Accelerated Regulatory Closure by In Situ Remediation for a 1,4-Dioxane, Chlorinated Solvent, and Petroleum Mixed Plume in a Clay Aquifer

Scott Poynor, Geologic Science and Technology and Steven George, Green Star Environmental

**Background/Objectives** Due diligence as part of a building lease termination revealed shallow groundwater and soil contamination from historic cleaning of hydraulic fluid spills and leaks which were associated with a central underground tank. The building was used for flight training and housed four large hydraulic flight simulators in the basement. Releases of chlorinated solvents, solvent stabilizer 1,4-dioxane, and petroleum hydraulic oil created a co-mingled groundwater plume in a very low permeable clay aquifer beneath the building. Hydraulic oil was present as separated phase and dissolved phase hydrocarbons. The chlorinated solvent and solvent stabilizer portion of the plume (dissolved phase only) extended down gradient beyond the building beneath an adjacent property. The remedial objective was to meet regulatory agency requirements for groundwater contaminant reductions without future property use restrictions. The adjacent property required continued use as a hotel and conference center without disruption during remediation.

**Approach/Activities.** Enhanced, staged, in situ chemical oxidation (ISCO) was selected as the preferred remedy. State regulators, property owners, and building owners were included as critical stakeholders during remedial planning. Pilot testing in the source area under the building confirmed the technical viability of the selected remedy for treating soil, separated phase and dissolved phase groundwater contaminants. Site remediation was divided into two implementation phases. The source area media (plume core) under the building was first treated and remedial goals were verified. This was then followed by treating the outside dissolved phase groundwater plume. A sequentially staged treatment train was specifically designed for different portions of the plume using site-specific data. Continuous monitoring during ISCO implementation with purposeful intermittent monitoring and data collection for validation between phases allowed for frequent adjustments and ultimate success.

**Results/Lessons Learned** The quiet and minimal footprint of this approach allowed for the continued use of the surrounding property as a hotel and conference center and immediate property reuse. It allowed cleanup to be completed and approved in less than 3 years. The regulatory agency issued site closure under the Voluntary Cleanup Program with no property use restrictions (clean closure). Significant lessons learned during this project included the need for active collaboration among stakeholders and for detail source area characterization and pilot testing. The lessons also found that the enhanced ISCO process when properly applied will not affect utilities, can clean up shallow clay aquifers and soils, is able to successfully destroy 1,4-dioxane, and can reduce VOC levels in soil and groundwater to very low part-per-billion levels within months. State regulatory agencies seem to accept and favor this technology once they understand it and see its capabilities.

J. Scott Poynor, PG

Mr. Scott Poynor is the President of Geologic Science and Technology Group, Inc. founded in 2000 as a boutique environmental mitigation firm. Mr. Poynor is a Registered Professional Geologist practicing environmental consulting for the last twenty-eight years. He has broad experience in environmental regulatory compliance, contaminant assessment and remediation. Mr. Poynor’s expertise focuses on green, sustainable remediation, accelerated site closure, in situ remediation, risk-based remedies, and environmental liability estimation. Mr. Poynor has developed several proprietary remedial technologies that produce industry leading contaminant destruction efficiency.

R. Steve George, PG

Mr. Steve George is a Principal Geologist with Green Star Environmental, Inc. in Arlington, Texas. Mr. George seven years of oil and gas exploration experience prior to twenty-seven years in environmental consulting practice. Mr. George’s expertise includes development of risk management, remedial strategies, closure services, and litigation support on environmental projects for industrial, commercial, and municipal clients in the United States and Canada.
Application of Injected ZVI PRB to Control Off-Site Migration of a VOC Plume at a Drycleaner Site in Quebec

Andrzej Przepiora and Simone Smith, Geosyntec Consultants Inc.

A 100-metre (m)-long L-shaped zero-valent iron (ZVI) permeable reactive barrier (PRB) located along the southern and eastern boundary of a dry-cleaner facility was installed in November 2013 to intersect and treat chlorinated volatile organic compounds (cVOC) in groundwater originating at the Site. The cVOC-impacted groundwater resides in shallow overburden till and underlying intermediate fractured shale water bearing units from a depth of approximately 3 metres below ground surface (m bgs) to a total approximate depth of approximately 8 to 9 m bgs. The major cVOC found at the location of the PRB prior to its construction included tetrachloroethene (PCE) and trichloroethene (TCE) at maximum concentrations of 420 µg/L and 33 µg/L, respectively in the shallow zone, and 1,100 µg/L and 100 µg/L, respectively in the intermediate zone.

Initially, the PRB construction planned to use pneumatic fracturing with nitrogen gas for ZVI placement; however, the subsurface was more permeable than investigations predicted and sufficiently receptive to the ZVI slurry being hydraulically injected into discrete intervals isolated by inflatable packers. Due to variation in cVOC concentrations along the PRB alignment, the amount of ZVI injected varied laterally in three PRB sections, as well as in the shallow and intermediate aquifer units. A total of 53 tonnes of micro-scale ZVI was installed via 41 injection points to create the PRB.

PRB performance has been monitored in quarterly to semi-annual monitoring events over 28 months using wells screened in the shallow till and intermediate weathered shale units located directly upgradient of the PRB, within the PRB and downgradient of the PRB. Monitoring results within the ZVI injection radius of influence indicated substantial decreases in PCE and TCE concentrations to below the applicable groundwater criteria as a result of direct contact with the emplaced ZVI material, without creation of substantial amounts of chlorinated breakdown products (i.e., cis 1,2-dichloroethene and vinyl chloride).

The maximum groundwater velocities in the shallow and intermediate units intercepted by the PRB were estimated to be approximately 5.8 and 2.2 m/year, respectively. Because of the relatively low groundwater velocity at the Site, the positive effects of the PRB on groundwater quality was not expected to be observed in the downgradient, off-site monitoring well network for several years after installation. However, gradual decreases in downgradient wells have already been observed to date in the closest shallow well located approximately 5 m downgradient of the PRB, where the concentrations of cVOC in April 2016 decreased to below detection. Comparison of the results from April 2016 to those from September 2013 (collected prior to PRB installation) for other monitoring wells located approximately 15 m downgradient of the PRB indicates that the impact of PRB treatment has reached the shallow wells, but has not yet been manifested in the intermediate wells. These temporal trends are in agreement with the difference in the groundwater flow rate in the two units. Overall, the ZVI PRB is performing as designed and its effective longevity is expected to be at least 5 years.

Andrzej Przepiora
Mr. Przepiora is a project hydrogeologist in the remediation group of Geosyntec Consultant’s Waterloo, Ontario operations. Mr. Przepiora has 16 years of experience in the use of ZVI-based approaches for treatment of groundwater and soil. He has participated in the implementation of over 40 ZVI permeable reactive barriers (PRBs) for treatment of chlorinated organic compounds and metals in North America and Europe, with direct involvement in initial evaluations, pilot testing, treatability studies on commercial ZVI materials, PRB designs and construction method selection, and performance evaluations. He has also contributed to several research and development programs related to reactivity control evaluations and long-term performance of iron-based technologies.
Approaches for Evaluating Natural Attenuation of 1,4-Dioxane

Ian Ross, Jeff Burdick, Erica Kalve, Erika Houtz and Caitlin Bell, ARCADIS

1,4-Dioxane is a common co-contaminant with chlorinated solvents, specifically 1,1,1-trichloroethane. Typical 1,4-dioxane remedial strategies include chemical oxidation (e.g., ex-situ advanced oxidation processes or in-situ chemical oxidation). Treatment of 1,4-dioxane via natural or enhanced biodegradation processes provides an alternative remedial strategy and there has been a significant amount of research conducted on a bench scale which verifies degradation of 1,4-dioxane via metabolic and cometabolic degradation mechanisms. Metabolic degradation is the direct consumption of a compound (1,4-dioxane) as an electron donor or an electron acceptor, with enough energy captured to support microbial growth. Cometabolic degradation occurs when bacterial growth cannot be supported by the target contaminant (1,4-dioxane), but enzymes are present which can destroy it. Additionally, although 1,4-dioxane is highly mobile, the fate of 1,4-dioxane at mature release sites may be to remain in immobile pore space, reducing concerns related to ecological or human health. As such, while 1,4-dioxane may not be amenable to natural attenuation at all environmental clean-up sites, it can be under certain circumstances. Mass flux quantification can be invaluable to support a natural attenuation strategy. Understanding mass flux of a constituent in groundwater allows for accurate estimation of transport of that constituent over time. Passive flux meters are down-well tools equipped with sorbent material that allows for time-integrated groundwater and mass transport estimates. Passive flux meters, equipped with media designed to sorb 1,4-dioxane, have been employed successfully at sites as advanced quantification tools as part of natural attenuation evaluations.

When evaluating a natural attenuation approach, it is preferable to demonstrate destruction of the constituent, specifically through biodegradation processes. While intrinsic metabolic biodegradation of 1,4-dioxane is limited, co-metabolic biodegradation can occur under a variety of environmental conditions. For example, 1,4-dioxane can be co-metabolically degraded in the presence of alkane gases (e.g., methane, propane, ethane) and oxygen by microorganisms that utilize these primary substrates as part of their metabolic processes. As part of natural attenuation evaluations, dissolved gas analysis and molecular biology testing have been successfully employed to better understand the co-metabolic biodegradation potential.

Approaches and results from a variety of environmental clean-up sites will be used to demonstrate the current state of the practice for these tools to evaluation natural attenuation potential of 1,4-dioxane in groundwater systems. Four case studies will be used to provide examples where mass flux tools were successfully implemented to demonstrate reduced mobility of a 1,4-dioxane plume and dissolved gas analysis and molecular biology testing have been successfully employed to better understand the co-metabolic biodegradation potential.

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Ian Ross, PhD
Dr. Ian Ross is a biochemist by training and now works for ARCADIS as a technical expert for assessment of contaminated land sites and remediation. He started R&D examining the biodegradation of xenobiotics some 23 years ago and worked for Blagden Chemicals, ICI and the Defence Science and Technical Laboratories (part of the UK Ministry of Defence) whilst at Aberystwyth, Bangor and Cambridge Universities.

He started working for ARCADIS in 2002 delivering innovative solutions for soil and groundwater remediation, and delivered multiple cutting edge in situ remediation projects involving addition of nitrate, sulphate, carbohydrates and differing oxidants to soil and groundwater.

To enable successful implementation of innovative strategies, which offered clients more cost effective and sustainable business outcomes, he set up and ran the European Treatability Laboratory which enabled design of innovative remediation projects for ARCADIS across Europe. This laboratory enabled research in collaboration with several UK Universities with multiple Ph.D. and MSc students who developed novel contaminated land solutions.

He designed and implemented the world’s first in situ remediation of carbon disulfide using activated persulfate, which won the 2011 UK brownfield briefing award for best in situ remediation project and the Italian Sapiem 2012 Innovation award.

He designed a combined soil washing and chemical oxidation project for a landfill contaminated with pharmaceutical waste which won a Brownfield Briefing award in 2012.

He spent 3 years as the technical and business manager for FMC Environmental Solutions in EMEA developing a detailed understanding of the remediation business and opportunities across Europe and further afield, winning work by designing large scale remediation projects in China, Hungary and South Africa.

As a result of his marketing of ARCADIS’s remediation capabilities at European conferences, ARCADIS were requested to tender for environmental works at a large pharmaceutical site and won a series of projects involving the largest site investigation done by ARCADIS UK and a series of remediation projects at the same site. He collaborated on technical proposals to win ARCADIS a series of substantial ERD projects in the UK and worked as part of a guaranteed remediation team devising innovative strategies to position ARCADIS as a provider cutting edge solutions for clients which offer a more cost effective and sustainable outcomes.

His recent focus has been on PFAS (poly/per fluorinated alkyl substances) as a result of developing novel in situ remedial solutions and he has assisted ARCADIS by authoring and reviewing the CONCAWE PFAS guidance document, to be published in 2016.

Caitlin Bell
Caitlin H. Bell, PE, is a Senior Environmental Engineer and 1,4-Dioxane Lead for Arcadis North America. Ms. Bell focuses on subsurface treatment of soil and groundwater using in-situ techniques. Specifically, she focuses on in-situ bioremediation applications for a variety of chemicals of concern, including emerging contaminants. She serves as a technical resource to clients on topics such as molecular biology tools, bioaugmentation, compound specific isotope analysis, and challenging bioremediation approaches for compounds like 1,4-dioxane. Ms. Bell was a member of the team that authored the Interstate Technology & Regulatory Council’s Environmental Molecular Diagnostics technical guidance document and has presented routinely on remediation topics at industry conferences.
Geochemical and mineralogical properties of the aquifer solid phase have a profound influence on the mobility of organic and inorganic contaminants in aquifer systems and their occurrence in the dissolved phase. Of particular importance for remedial design is understanding the presence, form (crystalline vs amorphous), and distribution of reactive minerals in the solid material in an aquifer (the aquifer solid phase). Reactive minerals can be both sources and sinks for groundwater contamination, and their behaviour in response to changing aquifer geochemical conditions (pH, redox, solution composition) is a critical consideration for remedial design, which often involves manipulating the geochemical condition of the contaminated aquifer. Failing to account for reactive minerals can invalidate the theoretical basis of treatment design. At worst, failure to consider the reactive potential of the solid phase may result in an overall increase in dissolved contaminant mass or result in new contaminants of potential concern.

This presentation focuses on the effects of reactive minerals on the success of remedial design strategies. Three main scenarios where reactive minerals determine success or failure for remedial design are presented in detail: (i) naturally occurring reactive minerals as sinks for contamination; (ii) naturally occurring reactive minerals as sources of contamination; and (iii) anthropogenically enhanced reactive minerals as sources or sinks for contamination. The long-term stability of reactive minerals in each scenario is described along with recommendations for assessing, monitoring, altering, and mitigating their reactivity.

Several methods are available to assess the presence, form, and concentrations of reactive minerals that affect contaminant mobility. These include (i) batch sequential extraction techniques; (ii) column sequential extraction techniques; (iii) optical mineralogy; (iv) x-ray diffraction (XRD); (v) scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS); and (vi) QEMSCAN (automated SEM-EDS). Understanding the limitations of each of these techniques and how sample preparation can influence results is critical to designing appropriate site investigation, as well as bench scale and pilot scale testing programs. Use of reactive mineral data can be both qualitative (presence or absence) or quantitative (molar concentration), and recent advances in geochemical modeling software create new opportunities to simulate complex geochemical environments and their influence on metal mobility/mineral reactivity.

Case studies are presented for each of the three scenarios to show what can go wrong when reactive minerals were not considered in design. Best-case examples are also presented to show how an adequate understanding of the presence of reactive minerals resulted in remedial success. Novel remedial approaches are presented based on the manipulating groundwater geochemistry to dissolve or precipitate reactive minerals. This is accompanied by a discussion on how results from advanced analytical techniques can be used for reactive transport modeling and simulating various remedial strategies involving reactive minerals.

Jake Gossen is an Engineering Hydrogeologist with 8 years of experience in the environmental consulting field. Jake’s work primarily focuses on evaluating the Fate and Transport of organic and inorganic contaminants in aquifer systems, typically in support of Human Health and Ecological Risk Assessment. Jake is also an aspiring geochemist, and has conducted geochemical modeling to evaluate remedial options and predict long-term mobility and stability of plumes on large contaminated sites. This work has led him to understand the critical importance of characterizing the aquifer solid phase, with particular emphasis on the role reactive minerals play in contaminant mobility and remediation success; Jake has a thorough understanding of novel laboratory techniques to quantify their presence and structure. Since 2009, Jake has also been responsible for physical and chemical performance evaluation of a permeable reactive barrier (PRB). In 2011 he participated in the design and installation of a new PRB, and has spent the past five years evaluating its performance and effectiveness in site remediation.
Assessment and Remediation of Contamination at the Gwawaenuk First Nation, Hopetown, BC

Mark Oikawa, SLR Consulting (Canada) Ltd.

The Gwawaenuk Tribe is a First Nation located in the Queen Charlotte Strait region along the north coast of Vancouver Island, BC. Gwawaenuk territory includes Watson Island, where the Gwawaenuk village of Hopetown is located. Hopetown is remote and is only accessible by boat or air. Due to its location, the village has historically utilized generators for electricity power which required an underground storage tank (UST) and piping for storage and distribution of fuel.

The physical footprint of Hopetown is on a historic shell midden with known archaeological significance, multiple artifacts have been discovered in the area. Prior to SLR starting ground disturbance works, significant effort and consultation was completed while planning various remedial options for the impacted areas of the site. Site assessments indicated that petroleum hydrocarbon and metals impacts existed surrounding the UST as well as in other fuel storage areas on the property. The petroleum hydrocarbon and metals impacts included soil, groundwater, and sediment in a creek that transected the site. The removal of 1,585 m³ of impacted soil/materials and 6,000 l of water was challenging due to the need to develop a barge landing area, replacement of a rip-rap barrier wall, as well as the logistics of staffing and housing work crews on live aboard barges during the majority of active remedial site work.

This presentation will provide a brief summary of the remedial plan development and implementation, and the various consultations that were conducted during remedial planning, including the Gwawaenuk people, regulatory agencies, contractors, archaeologists and arborists. Remedial works included site excavation and soil disposal along with Human Health and Ecological Risk Assessment. The presentation will focus on implementation of the selected remedial works, some of the logistics due to the remote nature of the work, challenging tidal conditions for barging supplies to and from Hopetown, and planning work around sensitive areas. Also the presentation will highlight select protocols for working with an archaeological team, while conducting an active remediation. Lessons learned during the remedial program, final site conditions following remediation and ongoing monitoring requirements will be summarized.

Mark Oikawa

Mr. Oikawa is the Vancouver Operations Manager and Principal with SLR Consulting (Canada) Ltd. and has over 25 years total experience in the consulting industry. His expertise includes planning, conducting and managing all levels of Environmental Site Assessments and Remediation including both Human Health and Ecological Risk Assessments, developing and implementing remedial action plans, community consultation, training, and mentoring and working with numerous other stakeholders. Outside of work, Mark was the Vice President of Membership for the Environmental Management Association of BC, and currently serves on the Environmental Committees of both the Urban Development Institute and British Columbia Business Council.
The Biggest Environmental Risk You Missed

Tadd Berger, Pinchin West Ltd.

Hydraulic elevators and contaminant migration pathways are ubiquitous in our urban centres, posing a potentially unique and significant environmental hazard given the hydraulic fluids that they use to operate. However, these Areas of Potential Environmental Concern (APECs), especially the portions below grade, are often completely overlooked or mis-assessed, due to a lack of understanding of their mechanisms and risk profiles, resulting in surprises during renovations, capital upgrades and redevelopment activities. The unexpected discovery of hydrocarbons, and sometimes PCBs, one or more storeys below ground surface during construction excavation works can easily translate into costly remediation and construction delays. Further, due to the location of elevator systems within existing buildings, when impacts are known or suspected to be present, the proper assessment and/or remediation of these impacts poses unique opportunities and challenges.

This presentation will provide:
• An examination of elevator systems to identify the high risk components above and below the ground surface;
• Clues into when an elevator system poses a risk; and
• Options for conducting subsurface investigations while buildings remain in place as well as remediating contaminated soil and groundwater during elevator maintenance, building renovations and site redevelopment.

Tadd Berger, MSc, PAg, EP, CSAP

Mr. Berger is an Operations Manager and Practice Leader with Pinchin West Ltd. He has over 19 years of environmental experience with site investigation and remediation projects. He has managed numerous subsurface investigations and remediations in multiple geologic environments throughout North America. Mr. Berger’s experience ranges from small commercial outlets to major chemical and refinery complexes to mine sites. These include numerous chlorinated and mixed contaminant sites, several of which have received regulatory closure under Mr. Berger’s guidance. He has been responsible for a variety of projects in which soil, groundwater, surface water, soil vapour and sediment quality in relation to regulatory standards and risk-based evaluations were investigated, and remediated. This includes conducting baseline risk assessments, corrective measures studies, remedial feasibility studies, and corrective measures implementation planning.
Biogenic Interference Calculation (BIC) Index for Eliminating False PHC Positives in Clean Peat Soils

Francine Kelly-Hooper, CH2M Hill

Site remediation/reclamation of petroleum hydrocarbon (PHC) impacted soils typically involves the continued execution of professional services, confirmation sampling, soil management, trucking, off-site disposal, and tipping fees. Accurate delineations of impact boundary zones are critical components of timely and cost effective projects. Highly organic peat soils can cause significant problems when natural background compounds falsely elevate reported PHC concentrations throughout entire sites. The Alberta Energy Regulator (AER) often addresses these uncertainties by requiring that contaminated soil remediation zones be expanded to include a buffer of surrounding clean peat that matches background reference peat samples. They may also use background concentrations to determine if remediation targets have been met. This background reference approach can produce highly inaccurate results due to the non-homogeneous nature of peat soils. The resulting uncertainties can lead to the over-remediation and excavation of clean soils, which can significantly increase project costs and timelines.

Biogenic interferences are important issues when considering that peat soils cover 120 million hectares of Canada, with 11 million hectares located in Alberta. Dr. Francine Kelly-Hooper of CH2M HILL Energy Canada, Ltd. (CH2M) pioneered the Biogenic Interference Calculation (BIC) Index during her PhD research project, which quantitatively identifies false PHC detections in clean organic soils. The BIC Index was developed in collaboration with Alberta Environment and Parks (AEP) over a 7-year period. AEP and AER are now encouraging its use on a Tier 2, case by case basis for peat sites. This background reference approach can produce highly inaccurate results due to the non-homogeneous nature of peat soils. The resulting uncertainties can lead to the over-remediation and excavation of clean soils, which can significantly increase project costs and timelines.

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Francine Kelly-Hooper, PhD

Dr. Francine Kelly-Hooper is a Soils Scientist with over 20 years of experience working in the private and government sectors. Francine operated her own environmental consulting business, Kelly-Hooper Environmental Inc., from 1998 until she joined CH2M HILL in March 2014. Francine completed her PhD at the University of Waterloo in July 2013. Her research focused on the development of a new solution to resolving false petroleum hydrocarbon detections in clean organic soils and compost materials. Francine’s F2:F3b PHC Presence Versus Absence Index has been approved for use by Alberta Environment on a Tier 2 level. She continues to develop her research and to offer soil contamination evaluation services at CH2M HILL.
Bioremediation of Hydrocarbons – Has Your Design Considered Potential Residual Contaminants Relating to Your Amendments?

Wenhui Xiong and David Alberti, Stantec Consulting Ltd.

An oil well site located near Millarville, Alberta was previously remediated for petroleum hydrocarbons (PHC); however, it was later discovered that the remedial activities may have resulted in a residual nitrate contamination issue.

Multiple remediation activities consisting of soil excavation and treatment of excavated soil were conducted since 2005. Treatment activities included rotospiking and incorporating 11-48-0 and 46-0-0 (N-P-K) fertilizer blends to accelerate the bioremediation of PHCs at the site. Groundwater sampling activities conducted since 2009 indicated that PHC concentrations were below applicable guidelines at the onsite monitoring wells. However, a nitrate exceedance identified within one of the monitoring wells resulted in challenges in obtaining a remediation certificate for the site. Since this monitoring well is located adjacent to one of the former soil treatment areas, the source identification for the elevated nitrate was required to verify if the previous remedial activities (which successfully removed PHCs from soil) caused this post-remediation nitrate contamination.

Potential nitrate source at the site could include natural sources (soil nitrate) and anthropogenic sources (domestic animal wastes, farm usage of nitrogen fertilizers, and ammonium fertilizers from bioremediation). Groundwater samples were collected from three wells, including the location with elevated nitrate concentrations. The nitrate concentration at this location was reported as 45.2 mg/L in November 2014 and other locations were consistently in the range from <0.02 mg/L to 0.2 mg/L. The groundwater samples were submitted to PACE Analytical Energy Services in Pittsburgh, PA (PACE) for stable isotopic analysis of $^{15}$N and $^{18}$O of nitrate to further define the source of this contamination.

The comparison between the $^{15}$N and $^{18}$O from the location containing elevated nitrate and the Kendall (1998) figure suggests that sources for the elevated nitrate in groundwater could be either from ammonium fertilizers (anthropogenic source) or soil nitrate (natural source). The groundwater quality piper plot indicates that groundwater quality at this elevated location was consistent with the other sampled locations, other than the variance in nitrate concentrations. The water quality consistency confirms that natural soil nitrate was not the source for the recent increase of nitrate concentrations in groundwater.

Therefore, the source for the localized nitrate in groundwater was likely related to the application of ammonium fertilizer (11-48-0 and 46-0-0) during the previous remedial activities. This case study demonstrates the importance of a proper bioremediation design, which should consider in advance the endpoints of both PHC constituents and the added amendments prior to the implementation. Without optimizing the C:N:P ratio, excessive amendment applications can be problematic and delay the site closure, despite effectively remediating the initial PHC contaminants of concern.

Wenhui Xiong, PhD, PEng

Wenhui Xiong is a professional engineer with more than 15 years of technical expertise providing environmental site assessment, soil and groundwater remediation, environmental forensics, human health risk assessment, soil vapour investigation, and surface water remediation in Alberta, Saskatchewan, Manitoba and Ontario. He has been involved in several specialized projects including: enhanced anaerobic bioremediation, chemical oxidation, multiphase vapour extraction and pneumatic fracturing, biopile and mycoremediation, soil vapour extraction and air sparging, surface soil bioremediation, groundwater monitored natural attenuation, and biological in-lake water treatment.
Brominated Flame Retardants –
Another Class of Emerging Contaminants
Monica Danon-Schaffer and William H. DiGuiseppi, CH2M

Bromine-based flame retardant (BFR) formulations are added to approximately 2.5 million tonnes of polymers per year globally. Approximately 70 different BFR compounds account for a global consumption of more than 300,000 tonnes of BFRs per year, which include 56,000 tonnes in North America alone. PBDEs, TBBPA and HBCDs are some of the many BFRs commercially used. Regulating these compounds across various jurisdictions has increased in recent years. BFRs are typically used in thermoplastics (e.g. acrylonitrile butadiene styrene (ABS), high impact polystyrene (HIPS), polystyrene (PS) and polycarbonate (PC) and are blended with polymer constituents, together with other additives such as plasticizers. They are also found in the effluents from the industrial facilities that manufacture and use them. BFRs are formed by substituting bromine for hydrogen in biphenyl molecules. They are divided into 3 subgroups depending on how they are incorporated into the polymer: brominated monomers, reactive (chemically bonded to the polymer) and additive (blended with the polymer). Additive flame retardants are more likely to leach out of the product.

BFRs are bioaccumulative, persistent, undergo long-range transport, are lipophilic and have the potential to act as endocrine disruptors. Their concentrations in the environment have been increasing since the 1970s. They may leach out of products, and go through wastewater treatment facilities to end up in sewage biosolids. BFRs may be present in leachate from landfills, but no previous studies have been carried out on their fate in waste disposal streams (landfills, sewage treatment plants, incinerators). There is also limited knowledge regarding their environmental fate and toxicity.

Trends in concentration depend on the location and type of BFR. For example, sediment in Norway showed a linear increase in concentrations from the 1960s to the end of the 1990s. Sediment samples in Germany were found to have lower concentrations of brominated congeners in the 1960s than in the late 1990s. North American PBDE levels are generally much higher than in Europe or Japan, as observed in ringed seals from Holman Island, in northern Canada.

Monica Danon-Schaffer, PhD
Monica is a Principal Chemical Engineer at CH2M. With 28 years of consulting engineering experience, Monica went back to school to work on her PhD in chemical engineering. She explored how brominated flame retardants from consumer products reach the environment, circulating from waste streams to water and soil, and to distant locations. Monica’s research indicated that these contaminants persist for decades with far-reaching implications on environment and future policies. She developed a comprehensive mechanistic model to assist in predicting the concentration of brominated flame retardants (PBDEs) in and near landfills. In addition, Monica works within the Emerging Contaminants practice at CH2M, including PFAS and 1,4-dioxane compounds. Dr. Danon-Schaffer is a registered P.Eng. in BC, ON, NT, NU and YK as well as Mexico, and has extensive experience dealing with environmental, social and geologic challenges of the Arctic. She has also taught Environmental Forensics at the British Columbia Institute of Technology and is a Certified Environmental Auditor.

Bill DiGuiseppi
Bill DiGuiseppi is a principal hydrogeologist and program technology manager with almost 30 years of applied experience on 100’s of soil and groundwater investigation and remediation sites. He is a licensed Professional Geologist and is the leader of CH2M’s Chemicals and Issues of Emerging Concern Community of Practice. In that role, Bill directs a team of professionals in the identification, prioritization and management of chemicals such as 1,4-dioxane, perfluorinated compounds, 1,2,3-trichloropropane, hexavalent chromium and other critical emerging pollutants. Bill has led large and complex environmental investigation and remediation projects, published technical articles, chaired sessions at international conferences and co-authored a definitive book on 1,4-dioxane with Tom Mohr.
Calgary West Village: Use of Human Health Risk Assessment to Inform Redevelopment Scenarios

Ian Mitchell, Millennium EMS Solutions Ltd.

Calgary’s West Village area has been used for various industrial and commercial purposes since the early 1900s. Of particular concern is the former Canada Creosote Site (CCS), where extensive contamination remains from the use of coal tar, creosote and pentachlorophenol. Existing land use in the CCS includes a City of Calgary snow dump and car dealerships. However, due to the location of the land along the Bow River and adjacent to downtown Calgary, there is a desire to redevelop this land. A West Village Area Redevelopment Plan was developed in 2010. Subsequently, CalgaryNEXT, a combined arena/event centre and multi-sport stadium/field house, was proposed for the area by Calgary Sports Entertainment Corporation in 2015.

Calgary Municipal Land Corporation (CMLC) commissioned environmental studies to assess the current environmental condition of the land as part of the evaluation of the potential redevelopment scenarios. One component of this work was a human health risk assessment (HHRA). The intent of the HHRA was not to consider unrestricted land use, but rather to evaluate health risks under the proposed redevelopment scenarios. Specifically the HHRA considered high rise buildings with underground parking, commercial use on ground floor, and residential above, as well as parkland/green space. Consideration was also given to the implications of the CalgaryNEXT proposals.

The HHRA concluded that the potential for human health effects was low for the proposed uses of the land. Some potential risks were predicted for construction and utility workers in the absence of remediation. These results were then used to feed into remediation and risk management plans around the potential redevelopment.

Ian Mitchell

Ian Mitchell has degrees in ecology, environmental engineering and toxicology, and nearly 20 years of risk assessment and guideline development experience. He has conducted human health and environmental risk assessments for a wide range of different contaminants and settings. He was also a key contributor to the Alberta Tier 1 and Tier 2 guidelines, as well as several guidance documents for Health Canada, CCME and other agencies. Ian also regularly teaches courses for industry, government, consultants and post-secondary institutions.
Case Studies Involving the Application of In-Situ Oxidation Technologies to Remedy Petroleum Hydrocarbons, Chlorinated Solvents and the Regulatory Compliance Process in British Columbia

Jay Rao, WSP Canada Inc.

This paper describes remediation of contaminants in soil and groundwater (dry cleaning compounds and petroleum hydrocarbons) by the use of chemical oxidants (sodium percarbonate based RegenOx™ by Regenesis Inc., CA, USA), oxygen release compound-advanced (ORC-A™) and a patented oxidation technology (PulseOx™, APTWater Inc., CA, USA) using ozone and hydrogen peroxide at four sites within British Columbia (BC). BC Ministry of Environment Instruments (Approval in Principle, Certificate of Compliance) were obtained for three of the four sites.

The four sites include an old dry cleaning facility that was redeveloped with a building to rehabilitate the homeless in Chilliwack, BC, a decommissioned gas station in West Vancouver, a property formerly used by a construction company that contained underground tanks for fuel and heating oil that was rezoned for residential use in Burnaby, BC and a light industrial site in Langley, BC with petroleum hydrocarbons in groundwater. The paper discusses the conceptual site models, site characterization and remediation methodologies, chemical changes in the sub-surface post-injections of oxidants, field observations, results and the regulatory compliance process.

A former dry cleaning facility with a history of dry cleaning from the early 1960s to the early 1990s. The Site was contaminated with petroleum hydrocarbons and dry cleaning chemical (perchloroethylene or PERC) and its degradation products. There was an offsite plume in groundwater heading towards residential properties. An advanced oxidation technology, PulseOx™ provided by APTwater Inc., Long Beach, CA that uses ozone and peroxide as well as a commercially available oxidation compound, RegenOx™ manufactured by Regenesis Inc., California were used to conduct in-situ soil and groundwater remediation of contaminants in a medium sand aquifer. The site received multiple BC Ministry of Environment instruments including an Approval in Principle and a Certificate of Compliance (risk-based). PulseOx™ was used for the first time in Canada.

A former gas station site in West Vancouver located close to a river with deep (6-10 m below grade) soil and groundwater petroleum hydrocarbon impacts in a conductive sand layer was extensively treated with RegenOx™. Approximately 11 metric tons of RegenOx™ was injected into the sub-surface and the site was monitored to determine the level of reduction of petroleum hydrocarbons. RegenOx™ was effective in reducing the concentrations of petroleum hydrocarbons in groundwater up to 70%. A human health and ecological risk assessment was completed for the site to obtain an Approval in Principle with the provision for the installation of a soil-vapour barrier for the proposed underground parking.

In-situ injections of RegenOx™ and ORC-A™ were completed at two other sites, one in Langley, BC and the other in Burnaby, BC, both with petroleum hydrocarbon impacts in the dense glacial till. Gravity feed of the oxidant mixture through injection wells was attempted as pressurized injections demonstrated low effectiveness in delivering the oxidant to the sub-surface. The oxidant was successful in lowering the concentrations of methyl tertiary butyl ether in the parts per billion range in groundwater at the second site in Langley as well as lowering BTEX in groundwater at the site in Burnaby, BC.

Jay Rao, MASc, PEng (BC&AB), CSAP
Jay Rao is a Senior Environmental Engineer with WSP Canada Inc. at its office in Richmond, BC. He holds a Bachelor Degree in Civil Engineering from India and a Master’s Degree in Environmental Systems Engineering from the University of Regina in Saskatchewan. He is an Approved Professional with the BC Ministry of Environment for recommendations with respect to numerical standard assessments. He has over 15 years of experience in conducting Staged Environmental Investigations, Remediation and Human Health Risk Assessments in BC. He has 19 years of Civil and Environmental Engineering experience. For the past two years, he has also been practicing in Alberta. He has been involved in successfully obtaining 22 Ministry of Environment instruments such as an Approval in Principle or a Certificate of Compliance for industrial and commercial sites in BC and has applied oxidation technologies extensively in projects. In 2011, his project “Cleaning up after the dry cleaners” which dealt with the remediation (chemical oxidation) of an old dry cleaning site in Chilliwack, BC was nominated for an Association of Consulting Engineers in BC award in the soft engineering category.
Case Study Validation of the New Alberta Reclamation Criteria for Wellsites and Associated Facilities for Peatlands

Doug Bright, Hemmera,

Alberta Environment and Parks (AEP) published in October 2015 peatlands reclamation criteria focused around upstream oil and gas releases and activities. These reclamation criteria augment wellsite and associated facilities reclamation criteria for various other ecosystem types such as cultivated lands, grasslands, or upland forest. The peatland reclamation criteria effectively codify data needs and conditions required to demonstrate equivalent land capacity in peatlands that have been physically disturbed and/or contaminated. The AEP (2015) reclamation criteria specifically define (i) sampling needs including sampling intensity, methods, and indicators; and (ii) specific criteria for determining success in achieving hydrological and vegetative criteria.

We use data obtained between 2007 and 2015 for several Alberta and British Columbia boreal wetland sites to critically evaluate the AEP peatlands reclamation criteria. The sites include both peatlands (fens, bogs) and transitional wetland types towards more open water systems (marshes, swamps), and the information was generally obtained in support of a detailed site-specific risk assessment in wetlands affected by produced water or mixed saline water and hydrocarbon emulsion releases. The major assessment endpoints consistently included bryophyte and plant community status, and the studies were thus aligned with the overall intent of the AEP peatlands reclamation criteria.

The presentation highlights areas of strong alignment between the AEP peatland reclamation criteria and our practical experience with assessing ecological risks at produced water and hydrocarbon release sites (for example, with regard to expectations about vascular plant biodiversity in reclaimed bog or fen settings). The presentation also highlights issues and approaches that can help to reduce the scientific uncertainty about return to equivalent land capacity on a site-specific basis.

Doug Bright

Doug Bright is an environmental toxicologist and risk assessment specialist, with a research background in biological oceanography, environmental toxicology, and soil/sediment geochemistry. He has almost thirty years of experience in the assessment and management of environmental risks/impacts associated with disturbances in and anthropogenic releases to the environment. In addition to his role as a senior technical resource within Hemmera, Doug is also an adjunct professor at Royal Roads University.
Challenges in Forensic Analyses of Petroleum

Deib Birkholz, Analytical Consultant, Inc.
Milan Ralitsch and Stephanie Hoeppner, Life Science Forensics

Forensic analyses has become a new phenomenon for many private contract labs. Some private labs feel this service is just merely an extension of what they are already doing, namely routine chemical analyses. While some investigations may be straight forward, and a simple chromatographic analysis may yield pertinent information, other investigations may be more complex. The problem is we often do not know beforehand what to expect. The consequences of inappropriate analyses and interpretation can be costly, resulting in misidentification of responsible parties and inappropriate cost sharing settlements for cleanup. Furthermore, there is always the reality that the laboratory may face a lawsuit from their client. Forensic analyses are often performed to determine sources of contamination. Ideally we want to determine responsible parties and their contribution to an observed contamination. These investigations are usually associated with property development and the information is needed to satisfy insurance underwriters or legal counsel for varying responsible parties. In this presentation we share the results of a recent international round robin study involving spill material and three possible sources of biodiesel. To complicate matters the spill sample was weathered and one of the source samples was actually a mixture. The presentation clearly shows that investigations can be complex and that attention to analytical detail is critical in deriving the correct conclusions.

Detlef (Deib) Birkholz, MSc, PhD, PChem

Over forty years of practical experience in analytical chemistry, research, environmental and human toxicology, and business. Major industrial clients, include: transportation, oil and gas, petrochemical, mining and pulp and paper. Dr. Birkholz has worked for both the Federal government and industry. Deib, has proven a valuable resource to industry, government, and consultants, offering expertise in sampling, chemical analyses, data interpretation, toxicology, industrial problem solving, and forensic analyses. He has given numerous hours of court testimony and provided evidence in Provincial Court, Queens Bench and Federal Court. Deib has provided training in evidence collection to industry and consultants and has organized several litigation seminars at key conferences with the assistance of defense lawyers, prosecutors and judges. Dr. Birkholz is currently an adjunct professor with the University of Alberta in Edmonton with teaching responsibilities at both the undergraduate and graduate level. He is a member of the oil spill identification network of experts within the Bonn Agreement (Bonn-OSINET).
Recent environmental impact understanding and regulatory changes in response to those concerns have a significant impact on the industry and our clients. It is important to understand these changes for anyone submitting samples for analysis. It will impact how they submit their samples, what results they get from the laboratory and how they are applied to various regulatory regimes in Western Canada. Emphasis will be on the Alberta Tier 1 & 2 and British Columbia Contaminated Sites Regulation Stage 10 update, as well as, touching on other relevant regulations. A brief discussion of the current and future role of Professional Chemists in the environmental industry and possible coming regulatory changes will also be discussed.

With the regulatory changes come opportunities for laboratories to add new testing capabilities, update and improve technology and deliver those improvements to the industry. Advancements and new technology are important to those who test samples. We will brief the audience with interesting new testing capabilities and technological improvements which aim to help provide the industry with more informative, accurate, comprehensive, faster, cost effective, transparent and/or more reliable data for their analytical projects.

Patrick Novak is an owner and the Vice President of CARO Analytical Services and has over 15 years of experience in the environmental analytical laboratory industry, providing a diverse range of chemical and microbiology analysis services for environmental and materials samples. Patrick has particular expertise in project management for soil, water and air analysis for contaminated sites, including sampling, chemical analysis, report preparation, and interpretation of results. He is familiar with Canadian environmental regulations on the national and the regional level, and has extensive knowledge of sampling and analytical test methods. Patrick has also participated in the design, implementation, and management of numerous environmental study programs, process improvement projects and information technology management initiatives. He also served as the President of the Environmental Managers Association of British Columbia, which is responsible for educating and bringing together environmental professionals in British Columbia and has been a board member of the organization for 11 years.
Cognitive Tool for the Selection of a Technology for the Remediation of Contaminated Sites

Marc Paquet, WikiNet

The presence of contaminated sites represents an obstacle to the development of the society because of the consequences related to the loss of property values, the risks to human health and the deterioration of the environment. The remediation of contaminated sites presents many challenges which are related to the choice of appropriate technology. The complexity of the choice of technology is particularly related to the presence of one or more types of contaminants, the specific chemical and physical properties of contaminants, migration path of the contamination, the geology and hydrogeology of sites, the presence of infrastructure, etc.

Moreover, the high costs combined with the uncertainty in the performance of technology are factors that can limit the remediation of contaminated sites. On the other hand, environmental experts today are exposed to extremely rapid growth of the information across the planet (Big Data) making it impossible for an individual to assimilate knowledge available and quickly integrate it to his expertise. While traditional information technologies allow experts to have access to a wide variety of information sources, a detailed review of the scientific literature is a complex and laborious task. In addition, the information is generally complex and available in different formats; structured and unstructured. Therefore, integration, synthesis and use of all information remains very difficult and require a lot of time.

Getting all appropriate information to identify all variables required to diagnose the problem and choose the most efficient solution with high level of confidence is key to an economic and efficient remediation of contaminated land and water. The evolutive technological tool is use to predict a better selection of contaminated site rehabilitation technologies by integrating environmental, regulatory and financial information. The technological application incorporates the new cognitive processing technology created by IBM/ Watson.

This technology allows experts to exploit very quickly and efficiently environment “Big Data”. Current cognitive tools are used to develop an access to different sources of structured and unstructured massive data in order to make their assimilation and treatment very quickly. In addition, this tool has the ability to enrich its knowledge exponentially by integrating the information, as soon as it is available.

Thus, the uncertainty related to the selection of the remediation technology is continually improving and is determined dynamically. The use of this tool allows the professional to work in natural language environment and in several languages. We also understand that the data must be depersonalized in order to protect data sources that may be sensitive and maximize the potential sources of scientific remediation data.

The application’s outcome is based on the search of benefits at different level: user, business, financial, environment and society by increasing and sharing the knowledge and the information related to development of remediation technologies for contaminated sites. Beyond the environmental benefits, the technological tool will allow environmental companies to develop new added value services and adapt the concept to other specialties.
Marc Paquet, MSc

Marc Paquet is a chemist and has Master Degree in chemistry from Laval University. He has 26 years of experience in the field of environment. Mr. Paquet has worked 11 years for the enviromental laboratory Envirolab as the organic department manager and 8 years for Maxxam Analytics in the business development sector. He has also worked 7 years as a project manager for the environmental consulting firm Technisol. During his career, Mr. Paquet has developed a strong expertise in the field of organic analysis, especially the interpretation of chromatograms and results.

He has also been involved in various scientific and technical committees with Réseau-Environnement and the Association des consultants et laboratoires d’essais (ACLE) which are related to the analytical and the environmental field. He also organized and presented several technical conferences pertaining the analysis and identification of petroleum hydrocarbons.

Marc Paquet is the president and co-founder of the company WikiNet which is specialized in the development of technological applications based on the cognitive computing and intended for the environmental sector.
Connecting Climate Change to Brownfield Redevelopment

John Georgakopoulos and Matthew Gardner, Willms & Shier Environmental Lawyers LLP

Multiple jurisdictions across Canada are regulating greenhouse gas emissions in order to address Climate Change. On January 1, 2017, Alberta’s carbon levy program and Ontario’s cap and trade program will both begin. Other Canadian provinces are working towards or have already implemented climate change legislation. Although Canadian provinces have not explicitly addressed brownfield redevelopment in their Climate Change plans, what opportunities exist to facilitate brownfield redevelopment through the Climate Change regime? This presentation will take a cross-Canada look at current and proposed climate change programs, and potential opportunities to enhance brownfield redevelopment through the Climate Change lens.

John Georgakopoulos, BSc (Hons.), MSc, LLB
John Georgakopoulos is a Partner at Willms & Shier Environmental Lawyers LLP and is a Certified Specialist in Environmental Law by the Law Society of Upper Canada. John resolves complex environmental legal issues for clients, uniquely drawing on his technical knowledge as a former senior environmental scientist with Ontario’s Ministry of the Environment. John has particular expertise advising property developers, REITs, industrial manufacturers, and municipalities about managing environmental risks and liabilities associated with brownfields and contaminated sites. John provides strategic advice to help protect clients against corporate and personal environmental liabilities including civil claims, regulatory orders, prosecutions and fines. John is called to the Bar in Ontario and Alberta.

Matthew Gardner
Matthew Gardner is a Senior Associate at Willms & Shier Environmental Lawyers LLP. He practices environmental law and environmental litigation. He provides advice and solutions about environmental due diligence and compliance to a wide range of clients including fuel oil distributors, industrial corporations, the construction and land development sectors and municipalities. Matthew also provides advice and solutions about contaminated land issues, environmental risk management, environmental transactional due diligence and regulatory compliance. Matthew regularly appears before the Ontario Superior Court of Justice, the Ontario Court of Justice and Ontario’s Environmental Review Tribunal. He represents plaintiffs and defendants involved in environmental civil disputes and negotiates settlements before and in the early stages of civil litigation, where possible. He also assists clients under inspection or investigation by federal, provincial and municipal environmental regulators, and defends clients against environmental regulatory prosecutions.
Determination of Local Background Concentrations in Groundwater (Dissolved Arsenic, Iron and Manganese) at an Industrial Site

Tyler Joyce and Robert Apking, Stantec Consulting Ltd.

Synopsis: Stantec was able to determine, using careful sampling and rigorous data analysis, that apparent groundwater contamination with dissolved metals in fact constituted a natural background condition, relieving the client of the obligation to remediate or conduct risk assessment.

Discussion: Stantec was retained to complete a Preliminary and a Detailed Site Investigation (PSI/DSI) of a multi-tenant light industrial property in Richmond, BC (Site). Current and historic activities at the Site included aircraft component repair, metal plating, automobile maintenance and repair, and hydraulic equipment manufacturing.

The PSI found contamination in soil, groundwater and soil vapour. Groundwater contaminants included total and speciated chromium (Cr+3 and Cr+6), trichloroethylene (TCE), and vinyl chloride (VC). In some locations, concentrations of dissolved iron, manganese, and arsenic exceeded applicable regulatory standards. A DSI was then completed at the Site and the affected adjacent property to delineate the contamination.

During the DSI, it was hypothesized that the dissolved arsenic, iron and manganese were associated with naturally-occurring conditions (i.e., background conditions), and were not a result of anthropogenic activities at the Site.

To test this hypothesis, Stantec completed a comprehensive groundwater monitoring and sampling investigation program. Stantec followed the BC Ministry of Environment’s (MOE’s) Protocol 9: Determining Background Groundwater Quality to determine the siting of monitoring wells, and the appropriate statistical approach to determining local background concentrations. Stantec then applied to MOE for a Direct Determination of Local Background Groundwater Quality.

Using ProUCL, groundwater analytical data were subjected to robust statistical assessment, to evaluate data set population distributions, to evaluate for outliers, to test hypotheses, and finally to determine the 95th percentile concentrations of the data sets. These concentrations were then taken to represent local background concentrations, and finally compared to concentrations elsewhere on the Site, demonstrating that these concentrations were consistent with background, and did not constitute contamination.

MOE accepted Stantec’s application and supporting reports, and issued its Determination on February 2, 2016.

Tyler Joyce, CTech
Tyler Joyce is a project manager in Stantec’s Site Investigation and Remediation team with over ten years of industry experience. His primary focus has been the assessment and remediation of industrial facilities contaminated with various contaminants. He has implemented and evaluated numerous investigation and remediation programs including Phase I and Phase II ESAs, Detailed Site Investigations, ex-situ remediation, in-situ chemical oxidation, multiphase extraction, and bioremediation. His roles on projects have been varied, from conducting routine field work to managing large scale remediation projects.
Development of a New Sustainable Thermal Remediation and Recovery Technology Using Low Energy Rapid Exothermal Reaction Technique

B.J. Min, Jevins Waddell and Simon Park, TRIUM Environmental Inc.

Thermal remediation technology which was originally adopted from hazardous waste incineration practices originating in the 1980’s. Often these approaches had a negative perception to contaminated site stakeholders due to high energy requirements, the residual, often, unsalvageable soil and air pollution controls. Starting the late 1990’s, various ex-situ thermal desorption technologies as well as in-situ thermal heating techniques for remediation and enhanced recovery of non-aqueous phase liquids (NAPLs) have been developed and commercialized. Although these direct or indirect heating technologies use relatively lower energy than incineration, they still have technical limitations, such as high concentrations of organic compounds/contaminants and elevated moisture contents in soil. However with innovation, thermally induced contaminant removal technologies can be considered an effective alternative for some waste materials that are often addressed by practices such as excavation and landfill disposal.

TRIUM is developing a novel heat enhanced remediation technology to overcome many of the above noted limitations, with an emphasis on not only domestic applications but also global expansion of the technology. The fundamental kinetics of this technology involve proprietary enhancement amendments and concentrated low energy heating techniques. The process is effective to remediate hydrocarbons and/or organic compound contaminates from on surface or subsurface soils by cracking, mass extraction, and enhanced volatilization and recovery of volatile and semi-volatile contaminants. This new sustainable approach decreases viscosity of hydrocarbons, generates pressure, and cracks long hydrocarbon chains. Released gases from the reactions also enlarge soil pores, thereby increases the mobility of hydrocarbons for removal. This technique can be applicable for both in-situ and ex-situ applications and allows product recovery for reuse/ recycle. The fundamental mechanisms of this technology can also be applied to address dissolved contaminates and non-aqueous phase liquids (NAPL) such as petroleum hydrocarbons, volatile and chlorinated compounds from oil & gas industries, dry cleaning operations, historic wood treatment facilities (creosote) and other organic/solvent related contaminants. To-date, bench scale and lab prototype testings have been successfully completed with registrations of patent applications. Currently our R&D team is executing field pilot scale applications.

This presentation will discuss findings of research and development efforts for a technically and economically sustainable thermal remediation technology to remove organic contamination in soil and other source materials. A presentation of the various tests results including differing soil types, organic contaminants, product recovery yields as well as engineering economic aspects will also be included.

Jevins Waddell, PTech(Eng)

Mr. Jevins Waddell is President of TRIUM Environmental Inc. Jevins has over 18 years of environmental industry related experience and received his diploma in Hydrogeology from the Northern Alberta Institute of Technology. Jevins’ expertise includes projects and technology development initiatives related to: alternative and conventional remediation, environmental site assessment and risk analysis. Jevins’ experience includes sites throughout Canada, South Korea, Taiwan, China and Yemen.

Simon Park, PhD, PEng

Dr. Simon Park is a professor at the Schulich School of Engineering, Dept. of Mechanical and Manufacturing Engineering, University of Calgary. He is a professional engineer in Alberta, and is an associate member of CIRP (Int. Academy of Production Engineers) from Canada. Dr. Park received bachelor and master’s degrees from the University of Toronto, Canada. He then continued his PhD at the University of British Columbia, Canada. His current research interests include nano engineering, nanocomposites, and energy applications. He is an Alberta Innovates Technology Future (AITF) iCORE chair in sensing and monitoring.

B.J. Min, MEng, PEng

Mr. B.J. Min is a Principal of TRIUM. BJ is a registered Professional Engineer (20+ years) in the Provinces of Western Canada and obtained B.Sc. in Environmental Engineering from Ajou University in S. Korea and M.Eng. in Environmental Engineering from the University of Calgary. His area of technical expertise includes new remediation technology development and commercialization, environmental site assessment and remediation, risk management/assessment, contaminant plume fate/transport modeling, regulatory liaison throughout Canada, and several countries around the world.
Embedding Sustainable Safety within Aggressive Remediation Projects at Operational Facilities

Jay Dablow, Charles Schalkwyk, Lucy Chesher, James Baldock, Kathryn Johnson and Lindsay Pepperel; Environmental Resources Management

Background/Objectives. The objective of all remediation is to achieve the remedial goals and to do this safely in relation to workers, occupiers, environment and property. ERM has recently carried out steam enhanced contaminant recovery and in situ chemical oxidation projects, addressing solvent impacts at fully operational facilities. Safety challenges such as migration of VOCs into buildings; steam ‘daylighting’; and interaction of site workers with remediation infrastructure. With upwards of 80% of industrial incidents attributable to human or organizational failures, safety performance is a continuing source of risk to business, both ERM and the operating client site. Clearly, these issues need to be managed both practically and safely when ERM introduces new and unfamiliar hazards to an operating site. This can be especially challenging if new or different attitudes towards safety management are also introduced.

Approach/Activities. Safety is made sustainable through combining active leadership, fit-for-purpose safe systems of work for people within a fair and just safety culture. Sustainable safety recognizes the additional requirements for process safety at high-hazard facilities and always takes human factors into account. In many parts of the world, remedial systems are classified under construction safety regulations, which place the emphasis on safety during the planning as well as the ‘construction’ phase of any work. This is a good ‘fit’ for embedding sustainable safety and at the project level this enables the work to be undertaken in a controlled manner without affecting the operating client site. Key aspects of planning are HAZID, HAZOP and process safety reviews, which are undertaken by ERM, the client and ERM subcontractors. The operations and constraints of each site are considered in the HAZID to identify interfaces and risk areas for the site. ERM and client technical staff have key roles to ensure safe design and system commissioning. Hazards that require more procedural controls through correct positioning of whip-stops, pressure relief valves etc. are also highlighted. During all work phases there are challenges to manage at remediation sites and safety is a component in all system reviews. Challenges include contractor and client safety attitudes towards steam system management, vapour recovery procedures and the correct use of thermal PPE during hot weather. For this to be sustainable ERM carries out regular client and contractor engagement to ensure ERM’s safety standards are mirrored by the client and the site’s existing safety attitude.

Results/Lessons Learned. ERM’s experience at multiple thermal sites has enabled a good understanding of the behavior of steam and thermal systems at operational client sites. In these cases the remedial goals were met with over 16,000 working hours with no Lost Time Accidents. The challenges for thermal remediation projects are overcome by strong leadership, staff competency training, field coaching and proactive on-site management to encourage safe behaviors from all personnel. This also resulted in safety observations and suggestions from ERM, client and contractor staff, which led to an observable change in safety planning and attitudes from the contractors and our clients.

Jay Dablow

Mr. Jay Dablow is a Technical Fellow with ERM. He has 35 years of environmental and geotechnical experience with site investigation and remediation projects. As a Technical Fellow, he supports global implementation of bench- and pilot-scale testing, feasibility studies, engineering cost evaluations and full scale implementation of aggressive thermal and in situ enhancement technologies. A member of ERM’s Remediation Technology Group, Mr. Dablow is an industry-recognized expert in developing and implementing thermally enhanced, in situ oxidation, and metals stabilization remediation systems. He is a worldwide expert in the design, monitoring and full scale implementation of thermally enhanced soil vapor extraction (SVE) and NAPL mobilization systems using steam injection, hot injection, and electric resistance heating.
Emerging contaminants (ECs) represent ongoing and future liabilities to many governmental and commercial entities. Hundreds of chemicals have been identified as ECs within regulatory programs worldwide. These may be ECs because they are not captured in existing regulatory programs, have new data on human health or ecological effects, have evolving regulatory standards, or are the focus of a public health controversy. There are also “emerging issues”, which represent increasing concerns for society, regulators, manufacturers or property owners, such as vapor intrusion, emerging technologies (e.g., nanotechnologies) and sustainability. In other words, many ECs are now becoming compounds of concern, and therefore, ECs are an increasingly important facet of site characterization and remediation planning for many entities, both private and public sector. This presentation will discuss the process whereby chemicals in commerce become emerging contaminants, specifically the toxicology and regulatory pathways. Example ECs will be presented to demonstrate this process, specifically 1,4-dioxane and per- and polyfluorinated substances (PFASs) related to aqueous film forming foams (AFFF).

1,4-Dioxane has been classified as an emerging contaminant for over a decade, yet still blindsides facility owners with discovery late in the environmental remediation process. With changing regulatory standards and variable interest from stakeholders, this emerging contaminant is often overlooked during initial site investigations and can sometimes be identified after remedial planning or implementation has occurred, upsetting established monitoring and remediation programs. Given recently published documentation of co-occurrence with trichloroethene and other solvents and lack of testing at numerous sites where chlorinated VOCs have been detected, the likelihood of 1,4-dioxane being present but not detected at chlorinated solvent sites appears to be relatively high.

PFASs have been identified at various release sites as compounds of interest and are generally considered emerging contaminants due to their regulatory uncertainty. PFAS are the “active ingredient” in AFFF, which has been in common usage as a petroleum fire suppressant since the 1970s, especially in the United States Department of Defence (US DoD) since the development of the Mil Spec for AFFF in the mid-1960s. PFAS contamination has been found to be present at fire fighter training areas, fire stations and related storage facilities (DoD, civilian and others), at sites where petroleum fires were extinguished or suppressed using foam (automobile and aircraft crashes, petroleum handling facilities, refineries and aircraft hangers) and storage at shore facilities for tankers and military ships. An evolving body of toxicological and risk assessment knowledge emanating from academia and the environmental consulting industry is driving regulatory uncertainty. Regulatory agencies struggle with defining screening levels and cleanup objectives in this ever-changing landscape.

Monica Danon-Schaffer, PhD
Monica is a Principal Chemical Engineer at CH2M. With 28 years of consulting engineering experience, Monica went back to school to work on her PhD in chemical engineering. She explored how brominated flame retardants from consumer products reach the environment, circulating from waste streams to water and soil, and to distant locations. Monica’s research indicated that these contaminants persist for decades with far-reaching implications on environment and future policies. She developed a comprehensive mechanistic model to assist in predicting the concentration of brominated flame retardants (PBDEs) in and near landfills. In addition, Monica works within the Emerging Contaminants practice at CH2M, including PFAS and 1,4-dioxane compounds. Dr. Danon-Schaffer is a registered P.Eng. in BC, ON, NT, NU and YK as well as Mexico, and has extensive experience dealing with environmental, social and geologic challenges of the Arctic. She has also taught Environmental Forensics at the British Columbia Institute of Technology and is a Certified Environmental Auditor.

Bill DiGuiseppi
Bill DiGuiseppi is a principal hydrogeologist and program technology manager with almost 30 years of applied experience on 100’s of soil and groundwater investigation and remediation sites. He is a licensed Professional Geologist and is the leader of CH2M’s Chemicals and Issues of Emerging Concern Community of Practice. In that role, Bill directs a team of professionals in the identification, prioritization and management of chemicals such as 1,4-dioxane, perfluorinated compounds, 1,2,3-trichloropropane, hexavalent chromium and other critical emerging pollutants. Bill has led large and complex environmental investigation and remediation projects, published technical articles, chaired sessions at international conferences and co-authored a definitive book on 1,4-dioxane with Tom Mohr.
Environmental DNA: A Revolutionary Sampling Technique for Aquatic Ecological Studies

Elizabeth Vincer, Hemmera

Animals living in aquatic environments exogenously shed DNA as they complete their life processes. DNA is suspended in aquatic ecosystems and can be detected via collection and subsequent laboratory analysis of water samples collected from occupied habitats. This method, referred to as environmental DNA (eDNA), has recently gained recognition and acceptance as a robust and efficient method for reliable detection of species presence in both lotic and lentic systems. eDNA provides a cost effective and efficient alternative survey method for aquatic and semi-aquatic organisms. Field effort associated with sample collection is often less intensive than that associated with traditional baited trapping, electro-shocking and physical searches. In addition, this method is non-invasive to the target species and their habitat, reduces the risk of pathogen transfer between sites, is highly accurate and highly sensitive to the detection of species in lotic and lentic habitats, is able to detect the presence of pathogens and, in most cases, more cost-effective for species that are difficult to detect using traditional survey methods.

This presentation focuses on the application of eDNA to better inform decision-making and guide effective mitigation efforts during resource development projects in the baseline, permitting, construction and operational phases. We explore how eDNA can be used to meet regulatory monitoring requirements and assess the effectiveness of reclamation efforts. Methodological strengths and limitations are also identified and discussed.

Since 2014, Hemmera has delivered over 20 eDNA projects across Western Canada for a range of clients including government agencies and resource development companies. Studies have been conducted for 15 aquatic taxa, including fish, amphibians, water shrews and pathogens. Application for several projects is already anticipated for 2017, with additional focal species assessment planned. Hemmera has also recently developed a provincial sampling standard for collection of eDNA for the BC Ministry of Environment. There have been numerous lessons learned in field sampling and processing methodologies, in the laboratory analytical procedures, including quality control, and in development of validated primers for new species of interest to mine and environmental managers in western and northern Canada.

Elizabeth Vincer, MRM, PAg
Elizabeth Vincer is a Professional Agrologist with 5 years of experience in environmental consulting. Elizabeth is an ecologist with terrestrial vegetation and wildlife experience and an educational background in natural resource management and wildlife ecology. Elizabeth’s experience includes designing and executing terrestrial field studies, conducting environmental monitoring of species at risk, and technical report writing and review. Elizabeth co-authored Hemmera’s eDNA standard sampling document for the BC MoE and has been involved with the implementation of five eDNA projects across BC.
Evaluation of Crude Oil Spills and 70 years of Natural Reclamation along the Historic Canol Oil Pipeline, Northwest Territories

Stephen Livingstone, ARCADIS Canada Inc.

Between 1942 and 1945, the Canol Project was a cooperative effort between the United States and Canada to ensure a continuous supply of oil to American forces stationed in the Pacific during World War II. The project, which included the construction and short term operation of a crude oil pipeline and associated infrastructure, covered a total distance of approximately 800 km from Norman Wells in the Northwest Territories (NWT) to Whitehorse in the Yukon. This evaluation concentrates on approximately 372 km from Norman Wells in the northeast to MacMillan Pass in the southwest.

The construction of the Canol Project was a massive undertaking in a harsh and remote environment. Mountain passes, low wetlands, unstable ground, ice-rich soils, numerous water crossings, extreme climate and difficult access each represented a significant challenge. A 4” crude oil pipeline that was laid directly on the ground without expansion joints. No insulation was used due to the oil's low pour point (it remained viscous at -70 F). Due to the construction technique used, the pipe suffered a great deal of damage from construction equipment, rock slides, river washouts, and even rifle bullets. The first reported oil spill occurred twelve hours after the pipeline was commissioned. In April of 1944, the first oil reached Whitehorse. However, in April 1945, after less than one year of operation, the entire project was abandoned. On March 13, 1945 pipeline operations were completely suspended. A total of 60,275 barrels of oil were left in the pipeline system. The amount of oil spilled in the NWT during the construction, operation and salvage phases of the Canol Project has been estimated at 162,748 drums (25,874,848 litres) with over 78 crude oil spill sites identified along the NWT portion of the Canol Project.

Detailed site reconnaissance and environmental investigations were completed from 2007 to 2012. In 2012 (with follow up monitoring in 2013), eleven specific petroleum hydrocarbon related impacts at selected spill sites along the trail were selected for detailed investigation. There was very limited visual and physical evidence of impacts to soil and vegetation, thus making the detection of the spills very difficult. As part of the detailed site investigations, no mobile oil was found beneath the spill sites or at downgradient discharge locations. Oil concentrations in soils were typically not near saturation concentrations (for mobility to occur) with impacts to soil above CCME PHC agricultural guidelines on the order of 3000-5000 m3 along the study area. Groundwater wells were free of oils and the soil assessments generally found limited horizontal and vertical impacts.

The entire aggregated area affected by spills on the Canol Trail appear to no more than a few hectares. In most cases, the oil spills were long streams up to 100 m long and less than 2 m wide. Overall, the field and chemical data (mass balance) does not support the documented historical spill volumes. With these large volumes of potential oil discharged into the environment, it was anticipated that larger areas of impact would have been encountered, which was not the case. As such, a number of factors could influence this discrepancy including overstated spill volumes, natural recovery since the spills occurred or remedial work completed at the time of the spill (e.g. burning, collection of oil in sumps).

Based on the research completed in northern environments, specifically along the Canol Trail, a number of detrimental changes to the ecosystem will certainly result from intrusive remedial work associated with the removal of hydrocarbon impacted soils. The main issues will come in the form of damage to the re-established plant communities; surficial scaring of the soils, alteration of surface hydrology, surface thermal changes, and permafrost/soil conditions. Such actions would not only destroy this valuable resource, they would also increase the area of disturbance and set sites back to a stage lacking plants and soil organisms. Decomposition of the crude oil is occurring naturally, and much can be learned by studying these spill sites. This valuable knowledge could then be applied to hydrocarbon-contaminated sites in similar environments in the future.
Stephen Livingstone, MSc, PGeo

Mr. Livingstone is a Senior Hydrogeologist and Senior Vice-President of ARCADIS Canada Inc. Stephen is a licensed member of the Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories and Nunavut and Professional Geoscientist in Ontario and Professional Association of Engineers and Geoscientists of British Columbia. He serves clients across industry (Oil & Gas; Natural Resources, Chemicals/Conglomerates and Automotive) and government sectors with over 26 years of experience managing complex environmental projects. Stephen develops strategic direction for ARCADIS Canada Inc. with a focus on performance and growth. He identifies and actively pursues new business initiatives for the company. He serves as the Principal-in-Charge for several key national corporate and government clients.

Stephen brings deep expertise in environmental assessments, brownfield redevelopment, compliance, site remediation, risk assessment projects and strategic environmental management systems across Canada and internationally. His work has included the assessment, evaluation, risk management and remediation of soil, groundwater, and sediment contamination from storage facilities, factories, brownfield sites, railway yards, landfills and mines. Mr. Livingstone has managed high profile and complex sites in Canada including hazardous waste sites (PHCs, metals, PAHs), radiological impacts (uranium), off-site chlorinated solvent plumes (TCE, PCE and 1,4-dioxane) and “cancer cluster” sites. Mr. Livingstone has been responsible for environmental assessment and remediation projects in remote areas of the north which require innovative and novel approaches. Mr. Livingstone has worked on several numerous DNAPL and LNAPL contaminated sites from assessment to pilot scale testing and implementation of remedial systems. Many of the sites required advanced contaminant groundwater flow and transport interpretations and modeling.

Internationally, he managed the development of a joint venture in Mongolia pursuing environmental and hydrogeological mining projects acting as the CEO of OUG-FRANZ Mongolia LLC.

He has developed several strategic policy and guidance programs on behalf of several Federal government departments. Mr. Livingstone developed National Defence’s Contaminated Sites Management Plan, Public Works-Contaminated Sites Risk Management Best Practice; Department of Indian and Northern Affairs 5 year Environmental Management Plan and the Federal Government Strategic Brownfield Program. His team received an “Award of Recognition” for hard work and dedication from Aboriginal Affairs and Northern Development Canada for the Axe Point Military Site Remediation in 2011 and the Colomac Mine Remediation in 2012.

Stephen has worked in the USA, Mexico, Sweden, Argentina, Brazil, China, Mongolia, Japan, Russia, Ukraine, Turkey, Greece, Kazakhstan, Haiti, Sweden, Denmark, Finland, Norway, Dominican Republic, and Guatemala. He has been responsible for host-country training initiatives and capacity building and technology transfer development.
Evaporative Desorption Technology as Remedial Measure for On-site Soil Treatment during RCRA-facility Closure Process

Steven Bay and Joseph Muzzio, Reterro, Inc.

Background/Objectives. A former instrument manufacturing facility which operated in Fullerton, California between 1954 and 2010, was designated a “large quantity generator” for hazardous waste. In 2008, under oversight of the Department of Toxics and Substance Control (DTSC), a RCRA Facility Investigation identified volatile organic compounds (VOCs) including tetrachloroethene (PCE), trichloroethene (TCE) and degradation compounds in soil, soil vapor and groundwater. With the objective to expedite site redevelopment for residential and commercial uses, the environmental consultant evaluated ex situ measures to remediate soil and soil vapor contamination. A relatively new evaporative desorption technology (EDT) offered the fastest and most cost-effective remedial alternative, and met stringent cleanup standards for the protection of human health and groundwater. During the course of EDT pilot testing, final DTSC site soil and soil vapor cleanup goals were negotiated from USEPA Region 9 Regional Screening Level for residential use (RSLs) to risk-based concentrations (RBCs) and soil screening levels (SSLs) three orders of magnitude more aggressive, to facilitate unrestricted property uses.

Approach/Activities. Advantages of on-site ex situ thermal soil remediation are well documented, but development of approaches that provided these advantages and complied with recent air emission regulations was limited. The project consultant identified EDT as the preferred remedial alternative, eliminating the environmental impacts identified with transport and off-site disposal. EDT is a static process using electrically heated air to evaporate contaminants from soil with no PM10, NOx and SOx emissions. Evaporated contaminants were captured on granular activated carbon (GAC). The EDT pilot test was performed in accordance with a DTSC-approved work plan, Corrective Action Management Unit rules (40 CFR 264.550), and permits issued by the South Coast Air Quality Management District. EDT pilot testing was conducted in a phased approach to confirm that negotiated cleanup goals could be achieved.

Results/Lessons Learned. Initial EDT pilot testing successfully treated 1,100 tons of soil to five times below USEPA RSLs (4.4 milligrams per kilogram (mg/kg) PCE and 0.182 mg/kg TCE), and DTSC approved an extended EDT pilot test to 8,800 tons using a risk-based soil matrix cleanup goal three orders of magnitude lower than the original RSLs (0.0023 mg/kg PCE and 0.0018 mg/kg TCE). DTSC also added the requirement for soil vapor testing of treated soil to meet shallow residential soil gas cleanup goals. The extended EDT pilot test was successful and DTSC approved EDT as the remedial measure for the remaining 90,000 tons of VOC-impacted soil. EDT process engineering, supported by instrumentation and pre- and post-soil monitoring increased soil treatment throughput, provided cost effective operation, and allowed treatment to a very aggressive cleanup target. Continuous data capture from the EDT treatment process, batch-level soil testing, analysis of GAC loading, and periodic soil and soil vapor chemical analyses provided multiple lines of evidence to demonstrate the effectiveness of EDT on VOC-impacted soil which facilitated expedited DTSC closure for site soil. On November 25, 2015, two years from the start of the EDT pilot test, DTSC issued a Soil Corrective Action Completion for the soil treatment phase of the RCRA process.

Joe Muzzio

Joe Muzzio has 28 years of experience as an environmental and geotechnical consultant, and holds a bachelor’s degree in geology and a law degree (JD). He is a California professional geologist, certified engineering geologist and licensed general engineering contractor (certified in hazardous substance removal), and active member of the California State Bar. Joe has worked extensively under State and Federal regulations concerning hazardous materials and wastes, and has designed and managed assessment and remediation projects at hundreds of contaminated commercial and industrial sites throughout the western US. Joe has been the Senior Technical Program Manager at Reterro since 2014, and is involved in all aspects of Reterro’s soil remediation projects from initial evaluation through project execution. Joe is responsible for the technical evaluation of site-specific project data and works directly with Reterro’s Operations and Engineering Groups to determine the feasibility of the Reterro Evaporative Desorption Technology for each project. As a Reterro Program Manager, Joe has been overseen a wide range of soil remediation projects in California, Texas and Alaska ranging from less than 1,000 tons to greater than 100,000 tons of soil.
A Farmland (Site) located near the outskirts of the City of Calgary was assessed for potential environmental impacts prior to being developed as a residential community. During a Phase I environmental site assessment (ESA), areas of potential environmental concern (APECs) were identified, some of which were localized (e.g., AST area and garbage pit).

Phase II ESAs were conducted to investigate the site geology, hydrogeology and presence/absence of soil and groundwater impacts of various potential contaminants of concerns.

The soil encountered beneath the Site generally consisted of topsoil underlain by silt and/or clay till. Bedrock (sandstone/mudstone) was encountered at depths ranging between 1.5 and 15.9 metres below (mbg).

Impacts of one or more of petroleum hydrocarbon (PHC) parameters and select metals exceeding the referenced Alberta Environment and Parks (AEP) Tier 1 guidelines were reported in soil to a depth of 8.0 mbg. Detectable (above the laboratory method detection limits (MDL)), but below AEP Tier 1 guidelines, concentrations of PHC parameters were reported to a depth of 15.0 mbg. Impacts of PHC parameters (within the former AST area) and select metals were identified in groundwater. The metals in groundwater were considered to be naturally occurring based on a comparison to the results reported for the background monitoring wells.

Due to the sensitivities related to single-family residential land use, the City of Calgary indicated that no form of risk management would be accepted. A unique remediation objective for soil and groundwater PHC impacts below laboratory MDLs was requested due to the shallow bedrock and uncertainties associated with the degree of bedrock competency. Remedial excavations were carried out in APECs including the AST area and the garbage pit, which extended to a maximum depth of approximately 15.0 mbg.

Confirmatory soil samples collected from the final walls of the AST area excavation reported concentrations of PHC parameters below the laboratory MDL. Due to the presence of water and bedrock hardness, soil samples could not be collected from the base of the excavation. Alternatively water samples collected from the base and at two different depths, reported concentrations of PHC parameters below the laboratory MDLs. In addition, monitoring wells installed within the immediate downgradient of the excavation also reported PHC concentrations below the laboratory MDLs.

Soil samples collected from the final walls of the garbage pit excavation exceeded the AEP Tier 1 guidelines for selenium. Review of regional background concentrations of arsenic, barium, and selenium concluded that a large area in southern Alberta, including the Site area, was subjected to volcanic ash deposition from the eruption of Mount Mazama in Oregon circa 5700 BC. This has contributed to the elevated levels of regional background metals including arsenic, barium and selenium. Based on these findings and recommendations received from Alberta Health Services and AEP, the garbage pit excavation was remediated to the background levels.

Ripon Banik
Ripon is an Environmental Engineer with Stantec Consulting Ltd. in Calgary, Alberta. He works primarily in the areas of environmental site investigation and remediation. Ripon received his Master’s degree in Environmental Engineering from the University of Windsor, with a focus on micro-pollutant’s (e.g., mercury) environmental behavior and circulations and their relationship to various meteorological variables. Since joining Stantec, Ripon has contributed to a number of projects involving environmental site investigations, risk management and remediation.
Field Performance of Dispersive Colloidal Activated Carbon – Lessons Learned from Multiple Geological Settings

Ashley Cedzo, Jeremy Birnsting, Craig Sandefur and Kristen Thoreson, Regenesis

Background/Objectives. There is growing interest in the use of carbon injectables to expedite groundwater clean-up through coupling contaminant destruction with sorption. While an appreciation of the theoretical benefits of this approach is widespread, so is a natural caution among experienced remediation practitioners, as is understandable with any new technology. Among questions related to effective practical application of the technology are concerns regarding the ability to secure adequate subsurface distribution in the field, applicability in low-permeability or heterogeneous formations, efficacy against NAPL and limits of treatable contaminant mass. Further important questions include long-term efficacy, and the related validation of post-sorption field degradation.

Approach/Activities. This presentation will examine evidence from the field exploring these and other concerns. Data will be drawn from over 20 field applications, variously addressing chlorinated solvent and hydrocarbon impacted sites and encompassing a variety of geological settings within both the United States and Europe. Contaminants investigated range from chlorinated ethenes and ethanes to aromatic and aliphatic hydrocarbons and PAHs. Sites considered include legacy MNA sites, dry-cleaners, industrial sites, post-industrial development sites and filling stations. Field data will be presented describing performance against remediation goals, performance validation and also lessons learned with regard to material placement, site characterization and the importance of application-feasibility pre-testing.

Results/Lessons Learned. Results include multiple achievements of “three nines” contaminant reductions over short timeframes (<3 months) and lines of evidence of post-sorption degradation using microbial diagnostic techniques coupled with geochemical analysis. Such data provide a valuable means of mechanism validation underpinning sustained contaminant capture beyond the point of predicted sorptive equilibrium. Further lessons learned relate to divergence of encountered field conditions from documented characterization, and the potential to avoid unforeseen project failure (false positive) or unnecessary project abandonment (false negative) through use of appropriate pre-testing methodologies. Examples are given of each.

Ashley Cedzo

Ms. Cedzo has 5+ years in the Environmental Industry and her past experience includes both laboratory and field research, most notably as a Hollings Scholar for the National Oceanic and Atmospheric Administration (NOAA). In that position Ashley participated in environmental sampling and ecosystem monitoring projects on marine ecosystems. Ashley also completed an undergraduate honors thesis on the effects of urban runoff impacts to the sensitive coral reef ecosystems of Curacao. She has educated student groups on sustainability and the environment, specifically the natural ecology of the Pacific Northwest.

In her current position, as the Northwest District Technical Manager for REGENESIS®, Ashley works directly with environmental consulting, construction and engineering firms throughout the Northwestern United States and Western Canada to develop successful remedial approaches for their clients by offering design, application and performance review services for in situ-applied groundwater and soil remediation as well as vapor intrusion mitigation across a broad spectrum of technology classes. In this capacity, she has reviewed hundreds of potential projects and provided recommendations of remedial strategy.

Ashley holds a Bachelor of Science degree in marine biology, minor in chemistry from the University North Carolina Wilmington and a Master of Education in curriculum and instruction, with an emphasis in science education from the University of Washington.
Field Remediation Trials for Sulfolane Impacted Soil and Groundwater: Aeration, Nutrient Amendments and/or Peroxide?

Brent Lennox, Waterline Resources Inc.

A trial sulfolane remediation program was conducted using aeration, hydrogen peroxide, and nutrient amendment methods at an upstream oil and gas site in southern Alberta. The most successful approaches used aeration and/or nutrient amendments in both soil and groundwater, while hydrogen peroxide treatments of soil and groundwater were less successful at reducing sulfolane concentrations.

Soil remediation trials included: aeration and nutrient amendment using an ex-situ treatment system or an ALLU bucket and peroxide application using an ex-situ treatment system. The soil remediation trial that used an ALLU bucket to aerate and apply nutrient amendments to sulfolane impacted soil was considered to be the most effective trial and was coincidently the most economical approach. Within 45 days of these treatment activities, sulfolane in soil was remediated from an average concentration of approximately 3 mg/kg to less than detection limits and Tier 1 guidelines. Other aeration and/or nutrient amendment soil remedial trials using an ex-situ treatment system were successful at reducing sulfolane concentrations by 97%.

Groundwater remediation approaches included sparging, peroxide addition, and water re-circulation. The most effective approach was the use of a trash pump to circulate and aerate water within a test cell; during this trial sulfolane concentrations were reduced by 94% after just over seven hours of treatment.

Brent Lennox, MSc, PGeol

Brent Lennox is a senior hydrogeologist with Waterline Resources Inc. with ten years of experience in contaminant hydrogeology, physical hydrogeology, and environmental geoscience. He holds a M.Sc. degree in geology from Acadia University and a B.Sc. (Hons) in geology from University of Toronto. He has conducted work in Alberta, British Columbia, and the Northwest Territories.

Mr. Lennox is a project manager and hydrogeologist who develops and manages comprehensive work plans, schedules, and budgets for all scales of hydrogeological and environmental investigations. He has experience in: compliance and due diligence based soil and groundwater assessments; project design, implementation, and feasibility assessments of in-situ and ex-situ remediation methods; interpretation of downhole and surface geophysics; Phase I environmental site assessments; and liability assessments. Mr. Lennox has completed investigations at: upstream and downstream petroleum operations, wood preservers, dry cleaners, pulp and paper facilities, proposed mines, and other commercial, residential, and industrial properties. He is familiar with a variety of contaminants of concern (e.g., hydrocarbons, salinity parameters, metals, sterilants, glycols, amines, PCE, NORMs, etc.) and geological and hydrogeological settings. In-situ and ex-situ remediation techniques that he is familiar with include: multi-phase extraction, pump-and-treat, soil vapour extraction, chemical oxidants, monitoring natural attenuation, remedial excavations, and oleophilic-hydrophobic sorbent socks.

Eric Pringle, MASc, PEng

Eric Pringle has B.A.Sc., and M.A.Sc. degrees from the University of Waterloo, and 25 years of environmental and hydrogeology consulting experience in Canada and abroad. His project experience includes: environmental site assessment, environmental impact assessment, routine compliance or diligence based monitoring programs, contaminant fate and transport modelling, natural attenuation assessments, landfill siting, landfill operation and design, remedial design and remedial implementation. Physical hydrogeology projects that Eric has contributed include: aquifer testing and evaluation, well performance testing, municipal well head protection, well capture delineation, as well as analytical and numeric modelling of groundwater flow. Eric has contributed to projects dealing with a wide variety of contaminants or contaminant sources, such as: upstream petrochemical products and wastes, pulp and paper mill wastes, municipal waste, gasoline, diesel, heavy fuels, pesticides, herbicides, aromatic organics, chlorinated organic solvents, ketones, and phthalate esters. Remediation and control projects that Eric has been involved with include: containment well testing and optimization at landfills and industrial sites, horizontal groundwater collector trenches, soil vapour extraction, air sparging, bio-sparging, multiphase extraction, groundwater depression and LNAPL skimming, as well as soil excavation and treatment or disposal.
Former Camp Ipperwash is located on the western shores of Lake Huron in Lambton Shores, Ontario. From 1942 until 1995, Camp Ipperwash was utilized by the Department of National Defence (DND) as a military training ground. Training activities included infantry training, artillery training, mortar training, anti-tank weapons training and grenade training. As a result of these training activities, there are significant issues related to unexploded ordnance (UXOs) at the site. In addition, the site also has a long history of use by First Nations, and accordingly, there are also significant cultural artifacts present at the site, as well as the presence of plant and animal species at risk (SAR) throughout the site.

Amec Foster Wheeler was retained by Defence Construction Canada on behalf of DND to conduct a Phase II Environmental Site Assessment (ESA) at the site utilizing a multi-disciplinary team consisting of environmental, UXO, archaeological, and SAR (biologist) professionals. The multi-disciplinary approach allowed for the avoidance of UXOs, the identification of cultural artifacts, and the identification and avoidance of SAR throughout the work areas prior to the collection of environmental soil, sediment, and groundwater samples.

This multi-disciplinary approach was used throughout the entire assessment process to ensure that safe access was provided to the teams, that any cultural artifacts were protected, and that any SAR were avoided prior to the identification of the sampling locations.

In addition, aquatic risk assessments were completed related to fish found in two bodies of water located within the site to assist in determining the appropriateness of human consumption of these fish.

The results of the Phase II ESA will be utilized by DND to develop a scope of work for the further delineation of soil, sediment, surface water and groundwater impacts identified at the site. Those impacts include metals, energetics, dioxins/furans, and polycyclic aromatic hydrocarbons. Energetics are those compounds utilized as propellants or as the explosive components of military ordnance. These energetics can survive intact in the environment after the partial detonation of the ordnance, and can then break down into their component elements, including metals. These contaminants are a concern in Canada due to the number of current and former military training grounds where these types of contaminants may be found.

The purpose of this paper will be to discuss the process utilized to conduct the Phase II ESA activities as supported by the UXO, cultural, and SAR teams, and to discuss how the emerging contaminant of UXO energetics is assessed and the implications of that work for future activities at the site.

Steven W. Gable, PEng, MBA, rmc
Mr. Gable has over 30 years of experience as an engineer, 20 of those years as an environmental consultant. He attended the Royal Military College of Canada, the Royal Naval Engineering College at Manadon, Plymouth, England and Royal Roads University. Mr. Gable has experience in the completion of environmental site assessments, and the design, implementation and operation/maintenance of remedial systems for clients. He has completed assessments and remediation projects for sites impacted by radiological elements, heavy metals (including hexavalent chromium), polychlorinated biphenyls, phenolics, VOCs, PAHs, PHCs, pesticides, herbicides, heavy explosives and unexploded ordnance. He has also served as an expert witness in several Environmental Review Board hearings, in both Ontario and California, USA.
The Corporation of the City of Brantford retained Milestone Environmental Contracting Limited to undertake remediation on three adjacent properties in Brantford, ON collectively known as the Greenwich Mohawk Brownfield Site covering approximately 20.6 hectares (51 acres) and consisting of vacant land historically used for industrial purposes, surrounded by residential neighborhoods. The Site was impacted by various contaminants including, but not limited to: Petroleum Hydrocarbons (PHCs), Metals, including lead, Polycyclic aromatic hydrocarbons (PAHs), and Volatile organic compounds (VOCs). Remediation was associated with Property Specific Standards (PSSs) developed within a Risk Assessment (RA) approach representing the maximum allowable concentration of each contaminant concentration that was to be managed in place on each property through a series of risk management measures. Remediation was required to address lead, PHC, xylenes, and ethylbenzene.

The remedial strategy developed included:

- lead in soil to be addressed by excavation and offsite disposal;
- Fuel related PHCs and xylenes in soil to be treated by excavation, screening to segregate fine-grained soil and coarse material, biopile treatment of the fine-grained soil, washing of the coarse material, and subsequent placement of treated soil and washed coarse material into the excavated areas;
- Heavy organic PHCs (F4) in soil to be addressed by excavation and offsite disposal

Subsurface conditions revealed during excavation involved greater amounts of free phase PHCs on the groundwater surface and a greater prevalence of F4 PHCs in soil resulting in strong nuisance odours emanating from the Site. This resulted in project adaptations involving expedited removal of free phase PHCs, implementing robust odour control mechanisms, altering the coarse washing to a full scale soil wash (fine and coarse) to expedite soil treatment and to provide on-site treatment of heavy organic F4 PHCs in soil, in lieu of offsite disposal. Further adaptations included design and installation of two concrete barrier walls along an active rail line and installation of a polyethylene liner barrier to address off-site contaminants migrating back onto the Site.

Within 17 months – approximate overall project volumes included:

- Breaking, removal, crushing and reuse of 40,000 m³ of former concrete slabs & foundations
- Excavation of 283,000 m³ of overburden and PHC impacted soil
- On-site treatment of 136,000 m³ of PHC impacted soil
- Off-site disposal of 2,100 tonnes of hazardous lead impacted soil
- Off-site disposal of 90,000 tonnes of PHC impacted soil
- Recovery and recycling of approximately 125,000 litres of free phase PHC

Wayne Harris, C.Tech
Wayne Harris is an Environmental Technician and Project Manager for Milestone Environmental Contracting Inc. with 22 years of experience in a variety of environmental and heavy civil disciplines. A Certified Technician with the Ontario Association of Certified Engineering Technicians and Technologists, Wayne has direct experience managing and supervising projects for soil and groundwater remediation, brownfield remediation, site decommissioning, landfill construction and closure, heavy civil construction projects including site servicing, excavation and grading, and implementing project specific health and safety plans, policies and procedures. Wayne’s past experience includes working environments sites such as brownfields, landfills, oil and gas, forestry, pulp and paper, mining, industrial and commercial, power generation and transportation.

Wayne obtained a diploma in Terrain and Water Resources from Sir Sandford Fleming College in 1994 which followed with ten years working as a site technician, in a consulting role, for soil surveys, Phase 1 and 2 contaminated sites investigations, soil and water remediation projects, and soil, surface water and groundwater studies. In 2004, Wayne began working in a contracting role for contaminated sites remediation, including heavy civil construction, in varying positions such as site superintendent, general superintendent, project manager and operations manager.
(The) Greenwich Mohawk Brownfield Remediation Project – Remedial Technologies Employed and How the Project Adapted

Wayne Harris, Milestone Environmental Contracting Inc.

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Wayne obtained a diploma in Terrain and Water Resources from Sir Sandford Fleming College in 1994 which followed with ten years working as a site technician, in a consulting role, for soil surveys, Phase 1 and 2 contaminated sites investigations, soil and water remediation projects, and soil, surface water and groundwater studies. In 2004, Wayne began working in a contracting role for contaminated sites remediation, including heavy civil construction, in varying positions such as site superintendent, general superintendent, project manager and operations manager.
Groundwater Plume Analytics for Assessing Remediation Effectiveness

Joe A. Ricker, EarthCon Consultants, Inc.

Remediation effectiveness may be evaluated using a variety of techniques that oftentimes focuses on the performance of engineered remedial systems (e.g., flow rate, energy use, mass recovered, etc.). Rather than focusing on engineered systems, this session will focus on the evaluation of remediation effectiveness by evaluating the groundwater plume dynamics resulting from either anthropogenic or intrinsic remediation systems.

Groundwater plume analytics refers to the use of innovative evaluation techniques and methods to reliably and effectively communicate meaningful patterns in environmental data. Analytics relies primarily on graphical displays to communicate insight. Outputs from the Ricker Method® plume stability analysis¹ can be used to further dissect and evaluate dissolved plumes allowing the Ricker Method® to be a powerful tool in plume analytics. Various case studies demonstrating the use of plume analytics tools to evaluate remediation effectiveness will be presented, including a large remediation site in Edmonton, Alberta.

Multiple plume analytics tools derived from the Ricker Method® will be presented; however, the session will also focus on these tools as they apply to chlorinated constituent sites. It is useful when assessing chlorinated volatile organic compound (CVOC) data to also evaluate the data on a molar basis. This is especially important for evaluating the degradation of parent-daughter sequences such as the chlorinated ethenes and ethanes. For example, during reductive dechlorination the relative molar fraction of parent compounds progressively decreases through time and the fraction of daughter compounds progressively increases. Further, when a parent compound degrades to a daughter compound, the mass based concentration of “total CVOCs” decreases because one chlorine atom is released in each sequential reaction. However, the number of moles does not decrease since one molecule of a parent compound (e.g., PCE) produces one molecule of its respective daughter compound (e.g., TCE) and so on. The molar concentration only decreases once the parent constituent has been completely mineralized to ultimate benign end products (i.e., carbon dioxide, water, and chloride ion). In addition to demonstrating complete mineralization of CVOC compounds, this is especially important for evaluating and detecting potential new, separate, and/or episodic release sources within a plume. Examples demonstrating the importance and use of evaluating data on a molar basis will be presented.

The Ricker Method® has been successfully used as part of long-term risk management strategies to help stakeholders analyze unique groundwater plume characteristics including area, average concentration, and mass indicator, and describe the behavior of that plume as decreasing, increasing, or stable. Further, the Ricker Method® evaluation on a molar basis for chlorinated plumes has been successfully used for the cessation of remediation systems, identification of commingled plumes, identification of potential unrealized source areas, defining specific molar based signatures (biological or abiotic degradation), and providing additional lines of evidence for natural attenuation; examples of which will be presented.

Joe A. Ricker, PE

Mr. Ricker is a Principal Engineer for EarthCon Consultants, Inc. and is responsible for managing various environmental investigation, remediation, and property evaluation and redevelopment projects. Mr. Ricker has over 22 years of industrial and environmental consulting experience involving the development, implementation and management of complex, interdisciplinary environmental investigation and remediation projects. Additionally, Mr. Ricker has developed and/or collaborated on the development of various innovative approaches to interpreting environmental assessment and remediation site data. Mr. Ricker received his M.S. degree from the University of Memphis and his B.S. degree from Rose-Hulman Institute of Technology.

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Harnessing Wind Power for Remediation via Soil Vapour Extraction in Remote Areas

Anthony Knafla and Ian McIvor, Equilibrium Environmental Inc.

Various techniques are available for the remediation of organic volatile chemicals present in vadose zone soils. One common technique is to utilize soil vapour extraction, which typically involves the use of electrically powered air pumps to create depressurization zones and contaminated air flow from the subsurface into a collection vessel. This in turn requires a power source, which may incur significant cost for sites located in remote areas due to fuel consumption and maintenance (e.g., use of a propane, gasoline, or diesel generator).

A contaminated site in Alberta with volatile organic chemical impacts to a significant depth (> 10 m) was investigated and a remediation program implemented, which involved the use of wind power to extract subsoil vapours. The vapours were stored and treated above ground. Five low maintenance windmills were installed with modifications that allowed for the creation of a mechanically induced vacuum to depressurize subsoil, and subsequently extract soil vapours. The number of windmills used in a remediation program can readily be scaled upward or downward depending on initial and ongoing maintenance budget restrictions, and ultimately affects the time to cleanup. With the small number of windmills implemented at the Site, more than 140 kg of pure liquid product (or more than 200 L of product) can be removed annually with minimal operating costs.

This technique is cost effective and may be worthy of consideration by practitioners looking for technologies to apply for the remediation of volatile chemicals in vadose zone soils. No unique advantages are provided in terms of radius of influence for extraction, magnitude of chemical mass reduction, or time to clean-up compared to other methods for soil vapour extraction. The advantages are in terms of low startup cost, low maintenance and operating cost, and very low carbon footprint for vapour extraction.

Anthony Knafla

Anthony Knafla has worked in the environmental industry for 22 years. He is a biochemist and medical scientist by education and has spent his career on human health risk assessments, toxicological profiles and guideline methodologies for regulatory agencies, innovating a non-invasive approach for measuring genetic damage in humans, designing unique remediation approaches for salinity, hydrocarbon, solvent, and fertilizer impacts in soil/groundwater environments, developing microcosm studies to gauge the potential for microbial remediation of biodegradable pollutants prior to field scale implementation, and refining field screening techniques that can be used to guide investigation programs and remediation closure.

Ian McIvor, MSc

In 2012, Ian McIvor received his Masters of Science from the University of British Columbia in Biological Oceanography. Ian has been working for Equilibrium Environmental for the past three years. In addition to this involvement with soil vapour extraction, he is involved in aquatic toxicology, environmental risk assessment, and guideline development for various chemical of concern.
Have you Tested Your Environmental Unit Lately? We did

Jeff Blanchard and Tim Veenstra, Spectra Energy Liquids

In 2015 Spectra Energy’s Express Pipeline (Spectra Energy) completed an annual review of its Emergency Management Program (EMP) and identified that contractor support for its Environmental Unit (a Unit within the Incident Command System) could be improved.

Not many organizations can undertake an emergency response on their own; Environmental Contractors are an important addition to the Environmental Unit. Spectra Energy entered into an agreement with Stantec Consulting Ltd. (Stantec) to provide support for its Environmental Unit. One of the first tasks Stantec completed was to review Spectra Energy’s Environmental Unit response plans and provide recommended revisions of current plans and develop certain generic Environmental Unit plans.

At the same time as the Environmental Unit plan review and development, Spectra Energy completed an annual emergency response exercise (the Exercise). The Exercise in 2015 involved a tabletop drill for a Level 3 (worst case) emergency response and more than 70 people participated in the Exercise, including Spectra Energy personnel, first responders, regulatory agencies, Witt O’Brien’s, and Stantec. Overall the Exercise was a success and there were many takeaways from the “hot wash”. The Environmental Unit identified four areas of improvement: developing partnerships with contractors; developing additional strategic environmental plans and field level plans; increasing familiarity with tools available; and improving on control point locations.

The Exercise provided an opportunity to test the Spectra Energy - Stantec partnership. The Environmental Unit utilized Spectra Energy and Stantec internal resources and was a valuable training tool for understanding how Spectra Energy works, how Stantec works, and how the companies can collaborate to optimize the Environmental Unit response. The incident scenario required the Environmental Unit to produce several plans. The plans were developed using the generic templated plans. The generic plans were easy to modify with the simulated data, demonstrating their value. The Exercise presented a challenge to the Environmental Unit with a large number of sensitive environmental receptors in the simulated area. A question was asked, “Are there sensitive environmental receptors at the control point locations?” The Environmental Unit could not immediately answer this question, and by the time Specialists would have arrived to site, containment measures, equipment, etc. would have been deployed.

To address the Exercise findings, Stantec and Spectra Energy continue to develop the partnership with each other during the review and development of additional Environmental Unit plans. Both Spectra Energy and Stantec identified areas for improvement in utilizing internal resources such as databases. Information may be readily available, but timely access is key when responding to an emergency. In-house training and regular practice sessions (i.e. refreshers) are essential to be effective during an actual incident. Spectra Energy is currently evaluating internal resources and the feasibility of assessing the sensitive environmental receptors of more than 50 control points along the pipeline.

During an actual incident response, preparedness is key. Evaluating and testing the EMP allows the Environmental Unit to respond efficiently and effectively when needed most. Have you tested yours lately?

Jeffrey Blanchard, MSc
Jeffrey Blanchard is an Environmental Scientist with over 13 years of experience in both consulting and industry. After nearly 10 years of consulting work on contaminated sites throughout Western Canada, Mr. Blanchard transitioned into an Environment, Health and Safety (EHS), Security, and Emergency Response position with Spectra Energy. Jeff is one of two EHS Specialists for the Canadian portion of the Spectra Energy Express Pipeline, LP, and along with his coworker, is responsible for program development and implementation for EHS, Security, and Emergency Response. Mr. Blanchard holds a Master of Science in Environment and Management from Royal Roads University.

Sheri Gilmour, MSc, PGeo
Sheri Gilmour is a Professional Geologist with over 18 years of experience in both consulting and industry in the area of environmental site assessment and remediation for downstream, midstream, and upstream oil and gas, and industrial and commercial properties impacted by refined petroleum hydrocarbons, metals and inorganic parameters in Western and Northern Canada. Her extensive experience includes emergency response (operating under the Incident Command System (ICS) framework); managing large remediation projects with varying degrees of complexity; managing both short and long term monitoring programs and Phase I / II and III Environmental Site Assessments as well as implementing safety programs. Ms. Gilmour holds a Bachelor of Science and Master of Science degree in Geology from the University of Alberta and is a licensed Professional Geoscientist in the Provinces of Alberta and Saskatchewan.
Highly Successful ERD Pilot Study Using Simple Additive Delivery Approach Leads to Full-Scale Biostimulation Strategy for Destruction of Residual cVOCs

Kent Armstrong, BioStryke Remediation Products LLC, Geoff Bell, G2S Environmental, Inc. and Richard Schaffner, Pennoni Associates

The Site, a former dry cleaner, currently a vacant unit in a strip mall in Southern Ontario, Canada. Area zoned commercial and residential. Subsurface investigations since 2006 document chlorinated volatile organic compound (cVOC) impacts to soil and groundwater. Contaminants-of-Concern (COC) include Tetrachloroethylene (PCE) and associated daughter products; concentrations above Ministry of Environmental & Climate Change (MOECC), Table 3 Site Condition Standards (SCS).

In October 2011 G2S Environmental, Inc (G2S), the consultant of record, completed 6½-month on-site Pilot-Study. Evaluated efficacy of BioStryke® biostimulant ERDenhanced™ to enhance cVOC reductive dechlorination by native microbial populations under actual biogeochemical conditions. In March 2011 additive deployment performed using two (2) passive release sock (PRS) units suspended vertically within the screened interval of saturated soil column of existing 2-inch groundwater monitoring well MW-2. Three (3) PRS replacement events were performed during the evaluation to replace additive depleted units. The last replacement performed week-20 of the 26-week evaluation.

Baseline monitoring, sampling-analytical testing was performed prior to additive deployment. Four (4) post-deployment performance monitoring/testing events were completed concurrent with PRS replacement, the final monitoring/sample event completed at week 26.

Pilot results confirmed introduction of ERDenhanced™ at MW-2 enhanced scavenging of alternative terminal electron acceptors, exploited residual mass solubilization, and enhanced cVOC reductive dechlorination by native dechlorinating populations. Specifically, [PCE] decreased 46.9% by week-8, increased 233.3% by week 14 due to solubilization owing to ERDenhanced™ stimulated surfactant/co-solvent effects, then decreased 89.6% by week-26. Total [cVOCs] similarly decreased 49.6%, increased 282.6% then decreased 77.4%; and, the molar fraction (Parent-Parent/Daughter Molar Ratio (P:PD Ratio) decreased from 100% to 29.1% (70.9% REDUCTION) confirming dehalorespiration of parent PCE. Geochemical data provided a secondary line of evidence of enhanced reductive dechlorination.

Jul 2013 G2S implementing a MOECC approved full-scale remediation strategy combining source removal by excavation and biostimulation using ERDenhanced™ to address remaining residual and dissolved phase cVOC contaminants. Approximately 90 m² (250 m³) of cVOC impacted soils were excavated to roughly 3 meters bgs. Structural constraints limited additional excavation. An injection gallery installed in excavation footprint consisting of clear stone and 6-inch slotted PVC pipe placed 2-3 meters bgs. A groundwater sump was installed to remove groundwater from the excavation after backfill operations. In March and July 2014, 990kg and 840kg of ERDenhanced™ respectively was gravity fed into the gallery using 11,000 Liters of make-up water creating an approximate 9% slurry.

Five (5) rounds of groundwater monitoring-sampling were completed between March 2014 and October 2015. The following results summarize performance over approximately 19-months of treatment at monitoring wells MW-2, MW-3 and MW-6 located approximately 15-20 meters downgradient from the infiltration gallery.

With regards to [PCE], 99.9% (MW-2), 95.0% (MW-3), and 97.9% (MW-6) reductions were achieved. In terms of total [cVOC] 89.7% (MW-2), 75.8% (MW-3), and 88.1% (MW-6) reductions were achieved. In terms of molar parent fractions, ERDenhanced™ achieved a 99.0% (MW-2), 87.7% (MW-3), and 90.0% (MW-6) reduction, respectively.

Clearly, ERDenhanced™ expedited cVOC destruction within the desired treatment zone by increasing contaminant bioavailability via expedited solubilization and enhancing reductive dechlorination by native dechlorinating populations. As with the Pilot evaluation, secondary geochemistry metrics confirm enhanced reductive dechlorination achieved conducive conditions for reductive dechlorination including [Total Organic Carbon] (TOC) in the performance wells >100 mg/L.
Kent Armstrong

With over 35 years of experience working in the environmental industry, I have been afforded the chance to participate in a wide variety of environmental investigation, remediation and management activities. My beginnings started as a waste water treatment plant chemist for the LA Sanitation District while attending graduate school; Vertebrate Paleontology, Cal State University Long Beach. Transferring within the District to become a plant operator while teaching Human Anatomy at CSULB, I was presented with a chance to incorporate my chemistry and biology backgrounds with facility operations and truly learn the workings of the plant.

After 3 years with the District, next were 5 years as a hazardous waste mobile chemist analyzing soil and groundwater samples on-site at remediation projects throughout California, Nevada and Oregon. Next were several years performing RI/FS work for the largest independent landfill company in Southern California, and then a trip east to Connecticut where, for 6 years I worked with the CTDOT designing and managing environmental remediation projects for major highway, railroad and bridge rehabilitation projects throughout the 90’s. Since then my work experiences have included hazardous waste transportation/disposal brokering and 5 years with Lowes Home Improvement providing PCB, PHC and cVOC soil and groundwater management and remediation services at new store construction sites. Most recent was my joining forces in 2008 with Master Plant Products Inc. of Brampton Ontario Canada; where together, we developed BioStryke® Remediation Products LLC and a line of biostimulation additives designed to leverage existing site conditions to realize low-impact and safe, cost-effective and sustainable remediation of groundwater, saturated and vadose soil contaminants.
Hydrocarbon Data Interpretations for Highly Organic Soils

Chris Swyngedouw, Exova

Organic and muskeg soils have a high organic and moisture content. The soil analytical methodologies and regulatory standards are based on mineral soils with low moisture content and higher density than muskeg. Further, the results are to be reported on a dry weight basis. This creates assessment challenges when evaluating pollutants like petroleum hydrocarbons in muskeg, as laboratory analysis of these organic soils will result in an exaggerated reported concentration when the weight of the contaminant is compared to the dry weight of the solid portion of the sample. To confound the assessment, naturally occurring organics are co-extracted, not totally removed by a silica gel treatment, and thus mask the analytical results as noticed on the sample chromatograms.

This presentation will follow on Anthony Neumann’s presentation, Proper Interpretations of Lab Data for Highly Organic Soils, now focusing more on hydrocarbon analysis in a peat matrix, and discussing moisture, sample size, and method detection levels (for e.g., the Alberta Tier 1 guidelines). This presentation forms a compilation of current knowledge on hydrocarbon analysis (both volatiles and extractables) and data interpretations in organic soils. We will also briefly summarize the topic of biogenic organics.

Chris Swyngedouw, PhD

Chris joined Exova in June 2000 (then Norwest Labs) and is now the Group Technology Leader - Chemistry for Exova’s global operations. Other roles at Exova include Technology Transfer Consultant and Consulting Scientist for environmental analysis.

Dr. Swyngedouw has a Biosciences Engineering degree from Ghent University, Belgium; a Ph.D. in Organic Chemistry, and a Certificate in Management Consulting, both from the University of Calgary.

Chris has been employed by the industry for the last 25 years in various capacities, and has accumulated a breadth and a depth of knowledge and experience in method development and validation, technical and special project management, quality systems, and data review and interpretation.

As a consulting scientist, Chris has collaborated on numerous special projects, often requiring non-routine analyses in all sorts of matrices. As a consequence, Chris always has an opinion.
Identification of Terpenoid Compounds in Soils by GCMS as a Remediation Tool to Separate Petrogenic and Biogenic Hydrocarbons.

Nathan Scott and Ron Brockbank, AGAT Laboratories

Terpenes are an abundant biogenic class of organics produced by plants and animals. They are built up from five carbon isoprenoid units forming volatile and semivolatile compounds. The chemistry of terpenes touches us in every aspect of our lives. From aromas and taste, cleaning products, favorite coffees, beers and scotches, allergies, cosmetics to vitamins and hormones these compounds affect our environment. In forensic petrochemistry, the heavier hopanes and steranes (C25-C35) are retained in crude oil genesis and these compounds can be used to fingerprint different hydrocarbon sources. They form the “biogenic hydrocarbon pattern” found in the F3 region of CCME GC chromatograms. We will review the GCMS spectra of these compounds and how we can use the GCMS analysis of the F2-F4 extract can be used to chemically identify this biogenic pattern in remediation work by separating biogenic and petrogenic sources.

Nathan Scott
Nathan began working at AGAT Laboratories in their environmental laboratory shortly after graduating from U of C in 2005. Within a few months he was a part of their Client Services team, and shortly after that was helping develop a lab in the Maritimes. From that point on until present, Nathan has been involved with many facets of AGAT’s operations with an emphasis on the Environmental testing, Petroleum Testing, and Field Sampling Services. Currently Nathan is one of their senior managers from out of Calgary and continues to work closely with all of AGAT’s divisions servicing the Canadian oilfields.

Ron Brockbank, PhD
Ron joined AGAT Laboratories in 2007 and has a total of 10 years experience in the laboratory industry. He is also an active member of the Alberta Professional Chemical Society. Upon graduating, he was granted a Ph.D. in Biophysical Chemistry, specializing in two-dimensional NMR studies of phosphorylated proteins. He was then employed with a large-scale laboratory for eight years. While there, he began as an analyst and then progressed to the role of Senior Scientist. He was responsible for the mobile laboratory where complex projects were undertaken. These projects spanned Western Canada for up to six months at a time, bringing in significant revenue to the organization. Within this laboratory, he was responsible for the technical operation of the Organics department including; training, method development, automation and daily instrumentation maintenance. Ron was the very first analyst at a commercial laboratory to be accredited by CAEAL for CCME Petroleum Hydrocarbons. He has also been involved in numerous research projects including the simulation of fish toxicity in process water for a large oil and gas client using aryltriazoles. Currently he trains and supervises the Forensics Laboratory in Calgary for AGAT Laboratories.
Integrated Environmental Risk Assessments of Crude Oil Releases in Northern Ontario

Laura Lawlor and Andrew Pawlisz, GHD
Aaron Stadnyk, CN

Derailments of February 14 and March 7, 2015 near Gogama, Ontario resulted in releases of crude oil to aquatic environments of freshwater creeks, a river, and lakes. The derailment locations and community of Gogama are situated within rural northern Ontario, where consumption of local wildlife is prevalent amongst the public, tourists, and First Nations residents. The potential for effects on human and ecological receptors was assessed by collecting data on multiple lines of evidence and performing integrated ecological and human health risk/impact assessments. As part of the emergency response activities GHD collected air, surface water, sediment, benthic macroinvertebrate, and fish samples from the study areas for the analysis of crude oil constituents (CROCs), including parent and alkylated polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, xylene, and petroleum hydrocarbons (PHCs). GHD also prepared detailed records of local avian and mammalian wildlife. Based on the results of the air, surface water, and fish sampling, no risks to human health were anticipated since the concentrations of CROCs at exposure points were either non-detect, or were detected at concentrations below those associated with the potential for adverse effects. In contrast, the results of the ecological risk assessment for benthic macroinvertebrate communities at the March 7, 2015 derailment suggested the potential for adverse effects within an approximately 200-meter river section encompassing the source area. The main risk drivers were PAHs. The October 2015 post-remediation confirmatory sediment sampling and the ecological risk assessment indicated that there were no remaining risks to ecological receptors inside and outside of the remediation area.

Consistent communication and coordination with the agencies, public, and First Nations through the development of the integrated environmental risk assessments was a key component of obtaining acceptance of the integrated assessments and results within an emergency response framework. This presentation will outline the unique process and scale implemented in the preparation of this integrated risk assessment approach, the challenges of conveying the assessment results to both the agencies and non-technical stakeholders concurrently, and the lessons learned while working through a detailed technical evaluation in a condensed timeframe.

Laura Lawlor
Laura Lawlor is a Certified Ecologist with the Ecological Society of America and GHD’s Natural Resources Service Line Lead in North America. She obtained her undergraduate degree in Earth Sciences and Biology from Dalhousie University, and Master’s degree in Paleolimnology from Queen’s University. Laura’s 15 years of environmental consulting experience includes management and coordination of both public and private sector clients at all project stages from study design, data collection, data review and data management, through evaluation, assessment and reporting, and stakeholder communication. Her expertise includes ecologically-focused restoration design, benthic macroinvertebrates community assessment, and inter-disciplinary project design.

Andrzej Pawlisz
Mr. Andrzej Pawlisz has over 20 years of experience planning, executing, and managing projects dealing with ecological and human health risk assessments, avian and mammalian ecotoxicology, including the development of environmental media benchmarks, as well as assessment of fate, transport, and bioaccumulation of environmental constituents, mathematical modeling of toxicological, biological, and hydrological systems, statistics, probabilistic risk assessment, wildlife exposure modeling, risk communication, wetland restoration and contaminated sediments, community relations, assessment and remediation of contaminated sites, and vapor intrusion. Mr. Pawlisz is an active member of Society of Environmental Toxicology and Chemistry (SETAC), Society for Risk Analysis (SRA), and Society of Toxicology (SOT). He is a Diplomat of the American Board of Toxicology (DABT) and has published, presented, and peer reviewed numerous articles for various trade journals.
Integration of Multi-program Data Within a Single Web Based Geographical Information System (GIS) platform

Gordon Wilcox, Integrated Sustainability Consultants Ltd.

The amount and variety of information collected through site activities may differ significantly both in volume and complexity. Tracking and interacting with various data can prove to be challenging, especially when a variety of activities are occurring upon a site, and a user is attempting to establish a broader overview of what activities may be occurring, and why.

As programs progress data collected for many types of monitoring, reclamation and remediation programs are captured and processed independently of each other. In certain cases, core data is often collected and processed through specific systems designed to generate the most accurate results within the shortest time frame. The challenge then becomes, how to go about collating data in order to determine an overall understand of a site and what may be occurring on it.

The process of data evaluation often becomes time consuming and complex, as data from various sources must be drawn together and presented in a format that allows for it to be reviewed easily. This presentation will be a live demonstration of the Integrated Data Management System (IDMS). IDMS is designed specifically to enable users to access and view both their spatial and non-spatial data quickly and easily.

This presentation will demonstrate the some of the functionality available through the Environmental Monitoring module of the system which is designed to provide efficient access to all program data for one or more sites. Included within the module itself are tools that enable users to:

- Compare field collected results against regulatory guidelines, and control limits,
- Create and review time series charts of results for one or more locations,
- View documents collected as part of ongoing and historical activities, and
- Observe real time monitoring data as it is transmitted from the field.

All data within the system itself is presented within a simple and easy to use interface, that incorporates additional spatial information that may be used for overall site review and understanding.
Recurring rebound at the majority of ISCO sites illustrates that applications based on attempts to calculate oxidant demand doesn’t work well, and that an alternate approach is needed. Whether the reason rebound occurs is a result of poor investigations, the difficulty in estimating contaminant mass, or lack of contact between the reactants, analysis of data collected at ISCO sites suggest that more emphasis should be placed on developing an oxidation environment conducive to complete contaminant destruction rather than focusing on a theoretical oxidant mass.

This presentation will utilize data collected from several sites, and for time frames exceeding ten years of experience performing low volume chemical oxidant injections (LVCOI) on a semi continuous basis to demonstrate the efficacy of this approach. The concept was designed to develop a persistent oxidation environment that expands over time to overcome the tendency for insufficient reaction contact, impacts of matrix diffusion, and rebound. Data will be presented which highlights the benefits of real time monitoring of the oxidation potential of the aquifer to monitor and understand the location and magnitude of the oxidation front. Additionally, data will illustrate where this approach has been successful in developing oxidation zones greater than on half mile from the injection location.

Robert Luhrs
Senior Manager in Corporate EHS having over 25 years of combined technical and business management experience. Responsibilities include all aspects of Corp EHS, with primary focus on managing a large portfolio of contaminated property including: conducting more than $30 billion in M&A and property transfer due diligence; evaluating and managing environmental liabilities of existing or former properties; providing counsel technical guidance regarding agency and third-party matters; insurance recovery buyout of historic GL policies; negotiations with regulators, litigants, and other third parties; establishing and review of environmental reserve forecasts; and public presentations.
Landfill Closure – An Innovative Geosynthetic Barrier System

Dean Wall, AMEC Foster Wheeler

This presentation showcases an innovative high performance barrier system using nearly all geosynthetic materials. The landfill barrier system consists of a composite barrier consisting of High Density Polyethylene (HDPE) overlying a Geosynthetic Clay Liner (GCL). This barrier is sandwiched between two layers of DrainTubeTM, an innovative geosynthetic drainage product. The lower layer functions as part of the gas collection system, while the upper layer is designed to facilitate surface water drainage. The product is comprised of non-woven polypropylene geotextiles with a network of closely spaced, small diameter perforated polypropylene (PP) pipes. Amec Foster Wheeler designed and constructed the system for use at a pulp and paper landfill in a high precipitation environment. Due to the lack of locally available construction materials (i.e., clay, sand, gravel & drain rock), closure using geosynthetics resulted in significant cost savings over natural alternatives. Furthermore, the performance of the composite barrier system is expected to be several orders of magnitude better than a traditional clay cover.

Dean Wall, MSc, PEng
Dean Wall is an environmental engineer with over 25 years experience in all aspects of landfill permitting, design, construction, operation, monitoring, closure, and remediation. He is a Principal Engineer with Amec Foster Wheeler and is located in Nelson, BC.

Ian MacLeod, PEng
Ian MacLeod is a civil engineer who specializes in environmental engineering in the fields of waste management and site remediation. He has over 20 years of experience in the permitting, design and construction of waste management facilities throughout western Canada. He is a Principal Engineer with Amec Foster Wheeler and is located in Edmonton, AB.

Karen Fairweather, PEng
Karen Fairweather is an environmental engineer with over eight years of experience in landfill engineering applications in both British Columbia and northern Alberta. Her technical and field experience relates to landfill design, operation and closure planning, environmental site assessment, regulatory compliance monitoring, and QA/QC during landfill construction. She is a Staff Environmental Engineer with Amec Foster Wheeler and is located in Nanaimo, BC.
Liability Reduction from the Application of an Alternate Closure Protocol for Salt Affected Wellsites

Trevor Burgers, Millennium EMS Solutions Ltd.

Historically, the industry accepted practice is that elevated salinity within the upper soil profile (<1.5 m) would require further remedial action based upon exceedances of generic Tier 1 guidelines. The interpretation of the generic Tier 1 salinity guidelines may indicate the potential for an adverse effect when at many sites there may be no such potential. MEMS has developed and utilized an alternate closure protocol, which applies sound technical analysis of site conditions and the options available under the regulatory framework, coupled with our risk-based decision making philosophy to combine assessment and reclamation work at specific sites. MEMS application of an alternate closure protocol for salt-affected wellsites on native grasslands has resulted in a decrease in net environmental liability associated with upstream oil and gas wellsites. The application of this approach may reduce the need for intrusive site remediation, thus minimizing additional site disturbance and reducing net remediation/reclamation costs. Once native rangeland is disturbed, timelines to re-establish a satisfactory grassland community can be long, and therefore avoiding additional site disturbance can reduce the time required to achieve site closure.

The focus of this presentation is to provide a general overview of an alternate closure protocol for salt affected wellsites and to present examples of its successful application. The presentation will help identify sites where existing concentrations of salts in place in soil will not result in adverse effects on any valued receptor, and will provide an alternate route to regulatory closure for such sites. Examples will be presented that outline the approach and procedures used. This presentation will provide examples of different situations where this approach is advantageous including site location, setting and salinity characteristics and will present the overall management options for each situation. The presentation will also explain the information required to make the management decision to proceed with this approach to ensure project success and indicate potential problems to avoid. Case studies of completed projects employing this protocol will be discussed and the liability reduction achieved from this new technique will be summarized.

Trevor Burgers, MSc
Trevor has worked with Millennium EMS Solutions Ltd. since 2005, upon his graduation from the University of Alberta with an M.Sc in Land Reclamation and Remediation. He is an Environmental Scientist with industry leading expertise in the assessment and remediation of upstream oil and gas sites in western Canada and industrial settings. His work experience and training includes project management, site reclamation, environmental risk assessment and risk management, contamination remediation, due diligence for asset acquisition and divestment and managing and conducting hundreds of Phase 1 / Stage 1 and Phase 2 Environmental Site Assessment’s and remediation projects for several industrial and oil and gas clients. Since 2013, he has been the Technical lead for the Assessment and Remediation team within Millennium EMS Solutions Ltd.
In recent years we have seen a shift away from knee-jerk dig and dump remediation to more thoughtful and strategic risk management strategies. We seem to be entering the age of the plan: Risk Management Plans, Site Closure Plans, Remedial Action Plans, Long Term Monitoring Plans. These plans and the Conceptual Site Models they are based on generally come with a caveat along the lines of “this is a living document and will be updated as more information becomes available”. What does that actually mean? How are we as an industry managing living documents? Are they really “living” or just being reinvented every couple of years every time a new consultant takes over a file. This presentation will explore the purpose and many forms of a Living Document, how Living Documents inform data collection and gap analysis and invite discussion on what we as an industry can do to ensure that a document really “lives”.

Louise Burden, BSc, MSc
Louise Burden is a Principal Consultant in Risk Assessment and Hydrogeology and a Technical Director within the Liability Management and Remediation Service Group of Advisian. Ms. Burden has over seventeen years’ experience in environmental consultancy in the UK, Ireland and Canada, specializing in risk-based assessment of land contamination and hydrogeological conceptualization. She has a Bachelors degree in Geology from the Royal School of Mines, Imperial College, London, a Masters Degree in Hydrogeology from the University of Birmingham and is a Professional Geologist.
Manganese Activated Persulfate (MnAP) for the Treatment Recalcitrant Organics: Development and Commercialization

Bruce Marvin, Geosyntec Consultants; Pamela Dugan, Carus Corporation and Michelle Crimi, Clarkson University

**Background:** Geosyntec Consultants in collaboration with Carus Chemical Corporation and Clarkson University has developed a novel chemical oxidation method utilizing permanganate to generate mixed manganese and iron oxides that activate sodium persulfate (MnAP) for the treatment of recalcitrant organics. This innovative method was developed based on the hypothesis that mixed manganese- and iron-oxides can activate persulfate as demonstrated in recent academic literature (Mushtaque et al (2010) and Sedlak et al (2014)). However, the main objective of this academic literature was to determine the impact of naturally occurring organic and inorganic components, including iron and manganese oxides, on the activation of persulfate. The mode of action of MnAP will be discussed based on related water treatment literature and the findings of our research and development. Freshly precipitated manganese and iron oxides nano-particles are formed from permanganate consumption under controlled geochemical conditions that then act as activators for persulfate that propagate the persulfate radical-based oxidative chemistry.

Compared to the more well-known activation methods of persulfate (pH, iron, heat, peroxide), persulfate activation by reactions at mineral surfaces is not as well understood. Recent studies have shown that aquifer materials such as iron and manganese oxides can potentially activate persulfate. The recent lab-based academic studies Mushtaque et al (2010) determined that the greatest potential for persulfate activation was through an increased concentration of the mineral manganese dioxide (MnO2) (Mushtaque et al (2010)) and more recently, Sedlak et al (2014) determined that the rate of persulfate activation would increase in zones ‘rich’ in iron- or manganese-oxides.

**Approach:** A series of several laboratory treatability studies of MnAP have treated between 300 and 500 mg/L of trichloroethene (TCE) over 99.9% in both the aqueous and solid phases, as well as, benzene, ethylbenzene, toluene and dichloroethane. The treatability data also showed that MnAP can achieve high levels of treatment using less of each of the two oxidants (lower dosage) as compared to single oxidant approaches using typical permanganate and persulfate formulations. This circum-neutral pH process produces fewer by-products than the single oxidant approaches or classical persulfate activation methods evaluated (matrix, iron and base activation).

**Results:** Geosyntec designed and conducted large-scale applications of MnAP at the Middlefield-Ellis-Whisman Superfund Site in California, USA. The target zone is a heterogeneous mix of dense clays and sands. The site-specific design involved injecting 80,000 liters of oxidant solution (1,800 Kg of sodium permanganate and 5,500 Kg of sodium persulfate). Oxidant residual was present for 3-months after the completion of injection activities. The treatment removed more mass than 25 years of groundwater extraction and treatment. This combined oxidative approach is a lower cost than traditional permanganate or persulfate chemistries.

Bruce K. Marvin, PE
Bruce has over 25 years of hands-on civil engineering experience and a certification in safety management. He has a B.S. from Northeastern University and an M.S. from the Leland Stanford University. His technical expertise includes remediation strategy development, technology development and deployment, and remediation program implementation. Mr. Marvin has completed projects in North American, Australia, Japan and Europe. He established industry best practices for in situ chemical oxidation (ISCO) and in situ chemical reduction (ISCR) beginning in the late 1990s. He is a member of the Interstate Technology & Regulatory Council (ITRC) and was a contributing author to the Biochemical Reactors (BCR) for Mining-Influenced Waters team, the Dense Non-aqueous Phase Liquids (DNAPL) Site Characterization and Integrated DNAPL Strategy and Site Investigation teams. Bruce is an ITRC internet-based trainer and regular presenter at remediation conferences world-wide. He has organized technical sessions and moderated panel discussions at conferences and has presented over 50 times at major conferences. Mr. Marvin has designed and operated soil vapor extraction, water treatment (oxidation/reduction, biological, filtration, air stripping, and carbon adsorption) and in situ remediation (natural, chemical, biological, physical, and thermal) systems.
Modelling Uncertainty Analysis for Contaminant Risk Assessment

Paul Martin and Martinus Brouwers, Matrix Solutions Inc.

In Alberta, soil and groundwater contamination is often managed by establishing on-site clean-up targets within the context of risk assessment and on-site risk management measures (RMMs). The established process relies on analytical models facilitated through the Subsurface Salinity Tool (SST) to estimate the mass that can be left on site and result in acceptable risk. This approach is designed to be conservative, but can in many cases be unreasonably conservative. Furthermore, it does not directly account for the uncertainty that is inherently present when assessing subsurface conditions. Such uncertainty stems from having: 1) incomplete understanding of the hydrogeology and groundwater flow system, 2) incomplete characterization of the contaminant source / distribution in the subsurface, and 3) incomplete measurements of hydrogeologic parameters.

A more modern approach that more accurately reflects site-specific conditions and illustrates the implications of uncertainty for decision-makers is now practical. Recent developments in cloud computing and numerical analysis tools have made meaningful assessment of model prediction uncertainty more cost-effective and informative. With such advancements, detailed models that accurately depict our understanding of the hydrogeologic setting can be readily applied. The uncertainty analysis provides insights regarding the range of potential exposure levels, the most likely levels, and the timing of expected exposures. The goal of such analysis is to increase the transparency of the analysis and thus increase confidence regarding risk predictions or remediation measures designed to mitigate risks. Further, this process also highlights data gaps that control the predictions and the value of filling such data gaps with respect to reducing exposure level uncertainty.

Project stakeholders, including regulators, will find uncertainty analysis to be an especially valuable tool because it provides a high degree of confidence for human health and ecological risk assessment. This presentation will illustrate how modelling tools are being applied to evaluate contaminant prediction uncertainty, and evaluate remediation alternatives for selected sites.

Paul Martin
Mr. Paul Martin is a Principal Hydrogeologist in Matrix Solutions with over 25 years of experience in the development and application of groundwater modelling tools. Having successfully completed several hundred groundwater modelling projects, many of them for regional scale aquifer systems, he has gained a wealth of experience in the practical application of data analysis and modelling tools. Recognizing the role of the model as a decision making tool, he approaches problems with a focus on technical excellence, incorporation of detailed hydrogeologic structure and comprehensive uncertainty quantification.
“Omaha!” A Pundits Playbook to In-Situ Remediation of PHCs

Gary Winthrop & Blake Turnbull, Matrix Solutions Inc.

“Omaha is a run play, but it could be a pass play or a play-action pass, depending on a couple things: the wind, which way we’re going, the quarter, and the jerseys that we’re wearing. It varies, really play to play. So, there’s your answer to that one.” – Peyton Manning

Selecting a winning strategy for in-situ remediation of Petroleum Hydrocarbon (PHC) impacts is not unlike calling plays in football. There are many factors that should be considered in the decision making process such as field position (concentrations relative to numeric criteria), strength of the defence (geology – permeability), and time on the clock (desired or required closure date), to name a few. Unless you are certain to execute a hail mary, in-situ remediation usually requires the combination of two or more technologies to reach the end zone. Whether you are new to the remediation game, or a seasoned practitioner, a pundits look at in-situ remediation through a football analogy will offer Remtech delegates a fresh and fun view of the technologies available and relevant in Canada.

Through their project experiences, literature reviews, and participation at industry forums such as Remtech, Matrix remediation specialists have developed a playbook of remediation options to help clients make informed decisions on which technologies are best-suited for their remediation challenges. The playbook will help remediation practitioners systematically navigate through the many options available and more closely examine those likely to provide a successful outcome.

During this presentation, several offensive and defensive plays will be drawn up and the major factors contributing to, or limiting in-situ remediation success will be discussed. Typical remediation timeframes and costs will be identified at a rudimentary level, and technology combinations from project sites will be explored as examples. Offensive formations in the playbook include the Shotgun (vacuum and thermal technologies), Splitback (chemical oxidation and enhanced biodegradation technologies), and I-Form (LNAPL pumping). Defensive formations in the playbook include 3-4 Front (barrier and cutoff walls), and Cover 2 (permeable reactive barriers).

Gary Winthrop, PTech(Eng)
Gary Winthrop is a professional technologist and a San Diego Chargers fan with 21 years of environmental consulting experience across Western Canada. He has a field services and technical background in contaminated site assessment, ex-situ remediation, in-situ remediation pilot testing, design, construction, operations and maintenance, and performance monitoring of a variety of technologies in different subsurface and landscape conditions.

Mr. Blake Turnbull, PAg
Mr. Blake Turnbull is an avid New York Jets fan and has 8 years of experience in environmental consulting, contaminant hydrogeology assessment, site remediation, and technical data analysis. Currently, Mr. Turnbull works primarily on in-situ groundwater and soil remediation systems providing technical and operational support to a number of remediation projects across Western Canada including system design, installation, maintenance and optimization.
(A) New Take on Thermal Desorption - Using Enhanced Thermal Conduction (ETC) for the Remediation of Legacy Hydrocarbon Impacts at Sites in the Yukon and British Columbia

Chad Belenky, Iron Creek Group Inc.

Iron Creek Group Inc (Iron Creek) provides clients around the world with an innovative and cost effective thermal remediation technology to address legacy hydrocarbon waste and organic soil impacts. Using a process called Enhanced Thermal Conduction, Iron Creek was able to successfully treat more than 24,000 tonnes of hydrocarbon impacted soil at two separate legacy sites located in both the Yukon Territory and Northeastern British Columbia.

Location 1 – Yukon Territory
The Enhanced Thermal Conduction (ETC) technology was successfully utilized on a mineral exploration legacy site located in an extremely remote area of the Yukon Territory, Canada. Approximately 2,000 tonne of diesel impacted soil was treated with a version of the ETC equipment that was modified to fit in a de Havilland Twin Otter aircraft in order to be deployed to the air access only, backcountry site. Impacts at the site were a result of a historical diesel fuel release and were characterized by BTEX impacts as well as LEPH10-19 (Light Extractable Petroleum Hydrocarbons) and HEPH19-32 (Heavy Extractable Petroleum Hydrocarbons) all exceeding territorial Contaminated Sites Criteria. In some portions of the impacted soil, initial DRO concentrations exceeding 22,000 mg/kg were identified. Closure sampling and analysis that was conducted following the thermal treatment process resulted in all samples meeting the territorial Contaminated Sites Regulation requiring extractable hydrocarbon levels below 1,000 mg/kg for each of the LEPH10-19 and HEPH19-32 fractions. A broad range of soil types and soil moisture contents were processed during this project ranging from tight clays saturated to field capacity to wet fluvial material and even some discontinuous permafrost material. Following treatment, the clean soil was used to backfill the excavation area to facilitate reclamation of the site. Work was completed during the frost free summer months with heavy rainfall and extreme weather occurring routinely throughout the project.

Location 2 – Northeastern British Columbia
Approximately 22,000 tonne of crude oil impacted soil from a legacy oil & gas location in Northeastern British Columbia, Canada was remediated utilizing the Enhanced Thermal Conduction (ETC) process. Impacts at the site were characterized with BTEX parameters as well as with VPH6-10 (Volatile Petroleum Hydrocarbons) and LEPH10-19 (Light Extractable Petroleum Hydrocarbons) all exceeding provincial Contaminated Sites Criteria. Following remediation with the ETC process, confirmatory sampling of the soil resulted in 100% regulatory compliance for all samples collected and a large portion of the samples had analytical results below the detection limit. Once treated, the thermally remediated soil was used to backfill the excavation areas of the site in advance of site reclamation. Operations commenced in June during the extremely wet, rainy season and continued though into frost conditions with all-weather capability maintained during the treatment period. This presentation will highlight the versatility of the Enhanced Thermal Conduction process as a cost effective addition to the remediation practitioner’s toolbox, along with lessons learned from deploying the technology to these unique and remote project locations.

Chad Belenky
Chad Belenky is President of Iron Creek Group Inc. where he is responsible for the management and oversight of all aspects of the business. Chad has been active in the environmental field since 1996 working on energy and resource industry sites throughout Western and Northern Canada. With over 20 years of experience managing a diverse portfolio of projects, he brings a broad range of experience to Iron Creek. This includes extensive background in both soil and groundwater remediation, all phases of site reclamation, property transfer activities and project management.

Roger Richter
Roger Richter is Vice President of Operations at Iron Creek Group Inc. Roger has been active in the thermal remediation industry for the last 23 years and he has vast experience in planning, mobilizing and completing local and remote remediation projects throughout the world. Mr. Richter possesses a proven track record on soil remediation projects using Hot Air Vapor Extraction, Indirect and Direct fired TDU’s, Enhanced Thermal Conduction and the M1 Technology. Mr. Richter’s experience includes the permitting, construction and operation of several stationary treatment facilities in the United States and the deployment and operation of many remote thermal remediation systems. He pioneered the design, development and construction of the technology known as Enhanced Thermal Conduction (ETC) as well as the M1 Infrared technology. Roger holds numerous training certifications and has been awarded a number of thermal technology patents. At Iron Creek, Mr. Richter oversees field operations and technology development.
Permeable Reactive Barriers for Petroleum Hydrocarbons

Bruce Tunnicliffe, Vertex Environmental Inc.

Managing dissolved contamination along property boundaries or adjacent to sensitive receptors such as residential properties or streams has long been an area of focus for the environmental industry. Risk Control Measures are often required in conjunction with risk assessment or remediation. In the 1990s the permeable reactive barrier (PRB) was pioneered — an underground permeable “wall” which is a barrier to contaminants but allows the natural flow of groundwater to continue through the subsurface wall. The initial PRB used zero valent iron (ZVI), was termed the “Iron Wall”, and was very effective and widely applied for the treatment of chlorinated volatile organic compounds (cVOCs). Unfortunately the Iron Wall is ineffective for petroleum hydrocarbons (PHCs). For more than 20 years many attempts have been made at creating a PRB for the treatment of PHCs, but until recently each technique has had serious limitations.

The purpose of this talk is to showcase a new in-situ Granular Activated Carbon (GAC) based technology which has been successfully used to treat PHCs (and cVOCs) along property boundaries. The technology is referred to as a “Trap and Treat” concept. Previously the use of GAC in the subsurface has been limited due to the limited adsorptive capacity of the GAC. However, a new technology (to Canada) allows for both the adsorption and the treatment of the dissolved PHCs. Thus passive PRBs can be installed to allow for PHC plume capture and treatment over a long period of time.

This talk will present the “Trap and Treat” technology and describe how the technology can be applied along property boundaries, adjacent to streams, or along other sensitive receptors. A case study will also be provided.

Additionally, other emerging PHC PRB approaches will be showcased, compared and contrasted to the use of the Trap and Treat approach.

The talk will conclude with general recommendations on installation techniques for PRBs for PHC treatment.

Bruce Tunnicliffe, MASc, PEng

Mr. Tunnicliffe is President of Vertex Environmental Inc., is an Environmental Engineer, and has years of experience designing and implementing remediation of chlorinated solvents and petroleum hydrocarbons. Mr. Tunnicliffe holds a Master’s degree from the University of Waterloo where he studied oxidation in fractured bedrock.
Per- and Polyfluoroalkyl Substances (PFASs): Chemistry, Occurrence, Regulation, Mobility and Remediation

William H. DiGuiseppi and Monica Danon-Schaffer, CH2M

Per- and polyfluoroalkyl substances (PFASs), including from releases of aqueous film forming foams (AFFF), have been identified at various sites as compounds of interest and are generally considered emerging contaminants due to their regulatory uncertainty. PFAS contamination may be present at fire fighter training areas, fire stations and related storage facilities (military bases, civilian and others), at sites where petroleum fires were extinguished or suppressed using foam (automobile and aircraft crashes, petroleum handling facilities, refineries and aircraft hangers) and storage at shore facilities for tankers and military ships. Additionally, industrial uses for stain and water-repellency and lubrication are widespread. These complex compounds have unique chemical properties that control their behavior in the environment, as well as their toxicity. As a result of an increase in awareness and availability of toxicity information, regulations related to these compounds are rapidly evolving, with many agencies issuing new guidance or regulation in the past 2 years. This increase in regulatory and public scrutiny makes it important to have a better understanding of the chemistry and mobility of these compounds.

Remedial technologies capable of mitigating or destroying PFASs have proven elusive to the environmental consulting industry. The complexity of the AFFF mixtures, which can contain thousands of individual PFAS compounds, limit the capability of many technologies. A variety of remediation technologies have been attempted for treatment of PFASs. Many of these have only been tested or validated on perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), the two most common and most likely to be regulated degradation end-products of AFFF mixtures. While information regarding PFOS and PFOA treatment is useful, it does not answer the broader question of real-world applicability for these technologies. And although these two PFASs are presently the most watched and regulated, numerous other PFASs are being scrutinized, which is likely to lead to additional regulation of others, such as perfluorohexane sulfonate (PFHxS) or 8:2 fluorotelomer sulfonate (8:2 FtS). Recent technology tests, involving oxidation, sorption, thermal, and biological treatment from CH2M and others in academia and industry were reviewed and evaluated in terms of demonstrated effectiveness and applicability.

Monica Danon-Schaffer, PhD, P.Eng
Monica is a Principal Chemical Engineer at CH2M. With 28 years of consulting engineering experience, Monica went back to school to work on her PhD in chemical engineering. She explored how brominated flame retardants from consumer products reach the environment, circulating from waste streams to water and soil, and to distant locations. Monica’s research indicated that these contaminants persist for decades with far-reaching implications on environment and future policies. She developed a comprehensive mechanistic model to assist in predicting the concentration of brominated flame retardants (PBDEs) in and near landfills. In addition, Monica works within the Emerging Contaminants practice at CH2M, including PFAS and 1,4-dioxane compounds. Dr. Danon-Schaffer is a registered P.Eng. in BC, ON, NT, NU and YK as well as Mexico, and has extensive experience dealing with environmental, social and geologic challenges of the Arctic. She has also taught Environmental Forensics at the British Columbia Institute of Technology and is a Certified Environmental Auditor.

Bill DiGuiseppi
Bill DiGuiseppi is a principal hydrogeologist and program technology manager with almost 30 years of applied experience on 100’s of soil and groundwater investigation and remediation sites. He is a licensed Professional Geologist and is the leader of CH2M’s Chemicals and Issues of Emerging Concern Community of Practice. In that role, Bill directs a team of professionals in the identification, prioritization and management of chemicals such as 1,4-dioxane, perfluorinated compounds, 1,2,3-trichloropropane, hexavalent chromium and other critical emerging pollutants. Bill has led large and complex environmental investigation and remediation projects, published technical articles, chaired sessions at international conferences and co-authored a definitive book on 1,4-dioxane with Tom Mohr.
Phytoremediation of Impacted Soil: Field Research Trials with New Applications, Species and Challenges

Elizabeth W. Murray, Bruce Greenberg, Ben Poltorak, Kent Cryer and Perry Gerwing
Earthmaster Environmental Strategies Inc.

We have successfully developed and implemented advanced phytoremediation systems for cost effective removal of petroleum hydrocarbons (PHCs), polycyclic aromatic hydrocarbons, and salt from soils. Our plant growth promoting rhizobacteria (PGPR) enhanced phytoremediation systems (PEPS) create abundant root biomass in impacted soils, stimulate exponential growth of rhizobacteria which facilitate partitioning of contaminants out of the soil, degrade PHCs, and sequester salt into plant foliage. Soil remediation is usually complete within 3 years of treatment on PHC sites and longer term on salt sites. PEPS has been successfully deployed for 10 years on many sites located across seven Canadian Provinces/Territories to remediate PHC and salt (ECe levels up to 25 dS/m) impacts in soil. PEPS has been proven very effective and has provided significant cost savings in remote/northern areas, where harsh conditions/permafrost persist, distances are significant, and access to landfill is difficult or non-existent. Regulators support this sustainable green technology since PEPS associated plant growth assimilates carbon (CO2) and has a small carbon footprint compared to landfill disposal. Clients have adopted PEPS as an effective, low cost, green remediation technology for a variety of contaminated sites.

Earthmaster is conducting field research trials to expand the applications of PEPS. This presentation will detail field results obtained from conventional PHC sites located in northern Alberta, enhanced reclamation studies involving marginal soils and grasslands in central Alberta, preliminary data from PEPS application at a produced water spill within a wetland setting, and the use of hydro-seeding for deployment of PEPS on disturbed sites. We will also review the strategy for the selection of plant species for new phytoremediation applications.

Elizabeth W. Murray, PhD, P Biol, RP Bio
Elizabeth Murray is the Technical Reporting-QA/QC Manager for Earthmaster Environmental Strategies in Calgary, Alberta. Her background is in human genetics and she has worked for more than 20 years in medical related research and in plant based biotechnology, developing biologics as treatments for human diseases. Elizabeth has worked in environmental sciences for over 4 years and plays a lead role in the analysis and reporting of phytoremediation results.
Planning and Preparing– Effective Environmental Emergency Response

Dan Born, Enbridge Pipelines and Tanya Shanoff, Stantec

Effective Emergency response does not start at a response site. A well trained and equipped Environmental Unit is essential to execute an effective emergency response to an accidental release of hazardous materials to the environment. A programmatic approach to Environmental Emergency Planning and Preparedness can equip the Environmental Unit to respond efficiently in a coordinated and planned manner to safely restore the environment as well as help to reduce costs and liability, while preserving corporate reputation and building trust with the public.

Enbridge Pipelines Inc. and Stantec Consulting Ltd. have been working on a program of Environmental Emergency Planning and Preparedness for years in order to better support Emergency Response efforts. Based on their work, several key tools and procedures have been developed, and lessons have been learned through exercising and during implementation of the tools and procedures on actual responses in the field.

Successes have included:

• Standardized plans and guidance documents for key environmental issues during responses
• Establishment of scientifically defensible procedures for environmental response activities
• Training and preparing staff for events through Environmental Unit specific exercises and training modules.
• Preparing execution templates ahead of time to advance the timely completion of site specific plans at the time of an incident
• Verification of the program’s value through response experience.

Challenges have ranged from:

• Creating materials to apply across multiple jurisdictions and regulatory environments
• Establishing materials to address most eventualities
• Adapting plans to address changing site conditions and priorities during a response

By reviewing key approaches to Environmental Emergency Response Planning and Preparedness through examples of program elements and their benefits to common response situations, we will show how a well coordinated Environmental Unit operating based on an Environmental Emergency Planning and Preparedness program can be most effective.

Curtis Wakulchyk, P.Ag. is the Canadian Environmental Response Preparedness Coordinator with Enbridge Pipelines. He has been with Enbridge for four years and been working the in the oil and gas industry for thirteen years. He has lead environmental units on both small and large releases, and overseen numerous contaminated sites over his career. Mr. Wakulchyk holds a Bachelor of Science in Environmental Science from the University of Alberta, and is a licensed Professional Agrologist in the Province of Alberta.

Tanya Shanoff, MSc, PGeo
Tanya Shanoff is a Senior Hydrogeologist with over eighteen years of environmental consulting experience working in Ontario, Québec, British Columbia, Saskatchewan and Alberta. She is currently the Canadian Coordinator for the Emergency Planning and Response Discipline at Stantec. Her work history has included supporting environmental emergency response projects throughout Canada, as well as conducting environmental site assessments, remediation and risk assessment projects for a wide range of industrial, commercial and government sector clients. Mrs. Shanoff holds a Bachelor of Science and a Master’s of Science degree in Earth Sciences from the University of Waterloo, and is a licensed Professional Geoscientist in the Provinces of Alberta, British Columbia and Ontario.

Dan Born, MSc
Dan Born is the Canadian Contaminated Sites Program Team Lead with Enbridge Pipelines. He has been with Enbridge for four years and been working the in the oil and gas and environmental consulting industries for fifteen years. He has supported the Environmental Unit in ICS on both small and large releases, and overseen numerous contaminated sites programs over his career. Mr. Born holds a Bachelor of Science in Environmental Physical Sciences and a Master of Science in Earth and Atmospheric Sciences, both from the University of Alberta.
Proper Interpretations of Lab Data for Highly Organic Soils

Anthony Neumann, Darlene Lintott and Chris Swyngedouw, Exova Canada

The evaluation of lab results for highly organic soil samples can easily lead to misinterpretation of these sites. If results are simply interpreted and compared to the Alberta Tier 1 numerical guidelines, these sites often appear to be contaminated, even on sites that are supposed to be considered controls. This raises concerns that the contaminate may have traveled further off site than expected which can lead to unnecessary cleanup costs and to the needless disturbance of these ecologically sensitive sites. Alternatively, incomplete interpretation can lead to insufficient cleanup and extended disturbance of these sensitive sites.

Most guidelines for soil are based on the mineral qualities of soil and the guidelines determined are structured towards several of the physical characteristics of this soil type. Organic matter content in the soil can cause significant changes in the physical characteristics typical of a mineral soil. Organic matter content for soils in southern and central Alberta are typically below 10% of the total mass of the soil. Further, subsoils have almost no organic matter content. As such, the prevailing physical characteristics of mineral content in these soils lead to simple interpretation of the laboratory data.

Much of Northern Alberta and Northern BC consist of large swaths of soils that are highly organic such as muskegs, fens and bogs. They also typically go very deep and result in “subsoils” that are highly organic. These organic soils tend to have very different physical characteristics from typical mineral soils due primarily to the high organic content. Factors, such as moisture content, bulk density and available water content are often immensely different from mineral soils. These organic soils also act as sinks to absorb, incorporate and produce hydrocarbons, often leading to the incorrect interpretation of the movement of contamination off a site.

This presentation will focus on the differentiating aspects of organic soils from mineral soils and provide clarity on the use of these factors when interpreting the laboratory results. We will specifically look at how moisture content, bulk density and saturation percentages can affect metals and salinity results. We will also briefly touch on how these factors plus the potential extraction of naturally occurring hydrocarbons can affect the interpretation of hydrocarbon data.
PS3260 – How Accounting Will Shape Our Communities

Chris Gil, Stantec

Over the past several years, the Public Service Accounting Board (PSAB) has developed a new standard specifically to address potential environmental liability exposure to public entities. To date, very few federal custodial departments, provincial groups or municipalities have made any attempt to fiscally record such liabilities. The new standard (PS3260) was prepared to bridge this gap and ensure a full disclosure of liabilities is presented in annual financial statements. This standard applies to any public sector entity that subscribes to the PSAB standards. Examples include all federal departments, all provincial departments, all provincial hospital boards, municipal bodies, and even public school boards. The standard was adopted in April 2014 and requires all those subscribing to PSAB standards to fully adopt PS3260 by their year end financial reporting period. Through the steps involved in determining these liabilities, public entities will be ultimately creating inventories of known and potential impacted holdings. This will allow for the discovery of brownfield sites that can be ultimately transformed into assets. Through this accounting process, and its associated inherent requirement to prevent impacted sites to be theoretically ‘swept under the carpet, the resultant pressure to identify and record liabilities associated with these ‘derelict’ properties may ultimately be the catalyst that allows our communities to see the potential in these forgotten parcels and lead to reimagined spaces.

Chris Gill, BA(Env), EP, LEED AP

Chris has worked in the environmental and energy/natural resource industries in Western Canada for over 15 years. His experiences to date have focused primarily on the overall project management/planning/coordination, field work, reporting, and reviewing of over 500 Phase I, II, and III Environmental Site Assessments (ESAs) in western Canada for both local and national commercial real estate and development clientele. Chris recently joined Stantec's Environmental Services sector as an Associate focusing on the development of brownfield sites with the intent of blending his contaminated sites experience with Stantec's involvement in community development. His career to date has allowed him experiences not only in the technical practices surrounding contaminated site assessment/building sciences/property development, but also in various business development and client liaison activities including presenting numerous talks/presentations over the years at client and industry events.
Remediation and Risk Management Scenarios for Proposed West Village Development Area, Calgary, Alberta

Tom Jacklin, Advisian; Aaron Jambrosic, AECOM; Martha Watson, Watson Consulting and Julie Sullivan, Barr Engineering Co.

Redevelopment of the West Village site on the west end of downtown Calgary is being evaluated. The 56-hectare (139-acre) site is bordered on the north by Bow Trail westbound and the Bow River, on the east by 11 Street SW, on the south by Bow Trail eastbound and the CPR tracks and on the west by Crowchild Trail. The area is currently occupied by GSL GM City, Renfrew Chrysler, Hyatt Auto Gallery, Pumphouse Theatre, Mewata Armoury, the Greyhound terminal and a handful of other businesses.

The site was the former location of many industrial operations that adversely impacted the property, including the former Canada Creosote Site (CCS) which was active on-site between 1924 and 1962. A variety of other commercial and industrial facilities have historically been present on the surrounding lands, including fuel storage tanks, municipal waste incineration, light industrial businesses, car dealerships and service stations.

Recent work focused on a remediation analysis based around development scenarios in the approved Area Redevelopment Plan and a proposal by CalgaryNext. An identification and screening of remediation strategies was completed and various technology combinations were configured based on previous performance success on similar wood treating sites. Details for each technology combination or approach were examined for schedule and costing.

Tom Jacklin, MEng, PEng
Tom Jacklin is a principal environmental engineer at Advisian (a division of WorleyParsons Canada) in Calgary, Alberta. He obtained a M.Eng. from the University of Alberta in 1991, and has worked on petrochemical and wood treating sites for the past 25 years. His experience includes innovative development of site investigation approaches, remedial options and solutions for DNAPL and LNAPL sites.

Aaron Jambrosic, BS, MS
Aaron Jambrosic is an Senior Environmental Scientist at AECOM with ten years of experience in hydrogeological assessment and contaminated site investigation; remedial system design, construction and operation; hydraulic and multiphase modelling at contaminated sites throughout Canada, the United States and, Australia. Aaron received a B.S. degree in Geology from University of New Mexico a M.S. Environmental Science and Engineering from Oregon Health Science University in 2003.

Martha Watson, MS
Martha Watson has more than 30 years’ experience providing remedial investigation, design and management services for a variety of commercial and industrial projects within the United States and Canada. She obtained her M.S. in Environmental Science and Engineering from Stanford University in 1985 and is the past president of a consulting division of a Canadian-based environmental drilling company.

Julie Sullivan, MS, PE
Julie Sullivan is a senior environmental engineer and senior project manager at Barr Engineering Co. in Minneapolis, Minnesota. She has 18 years of experience in all areas of site remediation and redevelopment, including site assessment and investigation, remedial alternative evaluation, remedial design and implementation, cost estimating and value engineering for soil, groundwater, sediment, and soil vapour. Ms. Sullivan received a B.S. degree in Aerospace Engineering and an M.S. degree in Civil Engineering, with an emphasis in environmental engineering, from the University of Minnesota.
Remediation of Poly- and Perfluoro Alkyl Substances: New Remediation Technologies for Emerging Challenges

Ian Ross, Jake Hurst, Jeff Burdick, Erica Kalve, Erika Houtz and Tessa Pancras, ARCADIS

Poly- and perfluoro alkyl substances (PFAS) comprise a diverse class of contaminants which include PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctanoic acid). PFAS are not amenable to bioremediation or conventional chemical oxidation and are difficult to remediate in situ in soil and groundwater systems. Further complicating the remediation challenges are the presence of precursor PFAS that are often present at locations where AFFF (aqueous film forming foam) has been released and are not analysed for by standard analytical laboratory methods (US EPA method 537). These precursors can act as a source of perfluorinated carboxylates and sulphonates, as some precursors are less mobile but they all will biotransform over time forming perfluorinated compounds as dead end daughter products.

Remediation of PFAS impacted sources and plumes will require multiple approaches to achieve objectives to address sources and evolving plumes often to be protective of human health via treatment of water abstracted as a potable supply.

PFAS are relatively ubiquitous in the environment at very low concentrations, but point sources such as some industrial or many domestic landfills, areas used for fire training, some biosolids applications and locations of manufacture of PFAS themselves or derivative products could all be point sources of high PFAS concentrations, potentially causing elevated concentrations local to these sites.

Innovative and emerging remediation solutions for PFAS include a number of types of technologies to address highly concentrated source zones, mitigate mass flux of impacts to aquifers or address PFAS in abstracted water. Use of granular activated carbon (GAC) to treat PFAS will only effectively remove a proportion of these contaminants, whilst offering a very low binding capacity for PFOS (as compared to hydrocarbons), so can be costly.

Challenges of more comprehensive PFAS treatment are currently addressed using technologies such as reverse osmosis or nanofiltration. There are new precipitation technologies for water treatment, novel ion exchange resins and sorptive media which show promise and will be summarized.

Conventional chemical oxidation, which promotes formation of the sulphate and hydroxyl radicals as strong oxidants appears ineffective against some perfluorinated compounds, such as PFOS (perfluorooctane sulfonate). However, recent laboratory work has demonstrated that activated persulfate could be capable of degrading PFOS and the degradation mechanism is hypothesized to be a combination of oxidation and reduction as defluorination is observed. The decreases in PFOS concentrations are only observed when a specific activation method is employed, as with the smart combined oxidation and reduction (ScisoR®) technology. Recent results from laboratory trials with this technology will be presented.

Ian Ross PhD

Dr. Ian Ross is a biochemist by training and now works for ARCADIS as a technical expert for assessment of contaminated land sites and remediation. He started R&D examining the biodegradation of xenobiotics some 23 years ago and worked for Blagden Chemicals, ICI and the Defence Science and Technical Laboratories (part of the UK Ministry of Defence) whilst at Aberystwyth, Bangor and Cambridge Universities.

He started working for ARCADIS in 2002 delivering innovative solutions for soil and groundwater remediation, and delivered multiple cutting edge in situ remediation projects involving addition of nitrate, sulphate, carbohydrates and differing oxidants to soil and groundwater.

To enable successful implementation of innovative strategies, which offered clients more cost effective and sustainable business outcomes, he set up and ran the European Treatability Laboratory which enabled design of innovative remediation projects for ARCADIS across Europe. This laboratory enabled research in collaboration with several UK Universities with multiple Ph.D. and MSc students who developed novel contaminated land solutions.

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He designed and implemented the world’s first in situ remediation of carbon disulfide using activated persulfate, which won the 2011 UK brownfield briefing award for best in situ remediation project and the Italian Sapiem 2012 Innovation award.

He designed a combined soil washing and chemical oxidation project for a landfill contaminated with pharmaceutical waste which won a Brownfield Briefing award in 2012.

He spent 3 years as the technical and business manager for FMC Environmental Solutions in EMEA developing a detailed understanding of the remediation business and opportunities across Europe and further afield, winning work by designing large scale remediation projects in China, Hungary and South Africa.

As a result of his marketing of ARCADIS’s remediation capabilities at European conferences, ARCADIS were requested to tender for environmental works at a large pharmaceutical site and won a series of projects involving the largest site investigation done by ARCADIS UK and a series of remediation projects at the same site. He collaborated on technical proposals to win ARCADIS a series of substantial ERD projects in the UK and worked as part of a guaranteed remediation team devising innovative strategies to position ARCADIS as a provider cutting edge solutions for clients which offer a more cost effective and sustainable outcomes.

His recent focus has been on PFAS (poly/per fluorinated alkyl substances) as a result of developing novel in situ remedial solutions and he has assisted ARCADIS by authoring and reviewing the CONCAWE PFAS guidance document, to be published in 2016.

Caitlin H. Bell, PE
Caitlin Bell is a Senior Environmental Engineer and 1,4-Dioxane Lead for Arcadis North America. Ms. Bell focuses on subsurface treatment of soil and groundwater using in-situ techniques. Specifically, she focuses on in-situ bioremediation applications for a variety of chemicals of concern, including emerging contaminants. She serves as a technical resource to clients on topics such as molecular biology tools, bioaugmentation, compound specific isotope analysis, and challenging bioremediation approaches for compounds like 1,4-dioxane. Ms. Bell was a member of the team that authored the Interstate Technology & Regulatory Council’s Environmental Molecular Diagnostics technical guidance document and has presented routinely on remediation topics at industry conferences.
Review and Recommended Changes to the Saturation Paste Method to Determine Concentrations of Sodium and Chloride in Muskeg

Dan Gorsic, SynergyAspen Environmental

Summary  The analytical method currently used by industry grossly overestimates the concentrations of sodium and chloride in muskeg samples. SynergyAspen Environmental Inc. (SynergyAspen) applied for and obtained funding from the BC Oil and Gas Research and Innovation Society (BC OGRIS) to review the analytical method used and to propose a better one.

SynergyAspen worked closely with Maxxam Analytics (Maxxam) and CARO Analytical Services (CARO). Muskeg samples spiked with known concentrations and volumes of produced water were analysed using the following laboratory methods:

• Standard Saturated Paste Method (currently used by industry);
• As-Received “Squeeze and Analyze”; and,
• Intentionally Over-Saturate.

The following table summarizes the rankings (from best (1) to worst (3)) based on % recovery values (standard deviation and range values).

<table>
<thead>
<tr>
<th>Test Method Ranking Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODIUM</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Range (Maximum – Minimum)</td>
</tr>
</tbody>
</table>

CHLORIDE

| Standard Saturated Paste^ | M3 As-Received (mg/L) | Over Saturate* (mg/L) |
| Standard Deviation | 3 | 2 | 1 |
| Maximum – Minimum Range | 3 | 2 | 1 |

Note:  ^Method currently used by industry.
*Based on average values of the Over-Saturated Method (M4a and M4b) results; and,

Bold 1: Ranking as the most ideal result.

As can be observed in the Table, the over saturated method produced the best correlation and overall the best data with respect to percent recovery.

With this increased accuracy, SynergyAspen believes there will be enormous benefit to the upstream Oil and Gas industry, not only in cost savings by reducing the amount of muskeg being unnecessarily remediated without compromising environmental integrity, but also by preserving the natural muskeg setting which takes thousands of years to generate.


Daniel Gorsic, PChem

Synergy is led by Mr. Daniel Gorsic, PChem, CEO/Director. Mr. Gorsic started his contaminated sites career in 1994 and is a member of the Association of Professional Chemists of British Columbia. Mr. Gorsic is committed to meeting the needs of Synergy’s clients, to develop and share a vision for Synergy’s success, encourage and develop staff and to obtain results.
Risk Management Revisited – Corrective Actions Related to a Leaking Brine Lagoon

Frans Hettinga and Aziz Shaikh, Tetra Tech EBA Inc.

Large quantities of a concentrated brine (sodium chloride) solution used by an industrial facility in Alberta had been contained in two lined brine lagoons with a combined volume of more than 50,000 m³. The industrial facility operated under an Alberta Environmental Protection and Enhancement Act (EPEA) Approval and a compliance groundwater monitoring program had been in place since the late 1980s. Around 2001, the results of the monitoring program suggested that the groundwater quality near the brine lagoons was adversely affected by salt. The impact was traced back to an accidental release of brine. The extent of soil and groundwater quality impact was assessed and, as source removal was not deemed feasible, in part due to risks to the integrity of the liners, a risk management plan (RMP) was prepared and implemented.

Groundwater monitoring in accordance with the EPEA Approval, and as stipulated in the RMP, continued. At first the results were consistent with what was predicted by the groundwater quality model that was used to prepare the RMP; however, over the years the results diverted further from what was expected even though repairs were made to the liner material in the older, single-lined lagoon. Of particular concern was that soils underlying the lagoons are mostly coarse-grained and groundwater flow is directed towards a nearby creek.

As part of the compliance groundwater monitoring program, the water quality in the creek was also monitored. When two subsequent monitoring events in 2014 showed exceedances of freshwater aquatic life guidelines for chloride, it became obvious that the assumptions of the RMP were no longer valid and that corrective action was urgently needed. It was decided that the older, single-lined lagoon that had developed integrity issues needed to be emptied to stop further releases of brine.

The presentation describes how during 2015 a large number of actions were undertaken including several meetings with the regulator, design of a new and state-of-the-art containment lagoon, amending the EPEA Approval, tendering and constructing a new lagoon and preparation of a new RMP.

The contents of the older brine lagoon were transferred to the new double-lined lagoon in early 2016 and although some saline sludge remains in the old lagoon, the level is well below where leaks previously had occurred. The groundwater model used to update the RMP predicts that with some remedial activities, chloride concentrations in groundwater near the creek will decrease within one or two years. Initiatives to drastically reduce the volume of brine stored at the facility are also underway, and when the new brine lagoon is no longer needed, the design allows for it to be used as an additional anaerobic waste water treatment lagoon for the facility.

Frans Hettinga
Frans Hettinga is a Principal Specialist with Tetra Tech EBA Inc. in Calgary, Alberta. He has a background in analytical chemistry and chemical engineering and more than 25 years of consulting experience in the Netherlands and Western Canada. His project work focuses on environmental site assessments (ESAs), compliance soil and groundwater monitoring, risk management and remediation.

Aziz Shaikh
Aziz Shaikh is a Senior Hydrogeological Engineer and Team Lead in Tetra Tech EBA’s Calgary office. He has more than 15 years of experience in contaminant hydrogeology and groundwater modelling including at many sites where salt has affected the quality of soil and groundwater.
Rock Bay Remediation Project

Lindsay Thompson and Ryan Stewart, BC Hydro

Rock Bay, in Victoria’s upper harbor, was listed as a “High Risk” contaminated site by the MOE prior to the Project removing high risk contamination.

The Project removed tens of thousands of tonnes of contaminated soil and thousands of Litres of coal tar using innovative and sustainable techniques. The Project significantly reduced liability associated with contaminated land by obtaining Certificates of Compliance from MOE. The Project has received 7 Certificates of Compliance to date with 8 more Certificates of Compliance applications planned or with the Ministry of Environment for review.

After many years of frustrated stakeholders, the Project re-engaged with stakeholders following an open and transparent approach to discussions. The project partnered with local First Nations and was successful in re-establishing a positive relationship with BC Hydro. First Nations companies were contracted to perform some of the work and the Project engaged First Nations artists to prepare a First Nations focused mural on the fence around the site.

After a long stalemate trying to demolish a derelict heritage building that was beyond saving, the Project devised a plan and successfully negotiated a heritage revitalization agreement with the City. In the process the project gained community acceptance for the demolition whereas before there had been much opposition. Two key goals were achieved. The two most significant heritage buildings were saved for future community enjoyment and the third building was removed allowing the team to remove a deep well full of coal tar.

The Project is returning 5.3 acres and the two heritage buildings to productive use in the community.

Lindsay Thompson, MA, PMP

Ms. Lindsay Thompson graduated with a Master’s degree in Museum Design and First Nations Relations in 2005 from the University of British Columbia, and obtained Project Management Professional certification from the B.C. Institute of Technology in 2008. Prior to joining BC Hydro, Lindsay worked for five years as a Project Manager for two museums. In 2007, she joined BC Hydro and shortly thereafter commenced her work as Project Manager for the Rock Bay Remediation Project. Currently Lindsay is a Senior Manager with Aboriginal Relations for BC Hydro’s projects and programs.

Ryan Stewart, PGeo, PMP

Mr. Ryan Stewart is the Owner’s Environmental Representative for BC Hydro’s Project Environmental Risk Management business unit. In his position as Deputy Project Manager on the Rock Bay Remediation Project, Mr. Stewart led a team of environmental professionals to undertake remediation of one of the most heavily contaminated sites in the province of BC. Mr. Stewart has 17 years of experience in the environmental industry with most of this time spent leading investigation and remediation projects for BC Hydro.
Advisian was retained by Calgary Municipal Land Corporation (CMLC) to complete an Environmental Site Assessment (ESA) of the former Canada Creosote Site (CCS; the Site), at the West Village development in Calgary, Alberta. CCS wood treatment operations were active on Site between 1924 and 1962. A variety of other commercial and industrial facilities have historically been present on the Site and surrounding lands, including fuel storage tanks, municipal waste incineration, railway lines, car dealerships and service stations.

The purpose of the ESA was to further evaluate data gaps in soil, groundwater, soil vapour and bedrock characterization at areas of potential environmental concern (APECs). Recent ESA work supplemented earlier studies from the mid-1980’s onward. The ESA linked into concurrent risk assessment and remedial options evaluation in early 2016, to assist CMLC and other stakeholders in making informed decisions regarding environmental liabilities and redevelopment options.

ESA consisted of 54 boreholes advanced by sonic and direct push techniques into overburden (silty fill and sand/gravel alluvium deposits) and upper bedrock to a maximum depth of 20 metres below grade (mbgs). Groundwater monitoring wells were completed in 3 water-bearing zones, while soil vapour monitoring (SVM) probes were installed in fill. Downhole geophysical measurements were obtained from upper and lower bedrock boreholes using tools to assess temperature, conductivity, potential fluid flow, and fracture/joint orientations.

Both dense and light non-aqueous phase liquids (DNAPL/LNAPL) were observed near former CCS facilities and fuel tanks. DNAPL is present south of a remediation containment wall, installed in 1996 approximately 30 m south of the Bow River. The majority of DNAPL has accumulated in alluvium (sand/gravel) and 1 to 2 m into the weathered upper bedrock, particularly in topographic lows in the bedrock surface. LNAPL is also present in relatively limited areas. Multiple lines of evidence indicate residual DNAPL/LNAPL extent has been delineated. Soil impacts exceeding applied guidelines correlate with the inferred residual NAPL. Groundwater impacts typically extend 25 m beyond impacted soils.

Understanding of weathered bedrock fracturing has been improved. Discrete fractures represent both horizontal and sub-vertical pathways for potential DNAPL or dissolved phase migration. However, groundwater data from bedrock underlying the DNAPL footprint indicate dissolved COCs do not extend into the lower bedrock.

This presentation will focus on a brief site history, key findings of the recent ESA work, and present an updated conceptual site model to illustrate our current understanding of the Site.

Michael Brown, MSc, PGeol
Michael Brown is a principal hydrogeologist at Advisian (a division of WorleyParsons Canada) in Calgary, Alberta. He obtained an M.Sc. from the University of Waterloo in 1993, worked on applied contaminant hydrogeology research for 3 years, and has been a hydrogeological consultant for the past 20 years in western Canada. His experience includes contaminated site assessments, remedial options analysis, environmental liability assessment, and development of innovative in situ remedial systems for impacted groundwater and soil.

Brendan Christensen, MSc, EIT
Brendan Christensen is a hydrogeological engineer at Advisian in Calgary, Alberta. He obtained an M.Sc. from the University of Calgary in 2013, and has been a hydrogeological consultant in Alberta for the past 4 years. His experience includes groundwater monitoring, soil investigations, and hydro-geochemical analysis.
Successes of The City of Calgary’s Leachate Treatment Pilot Plant, and Use of Treated Leachate to Build a Greener Future

Owrang Kashef, CH2M and Lourdes N. Lugue, The City of Calgary

One of the biggest challenges facing landfill owners is how to handle landfill leachate, the black, foul-smelling liquid that may contaminate soil and groundwater, and is costly to manage and treat. The City of Calgary engaged CH2M HILL Canada Limited (CH2M) to undertake the conceptual design, supervise the fabrication and site construction, and provide operational support for a new Leachate Treatment Pilot Plant (LTPP). Operation of the LTPP includes studying system effluent reuse options.

Located at the City’s East Calgary Waste Management Facility (WMF), the pilot plant is one of the first facilities in Canada to study treated leachate and explore opportunities for its reuse. CH2M is assisting the City with implementing its vision to use the treated leachate as part of a greening initiative at the landfill and as process water within the pilot plant. An important objective of the study is to identify options for establishing ultimate treatment levels and effluent water quality from the treatment in order to optimize treatment cost. To do this, CH2M and the City are studying the reuse value of the treated effluent as horticultural irrigation water in a purpose-built greenhouse.

Landfill leachate presents challenges for treatment because of its composition variability over time, comprising of a wide range of contaminant types and levels. No one treatment process can treat raw leachate to discharge-quality on its own. The pilot plant is designed to take raw leachate and pass it through three different treatment processes, each of which removes specific types of the chemicals and compounds. The first treatment process involves chemical precipitation to remove heavy metals. This is followed by biological treatment using a membrane bioreactor (MBR) process to remove the organics and ammonia. Finally, a reverse osmosis (RO) process is used for dissolved inorganics removal, boron, and final polishing. The resulting effluent meets quality standards suitable for direct release to the environment.

To study reuse options for treated leachate, a small greenhouse was constructed by The City, next to the pilot plant to grow plants that will be used for a broader City greening initiative at the WMF. CH2M is supporting the City in conducting pilot study to evaluate the effect of the treated leachate on the growth of horticultural plants in the greenhouse.

This presentation will focus on the treatment capability of the LTPP, provide summary of findings and reuse alternatives being investigated by The City and CH2M.

Owrang Kashef, MBA, PEng

Owrang Kashef is a Senior Project Manager and an Environmental Engineer with 30 years of diversified engineering experience across North America in the areas of environmental and water resources engineering, mechanical design, and project implementation and management. In this role with CH2M’s Calgary office, he has worked on designs and operation of mechanical and instrumentation systems, managed numerous large and small scale studies and engineering projects and has successfully completed them. He has been a Project Manager on numerous projects for The City of Calgary, including the East Calgary Leachate Treatment Pilot Plant, which was selected as recipient of 2016 Consulting Engineers of Alberta awards of merit in the Environmental and Sustainable Design categories.
Surfactant Enhanced Aquifer Remediation of a Low Permeability Unit Containing Light Non-Aqueous Phase Liquid


**Background/Objectives.** A release of gasoline was discovered in 1991 at an active gas station facility in Richmond Hill, Georgia. Subsequent subsurface investigations documented the presence of persistent light non-aqueous phase liquid (LNAPL) beneath the dispenser islands at thicknesses up to 1.35 feet in 2012. Total benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations within the source area exceeded 100,000 µg/L. The subsurface lithology at the site consisted of lean to fat clays with an average hydraulic conductivity of 6.55x10⁻⁵ cm/sec. Previous high vacuum recovery (HVR) events conducted over several years failed to extract appreciable volumes of LNAPL and contaminated groundwater due to the low permeability of the surficial aquifer. The presence of LNAPL and vapor intrusion concerns with the on-site building necessitated additional corrective action.

Surfactant Enhanced Aquifer Remediation (SEAR) was selected as the most appropriate technology to achieve the remedial action objectives in a short time frame. The remedial objectives of SEAR implementation included reduction of LNAPL concentrations to residual saturation and to establish a steady state dissolved phase plume to allow for subsequent natural attenuation processes and risk-based closure.

**Approach/Activities.** Pilot testing results indicated a radius of influence of 10 feet for the 10-foot thick treatment area. The need for 2-inch diameter injection/extraction wells installed via hollow stem auger was also established. Given the limited radius of influence and the requirement for the site to maintain operation during remediation, the treatment area consisting of eight (8) existing monitoring wells and thirteen (13) injection/extraction wells was divided into two separate cells. SEAR events were conducted within each cell over a two week period. Within each cell, a 16-hour HVR event induced localized drawdown to expose the vadose zone and saturated zone interface, which contained the majority of the residual LNAPL mass. Immediately following the 16-hour HVR event, 250 – 500 gallons of a 4% nonionic surfactant solution was injected at 35 PSI into wells within the target cell. A 24-hour HVR event was conducted within the target cell approximately 24 hours following the conclusion of surfactant solution injection. The purpose of the 24-hour HVR event was to recover desorbed LNAPL, emulsified liquids, dissolved phase contamination, and surfactant injectate. In total, 4,864 gallons of surfactant solution was injected into the subsurface and 10,108 gallons of petroleum contact water and injectate was recovered.

**Results/Lessons Learned.** The SEAR events increased the recovery of petroleum by 80% over the most recent HVR-only event. A groundwater monitoring event was conducted forty (40) days following the completion of the SEAR events. The number of wells exhibiting LNAPL was reduced from the baseline condition of six (6) wells to two (2) wells, with a maximum thickness of 0.24 feet. Laboratory analytical data indicated an approximate 40% decrease in BTEX concentrations within source area monitoring wells. A smaller scale, focused SEAR event is planned to remove remaining LNAPL.

While the use of surfactants to mobilize sorbed LNAPL is a well-established remedial technology, the above strategy was utilized to overcome unfavorable lithologic conditions, a short time frame for remediation, and logistical challenges due to the active nature of the site.

**R. Luke Bragg, PE**

Luke Bragg is an environmental engineer with Terracon Consultants, Inc. Mr. Bragg is a 2011 graduate of Mercer University in Macon, Georgia with a Bachelor of Science degree in Environmental Engineering. Mr. Bragg is primarily involved in assessment and remediation of petroleum and chlorinated solvent impacted sites in the Southeastern United States. Mr. Bragg is a Professional Engineer licensed in the states of Georgia and South Carolina.
Sustainable Strategies for Site Remediation

Michael Lakustiak and Ron Sparrow, Trace Associates

Over the past three decades, much has changed in remediation solutions; however, our industry continues to excavate and landfill the majority of contaminated sites, while the general public is increasingly concerned with sustainability, especially carbon emissions. Societal expectations and environmental regulations have all had paradigm shifts. What would it look like if we approached things differently and the remediation community took a more holistic approach? Our industry has an opportunity to focus and consider other objectives such as:

- Optimizing energy intensive systems.
- Preserving the ecology and soil.
- Optimizing efficiency and cost.
- Minimizing our carbon footprint.

Trace will provide ideas and real-life examples of how these objectives can be applied. Examples include:

- Incorporating constructed wetlands to reduce remediation and reclamation costs, as well as greenhouse gas emissions.
- Utilizing phytoremediation and sustainable technologies.
- Discerning natural conditions in soils from actual petroleum-related impacts.

Ultimately, these objectives ensure cost effectiveness, increased worker safety, and reduced greenhouse gas emissions during the full life cycle of remediation projects.

Michael Lakustiak, BASc, PEng

Michael Lakustiak is a Senior Environmental Engineer at Trace with over 20 years of experience in environmental consulting across all market sectors. At Trace, Michael is responsible for providing senior technical environmental engineering guidance on environmental site assessment, monitoring, remediation, environmental liability, risk management, and investigation projects. Michael is committed to helping clients achieve their commitments of continual improvement of their environmental performance and prevention of pollution to the environment through the use of innovative and cost-effective practical solutions.

Monique Wismer, MSc, MBA

Monique Wismer is the Saskatoon and Regina Division Manager for Trace. Monique has over 13 years of experience working in environmental sustainability reporting, third-party reviews of environmental statements, greenhouse gas credit calculations, life cycle assessment, and environmental auditing. Monique works with clients to improve environmental regulatory compliance, communicate environmental performance, meet environmental targets, and reduce operational costs.

Ron Sparrow, BSc, RPF, CPESC

Ron Sparrow is a registered professional forester with over 25 years of experience working for industry and government in Alberta, British Columbia, and Saskatchewan. At Trace, Ron is responsible for providing senior level advisory to Trace personnel regarding various reclamation and natural sciences projects. Ron is a Partner in the firm and is involved in strategic planning and business development activities. He enjoys collaborating with clients to think “outside of the box” and find simple, cost-effective answers to all types of problems or challenges, whether simple or highly complex.
SVE System — Extracting Vapours and Value
Michelle Heffernan and Jason Hampson, Trace Associates

Trace Associates Inc. (Trace) provided a client in Central Alberta with an innovative and cost-effective remedial solution to address a condensate pipeline release. Trace personnel conducted assessment activities on the spill site and identified condensate impacts to a depth of 10 metres (m), with an impacted soil volume of 25,000 cubic metres (m³). Assessment activities were combined with remedial pilot testing to work toward a defined, end point of spill remediation and cost-effective site closure. This presentation will include an overview of the methods used to develop the remedial approach and the site conditions that led to the implementation of an in-situ approach:

- Large volume of impact (25,000 m³) to an extended depth (10 m).
- Assessment identified light end hydrocarbons as the only contaminant of concern.
- Groundwater was not present in the area of impact and soil impacts were present in very coarse-grained material with a fine-grained confining layer below.
- High costs associated with a “dig and dump” scenario due to large volume and extended depth of soil impact.

Throughout the process, Trace reviewed various remedial options. Following identification of the initial site conditions, pilot scale testing for a potential vapour extraction system (VES) scenario was built into the follow-up assessment activities.

Pilot testing was conducted by Sequoia Environmental Remediation Inc. in conjunction with Trace during the final impact delineation assessment, which was required in order to receive regulatory buy-in on the remedial option. Following the successful pilot tests on shallow and deep impacts, a full-scale treatment system was approved by the client and applicable regulators and was installed on the Site in January 2016.

Since installation, the system has been monitored monthly and annual groundwater monitoring for 2016 is pending. The monthly monitoring of the system identified the following:

- The SVE system is successfully extracting soil vapour, and therefore, removing contaminant mass.
- Groundwater is being produced during vacuum operation on the deep monitoring wells.

Challenges identified included the following:

- Water produced by the system during winter months created freezing issues which limited valve mobility.
- Vacuum on the deep wells was shut down in winter months; thus reducing system functionality.

Further system optimization is required and in progress to manage the water production; however, early monitoring results suggest that the system is indeed removing contaminant mass as intended.

Trace and the client are working closely with the appropriate regulators throughout the project to provide ongoing status updates. A plan for monitoring soil/groundwater and confirming remediation success was prepared and approved by the regulator.

Ms. Michelle Heffernan, BSc, PAg
Michelle Heffernan is a Partner and a Special Projects Manager with Trace, and has over nine years of experience in conducting environmental site assessments, remediation, reclamation, and groundwater monitoring related to oil and gas, industrial, and land development activities. At Trace, Michelle specializes in management of large scale, complex assessment and remediation projects and is involved in the strategic planning of the firm.

Mr. Jason Hampson, BSc, PAg
Jason is a Partner and Principal Scientist with Trace, and has over 16 years of experience in conducting Environmental Site Assessments, remediation, risk management plans, environmental liability assessments, and groundwater monitoring related to oil and gas, industrial, and land development activities. At Trace, Jason specializes in management of large scale, complex assessment and remediation projects and is involved in the strategic planning of the firm.
Tackling Chlorinated Solvent Contamination — What are the Options?

Jean Paré, Chemco

Chlorinated Solvents are challenging contaminants species as they tend to sink below the water table and their natural biodegradation pathways can generate toxic sub-product.

This presentation will review novel and existing treatment options that can be used to cope with these challenging sites. Presentation will cover the following methods:

- Chemical Oxidation
- Chemical Reduction
- Enhanced Bioremediation
- Permeable Reactive Barriers

Presentation will touch design and application parameters so that the attendees can understand under which circumstances each technology can be applied to existing sites.

One of the novel technology presented will be a liquid injectable product combining micrometric zero valent iron and a fermentable carbon substrate that when combined together create a synergistic destruction of the contaminant thus minimizing the problematic sub-product formation.

Case study will also illustrate the treatment capacity for these remedial options.

Jean Paré PEng

Mr. Paré P. Eng., has a degree in Chemical Engineering from Laval University. He has been involved for the last 18 year in the evaluation, development, design and promotion of both conventional and innovative environmental technologies within the Industrial sectors, the Engineering Firms, the Specialized Environmental Consultants and the various levels of Governments. As Vice-President with Chemco Inc., Mr. Paré responsibilities includes the development of remediation strategies, the assistance in drafting certificates of authorization, the technico-economical analysis, the design and the supply of storage equipment, pumps and the logistics of supply for the projects. Last year, Mr. Paré has worked with over 350 sites applying it’s expertise to various type of contaminants ranging from chlorinated compound, pesticides and petroleum hydrocarbons. He is also involved with many Environmental organizations like the Canadian Brownfield Network, ESAA, OCETA, CLRA and Reseau-Environnment where he is an active technical committee member and speaker.
Technical Challenges of Large Scale Spill Response and Remediation Projects

Jeremy Paul, Northshore Environmental Consultants

Most unplanned releases come with technical challenges surrounding clean-up activities, including but not limited to rapid logistics planning, unknown site conditions, and access constraints. However, large scale releases have unique and complex technical challenges that sometimes require innovative solutions to achieve project closure.

North Shore Environmental Consultants Inc. (North Shore) has worked on a large number of large scale spill response and remediation projects over the past decade and has faced many unique challenges that we have had to overcome. This presentation outlines some strategies and methods to consider when conducting large scale spill response and remediation activities.

During the initial response phase of a release, clean-up efforts are typically directed based upon visual assessment of the release area and reported release volumes. This can often result in underestimating contaminant plumes, as the release may visually be affecting a small surface area or appear to be naturally contained by the landscape. However, during initial assessment activities subsurface soil profiles need to be properly assessed as they play a large role in contaminant movement and migration. Fractured clay, gravel seams, and shallow ground water tables will all affect the rate and flow of contaminant movement, which can easily double or quadruple the size of the release depending upon the subsurface conditions.

Different sampling methodologies also need to be considered when sampling large releases spanning multiple ecosystems. Determining the correct sample medium based upon the landscape and ecosystem can be an extremely important part of the delineation and remediation process. Knowing when, where, and how to sample soil versus water may seem obvious; however in certain ecosystems this may not be apparent at the time of the release and can result in misleading analytical data. Different sampling methods or intervals may also need to be applied for different contaminants within the same medium.

When initial analytical results are received, it is critical to determine the main contaminants of concern and which parameters to focus analytical and remediation efforts. In many cases additional analytical data is required to determine these target parameters and to fill in the gaps from the initial sampling events completed under high pressure situations. Collecting the appropriate data is crucial to properly narrow down analytical parameters of concern and reduce noise from background data. This also helps to reduce overall project costs and laboratory turn-around times.

We will discuss these concepts in more detail and provide examples of how we have successfully utilized them on large scale spill response and remediation projects.

Jeremy Paul, BSc, PAg

Mr. Paul is the Vice President of Innovation and the Manager of the North Shore Emergency Spill Response Program. Mr. Paul has over a decade of experience working on projects throughout Western Canada including large scale reclamation, remediation, and spill programs. Jeremy manages our dedicated Spill Team which responds to upwards of 100 spills per year with volumes up to 15,000 m³. Mr. Paul’s involvement in these projects includes staff management, project planning, project training, and senior report review. He has multiple years of experience working with provincial and federal regulatory bodies, landowners, First Nations groups, and other stakeholders.
Emerging contaminants are broadly defined as any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. In some cases, emerging contaminants are not recognized until new analytical methods are developed. In other instances, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants. Generally emerging contaminants are characterized by their widespread presence and limited treatment options. Dioxane, poly- and perfluoroalkyl (PFCs) compounds, pharmaceutical and endocrine disruptors are emerging compounds of concern that have driven a significant amount of industry focus and investment to find cost-effective remedial solutions. Dioxane and PFCs are categorized as probable human carcinogens.

1,4-dioxane occurs as a reaction by-product during the manufacturing of soaps, polyesters and plastics. Historically, 1,4-dioxane was used primarily as a solvent stabilizer for 1,1,1-trichloroethane. Recent data from the Unregulated Contaminant Monitoring Rule (UCMR3) published in June 2015 (USEPA 2015) indicates that 1,4-dioxane detections have occurred in 6.7% of public water supplies at concentrations above the drinking water health advisory level of 0.35 micrograms per liter (µg/L). 1,4-dioxane’s low soil-sorption coefficient, complete miscibility with water, and relative resistance to biodegradation make it prone to migrate in groundwater and remain unaffected by conventional treatment technologies such as air stripping and adsorption to granular activated carbon.

Recent work has been done exploring the reactive synergies that occur with permanganate and persulfate as a potential treatment option for 1,4-dioxane, PFCs, pharmaceuticals, and endocrine disrupting compounds. In these unique treatment schemes permanganate decomposition products are used to activate persulfate. For example, the results of recent bench-scale kinetic experiments reveal that potential reactive synergies and enhanced kinetics can occur when mixtures of permanganate and persulfate are utilized for emerging contaminant degradation as compared to when they are applied separately. Results of recent laboratory and field efforts will be presented.
Thermal Desorption Impacts on Soil Chemical, Physical, and Biological Properties: Evaluation for Agricultural Production

Samantha Ritter, Thomas DeSutter, Peter O’Brien, Francis Casey, and Abbey Wick, North Dakota State University

With increasing crude oil production rates in the Bakken and Three Forks shale formations, accidental releases of petroleum hydrocarbons (PHC) from the oil are prone to occur during extraction, storage, or transportation. These releases require remediation because they alter soil chemical, physical, and biological properties. Ex situ thermal desorption (TD) is one approach to remediating PHC impacted soils, which involves heating the soil at high temperatures (200 to 500°C) to volatilize the hydrocarbons and remove the contaminant from the soil; the treated soil is then available for reuse. However, little information exists describing the effects of TD on soil properties and plant growth in treated soils. This presentation describes ongoing research around a crude oil pipeline spill in Mountrail County, ND (USA) that is utilizing TD as a remediation strategy. Since this spill occurred on agricultural land, the objective of this research is to determine the viability of using TD treated soil for cropland production by assessing soil chemical, physical, and biological properties. Binary exchanges of Ca-Mg, Ca-K, and Mg-K were examined using Vanselow exchange isotherms and Gibb’s free energies. In the Ca-Mg exchange, both the untreated and TD topsoil preferred Ca, whereas both subsoils favored Mg. For the Ca-K and Mg-K exchanges, all treatments preferred K. Additionally, cation exchange capacity, pH, and plant available nutrient concentrations were all altered by TD treatment. Examination of physical properties revealed that particle size and mineralogy were not affected by the TD process. However, soil organic C and total aggregation were substantially decreased in TD treated samples when compared to native, non-contaminated soils. Further, saturated hydraulic conductivity and dissolved organic C leaching were much higher in TD treated soils. Additionally, the impacts of TD on soil microbial functions and communities were assessed by determining the activities of N cycling enzymes (ammonium oxidation, nitrate reductase and urease) and quantifying important N transforming organisms. Both enzyme activity and abundance of soil biota were reduced following TD treatment, indicating reduced capacity for N cycling. While the results of this research indicate that many properties of TD treated soils differ from native, non-contaminated soils, the magnitude of those differences may not preclude the use of TD soils in agricultural land. These differences may be mitigated by mixing TD treated soil with native topsoil or applying some organic amendments. This project also highlights the need to redefine remediation end-points using criteria beyond contaminant concentration. By investigating a number of soil properties, this research may identify implications about the long-term effects of TD treatment on overall soil health and plant production. These implications may be relevant in future decisions about using TD as a remediation strategy for agricultural soils.

Samantha Ritter
Samantha is a Master of Science student in Soil Science at North Dakota State University in Fargo, ND. Her research involves chemical and biological properties of soils that have undergone thermal desorption from an active oil spill remediation site in western North Dakota. This research concentrates on the effect of thermal desorption on cation preference.

Thomas DeSutter, PhD
Dr. Tom DeSutter is an Associate Professor of Soil Science and Program Leader of Soil Science at North Dakota State University in Fargo, ND. His research focuses on saline and sodic soils, impacts of energy (coal, oil, gas) on soil land use, and also focuses on the use of industrial byproducts in agricultural.

Peter O’Brien
Peter is currently pursuing his PhD in Soil Science at North Dakota State University in Fargo, ND. His research revolves around an active oil spill remediation site in western North Dakota that is utilizing thermal desorption. This research will characterize the effects of thermal desorption on soil properties and determine how useful this technology can be for remediation in agricultural regions.
Unique Technical Issues and Solutions related to Redeveloping a Major Urban Shopping Centre in Victoria

Diane Zorn, Hemmera

One of Hemmera’s clients is redeveloping their older malls across the country to keep up with the current trends and styles in retail shopping and the new, modern malls being constructed. One of these malls is in Victoria, and has a myriad of “legacy” environmental issues associated with it: three former service stations, one former automobile repair facility, an historical leaking fuel oil UST beneath the mall, a dry cleaners, an area of impacts from historical infilling with contaminated material, and a former brick factory. The client wished to redevelop their mall in the summer of 2016, including construction of new elevated parking areas and façade improvements. As part of the BC and municipal regulatory regime, the client is required to obtain a Ministry of Environment “Instrument” for the redevelopment activities, or to have their permits released so that the construction can begin if the Instrument cannot be obtained in time.

This project included some very challenging technical issues and required careful navigation of the regulations, on top of having to evaluate many years of historical data and investigation and remediation activities done by other consultants. One major roadblock involved the applicability of the drinking water standards. An innovative solution was reached through specialized hydrogeological testing and obtaining buy-in from the Ministry of Environment. As well, we supported the developer and architect as they determined the specifics of the footings and foundations, balancing the desired future land use with the contamination present in the sub-surface and the vapour impacts.

This presentation will focus on the specific challenges and innovative solutions reached to position this high-profile mall for redevelopment under a tight schedule and budget.
Urban vs. Wildland Wildfires: Implications for Assessing Dioxin and Furan Impacts

Heather Lord and Terry Obal, Maxxam Analytics

While wildland wildfire events have been extensively studied over several decades, data from urban wildfires have appeared only more recently. It has been found that impacts from major wildfire events can be quite different depending on which types of areas have burned (wildland, agricultural, urban) and other characteristics of the fire event (type of vegetation, local geology, type and age of buildings).

For polychlorinated dibenzo(p)dioxins (PCDDs) and dibenzofurans (PCDFs), wildfires in the vicinity of burned buildings have been reported to produce 10x to 1000x higher TEQ levels in ash and soil relative to similar samples from burned wildlands and agricultural lands. In fact, it has been reported that an extensive northern Alberta wildland wildfire in 1998 did not result in any measurable increase to background PCDD/F concentrations beyond that attributed to common atmospheric sources. In contrast, the resulting atmospheric fallout of PCDD/Fs from urban wildfires is more likely to result in increased background concentrations throughout the local area, and because mobility of these components in the watershed may be altered significantly due to changes in vegetation and the soil/ash substrate properties, locations downstream in the associated watershed may be similarly impacted. If this is not properly recognized in future assessments, there is the potential for sites to be erroneously flagged as having been impacted by industrial activity and clean-up orders issued for non-industrial PCDD/F impacts.

In terms of PCDD/F impacts in burned urban areas, similarly large variabilities (100x to 1000x) have been noted in levels and types of PCDD/F produced from one burned building site to another. This is likely to complicate sampling and analysis within the burned area. Depending on the study objectives, composite sampling may be more appropriate than random discrete sampling. In the laboratory high sample heterogeneity between samples collected from the same vicinity, in terms of both target compound levels and interferences, can result in differences in the types of lab processing and clean-up steps required between samples from the same submission. The resulting impacts on quality assurance processes and reporting may be difficult to assess.

In this presentation we will describe current practices for PCDD/F analysis in standard soil and ash samples and discuss additional or alternative practices that may be considered for the analysis of urban wildfire impacts.

Heather Lord, PhD

Heather Lord joined Maxxam as Manager, Environmental Research & Development in October 2012. Managing Maxxam’s Environmental R&D team with a focus on increasing analytical sensitivity, reducing time and costs for field work and improving overall site characterization, she works closely with industry stakeholders to address new technical challenges. She is accountable for method development and for presenting and reporting on our research results. Heather has a wealth of experience in R&D planning, design and management; she has a successful track record in the execution of collaborative R&D projects.

Prior to joining Maxxam, Heather was a Research Associate in the Chemistry Department at the University of Waterloo. She managed all research activities carried out as part of the NSERC Industrial Research Chair for new analytical methods and technologies for sample preparation. Heather has co-authored a technology patent, edited two books on Sample Preparation, has delivered over 30 conference lectures in the past 10 years and has published over 50 papers in refereed scientific journals. She earned her PhD in Analytical Chemistry at the University of Waterloo.
Using Stable Isotopes in a Multiple-Lines-of-Evidence Approach to Evaluating Sources and Degradation of Trichloroethylene

Joel van Popta, Giffin Koerth Inc.

Chlorinated solvent impacts to soil and groundwater were documented historically by others at a former industrial property in southwestern Ontario. The remediation of impacts to groundwater using several remediation technologies—vacuum extraction, phytoremediation, oxidation—was ongoing under the direction of another consultant. Due to a legal action brought by the adjacent property owner, Giffin Koerth was retained by the owner of the former industrial property to determine whether chlorinated solvent impacts to groundwater documented at the adjacent property originated from the industrial property or were of different origin.

Our investigation focused on using a multiple-lines-of-evidence approach to determine the likelihood of a secondary source of trichloroethylene (TCE) at the neighbouring property. Four lines of evidence were evaluated:

1) The results of analyses of chlorinated volatile organic compounds (c-VOCs) in groundwater, which demonstrated that similar c-VOCs were documented at both the former industrial property and the adjacent off-site property. Larger concentrations of TCE and cis-1,2-dichloroethylene were documented at the former industrial property when compared to concentrations of TCE and cis-1,2-DCE at the adjacent off-site property.

2) The interpreted groundwater flow direction, which demonstrated that dominant shallow groundwater flow was toward the adjacent property. Estimated groundwater flow velocities were within the range of what could be expected considering the travel distance of the plume.

3) The evaluation of the ratio of TCE to its daughter products, which was used to determine likely source areas. The presence or absence of parent compounds and their breakdown products can provide evidence for source area identification. Parent-compound to daughter-product concentration ratios of chlorinated ethenes are frequently stable within source zones, but will temporarily decrease as a result of natural attenuation along the groundwater flow path. Abrupt increases in parent-compound to daughter-product concentration ratios indicate a contribution from additional sources of chlorinated ethenes, which affects the concentration of a particular parent compound.

4) The results of the analyses of carbon stable isotopes in selected samples of TCE from groundwater samples obtained from both properties, which indicated that it was unlikely that a source of TCE impacts to groundwater was present on the off-site property. \( \delta^{13}C \) values from TCE in samples from the off-site property were consistent with what would be expected if TCE had degraded along the groundwater flow path.

Our investigation also evaluated the degradation of the principal contaminant components through the use of stable isotopes. TCE in groundwater from locations farther down-gradient of the source areas may be expected to show increasing enrichment of 13C and increasing \( \delta^{13}C \) values in TCE, consistent with the increasing degradation of TCE to other c-VOCs. Studies have documented that TCE molecules become enriched in the heavier \( ^{13}C \) isotope as degradation occurs along a flow path in anaerobic environments. This pattern can be masked or altered in situations where active remediation has degraded the parent compound TCE by chemical oxidation or reductive dechlorination.

Joel van Popta

Mr. van Popta is a consultant with Giffin Koerth Inc., and has been practicing in Environmental Site Assessment and Remediation since 2004. He holds a M.Sc. degree in Contaminant Hydrogeology from the University of Waterloo, and a B.Sc. degree in Earth Science from McMaster University.

Mr. van Popta has designed and implemented numerous contaminated site assessment and remediation programs for a range of contaminants, including petroleum hydrocarbons, chlorinated solvents, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and metals. Also, he has experience with insurance claim and litigation support related to contaminant releases and trespass. He also has capability in spills response and management, contaminant nature and origin assessment, and contaminant fate and transport assessment.
Chlorinated volatile organic compounds (cVOCs) degradation by zero valent iron (ZVI) is a proven in-situ remediation approach that can provide long-term passive treatment of groundwater. However, the longevity and efficacy of ZVI remediation systems are highly dependent on site conditions and the remedial design. Over 250 full-scale ZVI in-situ treatment systems have been installed since 1995, mostly as permeable reactive barriers (PRBs), for remediation of cVOCs in groundwater throughout North America, Europe and Australia. Some of these ZVI PRBs have been applied at sites at a considerable cost, but have not performed as intended because of inadequate design and/or unrecognized prohibitive site conditions.

This presentation will include an overview of ZVI reaction chemistry and design principles, along with applicability of macro-scale, micro-scale and nano-scale ZVI materials. ZVI longevity and potential adverse effects of geochemical conditions on long-term performance will be discussed. Importance of selecting the right ZVI type and performing ZVI treatability testing with contaminated site groundwaters will also be presented. Finally, three published ZVI PRB case studies will be discussed where the performance was deficient due to: (i) unrecognized adverse geochemical conditions (elevated concentrations of nitrate that caused accelerated ZVI deactivation), (ii) ZVI fouling during construction (microbial sulfide precipitation due to the use of biodegradable guar gum slurry), and (iii) lack of conservatism in the design that led to breakthrough of cVOCs within 5 years of operation due to gradual ZVI passivation.

Andrzej Przepiora
Mr. Przepiora is a project hydrogeologist in the remediation group of Geosyntec Consultant’s Waterloo, Ontario operations. Mr. Przepiora has 16 years of experience in the use of ZVI-based approaches for treatment of groundwater and soil. He has participated in the implementation of over 40 ZVI permeable reactive barriers (PRBs) for treatment of chlorinated organic compounds and metals in North America and Europe, with direct involvement in initial evaluations, treatability studies on commercial ZVI materials, PRB designs and construction method selection, and performance evaluations. He has also contributed to several research and development programs related to reactivity control evaluations and long-term performance of iron-based technologies.