CONFERENCE PROGRAM

AGENDA

2022 North American Site Solutions Technology Transfer Conference

WEDNESDAY, NOVEMBER 9, 2022	
7:00 am to 8:00 am	Continental Breakfast
8:00 am to 8:30 am	Welcome, Opening Remarks, Health and Safety Moment *Presenter*: Mark Nielsen (Global Site Solutions Service Line Leader), Princeton, New Jersey *Remarks*: Jeanne Tarvin (Market Director, E&H Americas), Milwaukee, Wisconsin
Session 1 – Innovative Assessment A – Moderator: Bruce Kennington	
8:30 am to 8:55 am	Bioremediation of PFAS and Treatment of Hazardous Soils w/ BAM *Presenters*: Larry Kinsman and Tyler Emerson, ORIN Technologies, LLC
8:55 am to 9:20 am	Innovative Tools for PFAS Site Assessment and Client Outreach *Presenter*: Gina Daniel, Princeton, New Jersey
9:20 am to 9:45 am	Blind Brook Flood Resiliency Study, SCALGO – Efficient Site Assessment Tool *Presenter*: Elena Araya, Syracuse, New York
9:45 am to 10:10 am	Willowstick Geophysical Investigation at a Chlorinated Solvent Site *Presenter*: David Meyer, Overland Park, Kansas
10:10 am to 10:25 am	Break
Session 2 – Remediation A (NAPL) – Moderator: Tim Olean	
10:25 am to 10:50 am	Optimizing Remediation in Bedrock: Lessons from Successful Injection Projects *Presenters*: Will Caldicott and Paul Dombrowski, ISOTEC, Inc.
10:50 am to 11:15 am	Lessons Learned and Innovations Developed during Pilot Study Operations of a DNAPL Recovery System *Presenter*: Marcus Byker, Chicago, Illinois
11:15 am to 11:40 am	Use of a Two-Phase Barrier Approach to Address Mobile LNAPL and Residual Groundwater Impacts at a Refinery *Presenter*: Abigail Small, Edina, Minnesota
11:40 am to 12:05 pm	Good Vibrations: An Innovative Approach to NAPL Increase NAPL Recovery *Presenter*: Nate Keller, Milwaukee, Wisconsin
12:05 pm to 1:35 pm	Lunch

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WEDNESDAY, NOVEMBER 9, 2022	
Session 3 – Digitalization/Innovation – Moderator: David Heidlauf	
1:35 pm to 2:00 pm	Advances in PFAS Site Investigation Technologies *Presenter*: Charles Neslund, Eurofins Environment Testing (USA)
2:00 pm to 2:25 pm	Digitally Transforming Biodiversity Assessments: How Remote Sensing, AI, and Good Ole' Fashioned Expert Knowledge are Advancing Sustainability *Presenter*: Brittni Engels, Rochester, New York
2:25 pm to 2:50 pm	How ArcGIS Portal's Webmapping Capabilities Can Streamline Project Planning and Scoping *Presenter*: Geoff Gadd, St. Louis, Missouri
2:50 pm to 3:15 pm	Interim Measure Remedies Performance Monitoring Dashboard for a Refinery Site in Montana *Presenter*: Ruta Deshpande, Chicago, Illinois
3:15 pm to 3:30 pm	Break
Session 4 – Sediment/Sustainability – Moderator: Kim Groff	
3:30 pm to 3:55 pm	The Evolution of Two Remediation Technologies: *In Situ* Chemical Oxidation (ISCO) Combined with *In Situ* Stabilization (ISS) *Presenters*: Fayaz Lakhwala and Josephine Molin, Evonik Active Oxygens
3:55 pm to 4:20 pm	Design of a Treatability Study to Assess Sediment Remedial Technologies *Presenter*: Joseph Ridgway, Chicago, Illinois
4:20 pm to 4:45 pm	Estimating Time to Recovery of PCBs to Evaluate Monitored Natural Recovery Performance *Presenter*: Lauren Brown, Portland, Maine
4:45 pm to 5:10 pm	Nature-Based Solutions Transform a Riparian Corridor with Benefits to the Community and Environment *Presenter*: Mandi Miller, Denver, Colorado
5:10 pm to 5:25 pm	Announcements
6:00 pm to 9:30 pm	Dinner Event Location: Oak Barrel Public House (OBPH) Walking Directions: 7 minute walk (0.3 miles) to OBPH

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THURSDAY, NOVEMBER 10, 2022	
7:00 am to 8:00 am	Continental Breakfast
8:00 am to 8:30 am	Announcements, Health and Safety Moment
Session 5 – Innovative Assessment/Testing B – Moderator: Devon Rowe	
8:30 am to 8:55 am	Ramboll and TRS Group Partnership - Accomplishing the (near) Impossible with *In-Situ* Thermal Remediation in Glacial Till Beneath and Active Manufacturing Facility *Presenter*: Chris Thomas, TRS Group, Inc.
8:55 am to 9:20 am	Development and Implementation of an Innovative Field UV Screening Method for Identifying NAPL and Distinguishing Sources in Sediments *Presenter*: Jeff Kampman, Chicago, Illinois
9:20 am to 9:45 am	Supplemental Site Characterization and Investigation of a Gasoline Release in a Karstic Carbonate Environment *Presenter*: Kit Carson, Denver, Colorado
9:45 am to 10:10 am	Testing Carbon-Based Amendments in Treating PCB and Metal Contaminated Soils *Presenter*: Sarah Sauda, Syracuse, New York
10:10 am to 10:25 am	Break
Session 6 – Modeling/Sustainability – Moderator: Eric Tlachac	
10:25 am to 10:50 am	Delivery Methods for *In Situ* Remediation: Soil Blending, Direct Sonic Injection, Hydraulic and Pneumatic Fracturing *Presenters*: John Haselow and Kyle Clarke, Redox Tech, LLC
10:50 am to 11:15 am	Remedial Alternative Sustainability Evaluation During a Feasibility Study *Presenter*: Eric Hritsuk, Chicago, Illinois
11:15 am to 11:40 am	Red Mud Dams Alumina Groundwater Modeling and Remote Sensing *Presenter*: Katie Zheng, Emeryville, California
11:40 am to 12:05 pm	Evaluating Reductions in Modeled Flux as a Metric for Demonstrating Regulatory Compliance for Coal Combustion Residual (CCR) Surface Impoundments Following Closure *Presenter*: Jake Walczak, Milwaukee, Wisconsin
12:05 pm to 1:35 pm	Lunch

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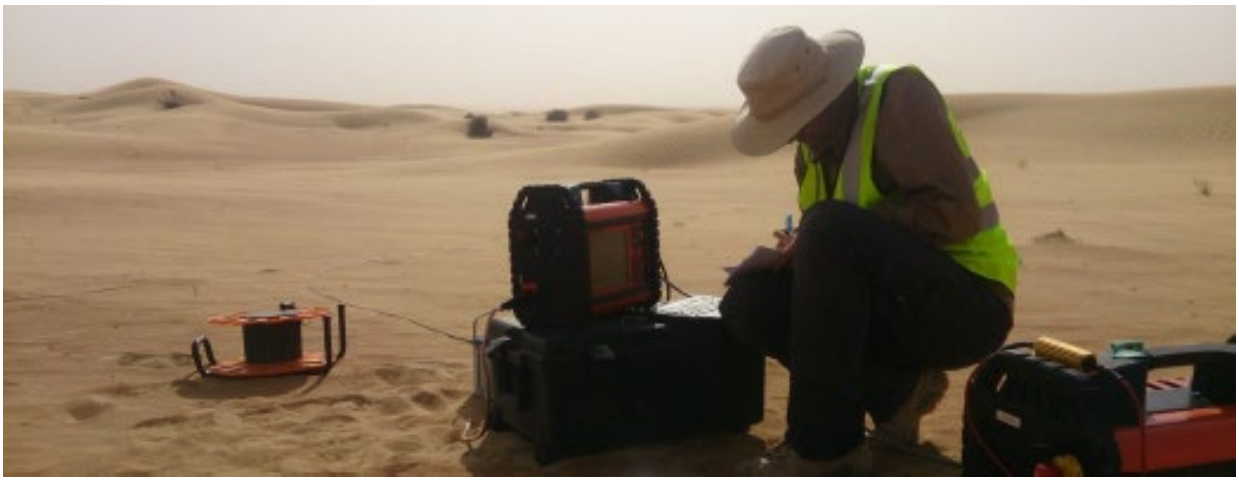
THURSDAY, NOVEMBER 10, 2022	
Session 7 – Remediation B (CVOCs) – Moderator: Mark Mejac	
1:35 pm to 2:00 pm	Bioremediation of Perchlorate using Hydrogen *Presenter*: Ruhui Zhao, Emeryville, California
2:00 pm to 2:25 pm	Large-Scale Plume, Nano-Scale Solution: Remediation of CVOC Using Sodium Persulfate and Ozone Nanobubbles *Presenter*: Gustavo Mello, São Paulo, Brazil
2:25 pm to 2:50 pm	*In-Situ* Anaerobic Bioremediation and Chemical Reduction of PCE in Groundwater *Presenter*: Eric Andruk, Hartford, Connecticut
2:50 pm to 3:15 pm	ART Pilot Study for a CVOC Contaminated Site *Presenter*: Emily Ireland, Princeton, New Jersey
Session 8 – The Next Big Thing – Moderator: Mark Nielsen	
3:15 pm to 4:00 pm	*Remarks:* Jesper Dalsgaard (Managing Director, Environment & Health), Copenhagen, Denmark Ramboll "Green Plays" *Panelists:* PFAS - Eric Wood (Westford, Massachusetts), Biodiversity - Chris Calkins (Syracuse, New York), Energy Transition - Melinda Truskowski (Denver, Colorado)
Closing	
4:00 pm to 4:15 pm	*Closing Remarks* - Mark Nielsen



SESSION 1

Innovative Assessment A

(Moderator: Bruce Kennington)

2022 Americas Site Solutions Technology Transfer Conference

Title: Innovative Tools for PFAS Site Assessment and Client Outreach

Authors' Names: Gina Daniel, Rebecca Siebenaler

Presenter's Name: Gina Daniel

Key Topic: Emerging Contaminants

PDP Manager/Managing Principal's Name: Kim Groff

Client Name: N/A

Project Name: N/A

Project Location: N/A

Primary Ramboll Project Staff (Office): Rebecca Siebenaler, Mary Cottingham (Princeton, New Jersey)

ABSTRACT

Background/Objectives:

Per- and polyfluoroalkyl substances (PFAS) are a hot topic and an increasingly important class of contaminants of concern in the fields of site investigation, risk assessment, and site remediation. As regulations advance beyond PFOA and PFOS at the federal and state levels in more environmental matrices, a greater number of potential liabilities and types of contamination may be identified. To be responsive to this evolving landscape, environmental consultants need to have the latest science, regulatory information, and network of experts at their fingertips.

Approach/Activities:

This talk will provide an introduction to the tools and resources available to support your site work within the Site Solutions network, highlighting the types of information on PFAS that are being compiled and maintained by the PFAS SME team, as well as points of contact for questions. Particular focus will be on displaying two innovative PowerBI dashboards: 1) the PFAS in drinking water across the US data dashboard, and 2) the PFAS chemical database PowerBI dashboard which displays physical/chemical properties, regulatory values, and toxicity information by chemical. Additional sources of information, including the PFAS publications reference library and Emerging Contaminants Sharepoint site may be discussed, time permitting.

Results/Lessons Learned:

Through the compilation of PFAS regulatory information as part of the PFAS SME team, we discovered that there is a need to rapidly access/view PFAS regulatory information by state and US-wide to adequately respond to client questions. This capability should be available to all within Ramboll, not just within the PFAS SME team, and can be used to help guide site investigation and risk assessment efforts. Accordingly, the PowerBI PFAS chemical information dashboard was built.

Aspect of Work that Relates to Sustainability:

By directly linking the PFAS chemical information dashboard to an underlying SQL database, the dashboard automatically updates when new regulatory, chemical information, or toxicity data are loaded to the base database. This eliminates the need to make updates in multiple locations, streamlining tracking efforts and reducing redundant work. Practitioners across Ramboll can access the dashboard as a central repository of information, reducing the chance of using conflicting phys/chem/toxicity information in fate and transport or risk assessment evaluations. All of these improvements enhance the sustainability of PFAS site investigation and remediation within Site Solutions, which in turn leads to better informed decision making for protecting drinking water sources and other natural resources.

2022 Americas Site Solutions Technology Transfer Conference

Title: SCALGO – Efficient Site Assessment Tool

Authors' Names: Elena Araya, Colin Stockdale, Piotr Domaszczynski

Presenter's Name: Elena Araya and Colin Stockdale

Key Topic: Innovative Assessment Methods

PDP Manager/Managing Principal's Name: Piotr Domaszczynski/Chris Calkins

Client Name: City of Rye

Project Name: Blind Brook Flood Resiliency Study

Project Location: City of Rye, Town of Harrison, and Village of Rye Brook, New York

Primary Ramboll Project Staff (Office): Syracuse, New York

ABSTRACT

Background/Objectives:

The objective of this presentation is to review capabilities of the SCALGO platform that was successfully implemented during execution of the Blind Brook Resiliency project. The Blind Brook watershed, a tributary to the Long Island Sound, is in southeastern New York. The portion of Blind Brook that flows through the City of Rye, New York, has experienced significant flooding and property damage due to extreme precipitation events such as nor'easters and hurricanes. Ramboll was retained by the City of Rye to evaluate a number of potential flood mitigation measures within Blind Brook watershed. The project included a screening phase where over 20 potential projects were rapidly evaluated using a combination of SCALGO and conventional assessment tools (e.g., H&H models, GIS, CAD).

Approach/Activities:

The Ramboll team utilized the SCALGO platform to efficiently evaluate conceptual site modifications. SCALGO is an on-line (operated from a browser) platform primarily used for climate adaptation, urban planning, emergency management and administration of watercourses. SCALGO uses on-the-fly terrain data-processing technology that allows the user to interact with high resolution 3D surfaces and view the effects of proposed changes (e.g., excavation, grading, berms, ponds). Capabilities include dynamic watershed delineation, identification of flood risk areas, surface profile generation, and terrain modification. For the Blind Brook project application, the SCALGO terrain editor allowed the team to easily identify the storage capacity of the pond and berm alternatives, adjust the dimensions and elevation of the pond or berm, and estimate the cut or fill volume of soil required for construction. These approximate measurements were used in the preliminary cost estimate and prioritization of the analysed alternatives.

Results/Lessons Learned:

SCALGO is an innovative and intuitive tool for understanding the characteristics of an area and evaluating impacts of terrain modification at a conceptual level. The team used the project site elevation model to identify and evaluate locations that could be utilized for a site management feature, and to optimize the size of the feature to match existing topography. The ability to make changes and view the effects in real-time eliminated the need for lengthy processing. The applicability of SCALGO for a project depends on the availability of terrain data. Westchester County has a robust LiDAR database from which the team obtained the necessary terrain data for the project site. Availability of high-quality digital terrain data will affect the accuracy of the tool.

Aspect of Work that Relates to Sustainability:

In the context of Blind Brook, the team used SCALGO to rapidly evaluate a large number of potential site modification alternatives as flood mitigation measures. If constructed, the selected alternatives would result in a more resilient City of Rye community.

2022 Americas Site Solutions Technology Transfer Conference

Title: Willowstick Geophysical Investigation at a Chlorinated Solvent Site

Authors' Names: David Meyer, Scott Hayter, William Campbell, Michael Wilson

Presenter's Name: David Meyer

Key Topic: Innovative Assessment Methods

PDP Manager/Managing Principal's Name: Aaron H., Steve M./Scott H.

Client Name: Whirlpool

Project Name: Whirlpool Fort Smith

Project Location: Fort Smith, Arkansas

Primary Ramboll Project Staff (Office): Kansas City, St. Louis, Indianapolis, Ann Arbor

ABSTRACT

Background/Objectives:

The site has a relatively thin transmissive zone and a complex flow regime with contaminants migrating radially away from the source area making precise identification of contaminant migration pathways difficult. The aquifer is impacted with elevated concentrations of trichloroethene and its degradation products and consists of a highly anisotropic and heterogeneous layer of sands, clays, and gravels at depths of 20-40 feet. Further understanding of the groundwater flow model was needed to develop a more targeted remedy approach for plumes across the site. A geophysical investigation was utilized to characterize and identify preferential groundwater flow paths.

Approach/Activities:

Willowstick Technologies, LLC has developed a patented method and proprietary software for assessing and identifying preferential groundwater flow path(s) within the subsurface. Four surveys were conducted to address contaminant plumes migrating in multiple directions from the source area. The geophysical surveys were conducted by (1) inducing an electrical current through the aquifer between electrodes installed in monitoring wells on either side of the survey areas, (2) measuring the magnetic field at predetermined locations throughout the survey areas, and (3) assessing the predicted versus measured magnetic fields with a 3D inversion modelling package that is used to identify potential preferential groundwater flow paths.

Results/Lessons Learned:

The six primary and six secondary preferential groundwater flow paths identified in the four survey areas appeared consistent with areas previously known to have experienced contaminant migration, and two boreholes completed after the geophysical survey corroborated results in areas with data gaps. The preferential flow paths are additional lines of evidence that can be used to refine the Site conceptual flow model in addition to site-wide potentiometric surface maps, historical aquifer testing and a recently completed plume flux meter investigation. Together, these and other lines of evidence provide a more complete understanding of Site hydrogeology and potential contaminant migration pathways. This data also helps create a targeted remedial design versus a broader stroke remedial design to help more efficiently address site contamination.

Aspect of Work that Relates to Sustainability:

Implementing a non-intrusive assessment method, corroborated by a limited amount of intrusive sampling, minimized site disruption and the level of effort to advance understanding of the site subsurface, which will allow for a targeted remedial design to reduce overall costs and disruption to the currently operating facility. The copper clad wire used to create the electrodes was recycled at a nearby metals recycling facility.

SESSION 2

Remediation A (NAPL)

(Moderator: Tim Olean)

2022 Americas Site Solutions Technology Transfer Conference

Title: Lessons Learned and Innovations Developed during Pilot Study Operations of a DNAPL Recovery System

Authors' Names: Jennifer Hagen, Andrew Barbeau, Tim Olean

Presenter's Name: Marcus Byker

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Jennifer Hagen

Client Name: WEC Business Services, LLC

Project Name: North Shore Gas South Plant MGP

Project Location: Waukegan, Illinois

Primary Ramboll Project Staff (Office): Chicago, Illinois/Milwaukee, Wisconsin

ABSTRACT

Background/Objectives:

A 6-acre DNAPL body was identified adjacent to a former MGP and within approximately 200 feet of surface water. Potentially recoverable DNAPL was delineated on property owned by the utility, the city, railroad, local port district, and an aerospace coating manufacturer. In consideration of property ownership constraints, the United States Environmental Protection Agency (USEPA) issued an interim Record of Decision (ROD) to recover as much DNAPL as practicable. The ROD specified a physically enhanced recovery approach that involved groundwater extraction, treatment, and reinjection to facilitate migration and recovery of DNAPL. Initial plans involved implementation of the system on all properties in one mobilization. This approach would have included construction of a 150-gallon per minute groundwater treatment plant, 40 vertical wells, four horizontal wells, and related infrastructure. Given the complexities of long-term DNAPL recovery and in consideration of third-party property owner concerns, the project team implemented construction in two phases with the first phase focused on utility-owned property and serving as a pilot study. The goal of the pilot study was to validate design assumptions, evaluate material and component specifications, optimize groundwater treatment plant operations, and refine construction methodologies prior to expanding to third-party property. The objective of this presentation is to demonstrate how a DNAPL recovery pilot study was used to optimize system design and construction prior to completing work on third-party properties.

Approach/Activities:

The pilot study was completed on utility-owned property, allowing greater flexibility on construction approaches and modifications to system operations. During pilot study development, key design and operation criteria were identified and a strategy was developed to validate those criteria during pilot study execution. The pilot study consisted of repurposing three existing vertical wells; and installation of three new vertical wells, a horizontal injection well, and a rented groundwater treatment plant. Throughout operations, key system components were evaluated to optimize full-scale design. In addition, systematic modification of operations was completed to inform full-scale operational criteria. Operational modifications included batch and continuous pumping of DNAPL recovery pumps, constant and pulse pumping of groundwater extraction pumps, and modification of heat trace settings.

Results/Lessons Learned:

The pilot study system operated between April and November 2020. From a design perspective, the pilot study identified the need for an alternate groundwater extraction pump, clarified selection of preferred DNAPL recovery pump, and confirmed the need for heat trace to facilitate conveyance of recovered DNAPL. From an operational perspective, multiple approaches to system operations were implemented, including passive recovery, pulsed pumping, and maximum gradient. The pilot study demonstrated that pulsed groundwater extraction was four times more effective at recovery of DNAPL and reduced influent treatment plant flow by approximately 50%. After several months of operations, DNAPL recovery rates declined indicating DNAPL recovery was nearing maximum extent practical.

Dissolved phase concentrations in surrounding wells remained slightly above regulatory objectives. Ramboll completed research and development activities to determine if there were low-cost ways to modify system operations to recovery remaining DNAPL. These research and development activities led to development of a customized vibration-enhanced recovery tool. After identification of the optimal frequency, DNAPL recovery rates the test well increased by over 300%. Based on the successes in Ramboll's modification to system operations, the regulatory agency requested inclusion of these approaches in the full-scale system.

Aspect of Work that Relates to Sustainability:

Ramboll advocated for the opportunity to control system operations. Doing so identified alternate approaches to system operations that decreased water treatment needs by 50%, resulting in a comparable reduction in electrical consumption and water treatment plant chemical consumption. In addition, vibration-enhanced recovery aided in recovery of residualized NAPL, thereby reducing the likelihood that a subsequent active remediation will be required to address dissolved phase impacts.

2022 Americas Site Solutions Technology Transfer Conference

Title: Use of a Two-Phase Barrier Approach to Address Mobile LNAPL and Residual Groundwater Impacts at a Refinery

Author's Names: Abby Small

Presenter's Name: Abby Small

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Jim Hutchens/Jennifer Hagen

Client Name: Calumet Montana Refining (CMR)

Project Name: AOC-16 Interim Measures Design and Construction

Project Location: Great Falls, Montana

Primary Ramboll Project Staff (Office): Dave Heidlauf, Scott Tarmann, Ruta Deshpande, Phil Brochocki, Paul Lindquist, Heath Ward

ABSTRACT

Background/Objectives:

Ramboll was tasked with designing and implementing interim remedial measures to address potential dissolved-phase impacts to the Missouri River stemming from a petroleum release near CMR's Loading Rack. Site characteristics constraining design and implementation included: 1) heterogenous hydrogeologic unit of generally low hydraulic conductivity with narrow seams of higher conductivity with the potential to transmit light non-aqueous phase liquid (LNAPL); 2) property access constraints which limited work to a 23-foot-wide parcel with a high density of utilities.

Approach/Activities:

Ramboll's design included a series of two trenches perpendicular to the direction of groundwater flow. A LNAPL recovery trench was installed upgradient to recovery LNAPL and limit LNAPL from entering the downgradient permeable reactive barrier (PRB) and overrunning the sorption capacity of the reactive media. Because of the heterogenous lithology, if migrating LNAPL was present, it was likely in thin, higher conductivity zones. Because the exact location of the thin, higher conductivity zones was unknown, the trench was installed to protect the entire face of the PRB. Recovery wells outfitted with passive skimming canisters were installed within the trench to monitor and extract accumulating LNAPL. The downgradient PRB was backfilled with a reactive media consisting of a colloidal activated carbon plus terminal electron acceptors (Regenesis Product Petrofix) incorporated into coarse sand. Groundwater contamination that flows through the PRB partitions from the dissolved phase by adsorption to the activated carbon particles and are anaerobically biodegraded stimulated by electron acceptors.

Results/Lessons Learned:

In the approximately one year since installation, LNAPL has been identified in 9 of 11 recovery wells and 90.5 gallons of LNAPL have been passively recovered. The initial three rounds of verification groundwater sampling indicate that the concentration of dissolved phase petroleum constituents of concern decrease across the passive treatment trench, initially meeting the remedial goals.

Aspect of Work that Relates to Sustainability:

The groundwater treatment and LNAPL recovery are occurring passively requiring limited resources for operation and maintenance as compared to more resource intensive alternatives such as pump and treat systems. The specified reactive media treats groundwater through a dual approach of adsorption and biodegradation. Due to the continuous biodegradation processes, the reactive media should never be fully consumed and anticipated lifespan is greater than 30 years.

2022 Americas Site Solutions Technology Transfer Conference

Title: Good Vibrations – An Innovative Approach to NAPL Increase NAPL Recovery

Authors' Names: Nathaniel Keller, Marcus Byker, Abigail Small

Presenter's Name: Nathaniel Keller

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Jennifer Hagen

Client Name: WEC Energy Group

Project Name: South Plant Remediation

Project Location: Waukegan, Illinois

Primary Ramboll Project Staff (Office): Ramboll Midwest

ABSTRACT

Background/Objectives:

Pump and treat under an optimized gradient was selected by the USEPA as the remedy for a site impacted with MGP residuals. A pilot extraction system was installed and operated to refine and optimize the design and operation of the full-scale system. The pilot extraction system was designed to remove DNAPL from the subsurface and evaluate potential treatment requirements.

Approach/Activities:

Ramboll Midwest evaluated several options to determine what technologies could be evaluated in the final weeks of the pilot test to increase the volume of NAPL extracted using the pilot system. Some literature review indicated that in the 1950s, scientists in the oil industry observed increases in oil production following earthquakes near petroleum reservoirs (Beresnev and Johnson, 1994). Subsequent observations of this phenomena were evaluated and in 1964 when scientists began laboratory investigations. More recently, Lovenetti, et. al (1994), Hartoz and Westerhoff (2010), Li (2006), and others have evaluated vibration enhanced mobilization of NAPL (or oil) as a remedial solution in laboratory or field settings. These studies have shown the potential for vibration to increase transport and recovery of NAPL. Vibrations were induced via a downhole pneumatic piston vibrator, powered by the same airline used to operate the DNAPL recovery pump. The range of frequencies identified in the literature that have been effective at enhancing NAPL mobility and recovery were between 50 Hertz (Hz) and 112 Hz. Vibrations were induced at three target frequencies (51, 64, and 75 Hz) for approximately four hours per day for three consecutive days. DNAPL thickness was gauged using standard site procedures and the frequency and amplitude of vibrations were assessed using geophones.

Results/Lessons Learned:

The amplitude associated with the 51 Hz trial was observed on the ground surface up to approximately 20 feet from the well, however the frequency resulted in no meaningful increases in DNAPL thickness in the EW01 well sump. The amplitude associated with the 74 Hz trial was observed up to approximately 30 feet from the well and resulted in no meaningful increases in DNAPL thickness in the well sump. Amplitude associated with the 64 Hz trial was observed up to approximately 50 feet from the well and resulted in an increase of DNAPL thickness from approximately 0.50 ft to 0.97 ft during the four days trial. This resulted in a total of 1.4 gallons of DNAPL accumulation in the well sump over the course of the test, or roughly 0.35 GPD. This flow rate does not appear significant, but when compared against the 0.6 GPD average DNAPL recovery rate from all wells during of the course of Phase 1, this increase of DNAPL recovery rate at one well resulting from vibration-enhanced recovery is notable. The vibrators selected for this trial were pneumatic bin vibrators which are not designed for submerged use. Vibrators functioned well during the first day of four hours of operations; however, the following morning the vibrator did not activate automatically when air was supplied. The vibrator did activate following a gentle hammering and ran continuously for the remainder of the 4-hour

operational period. It was hypothesized that water likely entered the vibration mechanism resulting in ceasing the moving components. Full-scale deployment would need to resolve this issue through either specification of a vibrator intended for submerged use or enclosure of the vibrator within a waterproof housing.

Aspect of Work that Relates to Sustainability:

This solution can potentially reduce the timeframe required for cleanup, thereby reducing energy consumption. The increased NAPL volumes reduce the amount of water being pumped and treated, reducing withdrawals from the aquifer and consumption of the treatment media.

SESSION 3

Digitalization/Innovation

(Moderator: David Heidlauf)

2022 Americas Site Solutions Technology Transfer Conference

Title: Digitally Transforming Biodiversity Assessment*s: How Remote Sensing, AI, and Good Ole' Fashioned Expert Knowledge are Advancing Sustainability*

Authors' Names: Mike Rawitch, Brittni Engels, Emilia Stepinski, Margaret Lindman, Carolyn Craveiro de Sá, Randy Mandel, and Amy Malick

Presenter's Name: Carolyn Craveiro de Sá; Brittni Engels

Key Topic: Digitalization/Visualization

PDP Manager/Managing Principal's Name: Amy Malick and Christopher Bowles

Client Name: Dallas Fort Worth (DFW) Airport

Project Name: Biodiversity Baseline Assessment Dallas Fort Worth International Airport

Project Location: 2400 Aviation Drive, DFW Airport, Texas

Primary Ramboll Project Staff (Office): Mike Rawitch (Overland Park, Kansas), Emilia Stepinski (Arlington, Virginia), Margaret Lindman (Portland, Maine), Randy Mandel (Denver, Colorado), Carolyn Craveiro de Sá (Denver, Colorado), and Amy Malick (Emeryville, California)

ABSTRACT

Background/Objectives:

Large and/or remote areas of land are often challenging and expensive to monitor solely through traditional ground-based methods. Remote monitoring techniques (i.e., satellite and drone imagery) are becoming a prevalent part of environmental monitoring and characterization. Developments in artificial intelligence allows for the rapid analysis of large volumes of remote sensing data. When combined with analysis of publicly available and privately held background data and traditional ecological characterization methodology, locations can be assayed with higher speed and accuracy with lower cost investment for stakeholders. This presentation will focus on a brief introduction to how remote sensing and cloud-computing based artificial intelligence alongside traditional on-the-ground verification, are changing the way environmental monitoring takes place. Following the technical introduction into these technologies, we will present a case study of remote sensing techniques utilized at Dallas Fort Worth (DFW) Airport (17,000-acre site) in which the goal of the project was to understand and measure habitat types and biodiversity. The purpose of this project was to create a system that enables data-driven decision making to support DFWs sustainability goals and quantify key performance indicators.

Approach/Activities:

During the development of DFW's sustainability plan, Ramboll recognized a significant opportunity for the airport to demonstrate the enhancement of biodiversity and habitat uplift. The airport desires to improve biodiversity net gain and has engaged Ramboll to help them achieve their aim. DFW owns more than 17,000 acres of land and needs to improve biodiversity to satisfy their sustainability goals. Galago, the Transformational Sustainability Service Line (TSSL), the ecological restoration and biodiversity team are collaborating to establish a baseline assessment of biodiversity through the combination of science-based targets, remote analysis, and traditional on-the-ground verification. The baseline will help DFW set measurable targets and develop a plan to improve biodiversity. To accomplish this, Ramboll's ecological restoration and biodiversity team evaluated existing habitat tranche studies, tree surveys, landscape plans, and geospatial data from Texas Parks and Wildlife Department (TPWD) to modify the biodiversity quantification methodology developed by Natural England to ensure science-based targets are reflective of local ecology. In concert with these efforts, Ramboll's Galago team compiled and analysed a variety of remote sensing data including high-resolution multi-spectral satellite and aerial imagery as well as light detection and ranging (LiDAR) data. These remotely evaluated datasets were then verified through ground-based ecological surveys. The analysis produced from this project provides support to future sustainability initiatives and creates

the possibility of monitoring biodiversity changes over time with the overall goal of improving biodiversity of the area.

Results/Lessons Learned:

Project success came from the ability to quickly garner information about project wide trends in vegetation, habitat types, and biodiversity enabling fast and accurate decision making. When using remote sensing technologies, selecting the correct data collection tool was important and resulted in large amounts (hundreds of gigabytes) of data. Reviewing this data manually has historically been extremely time consuming or even impossible. By utilizing machine learning (ML) we were able to quickly review and analyse large amounts of data to identify priority locations which were then field verified related. Key Lessons learned also include:

— Biodiversity quantification through the application of international methodology to local applications.

— Interdisciplinary collaboration to streamline and improve traditional site characterization methodology by leveraging remote sensing data and analysis, significantly decreasing time and cost investments with Tech-Enabled Consulting from Galago.

— Identifying opportunities or project areas for preservation, connectivity, and/or habitat uplift.

Overall data deliverables provided an online mapping application to visualize results allowing the client to make strategic decisions to enhance land management, implement sustainability strategies, and minimize environmental impacts to sensitive habitats.

Aspect of Work that Relates to Sustainability:

Galago endeavors to radically digitalize and transform how we work with clients to deliver greater insights and measurable sustainable impact. Combining this work with Ramboll's ecological experts creates a unique opportunity to deliver on Ramboll's Partnership for Sustainable Change Strategy and provides the unifying theme of biodiversity and ecosystem enhancement. By using a combination of remote sensing technology, strategic data processing, and traditional on-the-ground ecological assessment Ramboll was able to direct large scale site evaluation and establish a biodiversity quantification baseline to inform future land management.

2022 Americas Site Solutions Technology Transfer Conference

Title: How ArcGIS Portal's Webmapping Capabilities Can Streamline Project Planning and Scoping

Authors' Names: Geoff Gadd and Kit Carson

Presenter's Name: Geoff Gadd and Kit Carson

Key Topic: Digitalization/Visualization

PDP Manager/Managing Principal's Name: Doug Burge

Client Name: Calumet Montana Refinery

Project Name: 2022 RCRA – RFI and RA Project Scoping

Project Location: Great Falls, Montana

Primary Ramboll Project Staff (Office): Ann Arbor, Michigan

ABSTRACT

Background/Objectives:

Calumet Montana Refinery (CMR) is a long-term environmental investigation/remediation project (RCRA Facility Investigation – RFI and Baseline Risk Assessment – BRA) that is scoping a large field investigation. ArcGIS Portal webmapping is being used by the project team to facilitate and support scoping decisions. The webmap has been used to analyze and visualise current and historic project data including utilities, historical borings/wells, proposed borings/wells, areas of concerns/solid waste management areas, well logs, cross-sections, etc. The webmap is used in meetings with the client and regulators with real-time editing of GIS data that expedites and enhances the scoping process. Data stored within the ArcGIS portal is used by technical personnel to develop static figures for various deliverables. Ramboll personnel onsite can respond to issues quickly by reviewing/evaluating what impacts/contaminants are present across the site as shown on the webmap. The webmap is an ever-evolving tool that is constantly being updated to better serve the project and client needs.

Approach/Activities:

Using the interactive webmap instead of static (PDF) maps gives the project management team a better and more useful tool for project planning and managing. The webmap is a living document that is constantly being edited and updated. It can be used directly in meetings instead of static maps, which allows for more organic, fluid, and interactive meetings.

Results/Lessons Learned:

The interactive nature of the webmap aided Ramboll's ability to come to a scoping agreement with the regulators prior to generating Work Plans. It limited document revisions and the "back and forth" editing of static PDF maps. Site solution decisions can be determined in a single working session. With limited to no GIS experience, project managers can use the interactive webmap for project planning and management.

Aspect of Work that Relates to Sustainability:

The use of a webmap streamlines project planning and managing, which leads to more efficient project outcomes regarding remediation and investigations. This tool allowed Ramboll to convey complex strategies/approaches via virtual meetings which helped to reduce the need for some parties to visit the site, reducing the need for travel.

2022 Americas Site Solutions Technology Transfer Conference

Title: Interim Measure Remedies Performance Monitoring Dashboard

Authors' Names: Ruta Deshpande, Abigail Small

Presenter's Name: Ruta Deshpande

Key Topic: Other Innovative Analysis

PDP Manager/Managing Principal's Name: Beth Richter

Client Name: Calumet Montana Refining, LLC (CMR)

Project Name: CMR this Area of Concern-16 (AOC-16) Interim Measure (IM)

Project Location: Great Falls, Montana

Primary Ramboll Project Staff (Office): Midwest Central

ABSTRACT

Background/Objectives:

In 2021, Ramboll installed IM remedies to address historic petroleum releases resulting in Light non-aqueous phase liquid (LNAPL) and dissolved phase groundwater impacts in the AOC-16 area of the CMR's Great Falls, MT facility. IM remedies consist of dual-phase extraction (DPE), LNAPL recovery trench and a passive treatment trench (PTT). To ensure that these IM remedies are achieving their objective, Ramboll developed a robust performance monitoring plan.

Approach/Activities:

A PowerBI dashboard was developed to track performance monitoring data for these IM remedies. Data from various sources such as field measurements, treatment system instrumentation, and laboratory analytical data are input to PowerBI, and the dashboard provides analysis and visualization. Performance monitoring parameters along with other general operational parameters such as system run time, discharge volume, and groundwater/LNAPL depths are shown on the dashboard. This dashboard serves as a data presentation and reporting platform for the stakeholders (CMR and Ramboll).

Results/Lessons Learned:

This dashboard is instrumental in providing a complete picture to our client by integrating and visualizing OMM data from different sources on a single platform. This approach has assisted with evaluating IM remedies performance as well as with troubleshooting efforts. Dashboard has also streamlined our routine reporting needs i.e., graphics are relatively automated and easily extracted, which allows for efficiencies and to be made on time and cost.

Aspect of Work that Relates to Sustainability:

1. The use of the dashboard allows us to monitor remotely and utilize the local maintenance personnel for hands on work when needed. This is a sustainable approach considering the site location and the travel involved.
2. By automating the OMM data management, analysis, and visualization, we are saving significant amount of time and energy.

SESSION 4

Sediment/Sustainability

(Moderator: Kim Groff)

2022 Americas Site Solutions Technology Transfer Conference

Title: Design of a Treatability Study to Assess Sediment Remedial Technologies

Authors' Names: Joseph Ridgway, Jeff Kampman, Tim Olean

Presenter's Name: Joseph Ridgway

Key Topic: Sediment Management/Shoreline Stabilization

PDP Manager/Managing Principal's Name: Tim Olean

Client Name: Confidential Client

Project Name: Sediment Remediation Treatability Study

Project Location: New York City

Primary Ramboll Project Staff (Office): Chicago, Illinois; Milwaukee, Wisconsin; Syracuse, New York; and others

ABSTRACT

Background/Objectives:

The subject Superfund site is advancing through the Remedial Investigation process into the Feasibility Study (FS) stage. To better assess remedial technologies as part of the FS, the client and other stakeholders wanted to develop a field treatability study (TS) with a focus on capping and *in situ* solidification/stabilization (ISS) of soft sediments. Ramboll developed a detailed design package, which includes: a structural bulkhead evaluation; an ISS treatability assessment; a chemical cap model; surface water velocity and cap material sizing evaluations; geotechnical assessments of cap placement and stability; construction drawings; technical specifications; and a construction quality assurance/quality control plan.

Approach/Activities:

Once the scope of the TS was established in coordination with the client and regulators, Ramboll developed a comprehensive pre-design investigation (PDI) work plan. The PDI was performed from late 2019 through early 2020, which included: sonic, vibracore, piston core, and hollow-stem auger drilling methods; passive and active porewater sampling using solid-phase microextraction (SPME), dialysis membrane cells, and temporary wells; hydrographic and terrestrial surveying; and seepage/hydraulic measurements using Distributed Temperature Sensing (DTS) as well as pressure transducers. The techniques for measuring seepage were of particular interest, utilizing a combination DTS, hydraulic gradient rods, and assessment of hydraulic conductivity using traditional methods and a recently developed method of monitoring gravity drainage from vibracore samples. With the robust PDI dataset, the design efforts commenced in 2020, with collaborative support from over 15 engineers and scientists from six Ramboll offices. The design package is a work plan that lays out the basis of design and how the TS will be implemented. The work plan was developed so that it could be included as part of the bid package for selecting a contractor and includes the detailed technical evaluations as appendices to support development of the design and approach, in addition to technical specifications, construction drawings, and monitoring plans. The work plan was completed within the approved budget and delivered to regulators on time, meeting an aggressive schedule.

Results/Lessons Learned:

This project provided an opportunity to utilize innovative investigation techniques and source a wide range of technical expertise from multiple Ramboll offices. This project is an example of how Ramboll's broad technical knowledge can be applied to develop a comprehensive design package to test remedial technologies at a complicated sediment site.

Aspect of Work that Relates to Sustainability:

The focus of the TS is to evaluate the implementability of capping and ISS at the project site. Both of these technologies provide opportunities to more sustainably address impacted sediments by generating less greenhouse gas emissions than traditional dredging approaches that would be considered for a site of this nature.

2022 Americas Site Solutions Technology Transfer Conference

Title: Estimating Time to Recovery of PCBs to Evaluate Monitored Natural Recovery Performance

Authors' Names: Lauren Brown, Kristin Searcy Bell, Victor Magar, Phyllis Fuchsman

Presenter's Name: Lauren Brown

Key Topic: Sediment Management/Shoreline Stabilization

PDP Manager/Managing Principal's Name: Annette Bachand/Henry Clauson

Client Name: DGIC

Project Name: Cottonwood Bay Monitored Natural Recovery Evaluation

Project Location: Dallas, Texas

Primary Ramboll Project Staff (Office): Kristin Searcy Bell and Victor Magar (Chicago, Illinois), Phyllis Fuchsman (Cleveland, Ohio), Lauren Brown (Portland, Maine)

ABSTRACT

Background/Objectives:

Monitored natural recovery (MNR) is a sediment response action that involves leaving contaminated sediments in place and relying on ongoing natural processes to reduce environmental risks. MNR relies on physical, chemical, and biological processes to isolate, destroy, or reduce exposure to or toxicity of contaminants in sediment. At the Cottonwood Bay Site (Dallas, Texas), the Texas Commission on Environmental Quality (TCEQ) approved a 2009 Remedial Action Plan (RAP) for the Site; the RAP identified dredging as the approved remedy to address contaminated sediment. However, 2014 surface sediment sampling results and an initial evaluation of MNR processes suggested that current surface sediment conditions at the Site were approaching site-specific performance targets. Consequently, with TCEQ approval and under TCEQ supervision, the project team revisited the Site to determine whether MNR is a viable remedy alternative. The objective of this project was to evaluate MNR performance, and to determine whether MNR can achieve site-specific remedial goals within a reasonable time frame. Multiple lines of evidence were evaluated to demonstrate MNR could achieve site-specific remedial goals for Cottonwood Bay in a reasonable time frame. Here we present the results of a provisional analysis modelling the time to recovery of sediment polychlorinated biphenyl (PCB) concentrations to reach human health-protective target concentrations in fish. When fish tissue PCB concentrations decline to target concentrations, then it is expected that fish consumption advisories can be eliminated.

Approach/Activities:

We estimated the time to recovery for PCBs in fish tissue in Cottonwood Bay and its adjacent waterbody (Mountain Creek Lake) by comparing modelled future sediment concentrations to target sediment concentrations. Future sediment PCB concentrations are estimated using the SEDCAM sediment attenuation model. Inputs to the model include site sediment PCB concentrations, incoming sediment PCB concentration, sediment deposition rate, and sediment mixing depth. Target sediment PCB concentrations are estimated through a series of calculations using site-specific sediment and fish tissue data and applying a fish tissue health assessment comparison (HAC) value to raw fish. We conducted the time to recovery evaluation using probabilistic modelling in R, a language and environment for statistical computing. For the probabilistic modelling, parameters with more than one value were input into the model as distributions, and the model was run using these distributions over 5000 iterations to provide a range of anticipated time to recovery results.

Results/Lessons Learned:

The time to recovery modelling indicates that PCB levels in white crappie and largemouth bass from the site are already acceptable for human consumption. Since largemouth bass are relatively territorial and expected to have a home range smaller than the combined Cottonwood Bay and Mountain Creek Lake waterbody, we also modelled time to recovery for the largemouth bass in Cottonwood Bay, which

has higher PCB concentrations. In this scenario, largemouth bass is predicted to achieve acceptable levels, with median estimated time to recovery of nine years. Channel catfish is also predicted to achieve acceptable levels in approximately eight years. The PCB concentrations in common carp, freshwater drum, and smallmouth buffalo (bottom-feeding species with high lipid content) are expected to decrease over time, but depending on incoming PCB concentrations, the long-term fish tissue PCB concentrations may continue to be greater than the HAC. Important uncertainties in the time to recovery model are related to limited data on PCB concentrations in incoming sediment and in some areas of the waterbody, as well as the simplifying assumption that PCB bioaccumulation from sediment to fish is constant over time. The monitoring plan includes collection of incoming suspended sediment samples from seven sources entering Cottonwood Bay for PCB analysis; the new data will be used to update the time to recovery estimates.

Aspect of Work that Relates to Sustainability:

Monitored natural recovery is applied at the site as a remedy that minimizes the disturbance on the existing habitat and the need for construction transportation and materials.

2022 Americas Site Solutions Technology Transfer Conference

Title: Nature Based Solutions Transform a Riparian Corridor with Benefits to the Community, Environment in Butte, Montana

Authors' Names: Lis Nelis and Mandi Miller

Presenter's Name: Mandi Miller

Key Topic: Sustainable Solutions

PDP Manager/Managing Principal's Name: Eric Hodek

Client Name: Atlantic Richfield

Project Name: RMSC: Monitoring for Ecosystem Services

Project Location: Butte, Montana

Primary Ramboll Project Staff (Office): Lis Nelis (Seattle, Washington), Mandi Miller (Denver, Colorado)

ABSTRACT

Background/Objectives:

Historic mining practices resulted in contamination of soils across Butte hill and impacts to surface water and groundwater at and below the Silver Bow Creek riparian corridor in Butte, Montana. As part of the superfund remedy, the Butte Priority Soils Operable Unit Silver Bow Creek Conservation Area (SBCCA) will utilize the implementation of Nature-Based Solutions (NBS) to benefit the community and the environment. The NBS will complement historic mine waste removal and the capture and treatment of contaminated groundwater to ensure that surface water resources will be further protected, biodiversity will increase, and the community will gain a public natural area. The resulting Silver Bow Creek Conservation Area will be a 160-acre urban greenway in the heart of Butte which will provide many ecosystem services (ES). To achieve this goal, Ramboll is providing on-call consulting for NBS, remediation and restoration activities, and long-term monitoring for ES. This presentation focuses on the monitoring study, including how it is being used to quantify ES, inform adaptive managing, and increase the probability of overall success of the remediation project.

Approach/Activities:

Atlantic Richfield plans to use remediation, restoration, and NBS to help Atlantic Richfield increase ecosystem services (ES) across the SBCCA. ES are defined as the benefits that humans receive from functioning ecosystems. Ramboll uses ES long-term monitoring, both before and after restoration/remediation activities. We also worked with local landscapers to develop an appropriate planting schedule that creates and supports a diverse habitat. This habitat will allow wildlife to thrive, and it will beautify the community. Ramboll developed a monitoring plan and began baseline sampling in June 2022. This monitoring plan focuses on the following ES: climate regulation, carbon sequestration, habitat development, pollination of flowering plants, soundscape improvement, viewshed improvement, pest and invasive species control, flood regulation, nature viewing, physical activity, and support and increase of biodiversity. Field surveys and assessments will allow us to understand how these ES are changing over time and whether we need to advise Atlantic Richfield to make changes to the remediation plan through adaptive management to successfully increase ES.

Results/Lessons Learned:

Ramboll conducted our baseline data collection for ES in June 2022, before remediation activities take place in fall of 2023. Our baseline surveys have provided lists of native species that are thriving without irrigation, suggestions on how to save natural capital for reuse, and overviews of areas of special concern during remediation. After reviewing these initial assessments, we will also be updating survey protocols from what we have learned in the field to better ensure ES goals are met.

Aspect of Work that Relates to Sustainability:

Instead of using only engineered solutions to accomplish the project goals, this project uses innovative and sustainable solutions in conjunction with engineered solutions, such as integrating NBS, while increasing ecosystem services. The monitoring study also involves innovative assessment methods which allow us to understand the success of the project's sustainable NBS by measuring how ES, such as biodiversity, are changing over time. If we are not seeing the predicted change, adaptive management will increase the chance of a successful outcome.

SESSION 5

Innovative Assessment/Testing B

(Moderator: Devon Rowe)

2022 Americas Site Solutions Technology Transfer Conference

Title: Development and Implementation of an Innovative Field UV Screening Method for Identifying NAPL and Distinguishing Sources in Sediments

Authors' Names: Marcus Byker, Eric Hritsuk, Jeff Kampman

Presenter's Name: Jeff Kampman

Key Topic: Innovative Assessment Methods

PDP Manager/Managing Principal's Name: Joseph Ridgway

Client Name: WEC Business Services, LLC

Project Name: Chicago Sanitary and Ship Canal (CSSC)

Project Location: Chicago, Illinois

Primary Ramboll Project Staff (Office): Chicago, Illinois

ABSTRACT

Background/Objectives:

The Chicago Sanitary and Ship Canal (Canal) has received pollutant loading for over a century from diverse industry and combined sewer discharges that continue to the present. Identifying the input of nonaqueous phase liquid (NAPL) in sediment potentially attributable to a former manufactured gas plant (MGP) is complicated by the potential for multiple legacy non-MGP NAPL sources. Ramboll developed an investigation approach to broadly characterize the extent of NAPL in sediment likely attributable to MGP operations.

Petroleum hydrocarbons and coal tar NAPLs are partially composed of individual polycyclic aromatic hydrocarbons (PAHs) of varying concentrations. PAH-rich NAPLs will generally fluoresce under excitation by ultra-violet (UV) light and characteristics of the fluorescence indicate characteristics of the NAPL. The intensity and "color" of the fluorescent response provides a qualitative indication of the relative magnitude of NAPL present and its composition. This phase of investigation at the Canal was identified as a candidate for field testing of Ramboll-developed UV screening tool.

The primary objective of this field test was to qualitatively identify NAPL presence in the field by screening of UV fluorescence response while simultaneously visually inspecting the matrix for the NAPL presence using traditional methods. A supplemental objective was access if the color of fluorescent response correlated with findings from forensic assessments.

Approach/Activities:

The custom field fluorescence screening tool develop by Ramboll consisted of an opaque box that was placed on top of a split sediment core. White light and UV light (365 nm) fixtures were mounted within the box with exterior controls. An electronic tablet was configured to provide a viewport to the box interior and collect photos under each lighting condition. The photos collected by the field UV fluorescence screening tool were used to guide selection of core intervals for NAPL mobility sampling and relate fluorescent response to results of forensic analysis.

Results/Lessons Learned:

The custom field UV fluorescence screening tool was a cost-effective approach to improve white light photo collection and obtain field data regarding fluorescent response of NAPL-impacted sediment. Field use of fluorescent screening provided an effective means of aiding identification of NAPL within dark-colored sediment. The tool, once calibrated and supplemented by other lines of evidence, was useful to select a diverse set of samples for laboratory testing of forensic and NAPL mobility. Furthermore, the color of the fluorescence response combined with other visual observations correlated with laboratory forensics testing, which allowed for improvement of the forensic characterization of sediments.

Aspect of Work that Relates to Sustainability:

Utilizing this innovative method of sediment NAPL characterization can allow for more efficient field data collection and inform project decision making without relying on multiple field mobilizations. This provides the opportunity to achieve project goals more sustainably by generating less greenhouse gas emissions than multiple field mobilizations and submittal of additional samples to similar UV-testing laboratories using traditional shipping methods.

2022 Americas Site Solutions Technology Transfer Conference

Title: Supplemental Site Characterization Investigation of a Gasoline Release in a Karstic Carbonate Environment

Author's Names: Kit Carson

Presenter's Name: Kit Carson

Key Topic: Innovative Assessment Methods

PDP Manager: David Heinze

Client Name: Metropolitan Nashville Airport Authority

Project Name: MNAA: Supplemental Site Characterization Investigation

Project Location: Nashville, Tennessee

Ramboll Principal-in Charge/Project Manager: David Heidlauf (Chicago, Illinois), Dan Price (St. Louis Missouri)

ABSTRACT

Background/Objectives:

An underground gasoline pipeline was struck and damaged by others during an April 2019 geotechnical drilling operation at the Berry Field Nashville Airport (BNA), releasing an estimated fourteen thousand gallons of gasoline. Within two days of the gasoline release, a petroleum sheen was observed in the western stream bank of McCrory Creek, the primary receptor for the release was approximately 925 feet away. Gasoline migrated to McCrory Creek via a combination of overland and subsurface flow through a karstic carbonate aquifer. Immediately following the release, spill response measures was completed by others, including the recovery of light non-aqueous phase liquid (LNAPL) through five interceptor trenches and nine recovery wells. By March 2020, less than 2,000 gallons of LNAPL and 120,000 gallons of petroleum-impacted water were recovered. The initial site characterization was limited in scope to the area near McCrory Creek and, consequently, the nature and extent of petroleum-impacts to the entire Area of Interest (AOI), which covered an area of approximately 9 acres near the gasoline release, was not well defined. In conjunction with a follow-on litigation action with allegations of a $5 million plus outstanding environmental remediation liabilities, which was delaying a multi-billion dollar airport expansion project, Metropolitan Nashville Airport Authority (MNAA) engaged Ramboll in 2021 to undertake an expedited two-phase, three-month long Supplemental Site Characterization Investigation to better understand the lateral and vertical extent of contamination and to estimate remaining environmental remediation liabilities.

Approach/Activities:

Ramboll employed a two-phase approach to characterize the entire AOI, with an emphasis on the source area near the gasoline release and potential subsurface migration pathways to McCrory Creek and other potential pathways outside the AOI. Phase 1 of the Supplemental Site Characterization Investigation employed surface geophysical methods to identify potential indications of fracturing, faulting, weathering, karst activity and/or other geophysical indications of conditions within the upper bedrock that could lead to preferential pathways for fluid to flow. Geophysical methods employed included electromagnetic terrain conductivity surveys, electrical resistivity imaging tomography, and multichannel analysis of surface waves. The results from the geophysical data identified unique features that guided Phase 2 field activities, which included the installation of 16 soil borings, 14 temporary wells, and one monitoring well. Boring locations were primarily drilled using direct push technology through the overburden and rock coring through the limestone bedrock via a track mounted Geoprobe 3230DT drill rig. Rock coring provided a greater level of lithologic detail compared to other drilling techniques (i.e., sonic), which accurately identified petroleum-impacted fracture zones, dissolution features (cavities, voids, horizontal/vertical fractures) and water-bearing fracture zones. These detailed lithological observations were essential in the development of the Conceptual Site Model (CSM) along with integrating data from literature reviews, existing reports, and from the Supplemental Site Characterization Investigation findings.

Results/Lessons Learned:

Understanding the geologic and hydrogeologic conditions of the karstic carbonate environment underlying the AOI was essential in the development of the CSM. Initial geophysical surveys provided valuable insights into the lateral and vertical variability in the clay overburden and within the upper portions of the limestone bedrock. Rock coring provided sufficient lithological detail to identify an inferred geologic contact between two limestone formations based on changes in color, texture, abundance of brachiopod fossils, and frequency of natural breaks (i.e., bedding planes and/or fractures). A simplified stratigraphic sequence is presented below (top to bottom): (1) clay overburden, (2) lower member of the Carters Formation is a medium- to thick-bedded with abundant dissolution-enlarged openings, and (3) Lebanon Formation is a thin-bedded with thin shale partings and low dissolution-enlarged openings. The gasoline release migrated through the Carters Fm along bedding planes, horizontal/vertical fractures, and dissolution openings. A few notable preferential pathways were identified that likely contributed to the rapid containment transport of petroleum hydrocarbons to McCrory Creek. For example, at one location, an oil/water interface probe was used to measure the water level shortly after a 0.3-foot void was encountered in the Carters Fm. The lead driller and field geologist could 'feel' the metal probe being pulled, indicating the presence of moving water. Based on the findings from this investigation, LNAPL was not present in the groundwater within the AOI, and only very low residual petroleum constituents were detected in groundwater and surface water. Supplemental Site Characterization Investigation activities demonstrated natural source-zone depletion (NSZD) obviated the need for any further active remediation to be performed prior to BNA expansion projects. Only periodic monitoring of the surface water at McCrory Creek was required until the remaining residual petroleum impacts were mitigated through natural in situ degradation processes.

The Aspect of Work that Relates to Sustainability:

Supplement Site Characterization Investigation and Report successfully demonstration to the satisfaction to the Tennessee Department of Environmental Quality (TDEC) that no active remedial measures or further groundwater monitoring was needed, was key to the successful settlement of the outstanding litigation and eliminated the 2019 gasoline spill as an impediment to a multi-billion dollar airport expansion project.

2022 Americas Site Solutions Technology Transfer Conference

Title: Testing Carbon-Based Amendments in Treating PCB and Metal Contaminated Soils

Authors' Names: Sarah Sauda, Mark Harkness, Clare Leary

Presenter's Name: Sarah Sauda

Key Topic: Use of carbon-Based Sorbents to Sequester Organic Constituents

PDP Manager/Managing Principal's Name: Jennifer Reymond (PDP Manager)

Client Name: RACER Trust (Confidential Client)

Project Name: General Motors – Inland Fisher Guide Operable Unit 2

Project Location: Syracuse, New York

Primary Ramboll Project Staff (Office): Syracuse, New York

ABSTRACT

Background/Objectives:

As part of the Record of Decision (ROD) amendment process, the addition of a carbon-based sorbent, such as biochar or activated carbon (AC), has been proposed as an alternative to soil excavation to reduce the bioavailability of PCBs and co-located metals in both wetland and non-wetland forested/inaccessible areas of the project site. If selected as the final remedy, the proposed in situ treatment would preserve over 11 acres of mature trees and is anticipated to save the client tens of millions of dollars based on the feasibility study cost model. Carbon-based amendments like AC have been used as a sorbent for organic compounds for more than a decade now, though less research has been done with biochar. Much of the early work with AC was conducted in sediment/sediment caps, with less work applying to soil systems. A preliminary lab study was performed in 2021 to evaluate the use of biochar in reducing the bioavailability of PCBs and metals in site soils. The objective was to provide a proof of concept using biochar as an amendment, given biochar has similar properties to AC as a sorbent for organic compounds, but has a lower carbon footprint and additional benefits of promoting soil aeration and plant growth. The study found that biochar applied at 15% by mass loading resulted in a higher percent reduction in both pore water and leaching PCB concentrations (80-90%) as compared to the 5% loading application (13-32%). It is expected that a 15% loading would present implementability issues in a full-scale application; therefore, a second study was conducted in 2022 to compare the performance of biochar to that of AC, given literature values of 3-5% AC have been reported to achieve 80-90% reduction in pore water PCB concentrations.

Approach/Activities:

In both studies, the effectiveness of carbon-based amendments were evaluated in test jars by measuring the pore water concentration of PCBs using polyethylene SP3™ passive samplers and by observing the leachability of PCBs and metals using Synthetic Precipitation Leaching Procedure (SPLP) testing. For the preliminary study, duplicate sample jars were prepared with two different biochars applied to soil collected from one sample location at 5% and 15% application rates in addition to unamended controls. In the second study, triplicate samples were prepared with one AC and one biochar applied to two different soil sample locations at 3%, 5%, and 7% application rates plus the unamended controls. The SP3™ samplers were deployed into sample jars for a 28-day tumbling period. A modified SPLP extraction was performed following the 28-day period. Samples of the starting soil were also analyzed to understand initial PCB and metal concentrations and total organic carbon (TOC) content.

Results/Lessons Learned:

Both studies demonstrated the effectiveness of carbon-based amendments in reducing the bioavailability of PCBs and metals in Site soils. TOC concentrations in both studies ranged from 2.9 to 6.4 percent likely indicating the area where samples were obtained contained sediment dredged spoils. While the results of the second study are still being reviewed, a preliminary evaluation of the data showed that AC outperformed the biochar, with over 99% reduction of pore water PCB

concentrations consistently observed for the AC applied to both soil sample locations and at all three application rates (3%, 5%, 7%). The biochar provided 10-39% reduction of pore water PCB concentration for both sample locations and all three application rates. The percent reductions for the leaching concentrations were more comparable between AC and biochar at the 3% application rate, though AC outperformed biochar at both the 5% and 7% application rates. Overall, AC resulted in a higher percent reduction and the data produced aligns with the literature values. The results of both studies will ultimately be used to design a field pilot study to further verify this technology if the remedy selection process favors the proposed treatment alternative.

Aspect of Work that Relates to Sustainability:

Given the limited work in applying carbon amendments in the soil system and the challenges that will come with distributing the amendment in a forested setting, this project is seeking an innovative remediation technology that will not only preserve a viable forested area that provides many functions and values (e.g., floodflow alteration, sediment and nutrient retention, shoreline stabilization, wildlife habitat), but also provide a cost-effective remedy in lieu of excavating and disposing of over 140,000 cubic yards of soil/dredged material to a landfill, which is anticipated to result in significant disruption to both the human and ecological communities. While there are many questions that still need to be answered and future pilot studies to be conducted, the project team hopes that this technology will lead to a better solution for this Site, contribute to the growing body of science and technology in this area, and be useful to practitioners facing similar issues at other sites.

SESSION 6

Modeling/Sustainability

(Moderator: Eric Tlachac)

2022 Americas Site Solutions Technology Transfer Conference

Title: Remedial Alternative Sustainability Evaluation During a Feasibility Study

Authors' Names: Eric Hritsuk, Marcus Byker, and Staci Goetz

Presenter's Name: Eric Hritsuk

Key Topic: Sustainable Solutions

PDP Manager/Managing Principal's Name: Joseph Ridgway/Jennifer Hagen

Client Name: Glenn Luke of WEC Energy Group

Project Name: Former Manitowoc MGP

Project Location: Manitowoc, Wisconsin

Primary Ramboll Project Staff (Office): Chicago, Illinois and Milwaukee, Wisconsin

ABSTRACT

Background/Objectives:

A Remedial Alternatives Sustainability Evaluation was performed as a part of a Feasibility Study (FS) addressing sediment impacts associated with a former manufactured gas plant (MGP) in Wisconsin. The objective of the evaluation was to quantify sustainable remediation metrics in the FS remedy evaluation process, focusing on the short-term and long-term effectiveness National Contingency Plan (NCP) criteria. The evaluation used a net benefit of sediment remedial alternatives approach to evaluate and compare capping, dredging, and in situ solidification/stabilization (ISS). The evaluation also made it possible to compare different remedial goals. In a subsequent iteration of the FS, the sustainability evaluation was expanded to include an evaluation of differences in community impacts and environmental impacts associated with two preliminary remedial goals (PRGs) for total petroleum hydrocarbon (TPAH 13).

Approach/Activities:

SiteWise™ software was used to calculate key metrics, such as truckloads to and from the site during remediation, greenhouse gas (GHG) emissions, energy consumption, and emissions of sulfur oxide, nitrogen oxide, and particulates. SiteWise™ is an open-source, excel-based software program developed by the Naval Facilities Engineering Command (NAVCAC), United States Army Corps of Engineers (USACE), the US Army, and Battelle. Remedial areas and volumes for each alternative were input into SiteWise™ to calculate the metrics identified above. In addition, C-Tech Earth Volumetric Studio™ (EVS) was used to quantify contaminant mass removed or treated with each alternative. The SiteWise™ sustainability metrics (GHG and other emissions and energy consumption) were presented along with remediation costs and the mass of contaminants removed for each alternative, for sustainability comparisons.

Results/Lessons Learned:

This evaluation provided quantitative data to support discussion of the short-term and long-term effectiveness balancing criteria in a project FS that compare dredging, capping, and ISS remedies for a former MGP site. The sustainability evaluation was used to support the comparison of remedial alternatives, along with more conventional comparisons based on mass of contaminant removed, cost, and remedy effectiveness. For the dredging scenario, contaminated mass removed increased <5% when adjusting from the higher PRG to the lower PRG, while truckloads, GHG emissions, energy consumption, and emissions increased between 64% and 85%. In this evaluation, both ISS and a hybrid dredge/cap alternative showed fewer short-term effects relative to full-scale dredging. This presentation will discuss the efficacy of a remedial alternative sustainability evaluation to support environmental decision-making within the NCP's FS process. This type of evaluation also can provide value earlier in the remedy evaluation process, such as during the development of PRGs, to assess the net benefit of lower PRGs. Further, the evaluation can be refined during design to ensure that the sustainability remediation metrics that influence remedial alternative selection are maintained throughout remedial design process, and into construction; sustainability metrics can be tracked

during construction to provide real-time information on remedy performance, helping to improve the accuracy of future Remedy Alternative Sustainability Evaluations.

Aspect of Work that Relates to Sustainability:

Evaluate sustainability as a part of remedial alternative evaluation.

2022 Americas Site Solutions Technology Transfer Conference

Title: Striving Towards Sustainable Ecological Habitat through Groundwater Modeling and Remote Sensing

Author's Names: Katie Zheng

Presenter's Name: Katie Zheng

Key Topic: Modeling

PDP Manager/Managing Principal's Name: Ralph Morris

Client Name: Rio Tinto Alcan and Rusal

Project Name: QAL RDA Priorities – Groundwater Modeling

Project Location: Gladstone, Queensland, Australia

Primary Ramboll Project Staff (Office): Alka Singhal and Katie Zheng (Emeryville, California); Emilia Stepinski (Arlington, Virginia)

ABSTRACT

Background/Objectives:

Queensland Alumina Limited operates one of the world's largest alumina refineries since the 1960s in Gladstone, Queensland, Australia. The bauxite residue commonly referred to as "red mud", is a by-product of alumina production, red mud is neutralized using seawater prior to disposal in engineered red mud dams (RMDs) located adjacent to ecologically preserved habitat in the Great Barrier Reef Marine Park on Boyne Island. The decanting water from the RMDs is impacting the habitats with increasing salinity and has been a concern since around 2007. As the RMD levels continue to increase, groundwater levels and flux through and out of the RMD facility also will evolve. Ramboll's goal is to understand environmental impacts and protect sensitive habitats through groundwater modeling and remote monitoring techniques. The groundwater model was developed to test various mitigation approaches (a combination of engineering subsoil drains and cut-off walls) to reduce the potential flux impact on preserved areas and to initiate an assessment of these potential future conditions. The purpose of the study is to assist the client to rapidly and more frequently assess the changing vegetation conditions and to provide mitigation solutions.

Approach/Activities:

The groundwater model refinement process started with a base model developed by the firm GHD. However, the model run time was over four hours, and hence, found not suitable to test over fifty potential remedial designs. Thus, a simplified model with less than five minutes of run time was developed for the site. In this endeavor, a detailed 3D geologic model was developed using GeoScene3D software to support the conceptual site model. The transient groundwater model was calibrated for the site conditions that existed between 2009 to 2021. After the model calibration, various potential future scenarios were tested and compared to the field data to evaluate the impact on surrounding habitats. For each case scenario, the model predicted changes in groundwater elevations from 2022 to 2182. The mitigation options were evaluated, and recommendations were provided for the best-case scenario. The data processing for approximately 200 years of model output for over fifty model scenarios was not possible without automation. Thus, several python scripts were developed to automate the workflow and for the visualization of modeling results. Ramboll's Galago team analyzed current and historical high-resolution aerial and satellite imagery to determine sitewide trends related to vegetation health and dieback via a deep learning model. The model can be applied as new imagery becomes available, providing additional monitoring between ground surveys.

Results/Lessons Learned:

The combination of groundwater modeling and remote sensing analysis provides a more sustainable and cost-effective approach to support site investigation and monitoring activities at the site. The combined approach is applied in an accurate, defensible, and repeatable manner across large areas, enabling the client to implement remedial plans more efficiently and effectively. The developed

groundwater model is a robust and efficient tool to test numerous potential scenarios with different combinations of mitigation measures. The python scripts are scalable and provide value in presenting results to the client and other stakeholders. The deep learning model provides a path towards more frequent remote vegetation monitoring. Overall, the remote sensing analysis gives an additional line of evidence of the complex vegetation trends, including the impact of a recent drought on vegetation health and dieback. By collaborating with various multidisciplinary teams within Ramboll across the globe, we can bring new technology and innovation to projects and experience the rewards of true teamwork.

Aspect of Work that Relates to Sustainability:

The project provides a sustainable solution to preserve the ecological preserve located adjacent to the Great Barrier Reef Marine Park. The groundwater model and remote sensing assessment serve as a primary decision-making tool for the client and stakeholders to test various mitigation approaches to reduce the potential flux impact on preserved areas and local communities.

2022 Americas Site Solutions Technology Transfer Conference

Title: Evaluating Reductions in Modeled Flux as a Metric for Demonstrating Regulatory Compliance for Coal Combustion Residual (CCR) Surface Impoundments following Closure

Authors' Names: Jake Walczak, Brian Hennings

Presenter's Name: Jake Walczak

Key Topic: Modeling

PDP Manager/Managing Principal's Name: Brian Hennings/Jennifer Hagen

Client Name: Confidential

Project Name: Confidential

Project Location: Confidential

Primary Ramboll Project Staff (Office): Jake Walczak (Milwaukee, Wisconsin), Brian Hennings (Milwaukee, Wisconsin), Saskia Louise Noorduijn (Aarhus, DK), Pejman Rasouli (Farmers Branch, Texas), Katie Moran (Richmond, Virginia)

ABSTRACT

Background/Objectives:

Closure and groundwater corrective action at coal combustion residual (CCR) surface impoundments requires assessment of potential remedial alternatives that address both the source of impacts (CCR in the surface impoundment) and impacted groundwater. Groundwater flow and transport modeling is a useful tool for comparing the effectiveness of remedial alternatives, estimating time to reach applicable groundwater standards, and evaluating post-closure performance. Modeling may also be a requirement. For example, Illinois Part 845 regulations, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (promulgated in 2021), require results of groundwater contaminant transport modeling and calculations showing how compliance with the applicable groundwater standards will be met for corrective action and closure permit applications. Part 845 regulations also require closure plans which include Closure in Place (CIP) must demonstrate that CIP will control, minimize, or eliminate as much as feasible "post-closure infiltration of liquids" and releases of CCR, leachate, or contaminated runoff. Groundwater models were used to demonstrate compliance with Part 845 requirements by quantifying modeled reduction in hydraulic flux into and out of CCR remaining in place.

Approach/Activities:

Groundwater models were used to demonstrate reductions in infiltration into CCR and reduction of hydraulic flux out of the CCR compared to pre-closure conditions. Evaluations of post-closure water flux through the consolidated and covered CCR were completed using data obtained from the CIP prediction models when simulated post-closure heads in the groundwater monitoring wells were predicted to stabilize (approximate hydraulic steady state). The post-closure movement of water in and out of the CCR at approximate hydraulic steady state were compared to pre-closure conditions to determine the reduction in hydraulic flux following closure construction activities.

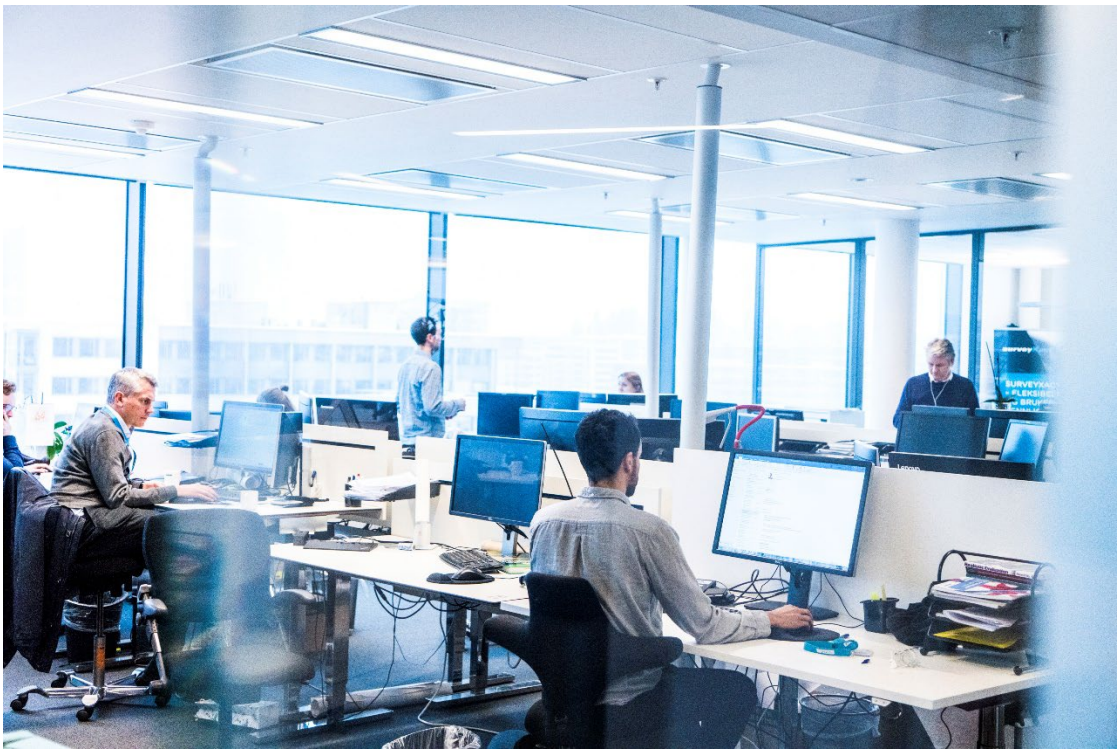
Results/Lessons Learned:

The pre-closure (calibration model) and post-closure CIP prediction model simulated hydraulic flux values were provided in appendices, tabulated, and illustrated in figures presented in the Groundwater Modeling Reports submitted to the agency in support of CIP designs and compliance with Part 845. Data export files (data extracted from the models using the computer code) used for flux evaluations were included along with electronic model files in Groundwater Modeling Report appendices submitted to the agency. In each case CIP was predicted to reduce both total flux in and out of the CCR when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize (approximate hydraulic steady state), thus demonstrating CIP will control, minimize, or eliminate as much as feasible "post-closure infiltration of liquids" and releases of CCR, leachate, or contaminated runoff in compliance with Part 845. Future work includes incorporating mass flux along with hydraulic

flux estimates. Feedback received thus far from industry contacts indicates we are way out in front of other owner/operators with CCR management units.

Aspect of Work that Relates to Sustainability:

Groundwater models can be used to demonstrate CIP is an effective closure and corrective action alternative, which also has the following sustainable benefits over other alternatives like landfilling: for example; less traffic congestion is expected, as compared to the off-site landfill option; accidents, noise, traffic, air pollution to nearby residents and communities would be less because of reduced off-site vehicle travel; short-term impacts of noise, visual disturbances, construction on scenic and recreational values will be smaller, due to shorter duration of construction; less impacts on greenhouse gas emissions and energy consumption. Risk assessments completed for each site also demonstrated that no risks to either human or ecological receptors will be present post-closure. CIP activities pose only short-term impacts on recreational use of neighboring surface water bodies and the terrestrial species located near the impoundments during construction activities (which are shorter than other alternatives).



SESSION 7

Remediation B (CVOCs)

(Moderator: Mark Mejac)

2022 Americas Site Solutions Technology Transfer Conference

Title: Bioremediation of Perchlorate using Hydrogen

Authors' Names: Ruhui Zhao, Uma Patel, Chris Ritchie

Presenter's Name: Ruhui Zhao

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Uma Patel

Client Name: Confidential

Project Name: Remedial Investigation and Feasibility Study

Project Location: Henderson, Nevada

Primary Ramboll Project Staff (Office): Emeryville, California

ABSTRACT

Background/Objectives:

Hydrogen is considered a universal electron donor because of the wide variety of bacteria that utilize it to support reductive bioremediation. Hydrogen may be a more sustainable alternative for bioremediation of perchlorate and other contaminants. While organic substrates are effective in stimulating biological perchlorate reduction, they require frequent reapplication and result in growth of non-target, heterotrophic bacteria competing for electron donors. In contrast, dissolved hydrogen specifically enhances the activity of autotrophic bacteria that use hydrogen as an electron donor and inorganic carbon (e.g., CO_2) as a carbon source. Here, we share results from multiple treatability studies aiming to develop more sustainable options for bioremediation of perchlorate.

Approach/Activities:

Three treatability studies were performed to evaluate bioremediation of perchlorate using hydrogen: 1) bench-scale batch microcosm tests using zero valent iron (ZVI); 2) column tests and an intermediate-scale sand tank study using bioelectrochemical treatment; and 3) an ex-situ pilot plant using membrane biofilm reactors (MBfRs) with direct hydrogen generation. Each study was comprised of multiple discrete tests and phases of operation to achieve experimental objectives. Sludge from the site's ex-situ perchlorate treatment plant utilizing Fluidized Bed Reactors (FBRs) was used as an inoculum in certain tests. Nutrient availability and competing electron acceptors were also variables that were studied.

Results/Lessons Learned:

Factors that control biological perchlorate reduction include the availability of organic carbon, the presence of competing electron acceptors, and the robustness of the biology. The primary factor as demonstrated here is the development and sustainability of a robust and functional biological community.

Aspect of Work that Relates to Sustainability:

Traditional remediation technologies such as pump-and-treat are energy-intensive and can take decades to achieve cleanup goals. Hydrogen may be a long-term sustainable alternative for in-situ bioremediation of perchlorate and other contaminants, if applied electrochemically via low-voltage direct current generated from solar arrays or via the sustained slow release from ZVI corrosion.

2022 Americas Site Solutions Technology Transfer Conference

Title: Large-Scale Plume, Nano-Scale Solution: Remediation of CVOC Using Sodium Persulfate and Ozone Nanobubbles

Authors' Names: Gustavo Mello, Gabriel Garcia, André Cervelin

Presenter's Name: Gustavo Mello

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Eugenio Singer

Client Name: Confidential

Project Name: Confidential

Project Location: São Paulo, Brazil

Primary Ramboll Project Staff (Office): São Paulo, Brazil

ABSTRACT

Background/Objectives:

The project's area of concern comprises two neighbouring industrial sites located in a mixed-use zone in the State of São Paulo, Brazil. There are two known primary sources of contamination: i) a former underground tetrachloroethene (PCE) tank in site A, removed in 2013; and ii) a portion of site B used as a waste disposal area until the 1990s. The combination of both sources created a chlorinated volatile organic carbon (CVOC) groundwater plume affecting the local sedimentary aquifer over a thickness of 15 m and a length of over 100 meters, reaching sensitive residential and commercial areas downgradient from site B. A remediation strategy was designed using an innovative *in-situ* chemical oxidation (ISCO) approach to destroy contaminant mass in the unsaturated and saturated zones of the hotspots in both sites to allow for future residential use.

Approach/Activities:

Preparation for remediation started in April 2018, with bench-scale tests for *in-situ* bioremediation (ISB) and ISCO, using groundwater from the source areas in sites A and B. While biostimulation-based ISB was ineffective in the bench test due to the absence of PCE-degrading microbes (confirmed by genetic testing), ISCO using an innovative technique combining sodium persulfate and nanoscale ozone bubbles (smaller than 300 nanometers) showed significant mass reduction of CVOCs, in addition to a tenfold increase of dissolved oxygen which can be explained by the high internal pressure and high mass transfer rate of the nanobubbles. In April 2019, pilot tests of bioaugmentation-based ISB and ISCO using sodium persulfate and ozone nanobubbles were performed in site A, and ISCO again proved most effective in the former PCE tank source area. Informed by the aforementioned tests and geological model of the sites, as well as MiHPT and historical analytical data, a network of 69 injection wells was designed, distributed in both source areas comprising 23 wells targeting the vadose zone (depths from 4 to 15 meters below ground surface [mbgs]), 32 wells in the shallow aquifer (depths from 16 to 22 mbgs) and 14 wells targeting the intermediate aquifer (depths from 23 to 26 mbgs). In December 2020, a baseline groundwater monitoring event was carried out with a network of 60 monitoring wells distributed along both sites. Five injection events are planned to occur between February and August 2022, with groundwater sampling occurring in-between injection events.

Results/Lessons Learned:

To date, five injection events have been completed and the sixty (final one) is scheduled for August 2022. In the first five events, over 72,300 kg of sodium persulfate was used to prepare 857 m^3 of oxidant solution, also containing 3% (v/v) ozone gas. After the first injection event, groundwater monitoring evidenced increases in PCE concentrations in both hotspots, indicating residual mass transfer from the vadose zone to the aquifer and from the adsorbed phase to the dissolved phase. To

contain this mobilization, the second injection event more strongly targeted the vadose zone and shallow aquifer, with increases to both oxidant concentration and oxidant solution volume, in the areas with highest PCE concentration. The third, fourth, and fifth campaigns were focused on the hot spots, areas with concentrations above the remediation goals. After these 5 events, reductions in PCE concentration of on average 85% were observed in the former PCE tank source area. In this source area, the redox potential (Eh) increased by up to 150 mV and dissolved oxygen was raised by 2 mg/L in relation to the baseline. The combination of sodium persulfate and ozone nanobubbles presents itself as a powerful technique to treat CVOC groundwater plumes. Compared to traditional injection of millimeter-sized ozone bubbles, the nanobubbles offer greater stability and larger specific surface area, leading to a better penetration factor, which is desired particularly in aquifers containing low-permeability layers.

Aspect of Work that Relates to Sustainability:

ISCO usually is not the preferred remediation technique related to sustainability. But in this case, after the development of Treatability Tests and Pilot Tests, a sustainable assessment was done and ISCO became the first option (against soil excavation, bioremediation). Therefore, this paper is a paradigm break related to the use of ISCO for chlorinated solvents. Also, the nano-scale application (using a patent registered supplier) is contributing to a more successfully remediation on this complex site.

2022 Americas Site Solutions Technology Transfer Conference

Title: *In-Situ* Anaerobic Bioremediation and Chemical Reduction of PCE Impacted Groundwater

Authors' Names: Mark Mejac, David Lis, John Metzger, Eric Andruk

Presenter's Name: Eric Andruk

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Tim Whiting/David Lis

Client Name: Confidential

Project Name: Former TCC – Branford

Project Location: Branford, Connecticut

Primary Ramboll Project Staff (Office): Hartford, Connecticut

ABSTRACT

Background/Objectives:

The approximately 30-acre Site consists of four adjoining industrial properties located in Connecticut. Past releases of chlorinated volatile organic compounds (CVOCs), specifically tetrachloroethene (PCE), were detected near former vapor degreasers and drum storage areas at several discrete locations across the site. CVOC groundwater plumes have been identified within shallow and deep heterogenous overburden soils and the underlying Middletown Formation, which is comprised of Ordovician-age weathered metamorphic bedrock. The releases of PCE migrated through the vadose zone into the saturated zone overburden and eventually into the weathered bedrock. Remedial objectives include reduction of CVOC concentrations in groundwater and to facilitate compliance with applicable Connecticut Department of Energy and Environmental Protection (CTDEEP) Remediation Standard Regulations (RSRs).

Approach/Activities:

Groundwater remediation using in-situ enhanced reductive dechlorination (ERD) technologies has been conducted since 2018 to treat the CVOC plumes within the shallow and deep heterogenous soils and weathered bedrock. In order to inject into low permeability soils within portions of the site, a method of discrete interval direct push injections were utilized. This approach reduced the potential for daylighting through cracks in the pavement, monitoring wells, or into nearby wetlands. Bioremedial injections were conducted in general accordance with a work plan and permits which were acquired from CTDEEP and municipal agencies. The injected amendments included an emulsified carbon substrate, which was composed of approximately 60% long-chain and 5% short-chain fermentable carbon to allow for both a short-term and long-term release. Sodium bicarbonate was co-injected as an aquifer pH buffer, and bioaugmentation using dechlorinating microbial cultures was conducted to enhance rates of biotic dechlorination. This approach allowed bioremedial amendments to be placed directly within the zones of interest in the overburden which would optimize remedial response. These discrete intervals varied per property and ranged between 10 and 30 ft bgs.

Results/Lessons Learned:

The results of post-injection overburden monitoring have identified significant reductive dechlorination of parent PCE concentrations with concurrent increases in degradation product concentrations. As the remedial efforts to date have primarily focused on impacted shallow and overburden groundwater, the following changes have been observed in CVOC concentrations in the most heavily impacted overburden monitoring well:

— PCE decreased from 1,710 micrograms per liter (µg/L) to 7.41 µg/L

— Trichloroethene decreased from 8,180 µg/L to 48.6 µg/L

— Cis-1,2-Dichloroethene decreased from 30,500 µg/L to 220 µg/L

— Vinyl chloride increased from <200 µg/L to 682 µg/L, then declined to 64.9 µg/L with concurrent generation of ethene.

Aspect of Work that Relates to Sustainability:

he rapid reductive dechlorination of PCE-impacted groundwater was achieved in the absence of operation and maintenance of a groundwater treatment system, and associated energy usage. The application of such direct injection approaches to achieve compliance with regulatory criteria via minimal environmental footprints demonstrates Ramboll's continued commitment to a sustainable future.

2022 Americas Site Solutions Technology Transfer Conference

Title: ART Pilot Study for a CVOC contaminated site in South Brunswick, New Jersey

Author's and Presenter's Names: Emily Ireland

Key Topic: Innovative Remediation Technologies

PDP Manager/Managing Principal's Name: Christopher Buzgo/Nestor Soler

Client Name: Sealy, Inc.

Project Name: Tempur Sealy

Project Location: South Brunswick, New Jersey

Primary Ramboll Project Staff (Office): Princeton, New Jersey

ABSTRACT

Background/Objectives:

In 2017, Ramboll was retained by Sealy, Inc. to complete a remedial investigation and implement a final remedial plan for impacted soils and groundwater at a site located in South Brunswick, NJ. Ramboll took over the O&M of two interim remedial systems, namely, a vapor mitigation and a groundwater P&T system. Historical discharges have impacted soil and groundwater media across different hydraulic units with VOCs, primarily PCE and its daughter products. Site investigations identified a 'hot-spot' source area within a 110,000 square foot commercial warehouse. PCE concentrations have been detected as high as 48,000 ug/L in groundwater under the warehouse. The existing SSD and P&T Systems were controlling the vapor intrusion pathway to buildings and minimizing off-site migration of groundwater, respectively; however, additional remedial actions were necessary to address the impacted media beneath the warehouse. Ramboll performed a remedial alternatives analysis and selected Accelerated Remediation Technologies, Inc. (ART), In-Well Integrated technologies, for controlling and reducing the source area within the warehouse. The ART In-Well technologies combine several proven remedial processes, specifically in-situ air stripping, air sparging, soil vapor extraction, and enhanced bioremediation/oxidation in addition to subsurface groundwater circulation, in one well. This technology addresses both saturated soil and groundwater and is easily adaptable to field conditions, with minor disruption to site operations.

Approach/Activities:

In 2018, Ramboll installed an ART well system for an initial six-month pilot study. The pilot ART system includes a 4-inch monitoring well, five monitoring wells/piezometers, an in-well water extraction and recirculation line, vapor extraction line, electrical lines, and connection to a treatment shed outside the warehouse, which includes an SVE blower, vapor/liquid knockout tank, air compressor, connection to two 200lb GAC vessels, and an air discharge stack. The pilot study was designed to evaluate the removal of volatile organic compounds (VOCs) within the shallow groundwater beneath the warehouse. A baseline groundwater sampling event was performed July 10-11, 2018, prior to system start-up on July 12, 2018. Initial groundwater concentrations of PCE ranged between 250 µg/L to 48,000 µg/L. After the system start-up, monitoring wells and piezometers were sampled and analyzed for VOCs every six weeks until January 2019. Weekly operation and maintenance monitoring, including vacuum, temperature, flow, and PID measurements, was performed during this period as well.

Results/Lessons Learned:

Results of the six-month pilot study showed a decrease in total VOC concentrations between July 2018 and January 2019. An approximately 40% mass reduction was observed over the 6-month period. No increase of contaminant mass was noted outside the source area within the same hydraulic units, a condition that indicates that the ART system was effectively removing and treating contaminants within the source area. Based on the results of the pilot study, two additional ART wells were installed and are expected to start up in September 2022. It is anticipated that the addition of these ART wells

will significantly reduce the mass of VOC contaminants in the source area, ultimately minimizing any additional impact to the existing groundwater units.

Aspect of Work that Relates to Sustainability:

Due to the nature of this in-situ remediation technology, (a) there is minimal waste generated over the lifetime of the system, (b) landfilling and the use of fossil fuels for truck transport is avoided, which is typically seen in dig and haul practices, (c) energy required to run the system is small, and (d) maintenance frequency tends to be lower, when compared to other technologies.

SESSION 8
THE NEXT BIG THING
Moderator: Mark Nielsen

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Milwaukee, Wisconsin

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Milwaukee, Wisconsin

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SESSION NOTES

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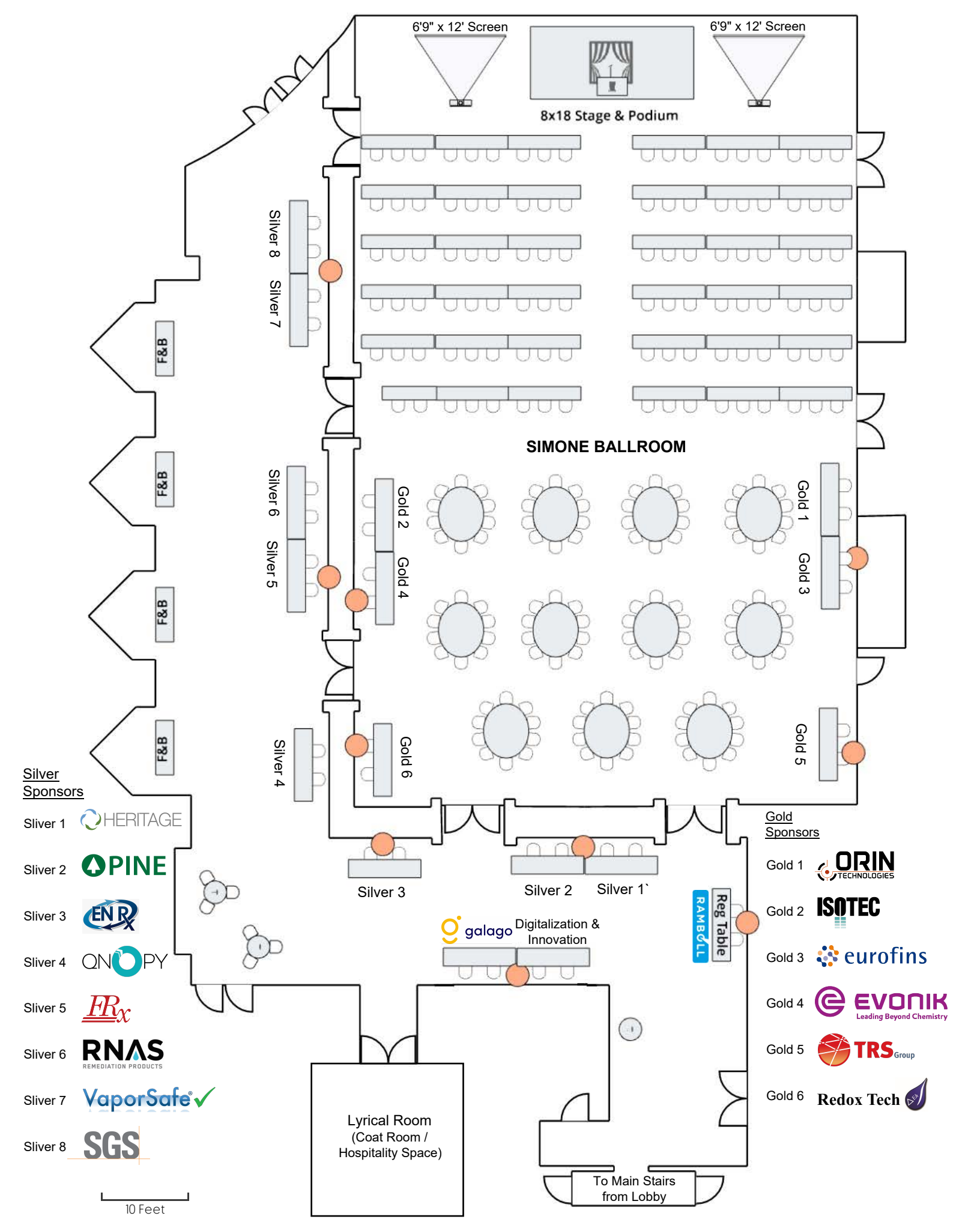
EVENT LAYOUT PLAN



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Simone Ballroom + Foyer for Ramboll Site Solutions - November 9, 2022, 12:00 PM

TRAVEL & LOCAL INFORMATION

The Saint Kate – the Arts Hotel (Saint Kate)

General Mitchell International Airport (MKE)

Amtrak Intermodal Train Station (Amtrak MKE)

Directions and info on the Oak Barrel Public House (OBPH) for dinner/live music after Day 1 the evening of November 9th

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