation at an active manufacturing facility. The groundwater at the site had been impacted by historical use of chlorinated solvents. The ISD™ equipment was installed in conjunction with a series of injection and extraction wells to extract groundwater and then recirculate the CarBstrate™-amended groundwater throughout the site restricted by aboveground structures. During operation, site data was collected for both the contaminant reduction process and ERD optimization. Both data sets will be presented for a technical discussion of the ERD process at the site. Also discussed will be a summary of challenges encountered with the application of the groundwater recirculation approach, treatment optimizations made real-time, and an overview of costs for implementation.

12:00 ***Day Two Luncheon*** *Sponsored by* ***CH2M***

Session 7: Annual Regulatory Panel Discussion

1:30 Topics/Speakers TBD

3:00 15-Minute Break

Session 8: Conceptual Site Models to Facilitate Successful Remedy Applications

3:15 **PCE and Daughter Remediation in Limestone Bedrock - Brownfields Redevelopment of a Former Tubing Manufacturing Facility**

Bill Brab, CPG, PG, AST Environmental Inc., Midway, KY

Virgin PCE used for parts cleaning was released from an aboveground storage tank into the shallow limestone bedrock at a former tubing manufacturing facility in Louisville, KY. Downhole geophysical and groundwater characterization methods determined contaminant migration in the shallow bedrock occurred along a bedding plane feature and extended to the subject site property line. Dual-phase extraction was utilized from 2002 through 2014 to prevent off-site migration of the release, however, source well concentrations began increasing following system shutdown. Interest in purchase of the facility spurred brownfields redevelopment and in-situ remedies were evaluated for their feasibility. The selected remedy for the site was an immiscible, activated carbon-based injectate impregnated with reactive iron designed for rapid degradation of chlorinated solvents. The corrective action plan included in-situ source mass reduction and two permeable reactive in-situ barriers to prevent further migration of contaminants from the source area. Remediation was implemented using a specialized injection system and straddle packer assembly using high flow rate (up to 180 gallons per minute) injections. Hydraulic connection was continuously monitored during injection using pressure transducers emplaced throughout the treatment area. Real-time well monitoring aided in optimizing the injection volumes and confirming that uniform distribution of the slurry was achieved. The monitoring demonstrated that the area of influence, using a 300-gallon slurry volume, varied up to 250 feet. Performance groundwater monitoring effectively demonstrated that contaminant migration ceased and contaminant destruction is continuing to occur across the treatment area. The site was granted no further action in May 2017.

3:40 **Controlled Release Environmental Reactants – In-Situ Soil and Groundwater Remediation of Recalcitrant Compounds and Emerging Contaminants of Concern**

Lindsay Swearingen, Managing Partner and Principal Scientist, Specialty Earth Sciences, New Albany, IN

The environmental science community has a collective interest in identifying viable and sustainable remedial solutions for groundwater contaminant plumes, seeking out remedies which reduce carbon footprint, minimize waste generation and limit energy inputs required for remediation implementation, operations and ongoing maintenance at sites impacted by CVOC's, PAH's, BTEX constituents and heavy metals. Stakeholders could benefit from greener cleanup technologies, especially in light of future requirements to remediate vast dissolved phase plumes of emerging contaminants of concern such as 1,4-dioxane. Sustained and controlled release reactant technology involves coating or encapsulating environmental reactant materials to facilitate a more user-friendly in-situ remediation implementation. The result is an efficient approach to soil and groundwater remediation that addresses the common challenges encountered with traditional liquid injection applications. Challenges include contaminant rebound, plume migration and the need for multiple mobilizations. Rather than pressurized liquid injection, the energy of concentration gradient-driven diffusion as well as natural groundwater movement is used to deliver oxidants in the subsurface without the need for specialized injection equipment or expensive injection field services providers. Sustained and controlled release reactant materials can be applied to the subsurface in a number of forms and methods. Multiple remediation practitioners have applied these materials at sites across the U.S., Europe, Canada and Brazil. Current and updated case studies will be presented including site selection, implementation design, cost and monitoring data.

4:05 **Selection, Construction and Initial Operation - Ozone Sparging System for 1/4-Dioxane Impacts at a RCRA-Regulated Industrial Facility in Puerto Rico**

Vicki Bierwirth, Assistant Staff Engineer, Trihydro Corp,, Jacksonville

Bradley Pekas, PG, PE, Senior Engineer/Team Leader, Trihydro Corp., Tampa

This presentation describes the selection, construction, startup and preliminary operational performance of the ozone/in-situ chemical oxidation system at a RCRA-regulated industrial site in Puerto Rico to treat groundwater contaminated by chlorinated solvents including 1,4-dioxane. The groundwater contamination has migrated offsite and is being influenced by the operation of a couple of water supply wells. Several types of treatment technologies were screened to potentially address the chlorinated solvent and 1,4-dioxane contaminants present within the sand unit aquifer system including in-situ chemical oxidation, in-situ bioremediation, phytoremediation and monitored natural attenuation. Of these different technologies, ozone sparging was selected and approved for implementation. The ozone system was installed in September, 2016, and bump-started in early October, 2016. The self-contained ozone sparging system is powered by a diesel generator and was installed offsite at the leading edge of the 1,4-dioxane plume. As designed, the system operates three ozone sparge points on a rotational basis, and it is controlled and remotely monitored through cellular telemetry. Per cycle, each sparge point operates for three minutes with a high concentration, low flow injection rate followed by 117 minutes operating at a low concentration, high flow rate. The higher flow rate and lower concentration are the result of using a secondary "air-flow booster" compressor. In December, 2016, Trihydro received approval from the client and regulatory agencies to begin full-time operation of the ozone sparging system. The initial operational performance of the system, included a preliminary discussion of the groundwater monitoring data will be presented and discussed.

4:30 **Applying an Electrical Scanning Technology to Enhance Conceptual Site Models**
Mark Kluger, SMG, President, Dajak LLC, Wimington, DE

A significant number of contaminated sites simply do not clean up. Many sites have experienced a range of spills that occurred over a period of time at various locations. Impacts to nearby receptors including municipal and residential water supply wells and surface water often occur years after operations have ceased, even after some form of remediation has occurred. The expression of NAPL to wells and water bodies in the form of sheens can cause significant public and regulatory concerns. Determining the pathway and source are difficult, as there are often a series of possible sources and pathways to the receptors. In the vast majority of cases, there is insufficient data density to understand the preferential pathways and impacts. Using ultra-high resolution characterization approaches, which typically generate tens or hundreds of thousands of data points, we can now generate a conceptual site model for pathway and source identification at these types of sites. Developing an enhanced CSM includes targeted confirmation drilling and sampling data and the preparation of 2-D and 3-D visualization models. As sites vary in geology, hydraulic properties and contaminant composition, selecting the correct scanning tools is essential. The talk will focus on an enhanced electrical resistivity imaging technology developed at Oklahoma State University and feature two case studies—petroleum hydrocarbon vapor intrusion and chlorinated ethene remediation.

5:00 **Conference adjourns**

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