# Table of Contents

## Platform Presentations *(arranged by session)*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOREMEDIATION</td>
<td>1</td>
</tr>
<tr>
<td>COMBINING REMEDIATION TECHNOLOGIES FOR OPTIMAL RESULTS</td>
<td>11</td>
</tr>
<tr>
<td>CONSTITUENTS OF EMERGING CONCERN</td>
<td>19</td>
</tr>
<tr>
<td>CONTAMINANTS OF EMERGING CONCERN</td>
<td>27</td>
</tr>
<tr>
<td>ENERGY</td>
<td>35</td>
</tr>
<tr>
<td>ENVIRONMENTAL FATE AND MODELING</td>
<td>43</td>
</tr>
<tr>
<td>ENVIRONMENTAL FORENSICS</td>
<td>51</td>
</tr>
<tr>
<td>ENVIRONMENTAL IMPACT OF NANOTECHNOLOGY</td>
<td>59</td>
</tr>
<tr>
<td>HYDRAULIC FRACTURING – REGULATORY AND TECHNICAL UPDATE</td>
<td>65</td>
</tr>
<tr>
<td>INNOVATIVE REMEDIAL TECHNOLOGIES</td>
<td>73</td>
</tr>
<tr>
<td>NAPHTHALENE - THE EMERGING STATE OF ITS SCIENCE</td>
<td>81</td>
</tr>
<tr>
<td>PETROLEUM HYDROCARBON VAPOR INTRUSION I</td>
<td>87</td>
</tr>
<tr>
<td>PETROLEUM HYDROCARBON VAPOR INTRUSION II</td>
<td>95</td>
</tr>
<tr>
<td>REGULATORY PERSPECTIVES ON SITE CLOSURE CRITERIA</td>
<td>105</td>
</tr>
<tr>
<td>REGULATORY PROGRAMS AND POLICIES</td>
<td>113</td>
</tr>
<tr>
<td>REMEDIATION</td>
<td>121</td>
</tr>
<tr>
<td>RISK ASSESSMENT</td>
<td>129</td>
</tr>
<tr>
<td>SITE ASSESSMENT</td>
<td>135</td>
</tr>
<tr>
<td>TECHNOLOGY ADVANCEMENTS IN REMEDIATION SCIENCE</td>
<td>141</td>
</tr>
<tr>
<td>VAPOR INTRUSION</td>
<td>151</td>
</tr>
</tbody>
</table>

## Poster Presentations *(alphabetical order by last name)*........... 159

## Presenter Contact Information *(platform and poster presenters)* ................................................................. 219

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BIOREMEDIATION

Improved ISCR Reagent for Safer, More Efficient Remedial Actions
Jim Mueller, Provectus Environmental Products, Freeport, IL

Biogeochemical Transformation of Chlorinated Solvents
Patrick Evans, CDM Smith, Bellevue, WA

Effect of Biosurfactants on Motility of Bacteria Under Heavy Metal Stress
Zhiwen Zhu, Memorial University of Newfoundland, St. John’s, Newfoundland and Labrador, Canada

Comparison of Natural Source Zone Depletion (NSZD) Characterization Methods
Steven Gaito, ARCADIS U.S., Inc., Braintree, MA

Environmental Molecular Diagnostic Tools for Green Remediation
Yi Wang, Pace CSIA Center of Excellence, Pittsburgh, PA

Managing Geochemistry and Hydrogeology While Performing Anaerobic Bioremediation
Nick Amini, Santa Ana Regional Water Quality Control Board, Riverside, CA

Evaluation of the Potential Impacts of Trichloroethene In-Situ Bioremediation on Vapor Intrusion at a Northern California Site
Anja Verce, Weiss Associates, Emeryville, CA
Indigenous methanogens often bloom following the addition of the organic hydrogen donors thereby liberating large amounts of methane gas. There are at least three important consequences of this response:

i) By utilizing hydrogen, the methanogens compete with dechlorinating microbes thus making inefficient use of the remedial amendment;

ii) Rapid growth of methanogens consumes alkalinity while generating acids thereby having the potential for aquifer acidification (which may liberate heavy metals causing secondary contaminant issues); and

iii) Elevated methane concentrations can exceed current and pending regulations of $< 10$ to $<28$ ppm in groundwater and/or $0.5\%$ v/v methane in soil gas (e.g., $10\%$ of the LEL) and/or indoor air regulations (methane is flammable between 5 and $15\%$ v/v).

We describe herein the use of a genuinely new ISCR reagent that uniquely combines nutrient rich, engineered-release, hydrophilic carbon sources + ZVI + other reagents along with a specially modified red yeast rice extract (RYR) as an inhibitor of enzyme systems that are responsible for the production of methane (US Patent 14268637; PCT/US14/36632). This improved ISCR Reagent contains natural monacolins (most importantly monacolin K, or lovastatin) which has the unique ability to block enzyme systems specific to methane production. The technology has been widely used in the cattle industry for many years to manage rumen microbiology, but is being newly applied to the environmental industry as a remedial supplement, a landfill gas management tool, etc. The modified RYR itself can be used as a stand-alone supplement to other ERD amendments such as molasses, sugars, EVO, etc. to make them safer and to improve their overall efficacy.

Data from laboratory and field studies will be presented to demonstrate effective antimethanogenic activity during remedial actions. Field performance and cost data will also be presented to discuss the ability of the improved ISCR reagent to accelerate and improve remedial actions.
Biogeochemical Transformation of Chlorinated Solvents

Patrick Evans

Biogeochemical transformation involves biological formation of reactive minerals (e.g., iron sulfides, magnetite) that can abiotically reduce chlorinated solvents such as TCE. This process has promise for active remediation and post-remediation management of large-dilute plumes. Unfortunately, the process is often implemented in the field in an ad hoc manner. A better understanding of the factors controlling the process is needed.

Laboratory column studies, a critical evaluation of full-scale systems, rejuvenation of under-performing biowalls, and an ESTCP demonstration of the process were conducted to increase our understanding and to develop engineering guidance for the process.

Column study results demonstrated that an optimal combination of sulfate consumption, residence time, electron donor, and iron oxides resulted in an abiotic pattern of TCE removal without accumulation of daughter products. Analysis of full-scale systems provided results consistent with the column study: high volumetric sulfate consumption rates and geochemical conditions that promoted nucleation of small-diameter, high surface area minerals favored an abiotic pattern of TCE removal. The results taken together indicate that biogeochemical transformation is a dynamic process that involves competing processes of reactive mineral formation and de-activation. Optimization of VOC removal requires design and operation of the biogeochemical transformation promote a sustained rate reactive mineral formation.

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Presenting Author: Patrick Evans
Effect of Biosurfactants on Motility of Bacteria under Heavy Metal Stress

Zhiwen Zhu, Baiyu Zhang, Bing Chen, Weiyun Lin and Xing Song

Heavy metal and hydrocarbon co-contaminated matrices pose significant technical challenge in the bioremediation process. Heavy metals could form strong bonds with soils, thus decreasing the ions available to microorganisms. They are also highly toxic to most microorganisms, thereby inhibiting the biodegradation of hydrocarbons. Studies have indicated that the addition of biosurfactant can aid the process of remediation. However, most existing studies about the role of biosurfactants focused on the reduction of the toxicity of heavy metals by acting as metal ion chelators, only limited ones indicating the improvement of the motility of microbes, which potentially provide a means for more rapid and uniform dissemination of indigenous bacteria, accordinly ease the biodegradation of hydrocarbon contaminants. This research thus provides an insight on the effect of biosurfactants on enhanced motility of indigenous bacteria under heavy metal stress in an experimental model.

In this study, common environmental pollutants Cd\(^{2+}\), Cu\(^{2+}\), Ni\(^{2+}\), and Pb\(^{2+}\) ions were selected as target heavy metal components. *Exiguobacterium antarcticum* N4-1P, an extremophile firstly found in Antarctica, was isolated from the North Atlantic Ocean and used to produce biosurfactant. The indigenous bacteria, namely *Bacillus*, *Rhodococcus*, and *pseudomonas* were isolated from the oily contaminated ocean sediment samples and used for this study. The bacteria have been well reported for the ability of biodegrading hydrocarbon contaminants. The enhanced motility of indigenous bacteria by the biosurfactant produced by *Exiguobacterium antarcticum* N4-1P under target heavy metals was explored. Zeta potential was determined for the change of bacterial cell surface charge. Bio-reduction potential of various metal ions by indigenous strains in soil was also evaluated. The research output is expected to deepen the understanding of the role of biosurfactants in aiding the remediation of heavy metal and hydrocarbon co-contaminated soil and generate more effective alternatives for co-contaminated soil remediation in Atlantic Canada.

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Presenting Author: Zhiwen Zhu
Comparison of Natural Source Zone Depletion (NSZD) Characterization Methods

Steven Gaito, Brad Koons, Andy Pennington, Jonathon Smith, Harley Hopkins and Mark Malander

Natural source zone depletion (NSZD) is a sustainable light nonaqueous phase liquids (LNAPL) remedy that changes the composition and reduces saturation through chemical redistribution of LNAPL constituents (i.e., dissolution, volatilization, and sorption) and through biodegradation by microbial or enzymatic activity. NSZD is increasingly being considered an important component of LNAPL management, and NSZD rates can serve as a benchmark for the relative benefit of active, engineered remedial alternatives.

Three methods for evaluation of NSZD rates are compared: (i) the conventional gradient method based on vapor-phase soil diffusion coefficients and soil gas concentrations (oxygen, carbon dioxide [CO2], methane, and petroleum hydrocarbons) from nested wells, (ii) shallow CO2 traps that intercept CO2 flux over a one to four week period and sequester it for subsequent laboratory quantification, i.e. the CO2 Trap method, and (iii) a field-deployable dynamic closed chamber (DCC) instrument measuring short-term (near-instantaneous) CO2 flux at the ground surface (the LI-COR method).

A study was conducted at an LNAPL site in south Texas to compare the use of these three methods to quantify NSZD rates. The gradient method and both CO2 flux methods were evaluated at co-located points. Supporting data were also collected, including vertical temperature profiles to measure the heat generated during the degradation of hydrocarbons and soil gas pressure data to characterize the significance, if any, of advective flow of soil gas.

A comparison of the results and interpreted NSZD rates for each method will be presented, along with lessons learned and recommendations for site conditions that favor the use of each technology. These serve to increase confidence in the results of NSZD evaluations as they become a more common benchmark of site progress.

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Presenting Author: Steven Gaito
Environmental Molecular Diagnostic Tools for Green Remediation

Yi Wang

Background:

In situ bioremediation is inherently considered “green remediation”. The mechanisms of destruction by in situ biotechnologies, however, are often unseen and not well understood. Further, physical effects of amendment application effect concentration data in an identical manner as the desired reactive mechanism. These uncertainties have led to the weight of evidence approach when proving viability: multiple rounds of data collection, bench studies, and pilot studies, etc. Skipping these steps has resulted in many failed in situ applications. Traditional assessment data are often tangential to the desired information; e.g., “Is contaminant being destroyed or just being pushed around and diluted?” and “What is the mechanism of the destruction and can it be monitored directly?”

Approach:

Advanced site diagnostic tools, such as “Compound Specific Isotope Analysis (CSIA)”, can assess viability of in situ biotechnologies by providing definitive data on contaminant destruction that are not concentration related. The most commonly used stable isotopes in environmental studies include carbon, hydrogen, and chlorine, etc. The development of combined gas chromatography-isotope ratio mass spectrometry (GC-IRMS) in 1990s has led to an explosion in applications using the technique of CSIA in the environmental fields.

Case Studies:

This presentation outlines the fundamentals of advanced site diagnostic tools and their benefits are highlighted through a series of case studies at chlorinated solvent and petroleum hydrocarbon contaminated sites around the world (United States, Canada, Japan, Italy, South Africa, Argentina, and Brazil). The CSIA tools located source zones and apportion remediation cost by identifying plumes of different isotope signatures and fractionation trends. Further, a combination use of such advanced site diagnostic tools allowed remediation professionals to evaluate effectiveness of treatment and make better decisions to expedite site closure for monitored natural attenuation (MNA) and minimize costs, consistent with US EPA’s initiative for “Green Remediation”.

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Presenting Author: Yi Wang
Chlorinated solvents originating from clothing and textile dry cleaning operations can quickly degrade an aquifer. The introduction of low-cost electron donor substrates and a microbial consortium into the heterogeneous aquifer has accelerated anaerobic biodegradation in the aquifer impacted with chlorinated solvents to less toxic forms. PCE and TCE have been reduced to non-detect in most of the wells, 90 days after injection. The key to success is managing the site geochemistry and hydrogeology before, during and after bio-stimulation and bio-augmentation injections.

The edible oil substrate was supplied as oil concentrate (EDS), cheese whey supplied as a powder, and buffering materials supplied as a solution, mixed in the field and pumped into the aquifer, making contact with greater areas of concern beneath the site. Data have confirmed the establishment of anaerobic conditions within 90 days after application. Field results have shown the ability to successfully establish an anaerobic bioremediation zone in the aquifer up to 30 or more feet from the injection point, depending on site-specific hydrogeological conditions.

Managing the microbial environment by characterizing the soil buffering capacity, adding the appropriate amount of buffer, monitoring the pH, ORP, TOC, other geochemical parameters, and microbial population counts for months after the injection is key to the success of the remediation.

Bench-scale study data along with pilot- and full-scale field results from a dry cleaners site where the low-cost electron donor substrates and a microbial consortium were injected will be presented. This presentation will show how the technology is implemented, share project data and illustrate the advantages of managing the site geochemistry and hydrogeology.

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Presenting Author: Nick Amini
Evaluation of the Potential Impacts of Trichloroethene In-Situ Bioremediation on Vapor Intrusion at a Northern California Site

Anja Verce and Mary Stallard

This Superfund site is part of a large trichloroethene (TCE) groundwater plume that has been the focus of a high-profile vapor intrusion (VI) evaluation over the past several years. Between 2003 and 2013, five rounds of air sampling were conducted within the site buildings. The results for these samples indicated no concentrations above the action standards. Although reductive in-situ bioremediation of TCE through carbon substrate injection has been applied at the site since 2005, the USEPA felt that the available site data were not sufficient to assess potential VI impacts resulting from this in-situ remediation. The potential impacts identified by USEPA include: 1) methane generation posing an explosive risk; 2) vinyl chloride (VC) generation causing increased carcinogenic risks; and, 3) short-term increased TCE vapor mobilization resulting in increased teratogenic risks. Monitoring to evaluate these potential impacts has included baseline and periodic indoor air sampling in site buildings and soil gas sampling along transects between the in situ injection area and the buildings. Baseline monitoring was performed in March 2014, carbon substrate injections were conducted in early May, and post-injection soil gas monitoring was initiated in June. In addition to TCE, VC, and methane, carbon dioxide and oxygen are being monitored as indicators of methane fate in the vadose zone. Results for this monitoring, as well as previously-collected data from this site and similar sites in the vicinity, indicate increases in TCE, VC, and methane in soil gas in some areas following in-situ carbon substrate injections. However, these soil gas increases have not translated into increased indoor air concentrations and risks at any of these sites. In particular, methane generated during in-situ bioremediation does not appear to present an indoor explosive risk at these sites because: 1) methane is readily degraded in the vadose zone; and, 2) methane generation rates are insufficient to create the volumes and pressures needed to create an explosion risk.

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Presenting Author: Anja Verce
COMBINING REMEDIATION TECHNOLOGIES FOR OPTIMAL RESULTS

Combined Remedy Synergies – Conceptual Road Map and Examples
Jeremy Birnstingl, Regenesis, Bath, UK

Combined Remedies New and Old – the Science Advances, but the Keys to Success Remain the Same
Kent Sorenson, CDM Smith, Denver, CO

Multi-component Remedy for a Co-mingled Chlorinated Solvent and 1,4-Dioxane Source Area and Plume
Ryan Wymore, Geosyntec Consultants, Inc., Centennial, CO

Title TBD
Belinda Butler-Veytia, ERM, Greenwood Village, CO

Combined Technologies to Capitalize on Synergies, Reduce Overall Costs, and Expedite Remediation
Christopher Gale, Geosyntec Consultants, San Diego, CA

Microbes Adapt, So Why Shouldn’t We?
Clint Bickmore, B Street Technology, Longmont, CO
Background/Objectives. Today, there are many in situ remediation technologies used regularly around the world in countries with established clean-up legislation, ranging from extractive (pump-and-treat, thermal), chemical (in situ chemical oxidation / reduction) to biological (enhanced / monitored natural attenuation). That so many options are available is testimony in itself that no one technology is ideal in all circumstances – if that were so, it would follow that that technology alone would be employed. The variety of technologies available is instead a direct reflection of the variety of performance characteristics they each present, be it in the balance of achievable cost vs. time, the degree of intrusion necessary for their furtherance, their optimum concentration range for maximum efficiency, or their suitability to a given geological, hydrological or geochemical setting. Integrated treatment design is developing as a progressive approach to remediation, incorporating a range of synergistic technologies to achieve site closure, each operating in its own particular area of individual strength. Specifically, the strategy requires pragmatic selection of compatible technologies, such that each compliments the others and operates at its greatest efficiency, ensuring optimum performance and cost-effectiveness throughout the project duration – which can be significantly shortened as a consequence. Through the deployment of a combination of compatible technologies, which may be drawn from physical, chemical and biological arenas, remediation goals and site closure can frequently be achieved more rapidly, and at lower cost, than through the use of any one approach used alone. This is due to each technology having very different strengths and weaknesses, and through suitable combination – either sequentially, spatially or both – the strengths can be combined and the weaknesses overcome to achieve far better results, more rapidly, and with less expense, than through the use of any of the technologies in isolation.

Approach/Activities. This talk briefly explores the driving pressures and evolutionary background to the widespread single-technology design predisposition still evident across much of the industry, and outlines the technical basis of its inherent shortcomings in the dynamic and heterogeneous context of an impacted aquifer undergoing clean-up. The physico-chemical principles favoring the use of integrated remedial approaches – both spatially and temporally – are summarized, and practical indicators for determining optimal points of inflection of technology change are outlined. The case is presented for incorporation of integrated design considerations with objective technology changeover trigger points into the initial remediation approval process, thereby securing efficiency and cost benefits to all stakeholders.

Results/Lessons Learned. The potential benefits of the concept are illustrated through field examples taken from different aquifer and regulatory settings around the world, offering striking illustrations of both the scale of the potential problem and the magnitude and ease of potential savings achievable through appropriate application of technology integration. It is anticipated that this talk will be of interest to end-users, regulators and professional remediation engineers alike.

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Presenting Author: Jeremy Birnstingl
Combined Remedies New and Old – the Science Advances, but the Keys to Success Remain the Same

Kent Sorenson and Tamzen Macbeth

While consensus that multicomponent remedies are a virtual necessity for cleanup of complex groundwater sites might be a fairly recent phenomenon, the concept isn’t actually new, and didn’t require a major change in regulatory framework to facilitate implementation. In fact, the 1995 Record of Decision and subsequent remedial action for the Test Area North (TAN) groundwater site at the Idaho National Lab provide an early example of an adaptive management strategy and multicomponent remedy conducted within the CERCLA framework. Some of the factors contributing to the complexity of the TAN site included its large horizontal and vertical scale, the fractured rock geology, the combination of organic and radioactive contaminants, and the lack of experience with today’s common in situ technologies. In contrast, combined remedy applications in the last few years have a huge advantage in terms of experience with a variety of in situ technologies, including an understanding of some important synergies that can be leveraged to maximize cleanup efficiency. This is reflected by the much more recent multicomponent remedy implemented at Hunter’s Point, Building 134, where a mixed chlorinated benzene and chlorinated ethene DNAPL in heterogeneous, low permeability soils was cleanup up in just 18 months. While the Hunter’s Point project certainly benefitted from the increase in technical understanding since 1995, a comparison of the two case studies reveals that the fundamental keys to success were the same.

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Presenting Author: Kent Sorenson
Multi-component Remedy for a Co-mingled Chlorinated Solvent and 1,4-Dioxane Source Area and Plume

Ryan A. Wymore, Theodore Kuehster, Garry Stanley, Jeff Kurtz, and David Folkes

A multi-component remedy has been implemented for over 15 years for co-mingled source area and plume consisting of chlorinated solvents and 1,4-dioxane. Hydraulic containment, bioremediation, monitored natural attenuation, and vapor mitigation are all being used in the context of a long-term site management strategy.

Historic releases of chlorinated volatile organic compounds (CVOC) at a former industrial facility impacted underlying soil, weathered bedrock, and shallow groundwater. The CVOC plume extended more than 13,000 feet downgradient and was up to 1,200 feet wide and 70 feet deep. The principal compound of concern was 1,1-dichloroethene (1,1-DCE), and to a lesser extent, trichloroethene (TCE). In addition, 1,4-dioxane has been found at moderate concentrations (approximately 100 µg/L) within the footprint of the former facility.

In the source area, hydraulic containment is being used to prevent contaminants from leaving the site. A residual DNAPL source area (total VOC concentrations as high as 25,000 to 30,000 µg/L) is located beneath a large industrial warehouse that houses an active business. Because of this, access to further characterize the source area or to attempt remediation is prohibitively expensive.

For the downgradient plume, bioremediation has been used to reduce concentrations by up to 98% in three discrete areas using emulsified vegetable oil injections. The downgradient plume has also caused vapor intrusion concerns for residential areas. A comprehensive indoor air sampling program has been implemented, with several hundred homes receiving vapor mitigation systems to date. A comprehensive monitoring program is in place to track attenuation of contaminants throughout the remainder of the plume, with CVOC concentrations declining in more than 90% of offsite wells.

While technologies exist that could treat CVOCs and 1,4-dioxane, source remediation would cost significantly more than the present value of several decades of hydraulic containment, primarily due to difficult access. Therefore, the current strategy is to continue operation of the hydraulic containment system with offsite remediation, vapor mitigation, and monitoring.

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Presenting Author: Ryan Wymore
Combined Technologies to Capitalize on Synergies, Reduce Overall Costs, and Expedite Remediation

Christopher Gale, Brian Hitchens, and Doug Riddle

Various factors are often considered in the remedy selection and design process. Although numerous remedial technologies exist, each has its own benefits and limitations and there is typically no silver bullet for a site. Each remedy is best suited for a given set of contaminants and hydrogeologic conditions. At many sites multiple remedial technologies can be combined to maximize the benefits of various technologies while minimizing limitations. Combining technologies not only capitalizes on the various strengths of different technologies but can also capitalize on synergetic benefits not realized by implementation of each remedy in isolation. This presentation will present a case study which combined multiple technologies concurrently to facilitate the rapid remediation of a complex site with chlorinated solvent and petroleum hydrocarbon impacts. Electrical resistance heating was implemented in the primary source area which had identified DNAPL and LNAPL impacts in low permeability vadose and saturated zone soils. Enhanced in-situ bioremediation was implemented over the dissolved phase groundwater plume. Soil vapor extraction was implemented in areas where primarily vapor phase impacts had been identified. Utilization of a combined remedies approach resulted in the successful remediation of a complex site with DNAPL and LNAPL impacts in approximately 3 years. In preparing the remedial design, some synergies and potential antagonisms of this combined remedies approach were considered and accounted for. Additional unforeseen challenges were encountered during implementation that required modifications to the operations and remedial design throughout implementation of the project. This presentation will include a discussion of the synergies realized by this combined remedies approach; highlight the antagonisms and challenges encountered during implementation and how these challenges were handled; and a discussion of the lessons learned from this case study.

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Presenting Author: Christopher Gale, PG
Microbes Adapt, So Why Shouldn’t We?

Clint Bickmore

Countless studies provide evidence for manipulating microbial cultures toward adaptive evolution. It is time that we adapt our design strategies and site practices to provide cost-effective restoration implementations. This presentation addresses design strategies for *in-situ* anaerobic site restoration. The many names for this technology include *In-Situ* Chemical Reduction (ISCR) and Enhanced Reductive Dechlorination (ERD), where ISCR more broadly describes the technology and allows for concepts tackling metals stabilization. The ISCR design approach should include redox manipulation and pH control in the design.

This presentation uses an “Easy” ISCR dry-cleaner site to illustrate how combining reactive metals into a bio-remediation strategy can help provide a better scenario for microbial health. The site was initially treated with modified Fenton’s ISCO. A follow-up design shifted the site to an ISCR approach by combining zero valent metal (zvm) and emulsified vegetable oil into injections. In addition to bio-stimulation, bio augmentation was implemented at the site for better donor use. The injection activity was monitored real-time by placing trolls into monitoring wells, such that monitoring subsurface geochemical parameters allowed adapting the injection technology to meet the design objectives on-site. Real-time monitoring provided subsurface injectate distribution evidence by watching pH, ORP, and DO trend changes.

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CONSTITUENTS OF EMERGING CONCERN

Reactivity of Chlorine Radicals and Chloramines with Wastewater Constituent Species
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Removing Carcinogenic Nitrosamines from Contaminated Waters
Brittany Daws, California State University Long Beach, Long Beach, CA

Sampling and Analytical Considerations for Management of Data Quality for Poly- and Perfluorinated Alkyl Substances (PFASs) in Groundwater
Ann Bernhardt, AMEC Foster Wheeler, Portland, OR

In Situ Thermal Remediation of 1,4-Dioxane and Advances in Heat Enhanced Bioremediation
John Sankey, True Blue Clean, Inc., Richmond, BC, Canada

Synthetic Media Remediation System Achieves Consistent Compliance with Evolving Massachusetts 1,4-Dioxane Permit Limits
Steve Woodard, ECT, Portland, ME
Reactivity of Chlorine Radicals and Chloramines with Wastewater Constituent Species

Kylie Couch and Stephen Mezyk

In the UV/H₂O₂ Advanced Oxidation Process (AOP) treatment of chemically-contaminated waters there is also a possibility of producing chlorine radicals as a result of UV photolysis of chlorine-containing compounds, which are of interest to many U.S. water facilities that maintain chlorine residual in their wastewater treatment systems. The generation of chloramines through addition of hypochlorite to wastewaters containing ammonia will form a mixture of monochloramine (NH₂Cl), dichloramine (NHCl₂), and trichloramine (NCl₃) and these species are also expected to form chlorine atoms in the UV/H₂O₂ AOP. Furthermore, in some wastewater treatment and water reuse systems, chloramines are deliberately added before the reverse osmosis (RO) process to control membrane biofouling. Interestingly, these chloramines easily pass though the RO membranes and enter the downstream UV/H₂O₂ AOP. The photolytically-induced chemistry of these chloramines within a UV/H₂O₂ AOP is complex. Measured absorbance and quantum yields for chloramine species suggest that they are a major competitor for UV photons as compared to added H₂O₂. Both the direct photolysis and indirect reaction of produced HO⁺ radicals with mono- and dichloramine with will produce NHCl⁺, NCl₂⁺, and Cl⁺ radicals. In addition, it has been observed that a significant amount of the prototypical contaminant 1,4-dioxane removal by UV/AOP in the absence of H₂O₂ still occurs when there are only chloramines present. Literature studies suggest that the chloramine radical does not yield much oxidizing power, which implicates the chlorine radical as the primary oxidant under these conditions. As a full understanding of the roles the Cl⁺ radical and chloramines play are important to the understanding the chemical dynamics and the optimization of any photolysis-based AOP, in this study we have measured the reaction kinetics of these species with a variety of important wastewater constituent species.

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Removing Carcinogenic Nitrosamines from Contaminated Waters

Brittany Daws and Stephen Mezyk

Limiting human exposure to carcinogenic compounds in the environment is an important element in the reduction of human cancers. Nitrosamines are a ubiquitous family of carcinogenic compounds that are derived from agricultural, industrial and material manufacturing processes. As a class of chemicals the nitrosamines, with very few exceptions, have been shown to be highly carcinogenic, mutagenic, and teratogenic, with at least 300 known carcinogenic nitrosamines that have been shown to induce tumors in over thirty animal species. The reactivity of the nitrosamines is highly dependent on the structure showing a significant variability based on the nature of the substituents on the nitrogen bearing the nitroso (>N-NO) group.

The removal of trace (ppt) levels of nitrosamines from waters of different qualities is extremely difficult. While UV light is typically used to directly photolyze nitrosamines in a solution, this may not be possible to do in all water qualities. There is also a problem with nitrosamine reformation after treatment. Therefore, we have examined in detail the impact of the use of an alternative remediation approach, using advanced oxidation processes (AOP’s), on a variety of nitrosamines, particularly with aliphatic chain species. AOPs most commonly utilize oxidizing hydroxyl radicals generated within the water to react with, and therefore destroy, chemical contaminants. However, there is far less information available for aromatic nitrosamines, particularly the CCL3 listed contaminant diphenylnitrosamine. We report here the reactions of the oxidizing hydroxyl and sulfate radicals, and the reducing hydrated electron with diphenylnitrosamine, in addition to a series of model aromatic nitrosamines. These nitrosamines have shown specific reactivity patterns based both on structure and the specific radical used. Absolute rate constants and transient radical spectra, from electron pulse radiolysis studies, as well as final stable product identifications from steady-state irradiations will be presented.

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Presenting Author: Brittany Daws
Polyfluorinated- and perfluorinated alkyl substances (PFASs) are important industrial chemicals that have been in production and use for at least 50 years. PFASs are resistant to degradation under harsh physical and chemical conditions, and have a diverse number of uses where stain resistance, water resistance, or a stable surfactant is needed for use in harsh conditions. Examples of common uses include the presence of PFASs in fire fighting foams used on petroleum fires, use to control surface tension or produce other necessary properties in a variety of etching and plating baths, and use in food packaging to impart waterproofing.

As a result of the widespread use of PFASs in multiple industries and for many consumer products, studies have detected individual PFAS compounds in biotic and abiotic environmental media throughout the world. While reports of the presence of these substances in environmental media date back to the early 1980s, scientific study of the nature and distribution of PFASs has expanded rapidly over the past decade. Despite increased academic interest in these substances, the US regulatory framework for PFASs in the environment is limited, as is experience in investigation and remediation of PFASs in soil, surface water, sediment and groundwater.

The unique physical and chemical properties of PFASs present challenges in both sampling and chemical analysis, and there are unique considerations that must be addressed to help assure generation of usable data. This presentation will review differences in physical and chemical properties between PFASs and other more conventional organic contaminants, and will describe how these differences effect planning and execution of groundwater investigation and monitoring programs where PFASs are a target. Factors that affect sampling, chemical analysis, data review and evaluation of data usability will be covered.

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Presenting Author: Ann Bernhardt
In Situ Thermal Remediation of 1,4-Dioxane and Advances in Heat Enhanced Bioremediation

John Sankey and Dan Oberle

1,4-Dioxane resists in situ treatment by conventional advective flow based technologies. Effective remediation is limited to expensive, ex situ treatment by advanced chemical oxidation using processes that produce hydroxyl radicals. However, significant concentration reductions (>99%) in 1,4-Dioxane were recently observed at two electrical resistance heating (ERH) projects where ERH was used for treatment of chlorinated solvents in groundwater. This observation lead to further bench testing to evaluate the effects of 1,4-Dioxane treatment by steam stripping. The tests showed that the vapor-liquid equilibrium mass fraction ratios of 1,4-Dioxane to water increase substantially as the system approaches the boiling point of water. The mass fraction of 1,4-Dioxane in steam produced during ERH is an order of magnitude higher than in the water being boiled. When the steam and 1,4-Dioxane vapors are combined with sufficient air, the bulk of the 1,4-Dioxane remains in the vapor phase where it can be readily treated using vapor phase activated carbon.

The efficacy of combining ERH and bioremediation technologies to reduce contaminant mass flux from the source zone and enhance reductive dechlorination in the downgradient plume has moved from concept to field application. Remedial designs are more frequently including the combination of these approaches into the site wide conceptual model.

Recent results including engineering design elements and costs of field applications will be presented.

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Presenting Author: John Sankey
Synthetic Media Remediation System Achieves Consistent Compliance With Evolving Massachusetts 1,4-Dioxane Permit Limits

Louis Burkhardt and Steve Woodard

The State of Massachusetts recently lowered their 1,4-dioxane permit limit from 3.0 μg/l to 0.3 μg/l. This paper describes the objectives, design, implementation and operation of a full scale Synthetic Media system for the treatment of 1,4-dioxane down to these evolving regulatory limits. The site was designed to treat 15 gpm of contaminated groundwater containing 1,4-dioxane and chlorinated volatile organic carbon (cVOC) compounds. The primary objectives of the remediation system were to provide long-term contaminant migration control, and to achieve consistent compliance with current and future permit limits.

Synthetic Media, specifically AMBERSORB™ 560 (AMBERSORB), was selected as the technology most capable of improving operational reliability, while simplifying process design, reducing long-term operating costs and meeting the 1,4-dioxane permit limits. Water is pumped in an up-flow mode through multiple synthetic media vessels operated in series, e.g. lead-lag-polish operation. The 1,4-dioxane and other contaminants preferentially adsorb to the media, and steam regeneration is performed in the vessel, in a down-flow mode. One vessel is regenerated at a time, leaving the remaining vessels in service to maintain continuous groundwater extraction and consistent treatment efficiency.

Influent 1,4-dioxane concentrations have ranged from 8 to 60 μg/l during the first 31 months of operation. Other than one brief period during startup, effluent concentrations have been consistently non-detect, at less than 1 μg/l, and more recently less than the new method detection limit of 0.04 μg/l. The other contaminants, total cVOCs, have been consistently treated from 3,000 μg/l down to non-detect levels for the entire 31-month operating period. There were several key lessons learned during this first full scale application of synthetic media for 1,4-dioxane treatment. These included: (1) understanding the unique conditions required to fully regenerate the media; (2) understanding the importance of considering local boiler requirements; and (3) the materials of construction/metallurgy in certain system components must account for the low pH of the condensate.

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CONTAMINANTS OF EMERGING CONCERN - CHALLENGES, PERSPECTIVES, AND RISK CONSIDERATIONS

Contaminants of Emerging Concern: An Introduction to Technical, Programmatic, and Business Challenges to Environmental Management
Bridgette DeShields, Integral Consulting, Inc., Petaluma, CA

EPA’s Unregulated Contaminant Monitoring Rule Results (UCMR-3)
Rick Zimmer, Eurofins Eaton Analytical, Monrovia, CA

What Do the UCMR-3 Results Tell Us About Emerging Contaminants in Drinking Water
Bruce Macler, USEPA Region 9, San Francisco, CA

Overview of Poly- and Perfluoroalkyl Substances Chemical Class and a Review of State and Federal Regulatory Guidance
Shalene Thomas, Amec Foster Wheeler, Minneapolis, MN

Explaining the Widespread Occurrence of 1,4-Dioxane in Municipal Water Supplies
Thomas Mohr, Santa Clara Valley Water District, San Jose, CA

Emerging Contaminants in the Workplace*
Meredith Williams, California EPA, Sacramento, CA

*Abstract not available at the time of printing
Contaminants of Emerging Concern: An Introduction to Technical, Programmatic, and Business Challenges to Environmental Management

Bridgette DeShields

Contaminants of emerging concern are broadly defined as chemicals that have a pathway to the environment and present real or perceived potential risks and that either 1) do not have environmental standards or 2) have standards that are evolving due to new science, detection capabilities, or pathways of exposure. We are well into our third decade addressing these compounds. Starting with endocrine disruptors, pharmaceuticals and personal care products in the 1990s, perchlorate and 1,4-dioxane in the decade after that, and perfluorinated compounds today, we are in a constant state of response to emerging threats, real or perceived. U.S. regulatory programs struggle to keep pace. Our risk-based approach to assessing environmental threats is data intensive, most often requiring decades to develop the sound science needed to support management decisions. Yet, in the face of new and emerging threats, pressure for regulatory action exists. This can result in management actions that are implemented well before the appropriate data assessments have been completed, the full costs and benefits of the decisions can be assessed, and/or the technology exists to address the emerging threats on the scale and scope perceived to be needed. This presentation explores the types of challenges faced by regulatory agencies, non-regulatory public entities, and businesses in addressing emerging contaminant threats, outlines strategies to move forward in the face of the need for environmental management, and discusses options for the future. Technical, programmatic, and economic challenges are discussed.

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Presenting Author: Bridgette DeShields
EPA’s Unregulated Contaminant Monitoring Rule Results (UCMR-3)

Rick Zimmer

EPA’s Unregulated Contaminants Monitoring Program (UCMR) serves to fill the data gaps which exist for contaminants identified by the Contaminant Candidate List (CCL) as candidates for future regulation based on health effects. In UCMR1 (2001-03), Perchlorate was the most prominent constituent detected, based on frequency. In UCMR2 (2008-10) NDMA was the most prominent detected constituent. In the first two monitoring years for UCMR3 (2013-15), some surprises have arisen which will change the landscape and priority of future regulations for drinking water systems in this nation. There have been significant detections of numerous contaminants, some at levels above the current Health Reference Levels (HRLs). In this presentation we will compare occurrence frequencies and concentrations to HRLs and discuss the implications for potential future regulations (MCLs) of drinking water.

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What Do the UCMR-3 Results Tell Us About Emerging Contaminants in Drinking Water?

Bruce Macler

USEPA’s Unregulated Contaminant Monitoring Rules attempt to provide information on the occurrence of constituents in drinking water sources that may pose health risks from ingestion and that are not under regulatory control. To the extent that practical analytical methods allow, the chosen constituents reflect those on USEPA’s Contaminant Candidate List. Results from the UCMRs are used to develop human exposure estimates. These are matched against health risk information to determine if there is "a meaningful opportunity for health risk reduction." Positive determinations generally lead to new drinking water regulations.

Several constituents on the UCMR-3 list have been found routinely, albeit at low concentrations: strontium, vanadium, chromium, molybdenum, chlorate. Most of these are naturally-occurring and ubiquitous, so that as detection limits lower, more detections will be found. A few others have been detected more often than expected, such as 1,4-dioxane. Most others were seldom or never detected, such as the perfluoro compounds and sex hormones.

Strontium is being considered for regulation as announced by USEPA on Oct 20, 2014 in its Preliminary Regulatory Determinations for Contaminants on the Third Drinking Water contaminant Candidate List (Federal Register 79: 62715). Chlorate will be considered for regulation as a disinfection byproduct in the 6-Year Review of drinking water regulations. The Agency deferred a determination for 1,4-dioxane, because adequate data were not available at the time. This presentation will provide details on these and other "emerging contaminants."

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Presenting Author: Bruce Macler
Overview of Poly- and Perfluoroalkyl Substances Chemical Class and a Review of State and Federal Regulatory Guidance

Shalene M. Thomas

Poly- and Perfluoroalkyl Substances (PFASs) are man-made chemicals that have been used in both consumer and industrial products for more than 50 years. Within the last decade, science has emerged that has indicated that some chemicals in this class of substances are persistent, bioaccumulative, and toxic. Studies have also shown that they can be found ubiquitously in the environment, from soil and sediment to groundwater and air worldwide, as well as in nearly 98% of the general human population. This presentation will provide an overview of PFASs, discuss how the commonly-known Perfluorochemicals (PFCs) fit into this developing class of emerging contaminants, and present the balance of developing policy and science to protect human health and the environment. An evaluation of State regulatory requirements will be presented as well as the current Federal guidelines.

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Presenting Author: Shalene M. Thomas
Explaining the Widespread Occurrence of 1,4-Dioxane in Municipal Water Supplies

Thomas Mohr

The results from the 3rd round of the Unregulated Contaminant Monitoring Requirements program are in for the first two years, and the detection rate for 1,4-dioxane is a surprising 20.2% of sources detected above 0.07 µg/L by EPA Method 522. UCMR3 results as of October 2014 show that 6.8% of Public Water Systems have sources with detections above the EPA Health Advisory Level (619 systems). The author’s August 2013 poll of laboratories performing EPA 522 on drinking water samples predicted a 13% rate of detection, and the 99th percentile concentration ranged from 0.5 to 3 µg/L. While most of these detections are well below actionable thresholds, the widespread occurrence of 1,4-dioxane evokes several questions:

- What rate of exposure to 1,4-dioxane is represented by these detections?
- Can the mass of 1,4-dioxane represented by these drinking water detections be explained by its occurrence at sites where 1,1,1-trichloroethane was released?
- A California survey of CECs in recycled water reported that the 90th percentile concentration of 1,4-dioxane in recycled water among 25 producers was 2.6 ppb. Can some of the 1,4-dioxane drinking water detections be attributed to surfactants originating from municipal wastewater due to leaking sewer lines, septic tanks, and irrigation with recycled water?
- Can wastewater marker chemicals be used to differentiate the origins of 1,4-dioxane in municipal supplies?
- What other sources of 1,4-dioxane may be contributing to drinking water detections?
- How are the 1,4-dioxane detections in municipal water sources distributed geographically with respect to known solvent release sites?
- Is 1,4-dioxane in drinking water associated with detections of 1,1,1-TCA and 1,1-DCE in the same sources?
- What treatment remedies are available where 1,4-dioxane detections exceed health advisory or regulatory thresholds?

This presentation examines the issues that these detections present to water utility operators and regulators.

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Presenting Author: Thomas Mohr
ENERGY

Renewable Energy Portfolios - What are They?
Paul MacGregor, Green Harbor Energy, Kennesaw, GA

Renewable Energy Production from DoD Installation Solid Waste by Anaerobic Digestion
Tyler Miller, CDM Smith, Denver, CO

Water Conservation Effects on Navy Energy Use, Drinking Water, and Wastewater Systems
Len Sinfield, U.S. Navy, Naval Facilities Engineering Command, San Diego, CA

Wind Turbines - Do They Pose a Threat to Human Health
Christopher Ollson, Intrinsik Environmental Sciences, Mississauga, ON, Canada

Water Footprinting and Mapping for Commercial/Industrial Facilities: Strategies for Water Conservation, Treatment, and Reuse
Hari Gupta, Coriolis Enterprises, Corona, CA
Renewable Energy Portfolios - what are they?

Paul R. MacGregor

Most utilities address sustainability and the promotion of green technologies though meeting the requirements of state Renewable Portfolio Standards (RPS). Presently, 29 states plus the District of Columbia have an RPS. These standards require utilities supplying electricity to retail customers in the state to achieve a certain percentage of their supply in renewable energy. Utilities can meet the obligation through developing their own renewable facilities or purchasing renewable energy. In either case, the obligation is met through retiring Renewable Energy Certificates (RECs), which are tradable commodities that represent the renewable energy created from a facility’s electrical production. This presentation discusses RPS programs in the United States, the regulatory and transactional framework for RECs and the various REC markets.

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Renewable Energy Production from DoD Installation Solid Waste by Anaerobic Digestion

Tyler Miller, Dave Parry and Patrick Evans

Food waste can be used to produce methane rich biogas through a biological process that provides a useful alternative energy source. Methane from a biogas source can be utilized rather than contribute to the greenhouse effect; unlike the methane emissions resulting from obtaining fossil fuels. In addition, solids reduction by the digestion of food waste significantly reduces landfill waste. This has become a focus by the DoD Environmental Security Technology Certification Program (ESTCP), presenting an opportunity to demonstrate the efficacy of methane production from food waste. This project uses anaerobic digestion of food waste and grease trap waste for producing, harnessing and purifying biogas, yielding a natural gas quality byproduct. In this application the gas would serve as an on-site energy source at the Air Force Academy's wastewater treatment plant. In addition to methane, biogas contains carbon dioxide, moisture and hydrogen sulfide which can be removed through a series of purification steps. During purification, hydrogen sulfide is taken out by Sulfatrap sorbents prior to undergoing vacuum swing adsorption, an innovative process that removes carbon dioxide and moisture. Over a one year period, a study on the production and purification of biogas from food waste was conducted with the use of two side-by-side anaerobic digesters. This demonstration successfully provided the practical ability to create a viable source of energy from solid waste, while reducing landfill waste and greenhouse emissions.

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Presenting Author: Tyler Miller
Water Conservation Effects on Navy Energy Use, Drinking Water, and Wastewater Systems

Len Sinfield

Electrical and water use are dependent upon each other. According to the California Energy Commission, pumping of water consumes approximately 20 percent of California’s electricity and every municipal drinking water system uses pumps to move water. Wastewater collection and treatment also consumes a tremendous amount of electricity. In many cases, even geothermal electrical generation requires imported water for injection into the geothermal field to maintain adequate steam.

Water conservation will lessen energy consumption by reducing water pumping requirements, so water conservation on the surface appears to be a win-win scenario. Unfortunately, these efforts can have unintended negative impacts to water and sewer systems. Lower flow rates through drinking water distribution systems can increase water age, resulting in the loss of chlorine disinfectant required to ensure the bacteriological safety of the water, nitrification in water systems using chloramine disinfection, increased trihalomethanes (THMs) in the drinking water, and taste and odor issues from stagnant water. Water systems have to increase the water flushing to mitigate many of these issues, wasting tens of millions of gallons per year and associated energy required to deliver the water. Lower sewer flow rates can cause “septic” conditions in the sewer lines producing hydrogen sulfide odors, excessive pipe corrosion, and Industrial User permit violations for dissolved sulfides (NBC).

To reduce flushing of water mains to maintain water quality, the Navy water system at NBC has successfully implemented several solutions including: Installing DC-operated water mixers in all the water reservoirs that require less electricity than AC-powered recirculation pumps; Installing water tank mixers (i.e. PAX mixers) improve disinfection mixing in the tanks, reduce biofilm formation, and help maintain a constant chloramine residual in the downstream distribution system; Reducing water age via hydraulic changes in the water system; and conducting detailed hydraulic models of Navy water systems to confirm areas with long water ages and help model potential solutions for water line dead-ends and other chronic water age areas. These measures will help the Navy to continue to save energy and water in the years ahead.

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Presenting Author: Len Sinfield
Wind Turbines - Do They Pose a Threat to Human Health

Christopher Ollson, Loren Knopper, Lindsay McCallum, Melissa Whitfield Aslund, Robert Berger, Mary Mcdaniel and Kathleen Souweine

Around the world, governments are increasingly turning to wind turbines as a source of renewable energy. The association between wind turbines and health effects is highly debated. Some argue that reported health effects are related to wind turbine operation (electromagnetic fields (EMF), shadow flicker, audible noise, low frequency noise, infrasound). Others suggest that when turbines are sited correctly, effects are more likely attributable to a number of subjective variables that result in an annoyed/stressed state. There are roughly 60 scientific peer-reviewed articles on this issue. The available scientific evidence suggests that EMF, shadow flicker, low frequency noise and infrasound from wind turbines are not likely to affect human health; some studies have found that audible noise from wind turbines can be annoying to some. Annoyance may be associated with some self-reported health effects (e.g., sleep disturbance) especially at sound pressure levels >40 dB(A). Because environmental noise above certain levels is a recognized factor in a number of health issues, siting restrictions have been implemented in many jurisdictions to limit noise exposure. These setbacks should help alleviate annoyance from noise. Subjective variables (attitudes and expectations) are also linked to annoyance and have the potential to facilitate other health complaints via the nocebo effect. Therefore, it is possible that a segment of the population may remain annoyed (or report other health impacts) even when noise limits are enforced. Based on the findings and scientific merit of the available studies, the weight of evidence suggests that when sited properly, wind turbines are not related to adverse health. Our research has led to a number of recommended best practices for wind turbine development in the context of human health.

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Presenting Author: Christopher Ollson
Water Footprinting and Mapping for Commercial/Industrial Facilities: Strategies for Energy and Water Conservation, Treatment, and Reuse

Hari Gupta

Water and energy are among the most important, valuable, and limited commodities that are currently and in the future expected to have enormous socio-economic impact in the lives of the global population. Commercial/industrial facilities currently make-up a significant portion of the daily energy and water consumption in the developing and the developed world. As with energy, the biggest bang for the buck is realized by efficient conservation and reduction in its use rather than investing in tapping new sources of water which can be extremely cost prohibitive (e.g., treating seawater for use). A co-benefit of water conservation is the reduction in energy demand associated with the production, treatment, storage, and transmission of water. A reduction in energy use also leads to reduction in Greenhouse Gas emissions. Using the mantra that what cannot be measured cannot be improved, this presentation will provide an overview of methods of water foot-printing and mapping for commercial/industrial facilities, strategies for energy and water conservation, reuse, treatment, and recycling of water/wastewater. Processes and activities which are energy and water sinks will be identified that can be targeted for conservation, including boilers, plating, autoclaving, commercial rinsing/washing/laundry, and cooling equipment. Lessons learned from the field and tips on conducting such water balance studies will also be presented. Challenges faced in energy and water conservation and reuse by typical commercial buildings and research laboratories to energy and water intensive industries such as the food and beverage manufacturing, textile, and metals manufacturing industry will be briefly discussed with a discussion on energy and water conservation best practices for the various industries. An update on local and state energy and water conservation regulations for California will also be provided.

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Presenting Author: Hari Gupta
ENVIROMENTAL FATE AND MODELING

Selenium Hydrogeology, Swamp of the Frogs, Newport Bay Watershed, Orange County, California
John Dodge, Daniel B. Stephens & Associates, Inc., Newport Beach, CA

LNAPl Mobility Assessment in Risk Based Site Closure
Kathleen Kerigan, GZA GeoEnvironmental, Inc., Norwood, MA

Measured vs Modeled Uptake of Metals in Plant Tissue
Diana Marquez, Burns & McDonnell Engineering Company, Inc., Kansas City, MO

Potential Aquatic Toxicity of Petroleum Biodegradation Metabolites
Using Groundwater Samples at Fuel Release Sites
Asheesh Tiwary, Chevron ETC, Houston, TX

Influence of Clays, Metal Oxides, and Organic Matter on the Adsorption
of Newly Generated Biosurfactants onto Soil
Zhiwen Zhu, Memorial University of Newfoundland, St. John’s, Newfoundland
and Labrador, Canada
Selenium Hydrogeology, Swamp of the Frogs, Newport Bay Watershed, Orange County, California

John Dodge, Greg Schnaar, Stephen Cullen and Jian Peng

This study presents the efforts of Orange County Department of Public Works, Watersheds Section to develop a hydrogeologic characterization, water balance, and selenium transport evaluation in the former “Swamp of the Frogs.” The former swamp area was a depositional environment in central Orange County, home to millions of tree frogs, receiving regional stream flow and surface water runoff for centuries. Naturally occurring selenium in the surrounding hills was eroded, oxidized, transported, then deposited onto the low-oxygen floor of the swamp where it accumulated over time in reduced forms (Se⁰, Se²⁻). Development since 1900 has led to significant hydrogeologic changes. An extensive network of agricultural and flood control channels was built to lower the water table, drain the marsh, and transport storm flow to assist agriculture and urban development. After the swamp was drained, the sediment was re-oxygenated and selenium was oxidized and mobilized with groundwater from the historical marsh sediments into the channels as the more soluble Se⁶⁺(selenate, SeO₄²⁻) species. Selenium is a micronutrient at low levels but toxic to aquatic species at elevated concentrations. An evaluation of water sources and sinks, a hydrogeologic characterization, recharge and infiltration estimation, groundwater flow mapping, and a quantitative water balance were completed that includes a rigorous watershed-scale model for estimation of deep percolation to groundwater from precipitation and irrigation. The water balance shows lateral groundwater flow from upgradient recharge areas accounts for most of the groundwater input to the former swamp area with additional input supplied by deep percolation of precipitation, and a relatively minimal amount of input from deep percolation of irrigation. Additional input could be due to sewer/water line exfiltration. The goal is to better understand and ultimately control selenium flux so it can be reduced or eliminated to meet the total maximum daily load (TMDL) requirements.

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Presenting Author: John Dodge
LNAPL Mobility Assessment in Risk Based Site Closure

Kathleen Kerigan, Patrick Sheehan and Albert Ricciardelli

GZA is using a mobility-based approach for permanent closure at a large light non-aqueous phase liquid (LNAPL) remediation site in eastern Massachusetts. GZA operated an extensive dual-phase extraction system on site for approximately 3.5 years and, though recovery has reached asymptotic conditions, LNAPL thicknesses in wells are still as high as several feet in isolated locations.

Because the Massachusetts Department of Environmental Protection (MADEP) is moving towards LNAPL mobility-based closure criteria under the Massachusetts Contingency Plan (MCP), GZA developed an approach to quantifying LNAPL stability. Demonstrating LNAPL stability on a macro-scale can be used to demonstrate No Significant Risk and reduce years of system O&M costs.

GZA implemented an innovative field program that included laser-induced fluorescence (LIF) screening, LNAPL sampling for fluid properties, and soil sampling to analyze for LNAPL initial and residual saturation; laboratory testing for physical soil characteristics such as porosity, capillary drainage, and hydraulic conductivity; and laboratory analyses for volatile and extractable petroleum hydrocarbons. These data were then used to calculate van Genuchten parameters, such as grain size distribution and inverse air entry pressure, which are used in recoverability modeling.

Laboratory analytical results demonstrated that residual LNAPL is largely immobile, with less than 15% of samples indicating mobility potential. LNAPL fluid and physical soil parameters were then used to calculate LNAPL transmissivities. These values are being used in the modeling of LNAPL stability on a macro-scale.

Once macro-scale LNAPL stability has been demonstrated across the site, soil, groundwater, and indoor air data will be evaluated in a Method 3 Risk Assessment to attain a Permanent Solution With Conditions under the MCP. Through advanced planning and project implementation scheduling, GZA will be poised to submit closure documentation as soon as the new MADEP regulations are promulgated, likely mid-May 2015.

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Presenting Author: Kathleen Kerigan
Uptake of metals by plants is often evaluated as part of baseline risk assessments, either in regard to ingestion of homegrown produce or ingestion of plant material by omnivorous and herbivorous species. Additional exposure may occur by human ingestion of animal species that graze on impacted plant tissue. Evaluation of these exposure pathways often begins with modeling the uptake of metals from soil to plant tissue. These models generally require the use of published or calculated biouptake factors, which introduces uncertainty into the risk assessment. This uncertainty is compounded if the predicted concentrations in plants are subsequently modeled to commonly-ingested animal species such as cattle. Uptake studies have been conducted at two facilities where human ingestion of impacted plant or animal species was considered a potentially completed exposure pathway. Each study involved collection of plant tissue samples and co-located soil samples, although the specific plants differed between the two sites. At one facility grass and co-located soil were sampled to evaluate potential uptake to cattle and subsequent human ingestion. At the other facility, roots, leaves, and berries from blackberry bushes were sampled to evaluate ingestion of blackberries that were growing in waste material. Since samples were collected from different portions of the blackberry bushes, this data set allowed for multiple comparisons including comparison of source concentrations in soil to different parts of the plant, comparison of washed to unwashed samples, and comparison of site data to background. Both the grass and blackberry data sets were used to evaluate the results of uptake modeling in comparison to the measured concentrations in the different plant tissues/species. The results of these comparisons indicate differences in metals concentrations that could noticeably impact human and ecological exposure levels. This presentation summarizes the data comparisons and the resulting implications to human health and ecological risk assessment.

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Potential Aquatic Toxicity of Petroleum Biodegradation Metabolites Using Groundwater Samples at Fuel Release Sites

Asheesh Tiwary, Renae Magaw, Dawn Zemo, Rachel Mohler, Kirk O'Reilly and Catalina Espino-Devine

Petroleum hydrocarbons biodegrade in the environment and are converted to polar (non-hydrocarbon) metabolites. These metabolites are extracted and incorrectly quantified as Total Petroleum Hydrocarbons (TPH) unless they are removed from the extract prior to analysis using a silica gel cleanup (SGC). SGC is effective at removing the polar metabolites from the extract; however, some regulatory agencies are hesitant to adopt this method, citing the unknown nature and toxicity of these complex mixtures.

Using state-of-the-art non-targeted GCxGC-MS analyses of groundwater samples from historic fuel release sites, we tentatively identified thousands of polar metabolites representing many distinct structural classes of chemicals including acids/esters, alcohols, phenols, ketones, and aldehydes.

The potential toxicity of polar metabolites to aquatic organisms has been investigated as part of this study. Briefly, upgradient (representing local background conditions) and downgradient groundwater samples were collected from several representative biodegrading fuel release sites, and submitted to a contract laboratory for chronic aquatic toxicity testing using EPA test methods 1000 (Fathead Minnow), 1002 (Daphnid) and 1003 (Green Algae).

Preliminary results show that aquatic toxicity in groundwater samples at fuel release sites is primarily due to background water quality, and not from petroleum biodegradation metabolites. Overall, the complex mixtures of polar metabolites, at concentrations typically found at petroleum release sites, are unlikely to pose a significant risk to aquatic life. Results from this study support the use of SGC for removal of polar metabolites prior to TPH analysis.

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Presenting Author: Asheesh Tiwary
Influence of Clays, Metal Oxides, and Organic Matter on the Adsorption of Newly Generated Biosurfactants onto Soil

Zhiwen Zhu, Pu Li, Baiyu Zhang, Bing Chen and Qinghong Cai

Biosurfactants are a group of diverse structurally biomolecules produced by a variety of microorganisms. The amphiphilic structure of biosurfactants can increase the surface area of two substances, thus make them excellent emulsifiers, foaming and dispersing agents. The addition of biosurfactants can increase the solubility and mobility of contaminants thereby accelerates the contaminants removal. The adsorption of biosurfactants onto soil is an important environmental behavior. It plays a significant role in describing the transportation and fate of pollutants in soil and in determining the feasibility of a remediation technique.

This study is to empirically determine the contribution of representative soil constituents (clays, metal oxides, and organic matter) to the adsorption of a newly generated biosurfactant in soil system. The biosurfactant was produced by *Exiguobacterium antarcticum* N4-1P, an extremophile firstly reported to be a biosurfactant producer by the Northern Region Persistent Organic Pollution Control (NRPOP) lab at Memorial University of Newfoundland. A series of batch suspension experiments were performed to determine the adsorption isotherms of the newly generated biosurfactant in the presence of representative soil constituents. Furthermore, two kinetic models were developed based on the experimental data according to the widely used Freundlich and Langmuir isotherms. In these models, the effects of different soil textures and physicochemical properties including effective cation exchange capacity (CEC) and surface area, were further analyzed to predict the adsorobility of the biosurfactant under different conditions. Multiple scenarios of Freundlich and Langmuir isotherms were then generated to facilitate the biosurfactant application. In general, this research helps to understand the contribution of soil constituents to biosurfactant adsorption, by both experimental and numerical means. The determined isotherms can thus provide effective decision support on biosurfactants utilization for soil remediation enhancement.

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ENVIRONMENTAL FORENSICS

Evaluation of Observed VI Attenuation Factors and Exposure for 50 Commercial Facilities in the Midwest
Megan Hamilton, EnviroForensics, Indianapolis, IN

Assessing Limited Water Resources - Water Resources Forensics
Adam Love, Roux Associates, Oakland, CA

Forensics Assessment Using δ13C and δ37Cl at a Site Impacted with Tetrachloroethene and Trichloroethene
Patrick McLoughlin, Pace Analytical Energy Services, Pittsburgh, PA

Evaluation of Manufactured Gas Plant PAH Contamination using Statistical Visualization: Finding Keys to Process Descriptions and Contaminant Sources
Michael Wade, Wade Research, Inc., Marshfield, MA

Identification of Microplastics in Fish as a Toxic Chemical Exposure Pathway Using Microspectrocopy and Electron Microscopy
Stephen Wall, California Department of Public Health, Richmond, CA
Evaluation of Observed VI Attenuation Factors and Exposure for 50 Commercial Facilities in the Midwest

Megan Hamilton and Jeffrey Carnahan

Much effort has been expended by environmental regulators and researchers in attempts to develop a generic approach for identifying structures where vapor intrusion (VI) assessment is, or may be necessary near subsurface releases of VOCs. Guidance on VI assessments from many agencies promotes the screening of structures based on conservative, generic attenuation factors (AFs) derived from statistical analysis of past sampling data at other structures (i.e. the U.S. EPA Database). The majority of available data used to derive these AFs has been compiled from residential structures. Larger commercial buildings may exhibit characteristics that differ from residential structures and can affect the attenuation of contaminants from the subsurface into the indoor air, effectively lowering the AF. Although there is a lack of compiled data to support this theory, several state VI Guidance documents have incorporated an adjustment to the generic attenuation factors for larger commercial structures. This study presents the analysis of AFs derived from a combination of soil gas, sub-slab vapor and indoor air data for commercial structures at and surrounding 50 different dry cleaner sites where subsurface releases of PCE have occurred. Each site was evaluated using the prescribed default screening approach. An analysis of the compiled data is presented and compared with observed trends from the U.S. EPA VI database. The result of this study provides a ground truthing of how the generic screening approach and default AFs compare for commercial structures, and whether there is a basis for an adjustment factor for commercial structures.

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Presenting Author: Megan Hamilton
Assessing Limited Water Resources - Water Resources Forensics

Adam Love and Andy Zdon

Environmental forensics is typically focused on the assessment of source and timing for contaminants dispersed in environmental matrices. As water is increasing being recognized as a limiting resource in some regions, assessing the sustainability of water use is key to ensuring both environmental and industrial sustainability. Many of the same forensics strategies and methods can be applied to understand the source and age of water – key parameters for understanding overall water system. This presentation will discuss characteristics of systems that could benefit from environmental forensics, the toolbox of forensic methods that can be applied and how multiple lines of evidence are necessary to weave together technically consistent forensic conclusions.

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Presenting Author: Adam Love
Forensics Assessment Using $\delta^{13}$C and $\delta^{37}$Cl at a Site Impacted With Tetrachloroethene and Trichloroethene

Patrick Mcloughlin and Robert Pirkle

As clean water becomes a more highly valued resource and vapor intrusion issues are found to be more of a hazard than previously realized, it often becomes paramount to understand site forensics. At one such property, multiple industrial uses resulted in impacts of chlorinated ethenes to the groundwater, and vapor intrusion issues. The site is characterized by complex, three dimensional structure, with separate lower and upper units in some areas, but no such separations in adjoining locations. The forensic study produced two separate lines of evidence: chemical composition and isotopic ratio as one line and a study of the site hydrology and transport as an independent line. This presentation focuses on chemical composition and isotopic analysis.

The site is impacted with tetrachloroethene (PCE) and trichloroethene (TCE). The site is mostly oxic. Though it has been analyzed regularly at this site there have been only sporadic observations of low concentrations of cis-dichloroethene (cis-DCE). More than thirty samples of groundwater were collected in locations ranging from presumed sources to distal locations where impacts of PCE and TCE were minimal.

Twenty-three and nineteen of the samples contained PCE or TCE (respectively) at a minimum of 5 µg/l and yielded reliable $\delta^{37}$Cl and $\delta^{13}$C. That data showed most of the TCE was directly released, not a product of the dechlorination of PCE. The ratio of PCE to TCE suggested five sources: two represented by only one well each and three others represented by multiple wells. The CSIA data confirmed a separate source to one of the single wells, showed the other to be impacted both by an independent source and one of the other groups, and helped resolve the three groups into five separate groups that better explained the concentration ratios.

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Presenting Author: Patrick Mcloughlin
Evaluation of Manufactured Gas Plant PAH Contamination Using Statistical Visualization: Finding Keys to Process Descriptions and Contaminant Sources

Michael Wade

Beginning in the 1800s, coal gasification provided energy for an emergent utility industry. With focus largely on production and distribution, the manufactured gas production (MGP) industry gave little thought to waste management practices, vestiges of which remain as a legacy over a century later. As a consequence, today the MGP industry's successor companies carry significant legal liability. Polycyclic aromatic hydrocarbons (PAH), with structures ranging from two to six aromatic rings, are dominant legacy pollutants. Sorting out possible multiple PAH sources at former MGP sites carries significant forensic geochemical challenges. Analyses of PAH data using statistical visualization by multiple linear regression and principal component analysis (PCA) have shown some utility in this area. Results of three different investigations will be shown using statistical analyses that aided in the identification of significant manufacturing processes that had been lost for over a century, helped delineate former MGP operation loci, and provided insight into multiple PAH source and mixing effects. Examples of statistical output graphics will be shown that offer readily understood explanations for potential courtroom application.

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Presenting Author: Michael Wade
Identification of Microplastics in Fish as a Toxic Chemical Exposure Pathway Using Microspectroscopy and Electron Microscopy

Stephen Wall, Jeff Wagner, Sutapa Ghosal and Zhong-Min Wang

Plastic debris may play a significant role in exposures of aquatic organisms to contaminants in aquatic environments. As plastics age and physically breakdown due to environmental exposure, the smaller size fraction of microplastics produced have the enhanced surface area to hyper-accumulate persistent organic pollutants. Microplastics identified in fish are a new environmental concern for the introduction of hazardous chemicals into the food chain. Due to the small size of microplastics, considered to be between 3 and 500 um, ocean environment prevalence is not known due to the larger mesh (333 um) netting used to collect plastic debris. Accordingly, direct evidence of microplastics in fish can provide the basis for estimating the importance of this transport mechanism for the delivery of concentrated toxic chemical contaminates into fish tissue.

In this study, advanced forensic techniques using Raman and Fourier Transform Infrared (FTIR) microspectroscopy, as well as, scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) were utilized to identify ingested microplastics present in sacrificed fish digestive tracks. Samples of the four types of microplastics fed to Medaka fish, commonly used for toxicology research, were analyzed to create an identification matching library. Both dietary polyethylene terephthalate (PET), and polyvinyl chloride (PVC) microplastics between 50 um and 500 um were identified in the fish gut samples, which readily matched spectra by both Raman and FTIR microscopy. Significantly larger in size, the dietary polypropylene (PP) and polyethylene (PE) microplastics were not detected in the fish gut samples, and may have not been selectively consumed or rapidly excreted. This novel methodology was extended to field harvested South Atlantic Myctophid fish, known to feed throughout the water column containing microplastics. Raman microspectroscopy identified both polybutyl acrylate (PBA), which is a component of synthetic rubber, and plasticizers such as diethyl adipate in the South Atlantic fish gut.

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Presenting Author: Stephen Wall
ENVIRONMENTAL IMPACT OF NANOTECHNOLOGY

Risk Management of Emerging Technologies
Lawrence Gibbs, Stanford University, Stanford, CA

Emerging Trends in the Environmental Implications of Nanotechnology
Arturo Keller, University of California, Santa Barbara, CA

Reducing Nanoparticle Exposure and Health Effects from Machining of Carbon Composite Materials
Michael Kleinman, University of California, Irvine, CA

Emerging Nanotechnology Regulatory, Enforcement and Potential Liabilities
Tim Agajanian, Ropers, Majeski, Kohn & Bentley, Los Angeles, CA
Risk Management of Emerging Technologies

Lawrence M. Gibbs

Nanotechnology is being heralded as a driver of the next technological and economic wave, and business enterprise development in this globally emerging field holds much promise. Applications utilizing nanomaterials are increasingly prevalent in many commercial arenas including consumer products.

An understanding of the major issues involved with the application of nanomaterials and nanotechnology is important to gain an appreciation of the issues related to risk management of this emerging technology. The properties of nanoparticles (e.g., size, surface area, reactivity) that yield many of the far-reaching societal benefits may also pose possible risks. The challenge is to determine whether the nature of engineered nanostructure materials and devices present new safety and health risks. At the same time, there is a need to address how the benefits of nanotechnology can be realized while proactively minimizing the risk. Growing concern over the potential and perceived risks of nanomaterials may lead to regulatory action that will impact organizations conducting research or developing new applications in the nanomaterials area.

This presentation will provide an introduction to and overview of the emerging field of nanotechnology, and review the major health, safety, environmental concerns, and emerging regulatory and related issues involved with newly emerging technical advances such as nanomaterials. The focus will be on identifying what is known and unknown about possible risks, review of exposure assessment techniques for small particles, and discussion of how to address knowledge gaps.

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Presenting Author: Lawrence Gibbs
Emerging Trends in the Environmental Implications of Nanotechnology

Arturo A. Keller

With more and more products making use of nanotechnology to enhance their performance, a key question is what may be some of the implications for the environment. New research in this area by many groups around the world indicates that there are significant differences in the impacts one can expect from different nanomaterials, depending on their properties, the mode of use and level of emissions, the environmental media into which they are released, their mobility in the environment, their ultimate fate, and their intrinsic toxicity. The behavior of three major classes of nanomaterials, namely metals, metal oxides and carbon nanotubes, will be presented.

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Presenting Author: Arturo A. Keller
Reducing Nanoparticle Exposure and Health Effects from Machining of Carbon Composite Materials

Michael Kleinman, Samantha Renusch, David Herman, Jeffrey Miller and Ramulu Mamidala

Carbon nanofiber composites are used extensively in manufacturing of products ranging from golf clubs to automobiles to passenger aircraft. Machining of these composite materials, during the fabrication, finishing and repair of products, results in the release of multiple tons of airborne and solid wastes. These wastes consist of dusts and fibers in a wide range of sizes, shapes and compositions; some wastes contain nanofibers with physical similarities to asbestos and glass fibers hence they might pose health risks. Current practice is to dispose of these wastes in landfills. Releases during processing, cleaning and disposal can lead to human occupational and environmental exposures. The goal of this project was to (1) identify and investigate the relationships between various machining techniques and the emission of potentially toxic nanofiber material during processing; (2) to perform in vitro assays to compare particle toxicity as a function physical and chemical characteristics and (3) to develop methods for testing the effectiveness of engineering control technology and work practices to reduce the risks of occupational hazards. A novel system for collecting and analyzing particles from machining of carbon composite materials was developed and will be described.

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Jeffrey Miller and Ramulu Mamidala, University of Washington, College of Engineering, Department of Mechanical Engineering

Presenting Author: Michael Kleinman
Emerging Nanotechnology Regulatory, Enforcement and Potential Liabilities
- How to assess and navigate this emerging environmental concern

Tim M. Agajanian

With the continuing mandate under Section 5 of the Toxic Substance Control Act ("TSCA"), the recent published TSCA Work Plan for Chemical Assessment: 2014 Update – and the rapid advancement of nanotechnology the subject of my presentation will cover identifying determining and assessing existing and new laws and regulations effecting nanotechnology manufacturers and companies introducing products into the stream of commerce containing nano materials. I will discuss how to deal with the regulations and laws governing nano materials. We shall take a close look at the current science of these nanotechnologies and track those findings with trends in the law to gain an insight on how the EPA, State, and local enforcement agencies will enforce existing laws and regulations. This will be a practical guide to assess the implications for regulatory and legal responses and how manufacturers and businesses may best navigate this emerging environmental concern to manage risk.

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Presenting Author: Tim M. Agajanian
HYDRAULIC FRACTURING – REGULATORY AND TECHNICAL UPDATE

Laws and Regulations Governing Hydraulic Fracturing*
John Borkovich, State Water Resources Control Board, Sacramento, CA

Legal Perspective and Recent Litigation Related to Hydraulic Fracturing
Charles Correll, King & Spalding, San Francisco, CA

Human Health and Environmental Issues Surrounding Hydraulic Fracturing: A Canadian Perspective
Donald Davies, Intrinsik Environmental Sciences, Calgary, Alberta, Canada

Evaluating Key Sources of Groundwater Quality Variability in Residential Water Wells for Pre-Drill Sampling
Stephen Richardson, GSI Environmental, Inc., Austin, TX

Hydraulic Fracturing for Oil and Gas Production in California - Water Use and Water Quality Issues
Eric Nichols, Substrata, Newfields, NH

North American Shale Development – From a Business & Regulatory Perspective
Charles Whisman, CH2M Hill, Philadelphia, PA

*Abstract not available at the time of printing
Hydraulic fracturing remains controversial, especially in California. Senate Bill 4 required California’s Division of Oil, Gas, & Geothermal Resources (DOGGR) to enact new regulations governing fracking and also to conduct a statewide Environmental Impact Report. Environmental groups continue to challenge fracking on a variety of fronts, and litigation is developing in other states that may have implications for California. At the same time, there is also a push to shut down water disposal wells in California oil fields. The presentation will provide updates on all these fronts and address other potential legal challenges that hydraulic Fracturing may face.

Presenting Author: Charles C. Correll, Jr.
Human Health and Environmental Issues Surrounding Hydraulic Fracturing: A Canadian Perspective

Donald Davies and Thia Sterling

Along with the prospect of enhanced energy security provided by advances in the technology of hydraulic fracturing of shale formations to recover natural gas and oil, numerous concerns have been expressed over the potential impacts of this technology on human health and the environment. These concerns have surfaced in many communities across North America and elsewhere, especially in communities with little or no history of oil and gas development. The concerns have led to increased scrutiny of the technology by government and non-government organizations with an aim to better understand its potential impacts. In some cases, the concerns have resulted in moratoriums being placed on hydraulic fracturing until this understanding is achieved. Canada is no stranger to these concerns, with a number of initiatives having been taken by industry as well as federal and provincial government agencies to address them. This presentation will outline the current status of hydraulic fracturing in Canada, highlighting a number of programs that are now in place or underway to promote or improve understanding of the potential impacts of the technology. One such program is that introduced by the Canadian Association of Petroleum Producers (CAPP) involving a series of Guiding Principles and Operating Practices for hydraulic fracturing. The CAPP guidelines cover several topics relevant to the technology, ranging from well design and construction, water sourcing, baseline groundwater testing, and disclosure of fracturing fluid additives. One of the operating practices focuses specifically on the risk assessment and management of fracturing fluid additives. A chemical hazard screening system developed by Intrinsik Environmental Sciences Inc. for CAPP to assist companies in complying with this practice will be described as part of the presentation.

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Presenting Author: Donald Davies
Evaluating Key Sources of Groundwater Quality Variability in Residential Water Wells for Pre-Drill Sampling

Stephen D. Richardson, Lisa J. Molofsky, Ann P. Smith, and John A. Connor

The media and general public have expressed significant concerns regarding the potential impact of shale gas extraction on surrounding drinking water resources. Determining whether changes in groundwater chemistry (methane, salts, etc.) are natural in origin or caused by drilling operations can be difficult, particularly when i) inconsistent sampling and analytical methodologies are employed and ii) water quality can vary naturally over time due to various factors (e.g., intensity of residential water use, well construction, aquifer geochemistry, precipitation events, changes in temperature). Understanding the sources of variability in concentrations of dissolved gases and other water quality parameters, and the isotopic signature of dissolved gases in residential water wells is critical to discerning natural changes in water quality from those associated with oil and gas extraction activities.

Two field studies were conducted at a series of private residential water wells in northeast Pennsylvania. Study objectives were to i) investigate the effects of sampling methodologies on pre-drill water well quality and ii) to quantify the degree of variability in methane concentration, isotopic signature, and general water quality parameters over an 18-month period. Evaluation of various sampling protocols revealed that the selected sample container has a predictable, and in some cases significant, effect on dissolved methane concentrations, while the volume of water purged prior to sample collection does not exhibit an obvious relationship with dissolved gas concentrations. In addition, our data show that, over time, dissolved methane concentrations correlate with redox indicator parameters as well as concentrations of total dissolved solids and associated dissolved ions. These findings improve our understanding of the inherent variability in pre- and post-drill results and offer insight into methods for improving sample collection protocols and data interpretation.

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Presenting Author: Stephen D. Richardson
Hydraulic Fracturing for Oil and Gas Production in California - Water Use and Water Quality Issues

Thomas Johnson, Scott Seyfried, Fred Stanin and Eric Nichols

Hydraulic fracturing has been used in California for well stimulation since 1953. In 2013, 830 wells were hydraulically fractured. Most wells are 1,000 to 4,000 feet deep. The average volume of water used to hydraulically fracture each well in 2013 was 127,000 gallons (0.39 AF), and the total volume of water used in 2013 for hydraulic fracturing was 323 AF.

The oil industry is exploring the potential of the deep Monterey shale at depths of 7,000 to 14,000 feet. Initial exploratory wells have used an average 10 AF of water per well for hydraulically fracturing. Recent estimates suggest that the volume of water expected to be used by 2030 for all hydraulic fracturing in California, including the Monterey Formation, is less than 2,500 AF, representing 0.004% of fresh water usage in California.

There have been no documented incidents of groundwater contamination in California caused by hydraulic fracturing. Factors include: 1) strict state regulations for well construction to protect groundwater; 2) hydraulic fracturing fluid consists primarily of non-toxic materials (water, sand, guar, etc.); 3) oil producing zones are isolated from fresh water and separated from overlying aquifers by several thousand feet of sediment; and 4) the practice has primarily been used in the western San Joaquin Valley, where fresh water is absent and groundwater is often naturally saline.

The deep Monterey Formation in the San Joaquin Valley is separated from overlying aquifers by 5,000 to 13,000 feet of sediment, and groundwater below a depth of 1,000 feet in many areas has been found to be brackish or saline, and commonly contains natural gas.

Current regulations require groundwater monitoring or proof that no protected groundwater is present. Protected groundwater contains less than 10,000 mg/L TDS and is not in an oil- or gas-producing zone. Regulations also require public disclosure of all hydraulic fracturing fluid components, baseline groundwater sampling, and ongoing monitoring.

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Presenting Author: Eric Nichols
North American Shale Development – From a Business & Regulatory Perspective

Charles Whisman

This presentation will explore how oil and gas development in the US and Canada is creating significant business opportunities worldwide, while also bringing our scientific community together to develop best practices, minimize risks, and lead research initiatives.

North American crude, natural gas, and natural gas liquid markets will be discussed, as well as their impact in the US and globally. For example, US natural gas liquids production is changing the landscape of the international petrochemical industry, providing a new low-cost feedstock in the US. The presentation will provide an overview of natural gas liquids, processing, petrochemical markets, as well as current and future initiatives. We will explore the impact on processing, manufacturing, pipelines, rail, and exporting and how it impacts the US as well as the world petrochemical industry. Similar impacts of North American crude and natural gas production will also be discussed, including their impacts on US refineries and LNG exporting projects.

The presentation will also explore some research and development initiatives in the US related to developing improved best practices, reducing risks, and providing enhanced regulatory compliance programs. We will explore the risks and best practices around important topics such as pre-drilling sampling, land development, permitting, water life-cycle management, sustainability, spill management, and other related topics. Examples of research projects will be shared, in addition to information on how stakeholders are working together to share research and best practices.

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Presenting Author: Charles Whisman
INNOVATIVE REMEDIAL TECHNOLOGIES

Safe and Effective Use of Stabilized Hydrogen Peroxide for Cleanup of a Gasoline and Diesel Groundwater Plume, Silverdale, WA
Gary Cronk, JAG Consulting Group, Santa Ana, CA

Slow-Release Chemical Oxidants for In Situ Treatment of Dioxane and Chlorinated Solvents
Patrick Evans, CDM Smith, Bellevue, WA

Comparison of In Situ Chemical Reduction to Enhanced Reductive Dechlorination to Treat TCE
Daniel Leigh, PeroxyChem, Walnut Creek, CA

Accelerated Biodegradation of Petroleum and Chlorinated Contaminants by an In Situ Colloidal Biomatrix
Ben Mork, Regenesis, San Clemente, CA

Vacuum Driven In-Well Air Stripping and Re-Circulation
Mehmet Pehlivan, Bays Environmental Remediation Management, Ladera Ranch, CA
Safe and Effective Use of Stabilized Hydrogen Peroxide for Cleanup of a Gasoline and Diesel Groundwater Plume, Silverdale, WA

Gary Cronk and Joe Rounds

Hydrogen peroxide stabilized with sodium citrate was used to clean-up a gasoline and diesel groundwater plume beneath a UST site in Silverdale, WA. Stabilized Hydrogen Peroxide (SHP) was selected for use at the site because of its effectiveness in destruction of petroleum hydrocarbons and its ability to act as an activator of sodium persulfate. Use of SHP has been shown to significantly slow down the rapid decomposition of peroxide which normally occurs during a catalyzed hydrogen peroxide (CHP) reaction. The life of the peroxide can be extended from less than 24 hours when using CHP to up to 10-14 days by the use of a stabilizer, which allows for further dispersion of peroxide into the aquifer and more complete destruction of petroleum hydrocarbons.

A total of 8 direct push injection borings were used to inject both SHP and sodium persulfate into a treatment area of approximately 2,400 square feet. Injections were performed at 2 foot depth intervals using a bottom-up technique that started at 20 feet depth and progressed upward to 10 feet depth. The stabilized hydrogen peroxide and sodium persulfate were injected simultaneously into each depth interval by use of a specially constructed dual hose injection apparatus. An important safety benefit of using SHP (a patent-pending process), is it minimizes the occurrence and severity of chemical daylighting during site injections. At this site, the SHP injections produced significantly lower temperatures in the subsurface (50 to 70 degrees Fahrenheit lower), and much less pressure buildup (20 to 40 psi lower) than compared to typical CHP reactions.

The contaminant levels in two monitoring wells located in the treatment area were reduced significantly over a period of 301 days following the SHP injections, including significant reductions in TPH as gasoline (99%), TPH as Diesel (100%), toluene (100%), ethylbenzene (90%), and xylenes (99%).

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Presenting Author: Gary Cronk
Long-term management of plumes containing 1,4-dioxane and chlorinated VOCs is a pressing need. The objective of this ESTCP research was to evaluate slow-release chemical oxidants – permanganate and unactivated persulfate – for in situ treatment of dioxane and VOCs.

Chemical oxidant/paraffin cylinders were evaluated as a slow-release platform. Batch and column studies were conducted to evaluate the reactivity and second-order rate constants of permanganate and unactivated persulfate with dioxane and VOCs. Tests were conducted in deionized water and with soil and groundwater.

Pseudo-second order rate constants showed that unactivated persulfate was approximately 30 times faster than permanganate in oxidizing dioxane. Rate constants with persulfate increased over time suggesting an auto-activation mechanism albeit without the intentional addition of activators such as hydrogen peroxide. Column studies demonstrated over 99% removal of dioxane and VOCs with persulfate. The rate was affected by the soil and groundwater matrix suggesting a complex effect on reaction chemistry. Permanganate columns demonstrated less removal because of manganese dioxide deposition which limited rate of oxidant release from the cylinders. These data indicate that slow-release chemical oxidants have potential for in situ treatment of dioxane and VOCs, but specific groundwater and soil chemistry needs to be considered.

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Presenting Author: Patrick Evans
Comparison of In Situ Chemical Reduction to Enhanced Reductive Dechlorination to Treat TCE

Daniel Leigh

Background: TCE occurs in the aerobic groundwater at Concord Naval Weapons Station (CNWS) Site 29 (Site) in a plume extending over 700 feet long and 100 feet deep. The Navy compared two processes, enhanced reductive dechlorination (ERD) and in situ chemical reduction (ISCR), to determine which approach would best achieve their goal of rapid divestiture of the site under the Base Realignment and Closure (BRAC) program.

Methods: Two pilot tests were conducted at the Site to compare biologically mediated ERD to combined biotic and abiotic ISCR. The ERD pilot test was conducted by distributing emulsified vegetable oil and a dechlorinating microbial culture (SDC-9™). The ISCR test enhanced biotic reductive dechlorination by distributing Emulsified Lecithin Substrate® (PeroxyChem Environmental Solutions) and SDC-9™. Abiotic processes in the ISCR approach were applied by distribution of zero valent iron (ZVI).

Results: ZVI effectively buffered the groundwater. Notably, arsenic persisted at over 4 times the MCL in the ERD test; whereas arsenic never exceeded the MCL in the ISCR test. TCE and DCE were degraded to below the maximum contaminant levels (MCL) in both pilot tests; however, vinyl chloride was only degraded to below the MCL in the ISCR pilot test. The ISCR approach achieved the remedial goals in approximately 1/3 the time required by ERD. This reduction of treatment time is attributed to the rapid abiotic degradation of DCE by ISCR.

Conclusion: ISCR was demonstrated to be a much more aggressive approach to remediate chlorinated ethenes than ERD. ELS® is an effective organic substrate for reductive dechlorination. The ISCR process was selected for full-scale treatment to more aggressively treat the contaminants, reduce the potential for generation of toxic degradation products, provide long lasting substrates that reduce the potential for rebound of the contaminants and to achieve the Navy’s goal of rapid divestiture of the Site.

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Presenting Author: Daniel Leigh
Accelerated Biodegradation of Petroleum and Chlorinated Contaminants by an in Situ Colloidal Biomatrix

Ben Mork, Kristen Thoreson, Stephanie Rittenhouse and Joy Gravitt

Enhanced biodegradation and monitored natural attenuation (MNA) are effective, widely-used tools for elimination of organic contaminants in groundwater. The timeframe for treatment by these methods is on the order of months to years, during which time the contaminants are biodegraded to non-toxic end products. To significantly improve remediation performance beyond that of traditional enhanced bioremediation, a new in situ technology has been developed that accelerates biodegradation and drastically shortens the timeframes for reaching groundwater treatment goals.

This presentation demonstrates the efficacy of a colloidal in situ remediation agent that consists of highly sorptive activated carbon particles (1-2 microns in size) stabilized to transport widely through an aquifer upon injection. The stabilized colloids deposit on soil surfaces, forming a biomatrix that traps contaminants and accelerates their degradation.

Microcosm studies were performed to evaluate the biodegradation of both benzene and PCE in the presence of the colloidal biomatrix material. Contaminant concentrations in water were monitored weekly over the course of the studies by static headspace using GC-FID or GC-ECD methods. In both studies, the colloidal agent facilitated >90% destruction of contaminant within 28 days compared with controls. To further the understanding of the process, full-bottle extraction methods were developed to measure contaminant mass across all phases in the bottles (soil, water, and colloidal sorbent). The extraction techniques confirmed that colloidal agents rapidly reduced groundwater contaminant concentrations via sorption (70-90% in the first 24 hours), and subsequently accelerated biodegradation of the contaminants. All conditions were run in triplicate and results analyzed for statistical significance.

The performance of the colloidal biomatrix material will be reviewed in detailed comparison with sterile and live control samples, as well as those treated with traditional enhanced bioremediation methods. Benefits of the colloidal technology will be discussed, including advantages for treatment of sites exhibiting matrix back-diffusion of contaminants.

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Presenting Author: Ben Mork
This paper presents the results of an in-well stripping and recirculation pilot test performed in New York. Two wells at 35 feet distance from each other were used for the pilot test. Both wells were screened in the same zone. One of the well was used for extraction and the other for injection. The results indicated that Extraction well was dewatered (8 ft. of Drawdown) shortly after the start of recirculation. Injection well had 6 feet of head in the well. VOC stripping ratio of over 90% during extraction was observed. Extraction cone of depression were potentially overlapping the injection head, which indicated that all of the water injected is being captured by one extraction well at 35 feet distance. The method uses no downhole pump, no moving parts in the well and very simple to install. The results indicated that the Vacuum driven in-well stripping and recirculation method may be a viable alternative for remediation of soil and groundwater that impacted with petroleum hydrocarbons.

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Presenting Author: Mehmet Pehlivan
NAPHTHALENE - THE EMERGING STATE OF ITS SCIENCE AND RISK ASSESSMENT

There’s Naphthalene In Our Fuels! Evaluations of Its Presence & Prevalence
John Hinz, USAFSAM/OEC - Retired, Schertz, TX

Air-Force Wide Occurrence of Naphthalene in Groundwater, Soil, and Other Media
Samuel Brock, Air Force Civil Engineer Center, JBSA Lackland AFB, TX

Naphthalene: Possible Human Carcinogen? Results of a Multi-Year Research Effort
True-Jenn Sun, Chevron, San Ramon, CA

Risk Assessment for Inhalation Exposure to Naphthalene
Fred Reitman, Shell Oil Company, Houston, TX
There’s Naphthalene in Our Fuels! … Evaluations of Its Presence & Prevalence

John Hinz

A natural component of petroleum-based products such as fuels, lubes and asphalts, naphthalene is a constituent of both jet fuel and its exhaust. This ubiquitous chemical is an important industrial chemical as a feedstock for the production of plasticizers, dyes, and carbamate pesticides. It is also found in cigarette and wood smoke, barbecued meats, foodstuffs, breast milk and toilet deodorants. Mothballs, available at your local supermarket, are 99.95% pure naphthalene -- the chemical represents both an everyday household product and a widespread environmental pollutant found in the air shed around airports and airbases alike as well as the groundwater underneath them.

Since naphthalene is a constituent of our major transportation fuels, if determined to be carcinogenic to man, especially at environmentally relevant concentrations, what impact might such a determination have? In part, the answer rests on the statutory authorities of two federal agencies. EPA-Office of Research & Development, through its NCEA and IRIS programs, is tasked with the authority for proposing guidance. On the other hand, OSHA is tasked with the authority for promulgating regulation, including regulations governing the communication of hazards in the workplace - here is where the “Report On Carcinogens” can have impact.

The Department of Defense uses approximately 5 billion gallons of jet fuel per year with the U.S. Air Force consuming about half of that amount. US commercial aviation consumes another 20+ billions of gallons each year. If our transportation fuels, as mixtures, serve as vehicles that convey a carcinogen, then such consumption rates represent a significant potential for human exposure. Our reports describe two programs designed to better characterize the amount of naphthalene in our fuels as well as the potential for monitoring exposure to it.

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Presenting Author: John Hinz
Air-Force Wide Occurrence of Naphthalene in Groundwater, Soil, and Other Media

Philip Hunter and Sam Brock

Naphthalene is a naturally occurring component of petroleum-based fuels. DoD is the nation’s single largest user of petroleum fuels. The Air Force alone uses billions of gallons of fuel annually for various aircraft and ground vehicles. The storage, handling, and transport of fuels represent the most common mechanism for release of naphthalene into the environment.

The Air Force’s central database, ERPIMS, consists of over 85 million analytical sampling results from over 200 installations. This extensive database was queried to assess the occurrence of naphthalene in key media spanning 1980 to the present. Cleanup actions are associated mostly with spill sites, USTs, landfills, and fire training areas. Key media affected include groundwater, soil, soil vapor, sediment, and surface water. Groundwater is the principal media of concern based on the number of detects exceeding environmental criteria. Because detection limits and EPA screening levels have changed significantly over the years, it is difficult to assess the environmental impact of naphthalene. Legacy data, which is compromised by higher detection limits, is inadequate for site characterization based on current levels of concern and new toxicology. This study will describe and analyze naphthalene concentrations representative of Air Force sites across the US. Differences in the suite of contaminants associated with naphthalene due to the various media sampled will also be addressed. This review will add insight to support exposure pathway evaluation and risk assessments at similar military and industrial sites.

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Presenting Author: Sam Brock
Naphthalene: Possible Human Carcinogen? Results of a Multi-Year Research Effort

True-Jenn Sun, Fred Reitman, Patrick Beatty and Anne Lehuray

Over the last decade, naphthalene has increasingly become a chemical of potential concern at petroleum release sites. During that time, risk-based screening levels for naphthalene in soil and air decreased by an order of magnitude, due largely to its classification as a possible human carcinogen by U.S. and international agencies in 2002. The classification was based on tumors observed in laboratory rats exposed to naphthalene for two years, while there is little evidence to suggest exposure to naphthalene is associated with cancer in humans.

In 2006, industries interested in the question of whether naphthalene should be classified as a human carcinogen convened a state-of-the-science symposium with support from U.S. EPA to evaluate existing scientific knowledge and its relevance for use in human health risk assessment. As a result of this symposium, the Naphthalene Research Committee (NRC) was formed and a multi-year research program was initiated to identify and fund scientific studies that could help answer questions about naphthalene carcinogenicity. Research efforts were completed in 2014 and have been presented in over 20 peer-reviewed publications. Results will be included in the upcoming U.S. EPA Integrated Risk Information System reevaluation of naphthalene toxicity. Key findings from the NRC research program and their implications for human risk assessment will be presented in this session.

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Presenting Author: True-Jenn Sun
Risk Assessment for Inhalation Exposure to Naphthalene

Fred Reitman

Naphthalene is a naturally occurring constituent of crude oil and certain petroleum products, including jet fuel. Trace amounts of naphthalene may be present in air and water, and are endogenously present in humans from intermediary metabolism. Exposure may also occur occupationally or due to the presence of naphthalene in facility emissions, accidental releases, or waste disposal sites.

Long-term naphthalene inhalation was found in 1992 and 2000 NTP studies to cause nasal tumors in rats and benign lung tumors in mice. However, the chosen naphthalene exposure levels caused extensive inflammation and cytotoxicity in these same tissues, confounding interpretation of the study results. Considerable research has since been conducted to better understand the applicability of these rodent findings to humans. Herein is presented a summary of key naphthalene research findings in terms of plausible modes-of-action and potential relevance to humans under realistic exposure scenarios.

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PETROLEUM HYDROCARBON VAPOR INTRUSION I

Back to the 1980’s for Products Liability and Environmental Litigation
Kevin Mayer, Crowell & Moring LLP, Los Angeles, CA

Speciation of C5 to C12 Aliphatic Hydrocarbons and C6 to C12 Aromatic Hydrocarbons using EPA method 8260 for Vapor Intrusion Risk Assessment Evaluations
Steve Jones, Jones Environmental, Santa Fe Springs, CA

Comparative Study of Indoor Air Databases and the Veracity of “Background”
Robin DeHate, GEI Consultants, Inc., Valrico, FL

Vapor Intrusion Evaluation at LUFT Sites with the Lead Scavenger Ethylene Dichloride (EDC) in Groundwater
Thomas Rejzek, Santa Barbara County Public Health Department, Santa Maria, CA

Updating Site Conceptual Models for Potential Sewer Gas and Vapor Intrusion into Indoor Air from Breached Sewer Conveyance Systems
James Jacobs, Clearwater Group, Point Richmond, CA

Soil Vapor Reproducibility in Duplicate and Purge Volume Test Samples
Suzie Nawikas, H&P Mobil Geochemistry, Carlsbad, CA
Back to the 1980’s for Products Liability and Environmental Litigation

Kevin C. Mayer

In light of today’s regulatory and litigation environment, vapor intrusion is an old problem rediscovered, with ominous potential ramifications for land owners, operators and other PRPs in 2015 and beyond.

This presentation will discuss vapor intrusion issues from the legal perspective, focusing on its anticipated impacts on tort litigation, notably including more complicated remedial actions; the re-opening of “completed” clean-ups; real estate development and Brownfields; new rounds of contribution litigation; RCRA sec. 2002 citizen suits; and toxic tort claims. Important affirmative defenses and strategies for challenging opposing expert testimony will also be discussed.

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Presenting Author: Kevin C. Mayer
The proliferation of gasoline stations, pipelines, oil field operations and refineries in California has made hydrocarbons common contaminants in subsurface soils, groundwater and soil gas. In addition, more and more firms are switching from Freon and chlorinated hydrocarbons to totally hydrocarbon based materials. The restricted use of tetrachloroethylene (PCE) in dry cleaners has led most of these establishments to resort to hydrocarbon cleaning apparatuses. Many propellants are now hydrocarbon based as well as many cleaning solvents. Many other applications such as paint thinners/solvents, paints, household supplies and others are switching to hydrocarbon bases because these mixtures have lower costs and risk levels than the compounds or mixtures that they are replacing.

Several states including California have adopted risk assessment values for aliphatic and aromatic hydrocarbon ranges. California recently included these risk values in a document that replaced the 2009 document that was retracted. The original document was retracted, among other things, due to lack of analytical protocol to measure individual carbon ranges. Simple, easy to use, readily available procedures exist to measure each parameter using common EPA method 8260 technology. A narrative will be given discussing how numbers can be obtained for each aliphatic and aromatic category. If time permits, C13 and higher hydrocarbon identification will be discussed.
A question that often haunts risk assessors is “Are my technical data and references accurate and relevant”? To address one aspect of this question we compared two historical datasets used as benchmarks for background indoor air quality within homes and businesses for the evaluation of soil vapor intrusion, to a more recent comparable dataset collected in homes and businesses adjacent to contaminated sites. EPA’s Building Assessment and Survey Evaluation (BASE) study sampled 100 buildings with a total of 298 indoor air samples analyzed for VOCs. The NYSDOH study included 104 homes, collected more than 400 indoor air samples analyzed for 69 individual VOCs. Our recent study collected 794 indoor air samples from 137 sites and compared the results to the “background values” found in the historical BASE and NYSDOH studies. The samples were analyzed for volatile organic compounds using EPA Methods TO-14A and TO-15 by an EPA approved laboratory. The BASE study used a combination of two sample collection methods: 6-liter SUMMA canisters and multi-sorbent tubes while the NYSDOH study used only 6-liter SUMMA canisters. Our study utilized 6-liter SUMMA canisters which is comparable to the BASE and NYSDOH studies. The historical datasets’ reporting limits ranged from 0.2 to 16.8 µg/m³. Our data set was then compared to the minimum and maximum and the 25th, 50th, 75th, 90th, 95th and 99th percentile values in the background data sets. Our results show that although similar to the background dataset there were significant differences, enough to conclude that the “background” dataset is limited and should be expanded to include additional data. This additional data is readily available through State programs that have been collecting indoor air samples through a variety of programs including soil vapor intrusion assessments. This expanded dataset would be more reflective of actual background; resulting in a more accurate assessment of risk to the human population that it is being applied.
Vapor Intrusion Evaluation at LUFT Sites with the Lead Scavenger Ethylene Dichloride (EDC) in Groundwater

Thomas Rejzek and Paul Mccaw

Ethylene Dichloride (EDC, aka 1,2-Dichloroethane, 1,2-DCA) is a chlorinated solvent that was used as a lead scavenger in leaded gasoline. Gasoline site investigations focus on characterizing the extent of Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) volatile organic compounds and fuel oxygenates (typically MTBE and TBA). However, EDC has been shown in a 2008 EPA study to be prevalent in older gasoline releases dating from the pre-late 1980's. As a chlorinated solvent, EDC does not tend to degrade aerobically like non-chlorinated aromatic compounds. Thus, EDC plumes tend to remain fairly stable while co-located BTEX plumes show decreasing concentration trends. California's Low Threat Closure Policy (LTCP) addresses the volatile organic compounds Benzene, Ethylbenzene, and Naphthalene with respect to vapor intrusion at gasoline sites, but not EDC. Modeling of EDC groundwater plumes and resistance to aerobic degradation suggest that EDC may pose a vapor intrusion threat.

The Santa Barbara County Leaking Underground Fuel Tank Program has been collecting EDC data at gasoline release sites since the mid-1980's (Natural Attenuation of Lead Scavenger 1,2-Dibromoethane (EDB) and 1,2-Dichloroethane (1,2-DCA) at Motor Fuel release Sites and Implications for Risk Management, US EPA, September 2008). Several sites in Santa Barbara County meet the LTCP criteria, yet still have fairly significant EDC plumes. This presentation examines several case studies where modeling suggested that EDC posed a potential vapor intrusion risk. At these sites, soil gas samples were collected to evaluate the potential vapor intrusion risk posed by EDC groundwater plumes.

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Presenting Author: Thomas Rejzek
Updating Site Conceptual Models for Potential Sewer Gas and Vapor Intrusion Into Indoor Air From Breached Sewer Conveyance Systems

James Jacobs and Kelly Pennell

Site conceptual models for vapor intrusion have generally focused on the migration of volatile organic compounds (VOCs) from subsurface soil, soil vapor and groundwater into indoor air. Inflow and infiltration (I&I) of groundwater and stormwater into sanitary sewer pipeline systems is well documented and is a potential mechanism of vapor intrusion. One case study of I&I of stormwater and shallow groundwater into a coastal northern California wastewater treatment plant with a normal daily flow of about 3 million gallons per day, shows an increase during heavy rainfall periods of up to about 10 times the normal daily flow rates.

Smoke testing, long been used to locate gross breaches where I&I enters sewer pipe systems, is a diagnostic technique in which pressurized smoke is applied to a leaking pipe network to visually identify the location and extent of system breaches. Sewer line breaches include corroded pipe walls, pipe cracks, pipe offsets, non-standard piping construction and pipe-to-pipe or pipe-to-fixture seal failure which can occur anywhere between indoor plumbed fixtures and the sewer plant. Sewer gases and vapors, including volatilization of any permitted or non-permitted discharges into the system, enter the sewer conveyance system. Proper sewer design seals off sewer gases and vapors from indoor air. Ineffective vapor seals, dry P-traps, improper plumbing construction or nonfunctioning vent lines, can create potential human exposure risks.

Such potential human exposure to sewer vapors in indoor air in structures with compromised sewer systems takes on a new dimension for properties directly overlying VOC impacted soil and groundwater or those properties whose sewer network otherwise intercepts soil or groundwater containing VOCs. The study of indoor air impacted by migrating soil vapor contaminants from a compromised sewer conveyance system has not been widely considered. A case study will present the role of breached sewer pipelines and ineffective vapor traps in degrading indoor air quality, suggesting that updates to site conceptual models be considered.

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Presenting Author: James Jacobs
Soil Vapor Reproducibility in Duplicate and Purge Volume Test Samples

Suzie Nawikas

Field duplicate samples are often requested with soil vapor surveys to evaluate the reproducibility and precision of the sampling and analytical process. Purge volume test samples are also requested and evaluated to determine which volume yields the highest results for target compounds. However, questions often arise with regards to differences between the samples. What is an acceptable variation, and if the variation is in exceedance, what does that indicate? Over the years, H&P has compiled a database of thousands of duplicate and purge test samples that have been collected and analyzed under various situations. The differences within the database have been evaluated with regards to sample container, analytical method, compounds present in the samples, as well as the contamination level in the samples. An average reproducibility trend has been determined for primary and duplicate samples, and the results of the evaluation have also identified patterns with regards to petroleum hydrocarbon compounds versus chlorinated compounds. The evaluation of the purge test results provides insight to the effect of sample volume on VOC results. Knowing what sort of reproducibility can be expected for duplicate and purge test samples will better prepare consultants and regulators with the information needed to evaluate variations in the data set, therefore aiding in the evaluation of the survey results.

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PETROLEUM HYDROCARBON VAPOR INTRUSION II

Beyond the Guidance – A Summary of the ITRC PVI Guidance Document and How it was Developed
Catherine Regan, ERM, Boston, MA

Approach to Determining Enough Data to Assess VI
Jackie Wright, Environmental Risk Sciences Pty Ltd., Carlingford, NSW, Australia

A ‘Conservative’ Biodegradation Model of Petroleum Vapour and Oxygen Under Buildings
Greg Davis, CSIRO, Wembley, Western Australia

The Effect of Pressure-Driven Flow on Petroleum Vapor Intrusion
George DeVaull, Shell Global Solutions, Houston, TX

Comparison of Biovapor and Johnson and Ettinger (J&E) Model Predictions to Field Data for Multiple Sites
Ian Hers, Golder Associates, Burnaby, BC, Canada

Evaluating Methods of Purging and Sampling to Determine Representativeness of Soil Vapor Data
Robin Davis, Utah Dept. of Environmental Quality, Salt Lake City, UT

Use of Vapor and Temperature Measurements from Monitoring Wells to Identify Depth and Rate of Biodegradation in Vadose Zone Soil
Robert Sweeney, Petroleum and Environmental Geochemistry, Etna, CA
Beyond the Guidance – A Summary of the ITRC PVI Guidance Document and How it was Developed

Matthew A. Lahvis and Catherine E. Regan

The Interstate Technology and Regulatory Council (ITRC) has been working for the past three years to develop a consensus-based document providing guidance on the assessment of petroleum vapor intrusion. The targeted users of this document are state/federal regulators and consultants as well as site owners and public and tribal stakeholders. As such, representatives from each of these groups have been active during document development.

An update on the status of the PVI guidance document (estimated to be finalized prior to the AEHS conference) will be provided as well as a summary of the main topics. This will include a summary of the PVI assessment strategy, site screening, investigation tools, mitigation options and community engagement detailed in the document. This presentation will also go beyond the guidance to provide insight into the development of the document. How was the guidance documents created? How do you build consensus between multiple stakeholders with varying opinions and perspectives? The development of the PVI guidance document was challenging and required the dedication of a core group of regulators, practitioners and subject matter experts as well as input from the regulatory and environmental community at large. The development process, including the give and take, the debates and the “hot topics”, will be discussed.

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Presenting Author: Catherine Regan
Approach to Determining Enough Data to Assess VI

Jackie Wright

Vapour Intrusion (VI) guidance for petroleum hydrocarbon sites was released 2 years ago in Australia. The guidance provides a clear decision framework for conducting petroleum VI assessments in Australia. The framework has been developed to be fairly prescriptive allowing greater certainty in the decision processes adopted and outcomes for both assessors and auditors/regulators. This paper will provide an overview of the regulatory framework and setting in Australia and an overview of how well the guidance is accepted within this framework.

More specifically this paper will provide more detail on the approach outlined in the Australian guidance for determining if sufficient data is available to make sound decisions in relation to VI risk issues on a site. The approach to be outlined involves the application of a margin of safety (MOS) approach. The requirement for the collection of additional data depends on the level of safety, which is essentially the difference between the VI risk for a site/situation and an acceptable level of risk. This approach presented relates to evaluating soil vapour data as well as ambient/indoor data, with the approach adopted different for each of these data sets. The MOS concept has also been utilised for the assessment of soil vapour data collected for other volatile compounds, including chlorinated hydrocarbons.

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Presenting Author: Jackie Wright
A ‘Conservative’ Biodegradation Model of Petroleum Vapour and Oxygen under Buildings

Greg B. Davis and John H. Knight

Knight and Davis (2013) showed that for smaller slab sizes, deeper depths to groundwater and lower strength sources of petroleum vapours that vapours could be fully biodegraded in vadose zones and as a result oxygen could be present under the entire sub-slab domain of a building, effectively eliminating the petroleum vapour risk posed to human health. This result was obtained for a two dimensional cross sectional building, accounting only for the smallest lateral dimension of a slab on ground building, and allowing only diffusive processes.

Recent investigations have extended the model to account for three dimensional gas transport and the lateral and longitudinal dimensions of the slab structure. The model was applied to variable dimensioned slab on ground buildings, and to square slab foundations allowing oxygen ingress from all sides. Whilst Knight and Davis provided a conservative screening model, this improvement provides a ‘conservative’ upper bound on conditions under which vapours may be entirely biodegraded and risks mitigated. Additionally, the model was even further extended to consider the spacing between slab on ground buildings, and its effect on oxygen ingress and vapour biodegradation. This provides confidence in an urban or commercial setting as to the ‘lowest’ level of biodegradation that might be occurring when assessing the risks posed by petroleum vapours threatening human health via vapour intrusion pathways. The model provides a simple tool for including or excluding sites from further investigation, where petroleum vapours may be resident in the subsurface.


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Presenting Author: Greg B. Davis
The Effect of Pressure-Driven Flow on Petroleum Vapor Intrusion

George DeVaull

Surface air-pressure fluctuations can induce pressure gradients and vapor flow in air-connected subsurface soils. These pressure fluctuations can originate from barometric pressure changes, atmospheric winds, and, in the vicinity of buildings, from the on/off switching of mechanical ventilations systems. This presentation is a summary of several screening-level estimates of the effect of these surface pressure changes on surface-to-soil gas differential pressure, on shallow subsurface vapor flow, and on subsurface soil gas concentrations, particularly for biodegradable vapors including petroleum constituents and methane.

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Presenting Author: George DeVaull
Comparison of BIOVAPOR and JOHNSON AND ETTINGER (J&E) Model Predictions to Field Data for Multiple Sites

Ian Hers and Parisa Jourabchi

Aerobic biodegradation of petroleum hydrocarbon vapors is a significant process for attenuation of subsurface vapor concentrations at many sites. When screening approaches based on exclusion distances or generic criteria indicate a potential concern, models may be useful to support the site assessment. Models can be used for multiple purposes: estimate indoor air concentrations and/or derive soil vapor criteria as part of a risk assessment; test the conceptual site model; evaluate the effect of changes in site conditions including predictions for future conditions; and prioritize site actions.

Several available analytical and numerical models incorporating biodegradation are reviewed, followed by a more detailed evaluation of the BIOVAPOR model, an analytical model based on the Johnson and Ettinger model framework that includes oxygen-limited aerobic biodegradation. A sensitivity analysis is conducted including where the influence of foundation type and conditions beside the building are evaluated with respect to oxygen ingress to the subsurface, a key parameter for the BIOVAPOR model.

The results of BIOVAPOR model predictions are compared to field data for multiple sites, and for baseline purposes (i.e., without biodegradation) to the results of the Johnson and Ettinger model. The differences in model predictions are quantified through a bioreduction factor, both with respect to hydrocarbon concentrations and attenuation factors. For selected cases, the steady state BIOVAPOR model is also compared to the MIN3P-DUSTY numerical model to illustrate the influence of soil heterogeneity and how concentrations change over time (“transient behavior”) as influenced by sorption and other processes, which is shown to lead to conservative predictions by the BIOVAPOR model in some cases.

A key finding of the modeling is that typically only a small oxygen flux is needed to degrade the upward hydrocarbon flux. For borderline sites (where there may be a concern), sustainable measures that could potentially be implemented to increase oxygen flux to the subsurface are discussed including barometric pressure or wind assisted vents with one-way valves or low power fans. The BIOVAPOR model and airflow venting calculations for subslab soil are presented to conceptually show how a model could be used to inform the design process.

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Presenting Author: Ian Hers
Evaluating Methods of Purging and Sampling to Determine Representativeness of Soil Vapor Data

Robin V. Davis

In January 2013, EPA Office of Underground Storage Tanks published a report of empirical petroleum vapor data from associated source strengths. This database report contains data consisting of 829 paired measurements of benzene in soil and groundwater, and associated vapor concentrations from 74 sites that represent a wide range of environmental and climate conditions in the United Stated and Canada. The report shows that petroleum vapors attenuate due to aerobic biodegradation within consistent and predictable vertical distances from a source. These distances can be used to screen sites for the petroleum vapor intrusion pathway.

The signature characteristics of aerobic biodegradation are marked by high concentrations of hydrocarbon near the source accompanied by low oxygen and high carbon dioxide concentrations. At vertical distances from the source, hydrocarbon and carbon dioxide concentrations decrease and oxygen concentrations increase. However, the EPA database contains a small population (6%) of anomalous data that exhibit relatively high oxygen concentrations in the presence of high hydrocarbon concentrations. Although this small anomalous data set does not affect the vertical screening distances, it does point to the importance of taking measures to ensure soil gas samples are collected from representative areas of concern.

Hal’s Service in Green River, Utah is a site that constitutes a large population of data in the EPA database report. In June 2014, a study at Hal’s Service in Green River, Utah was conducted by Bob Sweeney (Environmental & Petroleum Geochemistry) to better understand why oxygen and hydrocarbons in soil gas sometimes co-exist. This presentation shows a comparison of Dr. Sweeney’s 2014 data and data collected by UDEQ since 2003. The results indicate that the most likely cause of the anomalies is 1) Over-purging and high-flow purging, which can result in drawing vapors from non-representative areas, and/or; 2) Leaks at the vapor completion point due to inadequate hydration of the bentonite seal resulting in short-circuiting.

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Presenting Author: Robin V. Davis
Use of Vapor and Temperature Measurements from Monitoring Wells to Identify Depth and Rate of Biodegradation in Vadose Zone Soil

Robert E. Sweeney

A field study was completed in the summer 2014 at the former Hal’s retail site in Utah using a low purge method to evaluate whether or not valid soil vapor results could be obtained from existing groundwater monitoring wells. Assumptions tested by the field work were: 1) vapor in the well within the screened interval is equivalent to that for adjacent soil; and 2) vapor collection can be done in such a manner that convection within the well will not affect the composition of the vapor during sampling.

Using the low purge method, continuous measurement of O₂ and CO₂ concentrations were made for vapor pumped from the base of monitoring wells. In general, the concentrations became stable after about 15 seconds of purging. After stabilization, vapor samples were collected for laboratory analysis. Following sample collection, O₂ and CO₂ concentrations were again measured for vapor pumped from the base of monitoring wells. In all cases, the O₂ and CO₂ measurements made in the field and laboratory were essentially the same. For monitoring wells at LNAPL locations, the concentration of O₂ in vapor at the base of the vadose zone was not detectable at the 0.1 %-v level. In contrast, vapor at the base of the vadose zone in wells outside the LNAPL footprint was consistently aerobic. The O₂ concentration in monitoring wells located upgradient and downgradient from the LNAPL plume ranged from 13.4 to 18.5 %-v and from 5.1 – 5.6 %-v, respectively.

Based on the results of this study, it is concluded that the low purge method can be used to determine the vapor composition at the base of the vadose zone. This information can be used to determine whether or not anaerobic conditions exist in the soil previous to any intrusive emplacement of soil vapor probes. By adding temperature measurements down the monitoring wells, the depth of the aerobic/anaerobic (A/A) interface can be determined on the basis of an increase in soil temperature at the depth of aerobic biodegradation. Knowing the depth of the A/A, it is possible to calculated the rate of biodegradation as a function of the effective diffusivity of soil. The effective diffusivity of soil can be estimated from total and air porosities of the soil.

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Presenting Author: Robert Sweeney
REGULATORY PERSPECTIVES ON SITE CLOSURE CRITERIA

Michigan’s Risk-Based Approach for Contamination Site Closure
Bob Wagner, Michigan Department of Environmental Quality, Kalamazoo, MI

Strategies for Site Resolution in Kansas
Chris Carey, Kansas DEH, Topeka, KS

Risk Based Investigations for Petroleum Leaksites in MN
Andrew Eddy, Minnesota PCA, St. Paul, MN

California UST Site Closure Criteria
Yue Rong, California RWQCB, Los Angeles, CA

Balancing Risk, Uncertainty, and Resource Realities
Kenny Dixon, US EPA Region 9, San Francisco, CA

Completion of Groundwater Restoration for Superfund Sites, Guidance, and Tools
Herb Levine, US EPA Region 9, San Francisco, CA
Michigan’s environmental cleanup programs are regulated under Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the Michigan Natural Resources and Environmental Protection Act, 1994 Public Act 451, as amended (NREPA). In general, the current program allows for site closure in one of three ways: 1) remediation of contaminated media to below the State’s generic residential or non-residential cleanup criteria; 2) remediation of contaminated media to a site-specific, risk-assessment-based, cleanup criteria; or 3) an assessment of the relative risk posed by the contamination at the site and implementation of appropriate institutional controls, such as restrictive covenants, municipal ordinances, isolation distances, or engineering controls, to ensure that unacceptable exposures do not occur.

Through the 1980s, Michigan law relied on a non-degradation standard that set cleanup goals at the detection limit or documented background concentrations; it also relied on a strict liability standard that attached responsibility for cleanup activities to any owner or operator after a release occurred at a facility. Amendments to state law during the 1990s transitioned to a causation-based liability standard and established land-use-risk-based cleanup criteria. Even with these changes, an assessment of site risks alone was generally not sufficient to obtain site closure, especially in cases where non-aqueous phase liquid (NAPL) or significant residual source contamination was present. Additional changes to Michigan’s environmental laws in 2012 incorporated current scientific principles and understanding, particularly in recognizing standards for risk-based corrective action established by the American Society for Testing and Materials, and now allows for closure of sites with NAPL and other source material, even in the absence of significant active remediation. This presentation will focus on the recent changes of Michigan’s environmental law concerning site cleanups and closures; the various stakeholder processes involved in the recent changes to state environmental law; the current site closure options under the NREPA; the changes in administrative policies that delegated closure decisions to district offices to increase timeliness and efficiency; and the resulting effects on contamination site closures in the State of Michigan.
Strategies for Site Resolution in Kansas

Chris Carey

For remedial sites, the Kansas Department of Health and Environment employs a number of approaches to facilitate site reclassification to “resolved” or “no further action” status. These classifications may include certain restrictions or conditions on future use to reach the end points. This discussion will focus on KDHE’s approaches and criteria for site resolution, including the use of engineering and institutional controls, along with KDHE’s policies treating soil to groundwater migration, groundwater use and alternate treatment goals to enable timely site closure.

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Presenting Author: Chris Carey
Risk Based Investigations for Petroleum Leaksites in MN

Andrew Eddy and Mark Koplitz

This presentation will focus on 2 aspects of the risk based approach used in Minnesota. The first part will be presented by MPCA Petroleum Remediation staff and will focus on determining the level of risk following a petroleum release and file closure criteria based on the risk determination. The second portion of the presentation will be presented by MPCA Petroleum Brownfields staff, focusing on post-closure land use and development options, along with ways to mitigate potential future risk.

In Minnesota’s Petroleum Remediation Program (PRP) a leksite is created when 5 or more gallons of product are released from a petroleum tank. PRP has been using a risk-based approach to characterize site impacts and determine the level of risk involved with the release since the 1990’s. Following the initial investigative work a report is typically submitted and the Site falls into one of 3 categories of risk: high, medium, and low. Based on the results from the samples collected during the investigation, a determination is made on whether more work is necessary (high risk), or if the Site is eligible for closure consideration (low risk).

Once the leak investigation file is closed, the site may continue to be used in its current fashion or sold for redevelopment purposes. Once redevelopment enters the picture, the land use has changed and risk may need to be reevaluated. Minnesota’s Petroleum Brownfields Program (PBP) assists developers, bankers and others to complete the tasks necessary to provide liability assurances to voluntary parties. Soil excavation and development response actions are often necessary on contaminated property. Through the use of previous investigation data and a newly created response action plan, PBP reviews and approves plans with the main objective to protect future occupants from any remaining contamination.

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California UST Site Closure Criteria

Yue Rong

In 2012, the California State Water Resources Control Board adopted “Low-Threat Underground Storage Tank Case Closure Policy (Policy)”, which establishes statewide case closure criteria for leaking underground storage tank (UST) sites that pose a low threat to human health and the environment. The policy seeks to increase UST cleanup process efficiency. A benefit of improved efficiency is the preservation of limited resources for mitigation of releases posing a greater threat to human and environmental health at UST sites. The Policy was developed based on current and historical knowledge and experience related to the UST sites. The Policy provides some numerical criteria as UST case closure consideration factors. The Policy case closure criteria include 8 General Criteria, and 3 Media-specific Criteria (groundwater, vapor intrusion to indoor air, and direct contact and outdoor air exposure). This presentation discusses how the Policy is applied and what kind of situation is good for implementation of the Policy terms, and what kind of situations may not work well for case closure.

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Presenting Author: Yue Rong
EPA Region 9 UST Cleanups: Balancing Risk, Uncertainty, and Resource Realities

Kenneth Dixon

U.S. EPA Region 9 oversees the cleanup of approximately 300 Leaking UST sites in Indian Country throughout the Pacific Southwest, of which 75% have received No Further Action determinations. The Region also manages grants to state agencies overseeing petroleum UST cleanup programs in California, Arizona, Nevada, and Hawaii. The EPA Region 9 UST Program’s primary goal is risk reduction, and case closure remains a secondary goal whose timing is driven largely by stakeholder interest and economic factors. Although project managers will often compare soil and groundwater contaminant data to residential or industrial Regional Screening Levels (RSLs) as a starting point for closure decisions, these are not cleanup standards.

To prioritize limited resources (both staff time and money), the EPA Region 9 UST Program categorizes sites based on risk. Incorporating factors pertinent to both risk assessment and closure decisions—e.g., contaminant data, potential exposure pathways, LNAPL recoverability, groundwater plume stability, receptor well locations, and future site use—the program created an internal Priority Ranking System to score sites as Emergency, 1, 2, 3, 4, or 5. In general, both staff time and federal LUST Trust Fund money are directed more toward reducing the risk score at higher-threat sites than closing out lower-threat sites. Universe statistics will be presented.

An important part of both prioritization and closures decisions at our UST cleanup sites is uncertainty. How certain are we that a particular exposure pathway is blocked? That data in hand is representative of site conditions? That current use is indicative of future use? Arguably the most difficult aspect of our making closure determinations is balancing uncertainty with the resources actually available for investigation and remediation. The typical UST site, especially one located outside of an urban area, may be worth very little, and its contaminants are known to degrade over time. In these instances, how much public money is it practical to spend on investigation and remediation before closing sites? Case studies will be presented for discussion.

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Presenting Author: Kenneth Dixon
Completion of Groundwater Restoration for Superfund Sites, Guidance, and Tools

Herb Levine

There has been much interest lately in how the EPA evaluates completion of groundwater remedies. A recently published EPA guidance recommends evaluating each contaminant of concern concentration levels on a well-by-well basis to determine attainment everywhere throughout the plume. Conclusions are made based on individual wells to demonstrate that groundwater has met and will continue to meet cleanup levels. EPA has developed a statistical tool to assist the regulated community with evaluating attainment. A recommended method will be presented along with statistical requirements for evaluating attainment and trends. Another recent EPA guidance recommends a step-wise planning and decision making process for evaluating the operation of a groundwater remedy and progress towards achieving cleanup levels.

This talk will present these EPA guidance’s and existing regulations. In addition, case studies evaluating completion of groundwater restoration remedial actions will be presented from Superfund sites in California.

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Presenting Author: Herb Levine
REGULATORY PROGRAMS & POLICIES

Corrective Actions for the Port Angeles Landfill Potential Failure into the Strait of Juan de Fuca
Tom Bourque, GeoTek, Inc., Hayden, ID

Integrated Water Resources Management of the Iullemeden-Taoudeni/Tanezrouft Aquifer Systems Along with the Niger River
Daniel Pierre, Antea Group, France, Olivet, France

EPA’s Failed Efforts to Regulate Nutrient Discharges – The Florida Experience
Kenneth Oertel, Oertel, Fernandez, Bryant & Atkinson, P.A., Tallahassee, FL

Current Status of Water Quality Criteria Updates, Including a Comparison of Key Assumptions and Trends
Michael Ruby, Integral Consulting Inc., Louisville, CO

Closer Consideration of Assumptions Used to Derive Water Quality Criteria
Jennifer Sampson, Integral Consulting Inc., Seattle, WA

Evaluation of Perfluorochemicals (PFCs): Regulations, Analytical Methods and Risk Assessment
Usha Vedagiri, AECOM, Oakland, CA
Corrective Actions for the Port Angeles Landfill Potential Failure into the Strait of Juan de Fuca

Tom Bourque

Legacy environmental remediation, corrective actions, and containment systems are often based on historic regulatory standards, data, and standard engineering practice. There are many systems that were developed before more stringent regulations were applicable, often a race against more costly requirements. Some of these containment systems are now under duress.

Port Angeles Landfill is a historic solid waste disposal site where in the 1940s to 1970s waste was burned. Residue was pushed over the sea bluff onto the shoreline below or filled gullies leading to the shoreline. Waste also filled a five acre pit adjacent to the 135 ft high sea bluff. These "cells" were closed in 1992 before promulgation of RCRA Subtitle D. Since closure, bluff erosion and migration threaten the closed cells. A seawall was installed to protect a portion of the landfill in 2007. Accelerated bluff erosion into the landfill site has occurred creating an emergency situation. Coastal geomorphic models were developed to demonstrate how deep penetration into the landfill cells would occur over time, considering climate change trends such as increasing storm intensity, wave height, and tidal elevations.

The result was an ever increasing risk of potential landfill collapse into the Strait of Juan de Fuca with a high likelihood within five years. Various actions were evaluated for cost, permittability, constructability, and effectiveness to address this risk. A large-scale solid waste relocation approach was selected, the largest in Washington State history (Washington Department of Ecology). Waste was relocated to another on-site cell outside the 300-year bluff penetration extent. Project design elements to address site constraints included alternative cover systems, construction storm water controls, mechanically reinforced earth wall (tallest in Washington State), modified landfill gas system, and site reconfiguration. The waste removal area would convert to a feeder bluff for environmental benefits. The project is under construction with major waste removals in 2014 and shoreline stabilization and final cover installation in 2015.

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Presenting Author: Tom Bourque
Integrated Water Resources Management of the Iullemeden-Taoudeni/Tanezrouft Aquifer Systems Along With the Niger River

Daniel Pierre, Axel Aurouet, Victor Essayan and Christian Eberschweiler

This project involves eight African countries that share common catchment basins and trans-boundary aquifer systems - Iullemeden, Taoudeni/Tanezrouft and Niger River (2.5 million km²). Prior to this study, water resources in this area were poorly known and available data was of insufficient accuracy. Moreover, these resources were threatened by high water demand, climate variability, and quality degradation.

To help Algeria, Benin, Burkina Faso, Mali, Mauritania, Niger and Nigeria establish a respective national water resource development plan, this project involved a comprehensive assessment of the water potential of these aquifers and a definition of monitoring components.

Between April 2012 and May 2013, a team of senior socio-economists, hydrogeologists, modelers, environmentalists, GIS and remote sensing experts offered an innovative approach to perform the following services:

- Hydrogeological and hydro-climatological summary of the aquifer system
- Aquifer vulnerability, recharge assessment and modeling
- Hydrodynamic and hydrogeological modeling
- Groundwater flow model development and calibration; model application for climate change and population growth scenario
- Remote sensing, GIS analysis and data mining
- IWRM strategy

Other components of the project included the analysis and management of cross-border risks, impact assessment of climate change, and capacity building on water resource management tools, databases, GIS and modeling. Awareness-raising workshops to the general public focused on concerted cross-border water resources management.

Assessing these strategic water resources and updating and improving the knowledge on these systems contributed to the development of an IWRM strategy and provided national decision-makers with a management tool to identify the hydraulic potential of the aquifers and cross-border hydrogeological risks, and to simulate the behaviors of the water tables.

Client: Observatoire du Sahara et du Sahel

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Presenting Author: Daniel Pierre
EPA’s Failed Efforts to Regulate Nutrient Discharges – the Florida Experience

Kenneth Oertel

In 2010, EPA was sued by an environmental group to force it to supersede the State of Florida’s regulatory authority under the Clean Water Act (33 US Code Section 1251 et. Seq.). The complaint alleged that Florida had not adopted numerical discharge standards for nutrients (nitrogen and phosphorous). EPA settled the lawsuit by committing to over-ride the state and adopt such standards for Florida. EPA published its numeric nutrient standards in the Federal Register. This generated an outcry from the State of Florida, industry, local governments, etc. The standards EPA adopted were so stringent, existing technology could not achieve compliance. In certain areas allowable concentrations of Nitrogen could not exceed 0.51 mg/L; for Phosphorus the limit was 0.01 mg/L. Florida and other entities filed challenges to EPA’s rules in US District Court, Tallahassee, Florida. EPA’s methodology was based on samples from water bodies considered “pristine.” The Court determined EPA’s rules were, in part, invalid. EPA could not show that discharges which exceeded the ambient concentration in pristine water bodies were harmful. The Court determined that since the Clean Water Act only controls discharge of “pollutants,” if a discharge was not of sufficient concentration to be harmful, EPA could not regulate it. The Court gave EPA the opportunity to further justify the rules.

The State of Florida then began to develop its own less stringent, numeric standards for nutrients. An environmental group’s challenge to Florida’s rules was dismissed. Florida’s rules went into effect. EPA then requested the US District Court to excuse it from its settlement agreement. The Court allowed EPA to withdraw its rule. EPA’s foray into regulating the discharge of nutrients through numerical standards was held legally deficient and eventually abandoned.

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Presenting Author: Kenneth Oertel
Current Status of Water Quality Criteria Updates, Including a Comparison of Key Assumptions and Trends

Michael Ruby, Ellen Ebert and Priscilla Tomlinson

According to the requirements of the Clean Water Act, state environmental agencies and the U.S. Environmental Protection Agency (EPA) are obligated to establish numeric water quality criteria (WQC) for toxic substances and to periodically consider the need for revisions to those criteria. The human health–based WQC (HHWQC) are designed to protect public health and traditionally are derived using EPA-recommended equations that include parameters for risk, toxicity, and exposure. The values used for these parameters are revisited and adjusted periodically in response to new scientific studies and shifts in policy.

This presentation provides an overview of the approach used by different states in developing HHWQC. We will discuss the factors that are incorporated into the calculation of WQC, assumptions that underlie those factors, and implications of the selected factors on statewide and water body–specific WQC values. Particular attention will be paid to the factors that have the greatest impact on HHWQC: target cancer risk, fish consumption rates, and bioconcentration factors. We will then review the status of HHWQC for states in the western U.S. (California, Oregon, Washington, Idaho, and Colorado) that have recently or are currently updating their WQC. Finally, trends in HHWQC values over the last two decades will be discussed.

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Formulation of state and federal water quality criteria (WQC) for the protection of human health involves a series of assumptions, some of which are not well grounded in empirical data. Although certain parameters are deliberately general and designed to be protective (e.g., human body weight, rate of water consumption), others are overly general, not well supported by relevant studies, and ultimately result in WQC that cannot be attained. An example of these types of assumptions is the bioconcentration factor (BCF) used to back-calculate a safe water concentration from an acceptable tissue concentration. Application of BCFs for one chemical (e.g., 2,3,7,8-tetrachlorinated dibenzo-p-dioxin), to regulate a mixture of chemicals (e.g., other 2,3,7,8-substituted dioxins and furans) that have related but diverse properties and correspondingly variable rates of accumulation in biota, leads to water quality standards that cannot be achieved in most urban waterways and sometimes cannot be readily verified. Another example is fish consumption rates, which are often not well supported by rigorous empirical studies. This presentation will evaluate some of the technical weaknesses inherent in the derivation of WQC and identify those assumptions that have the greatest impact on resulting WQC and therefore require the greatest emphasis for developing empirical data in the future.
Evaluation of Perfluorochemicals (PFCs): Regulations, Analytical Methods and Risk Assessment

Usha Vedagiri, Cybele Heddle, Victoria Lazenby, Sandra Smith, Simon Cole and Dan Kim

There is increasing concern, in the US and world-wide, about the potential environmental and human health effects of PFCs (including perfluorooctane sulfonate [PFOS] and perfluorooctanoic acid [PFOA]). Due to their unique chemical characteristics of being both water-repelling and oil-repelling, PFCs are commonly used in innumerable industrial and consumer products, including fire-fighting foams, non-stick cookware, and water and oil-repellent textiles and coatings. With their high potential for persistence and bioaccumulation, they have been detected in a wide range of environmental and biological matrices, and are now found in even the most remote terrestrial and aquatic food webs. In the US, risk-based approaches to addressing releases and remediation of PFCs are still in evolution although the potential for adverse health effects has been acknowledged. This presentation provides an overview of regulatory directions and risk assessment approaches addressing PFCs from several countries. Project examples of analytical methods, and exposure assessment and dose-response methodology used to evaluate human health and ecological risk, related to PFCs are also presented.

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REMEDIATION

Hexavalent Chromium Contamination: Emergency Measures
John Donatucci, Kleinfelder, Irvine, CA

Study on the Effectiveness of Spent Waste Sugarcane Bagasse for Adsorption of Different Petroleum Hydrocarbons Water Pollutants: Kinetic and Equilibrium Isotherm
Nour El-Gendy, Egyptian Petroleum Research Institute, Cairo, Egypt

Rapid Remediation by In Situ Gas Thermal Remediation at Dry Cleaner Contaminated Sites
Grant Geckeler, GEO, Corona, CA

Progress in the Remediation of Petroleum Hydrocarbons and Oxygentates in California Groundwater
Thomas McHugh, GSI Environmental, Houston, TX

Reacting to Changing Site Conditions: Reevaluating Remedial Alternatives, From Soil Vapor Extraction to In-Situ Chemical Oxidation
Melissa Spitzmiller, ARCADIS U.S., Inc., Long Beach, CA
Hexavalent Chromium Contamination: Emergency Measures

John Donatucci, Michael Counte, Bill Golightly and Paolo Dizon

California’s San Fernando Valley (SFV) is infamous for complex environmental issues associated with decades of industrial use and releases of toxic chemicals to the subsurface. Resulting remedial challenges are complicated by comingled plumes, complex groups of potentially responsible parties, and a multitude of stakeholders including governmental agencies and neighborhood associations. In 2011, pursuant to Prospective Purchaser Agreements with the United States Environmental Protection Agency (US EPA) and the Los Angeles Regional Water Quality Control Board (LARWQCB), a national commercial retailer, as part of planned distribution center expansion, agreed to remediate soil at two adjacent former plating facilities. Operations associated with the former plating facilities resulted in the release of metals to vadose zone soil. In cooperation with LARWQCB, US EPA, and California Department of Toxic Substances Control, a Remedial Action Plan (RAP) was developed to address hexavalent chromium (Cr\textsuperscript{6+})-impacted soil by preventing future migration of Cr\textsuperscript{6+} to underlying groundwater. This RAP was not intended to address groundwater contamination, which is being addressed by the US EPA as part of the SFV Superfund Site.

The remedial approach involved in situ chemical reduction of the Cr\textsuperscript{6+} using calcium polysulfide mixed into the soil by a large diameter auger. Initial results indicated the approach to be effective; however, complications due to unanticipated geologic conditions resulted in leaching of Cr\textsuperscript{6+} to groundwater. Concerned about Cr\textsuperscript{6+} impacts for extracted water quality at a downstream and adjacent treatment system designed to treat lower concentrations of Cr\textsuperscript{6+} at a municipal water supply well, the LARWQCB issued an emergency modification to the Site’s Waste Discharge Requirement, allowing the direct injection of calcium polysulfide into groundwater between the point of release and municipal water supply well. The success of this aggressive emergency measure may be a model for future approaches to Cr\textsuperscript{6+} plume remediation.

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Presenting Author: John Donatucci
This study investigates the capability of spent waste sugarcane bagasse SWSB, obtained from bioethanol production process, for biosorption of diesel oil and kerosene, in an attempt to be applied for wastewater treatment with an enrichment of the SWSB for its use as a renewable solid biofuel. The chemical composition, microstructure, surface morphology and reactive surface functionalities of the adsorbent were determined. Effect of different pH, salinity, initial pollutant concentrations, temperatures and adsorbent dosages were also studied. The results showed that, the sorption of petroleum products depends on the adsorbent material and the adsorbate type. The biosorption was favorable, where the SWSB removed 63-41% of diesel oil and 70-50% of kerosene in solutions containing 5-20% w/v of these contaminants. The kinetic equilibrium was reached after 6 h and the biosorption follows the pseudo-second order rate expression. The SWBS expressed good biosorption capacity 44-86 mg/g and 78-110 mg/g over a wide range of pH and salinities. The biosorption potential increased with increase in the temperature and decreased with the increase of the biosorbent dosage. The sorption may be partly due to absorption/partitioning of pollutants onto the SWBS and partly due to adsorption onto the surface of SWBS. The linear, Freundlich and Temkin models could provide adequate fit for sorption onto the SWSB, while Langmuir model provided the best adequate fit at low temperature. The analysis of the obtained isotherm data proved the predominance of chemisorption and the endothermic nature of the biosorption process. The calorific value of the SWSB recorded ≈ 32.91 and 33.61 MJ/kg, for SWSB after biosorption of diesel oil and kerosene, respectively. The results recommend the applicability of the low cost, readily available, sustainable and environmentally friendly SWSB for wastewater treatment and production of a renewable solid biofuel which would have positive impact on economy, energy and environment.
Two former Dry Cleaner sites, contaminated by tetrachloroethylene (PCE) in clay and silty soils were rapidly remediated utilized Thermal Conductive Heating (TCH) by Gas Thermal Remediation (GTR) technology. The contamination at both drycleaner sites was beneath the buildings and extended to depths from 15 to 30 feet below ground surface (bgs). GTR technology was installed within the small buildings to remediate subsurface soil and groundwater successfully at both sites. Affected soils also contained low levels of PCE degradation byproducts such as trichloroethylene (TCE). The remediation goal was driven by vapor intrusion risk requiring final levels to be below commercial soil gas screening criteria.

TCH rapidly accelerates PCE mass removal by heating affected soils and/or groundwater to target temperatures of 100°C. C3 Technology refrigerated vapor condensation process was utilized to compress, refrigerate, and condense >99.9% of the PCE and TCE from the vapor stream. The combination of ISTR and C3 technologies enable rapid volatilization and removal of PCE from subsurface soil and groundwater, and condense the PCE above ground rather than transfer to the atmosphere or onto activated carbon destined for landfill.

Installation of TCH wells of 9 and 14, respectively, for each drycleaner were required to treat the entire source area. Multiple thermocouples were placed throughout the target treatment area, at varying distances and depths from the heating wells to monitor and track heating temperature performance and schedule to verify compliance with design.

Remediation goals were achieved within 7 months resulting in 99% reduction of PCE contamination from the subsurface soils at the dry cleaners. All air quality requirements were met. The site owners were able to request no further action or site closure by achieving EPA required cleanup goals. The cost to achieve cleanup was significantly less than alternative remediation options and with greater degree of certainty. Most other technology options were limited due to the small area and limited access within the buildings.
Progress in the Remediation of Petroleum Hydrocarbons and Oxygenates in California Groundwater

Thomas Mchugh, Sharon Rauch, Shawn Paquette, John Connor and Anthony Daus

Over the last three decades, substantial resources have been invested in the remediation of petroleum hydrocarbons and oxygenates associated with releases from leaking underground storage tanks. The number of open leaking tank sites in California has declined from over 20,000 in March 2000 to approximately 6,200 in March 2014. However, historically, tracking the overall progress in remediation of groundwater has been more difficult. We have analysed two publicly-available groundwater quality databases, GeoTracker and the California Department of Public Health (CDPH) database, in order to evaluate changes in dissolved concentrations of petroleum hydrocarbons and oxygenates in California groundwater. The GeoTracker database contains groundwater monitoring results from more than 10,000 leaking tank sites. The CDPH database contains petroleum hydrocarbon concentrations from more than 14,000 water supply wells.

Across the population of monitored leaking tank sites, maximum source area concentrations of benzene have declined by over 60% between 2001 and 2013 and MTBE by over 90%. However, this decline underestimates the overall decrease in constituent concentrations because the number of sites being monitoring has decreased by almost 50% since 2006, reflecting regulatory closure for cleaner sites. Evaluation of a subset of sites monitored continuously between 2001 and 2011 showed greater decreases in benzene and MTBE concentrations. These results reflect the significant progress in remediation of California groundwater over the last decade. Between 2000 and 2013, detections of either benzene or MTBE in public water supply wells have been rare. Over this time period, the MTBE has been detected in approximately 1% of public water supply wells tested and benzene has been detected in approximately 0.3% of wells tested. For both constituents, exceedances of MCLs have been observed in less than 0.2% of wells tested. Median detected MTBE concentrations have been declining over time, likely reflecting the phase out of MTBE from gasoline completed at the end of 2003.

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Reacting to Changing Site Conditions: Reevaluating Remedial Alternatives, From Soil Vapor Extraction to In-Situ Chemical Oxidation

Melissa Spitzmiller and Dwayne Campeau

Site characterization of a Southern California metals treatment facility identified and characterized the distribution of tetrachloroethene (PCE) in groundwater, soil, and soil vapor at the site. Pilot studies using conventional remedial technologies were conducted to evaluate their technical feasibility, and resulted in the selection of soil vapor extraction (SVE) as the preferred remedy for vadose zone remediation. Traditional saturated zone remedial technologies including air sparging, multi-phase extraction, pump and treat, and in-well stripping were evaluated for saturated zone PCE treatment but were determined to be ineffective due to factors attributable to lithology, hydrogeology, and ongoing declines in regional groundwater elevations. To take advantage of increases in the exposed vadose zone due to the declining groundwater elevations, deeper dual purpose SVE/groundwater monitoring wells were installed to maximize SVE mass recovery. Successful SVE treatment of PCE in the vadose zone and changing site conditions led to an increased focus on identification of viable remedial options to address PCE concentrations in the saturated zone. Changes in the site conceptual model were used to determine viable remedial alternatives and ultimately select in-situ chemical oxidation (ISCO) using permanganate as the preferred saturated zone treatment method. Initially scheduled for completion in 2013, ongoing groundwater elevation declines resulted in many existing site-wide monitoring wells going dry and an inability to evaluate target areas for permanganate injection. Construction of the deeper SVE/groundwater monitoring wells has allowed for continued groundwater monitoring to assess PCE distribution and groundwater elevations and determined when ISCO can proceed. Despite changing site conditions, PCE remediation continues to be successful as a result of continued site characterization, ongoing updates to the site conceptual model, reevaluation of the selected remedial alternatives and their optimization, and forethought as to how regional changes impact site conditions.

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Presenting Author: Melissa Spitzmiller
RISK ASSESSMENT

A Sensitivity Analysis of Input Parameters for Estimating Health Risks from Total Petroleum Hydrocarbons in Soil
Jane Curren, URS Corporation, Los Angeles, CA

What is the Source of Human PCB Body Burdens?
James Okun, O’Reilly, Talbot & Okun Associates, Inc., Springfield, MA

How to Redevelop a Brownfield Site Using California State Water Resources Control Board Resolution 92-49
Daniel Weis, Advantage Environmental Consultants, LLC, San Marcos, CA
A Sensitivity Analysis of Input Parameters for Estimating Health Risks from Total Petroleum Hydrocarbons in Soil

Jane Curren, Kanan Patel-Coleman and Usha Vedagiri

The authors prepared a presentation for the 2014 West Coast AEHS meeting that discussed USEPA’s May 2013 on-line Regional Screening Level (RSL) calculator method for developing soil RSLs for TPH chemicals. The RSLs were also compared to TPH screening levels from other sources, and the impact of different authorities’ toxicity values was evaluated. When initially released, USEPA’s TPH RSLs considered both cancer and non-cancer endpoints; however, for the May 2014 version of the RSLs, USEPA removed the carcinogenic endpoints from consideration for TPH.

In this presentation USEPA’s May 2014 approach is compared to selected state approaches and includes a sensitivity analysis of some input parameters used in TPH risk assessments, e.g., human exposure factors, chemical parameters, and toxicity criteria. The results of the iterative analysis will be presented, along with insights for practical application when evaluating health risks at TPH sites.

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What is the Source of Human PCB Body Burdens?

James Okun

All people carry polychlorinated biphenyl (PCB) body burdens and, in light of heightened concerns about PCBs in schools and other buildings, it is important to understand the sources of these PCBs. There are three possible sources: 1) people are born with them; 2) they are absorbed from food; and 3) they are absorbed from air. Although the human fetus is partially protected, some prenatal PCB exposure occurs. However, infants generally have much lower PCB body burdens than do older children and adults, so in-utero PCB exposure cannot explain adult body burdens; this leaves food and air as sources. Human foods contain 2 to 50 ug/kg of PCBs. Using USDA food consumption statistics with average PCB content of foods, suggests American ingest about 15 ug of PCBs/day in their diet; an average elementary school child ingests about 12.4 ug/day. For comparison, consider a child’s school inhalation exposure of PCBs under three scenarios: a) a low PCB air concentration (20 ng/m3) resulting in an average daily inhalation dose (ADID) of 0.21 ug; b) a mid-level air concentration (USEPA elementary school public health level of 300 ng/m3) with an ADID of 0.94 ug; and a high air concentration (equal to twice the USEPA elementary school public health level or 600 ng/m3) with an ADID of 1.7 ug. The percentage of total PCB dose (food plus air) derived from air is 1.7% for low air concentration; 7.1% for mid-level air concentration; and 12.2% for high level air concentration. This analysis suggests that PCB body burdens arise principally from diet with air exposures playing a small role. One consequence of this analysis is that any health benefit from reducing PCBs in school air is necessarily limited by the relatively small fraction of PCB dose arising from that source.

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Presenting Author: James Okun
How to Redevelop a Brownfield Site Using California State Water Resources Control Board Resolution 92-49

Daniel Weis, Mike Palmer and Barry Pulver

This presentation illustrates how a collaborative consultant-agency approach resulted in a successful redevelopment of an 11.86 acre Brownfield site in the City of San Marcos, County of San Diego, California. The subject property was historically used for the manufacturing of ophthalmic lenses, and site operations resulted in releases of various volatile organic compounds (VOCs) beneath the property. Davia Village, which will occupy the property in the future, is a proposed mixed-use project that encompasses 416 residential units (up to three levels) and ground floor retail space.

The framework of California State Water Resources Control Board Resolution No. 92-49 requires “dischargers” to identify, remediate and mitigate any dangers posed to the public health or waters of the state associated with the release of contamination. The Resolution also allows that technical and financial resources be evaluated as part of the investigation and implementation process and the consideration and implementation of alternative water quality objectives are allowed, should background conditions not be attainable. The use of 92-49 allowed for the consultant team, in collaboration with the San Diego Regional Water Quality Control Board (SD-RWQCB), to replace a previously selected MNA remedy with an RNA approach. This was supported by additional soil and soil gas samples in a grid across the property. Soil gas probes were subsequently placed in areas where soil gas flux was likely. Vapor intrusion based human health risk modeling was performed. Based on the site data and risk assessment, future soil management and the implementation of institutional and engineering controls would be required.

The proposed development received unanimous approvals from the City of San Marcos and construction is pending at this time. The use of Resolution No. 92-49 by the SD-RWQCB allowed for site closure that was protective of human health and facilitated future development and promoting economic growth.

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SITE ASSESSMENT

SERDP Study Explores Well Flow Dynamics for Active and Passive Sampling
Sanford (Sandy) Britt, ProHydro, Inc., Fairport, NY

Reemergence of MTBE: Drought Conditions Exacerbating a Problem that Many Thought was in the Past
Lisa Dernbach, CA RWQCB, Lahontan Regiona, South Lake Tahoe, CA

Field Comparison of LNAPL Transmissivity Measurement Methods
Brad Koons, ARCADIS U.S. Inc., Minneapolis, MN

Incremental Sampling Strategies for Improving the Cost and Effectiveness of Site Investigations in Hawaii
Jordan Nakayama, Hawaii Department of Health, Honolulu, HI
SERDP Study Explores Well Flow Dynamics for Active and Passive Sampling

Sanford (Sandy) Britt

All contaminated groundwater decision trees depend on accurate and reliable groundwater sampling data. Low flow purging and sampling techniques were introduced to improve sampling data, limit purge volumes, reduce turbidity and agitation during sampling, and to improve repeatability. Passive, no-purge, approaches have likewise been introduced to improve sampling by limiting waste generation, and improving cost structures. How do these methods reflect aquifer concentrations? Do they represent aquifer concentrations differently? How do the different approaches assure reliable groundwater data for remedial decision-making?

Strategic Environmental Research and Development Program (SERDP) project ER-1704 tested passive and dynamic sampling procedures in the lab, in the field, and in model domains to better understand flow dynamics in wells. Results describe a pumping flow field where water flows largely horizontally from the formation to the well, then vertically in the well bore to the pump. In many cases, several well volumes were required to clear the well and reach chemical steady state. “False” stability is a concern in early purge times as slow parameter drift may reflect continued contaminant concentration change. Ultimately, maintenance of steady flow rate, very stable parameter measurements (i.e. no slow drift), and several well volumes purged is required to obtain flow-weighted average samples using a low-flow purging approach.

Passive sampling approaches usually yielded similar results without purging, but care was necessary to understand whether stratification in the aquifer was maintained or homogenized in the unpurged well, or if stratification was partially maintained. Determination of these effects required substantial effort and is probably not warranted for standard monitoring. However, the study is informative in that it explains some of the dynamics associated with why passive and active samples often yield similar chemical results, and illustrates why practitioners still must always pay attention to seemingly unimportant details such as slow purge parameter drift.

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Ten years after California banned MTBE in gasoline, many believed the additive to be a non-issue as a threat to domestic and municipal wells. In that time, regulators and responsible parties worked hard overseeing clean up at petroleum release sites. As petroleum constituents in soil and groundwater were eliminated, or at least significantly reduced, many cases were closed.

South Lake Tahoe was one of the communities in California that was hit hard with multiple MTBE release sites affecting water supply wells. At its worse, one-third of the community’s 34 supply wells were shut down. Water purveyors scrambled to provide enough water, especially during the popular summer tourist season.

By 2014, more than 90 percent of MTBE release sites in South Lake Tahoe had been adequately remediated and cases closed under the State’s Low Threat Policy. The few cases that remained open were those with meager funding mechanisms and implementing limited remediation or monitored natural attenuation. Yet, as drought conditions got worse and water tables lowered, gasoline constituents are observed increasing in groundwater.

Such was the instance at the Tahoe Tom’s Gas Station overseen by the California Regional Water Quality Control Board, Lahontan Region. Over the past five years, the responsible parties sporadically applied in-situ remediation resulting in reduced hydrocarbons in groundwater. However, recent water table lowering caused hydrocarbon concentrations, such as BTEX, to increase in monitoring wells by up to 1,200 percent. The lack of ethanol detection in on-site water samples ruled out a new release. Samples from a nearby motel domestic well showed MTBE concentrations increasing during 2014 to 19 microgram per liter (µg/L), exceeding the 13 µg/L primary MCL.

This example demonstrates how residual petroleum contamination left in the environment and originally thought to be a non-issue in normal water years became a significant issue under drought conditions.

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Presenting Author: Lisa S. Dernbach
Field Comparison of LNAPL Transmissivity Measurement Methods

Brad Koons, Jonathon Smith, Allison Elder, Mark Malander and Harley Hopkins

LNAPL transmissivity is commonly used to measure LNAPL mobility, recoverability, and migration potential, and is increasingly being considered by state and federal regulators as a quantitative metric to define the practical endpoint of LNAPL recovery. LNAPL transmissivity can be measured using a number of field and laboratory methods, including 1) LNAPL baildown testing, 2) manual LNAPL skimming tests, 3) analysis of LNAPL recovery system data, 4) LNAPL tracer testing, and 5) theoretical calculations based on a combination of laboratory petrophysical data and field conditions. Each of the above methods varies with respect to the time required for data collection, the extent of aquifer material represented, and the cost to complete.

The above methods for measuring LNAPL transmissivity were tested in two separate LNAPL-impacted areas at a former petroleum terminal site in New Jersey. Where practical, multiple measurement methods were conducted at the same location (well) to allow direct comparison of results. Data collection and analysis were completed in accordance with relevant ASTM International and American Petroleum Institute best practices.

The results from the field methods for measuring LNAPL transmissivity were consistent within an order of magnitude, but the theoretical calculations based on petrophysical data were biased low at most locations by orders of magnitude. All of the results indicated that LNAPL transmissivity at the test locations is at or below values associated with the practical limits of LNAPL recovery by hydraulic methods as defined by the Interstate Technology and Regulatory Council. The low LNAPL transmissivity observed at the site made data collection and analysis for baildown testing and manual skimming challenging. While the short-term tests adequately demonstrated that the LNAPL transmissivity was low, the longer-term LNAPL recovery and dye trace tests may be better suited to resolving low LNAPL transmissivities if a high degree of accuracy is necessary.

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Incremental Sampling Strategies for Improving the Cost and Effectiveness of Site Investigations in Hawaii

Jordan Nakayama, Roger Brewer, Paul Chong, John Peard and Robert Chong

Successful identification of high concern areas is an integral component of any effective sampling plan and site investigation. Decision unit (DU) design strategies and Multi-Increment sampling (MIS) have proven to be efficient tools; whether it is for a limited release area, redevelopment of a former industrial site, stockpiles or large agricultural properties.

DU strategies are used to segregate a Site into smaller areas (e.g., release areas where contamination may be limited, stockpiles) and larger areas (e.g., exposure areas or areas where less contamination is suspected). DUs should be based on historical knowledge of a Site, proximity to potential sources of contamination and existing data. They are created to cover both lateral areas and vertical areas of targeted depths.

MIS—when compared to discrete sampling—is used to optimize coverage and increase data reliability, providing a more representative sample of an entire area rather than sampling a single point. MIS reduces analytical costs as fewer samples can be collected throughout the Site. A multi-increment sample consists of 30 to 100 increments that are collected randomly throughout a DU and composited into one sample. This may not be feasible for some subsurface DUs, but limitations on the reliability of the resulting data should be carefully considered.

DU-MIS approaches typically allow a majority of the Site to be characterized and confidently cleared for unrestricted use while focusing remediation and institutional controls (e.g., environmental hazard management plans) to the heavily contaminated areas. Environmental hazard management plans allow for effective, long-term management of contamination that must be left in place at a site and help ensure that the contamination will not be forgotten in the future.

Example projects are presented where these strategies have been effectively implemented. Contaminants of concern for these projects include but are not limited to, arsenic, PCBs, petroleum and dioxins.

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TECHNOLOGY ADVANCEMENTS IN REMEDIATION SCIENCE

Lessons Learned from Two Decades of Using Molecular Biological Tools for Site Investigations and Treatment
Dora Ogles, Microbial Insights, Inc., Knoxville, TN

Advances in In-Situ Injection and Monitoring Technologies
Gary Cronk, JAG Consulting Group, Santa Ana, CA

Remediation of PCBs and 1,4-Dioxane with an Aerobic Bacteria and its Cell-Free Extract
Stephen Koenigsberg, Brown and Caldwell, Irvine, CA

Characterizing Preferential Flow Paths in Fractured Bedrock and Complex Hydrogeology
Leif Law, Willowstick, Draper, UT

Passive Electrochemical Remote Sensing
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Reducing Environmental Liabilities and Preserving Sustainable Water Supplies through Automation
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Reduction, Adsorption, and Precipitation of Heavy Metals by Elemental Iron, Iron Sulfides, and Related Reactive Minerals
Alan Seech, PeroxyChem Environmental Solutions, Corona Del Mar, CA
Lessons Learned from Two Decades of Using Molecular Biological Tools for Site Investigations and Treatment

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With extensive, widespread and long-term use of qPCR, the data are now available to determine the range of field concentrations of key microorganisms (e.g. *Dehalococcoides mccartyi*) and functional genes (e.g. benzylsuccinate synthase *bssA*) responsible for biodegradation of common groundwater contaminants and most importantly answer the question “What do these numbers mean?”. The internally designed database is composed of over 20 years of qPCR results performed on more than 27,000 unique groundwater, soil, and sediment samples from all 50 states and 33 countries across 5 continents. While including approximately 100 unique gene targets, the dataset is driven by field samples and therefore directly reflects common contaminants and site management approaches with emphasis on the most frequently performed qPCR assays: (1) halorespiring bacteria (e.g. *Dehalococcoides mccartyi*), (2) reductive dehalogenase genes (e.g. vinyl chloride reductases), (3) functional genes involved in the aerobic (e.g. toluene monooxygenase) and anaerobic (e.g. benzylsuccinate synthase) biodegradation of petroleum hydrocarbons, (4) methane monooxygenase genes, and (5) functional genes for electron accepting processes. Overall, the results clearly demonstrate the power of analyzing an exhaustive database in establishing rules of thumb or threshold concentrations of key microbial groups. For example, ethene production was observed in 80% of the samples in which the *Dehalococcoides* population was greater than or equal to $10^4$ cells/mL. However, even allowing for the common and recommended practice of submitting baseline samples, median concentrations of *Dehalococcoides* ($n>15,000$) and reductive dehalogenase genes ($n>9,000$) on the order of $10^2$ copies/mL indicate that careful implementation and routine performance monitoring are essential for successful anaerobic bioremediation at chlorinated ethene sites. The database also can dispel preconceived beliefs regarding the environmental prevalence of specific functional genes. Detection frequency and median concentrations of *bvcA* and *vcrA* in water samples, for example, are comparable meaning that analysis of both is needed for thorough assessment. Perhaps most importantly, an external portal allows retrieval of percentile rankings of qPCR results along with uploading of chemical and geochemical data to directly investigate the correlations between subsurface microbiology, contaminant biodegradation, and site management activities.

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Advances in In-Situ Injection and Monitoring Technologies

Gary Cronk

Over the past 20 years the environmental remediation business has experienced a phenomenal growth in in-situ technology applications. The advancements have included technology improvements in the injection equipment, advanced chemical processes, advanced thermal remediation techniques, as well as greatly improved monitoring techniques. Hundreds of thousands of in-situ investigations have been performed since 1995 to characterize and treat groundwater and soil contamination. The technology available to environmental contractors today is light years ahead compared to the state of the art in 1995.

Some of the biggest advances have occurred in the equipment and tooling used for performing in-situ investigations and chemical injections. Up until about 1995, most of the site investigations were performed by hollow stem auger (HSA) rigs and injection wells were predominantly drilled by HSA. The development of the direct push rig (especially the Geoprobe® rig) for in-situ exploration and injection tooling for performance of in-situ injections has created a whole new market for drilling companies and injection contractors.

Innovative direct sensing equipment is commonly used today including Membrane Interphase Probe (MIP), Laser Induced Fluorescence (LIF), Hydraulic Profiling tool (HPT), and Electrical Resistivity Tomography (ERT), which allow us to more fully understand the subsurface lithology and the contaminant location. With the development of so many real-time investigative tools, today one can simply pick the tools of choice, and expect high quality results in a manner of minutes. Today we also have soil permeability enhancement technologies such as pneumatic fracturing, hydraulic fracturing and pressure pulse (Sidewinder tool) technology that help us obtain better chemical injection results.

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Remediation of PCBs and 1,4-Dioxane with an Aerobic Bacteria and its Cell-Free Extract

Stephen Koenigsberg, Ray Sambrotto, Kevin O’Driscoll, Robert DiFilippo, Paul Piccolo, Joe Guarnaccia

We assessed the efficacy of a novel bioremediation approach to the degradation of PCBs and 1,4-dioxane. The protocol is unique for PCBs in that it uses a specialized strain of the thermophilic bacterium *Geobacillus midousuji* in a single-step aerobic process - in contrast to an anaerobic-aerobic treatment train. Degradation rates were obtained for total and subsets of PCB homologs on soil dominated by the hexachlorinated Arochlor 1254. Since the organism is a thermophile the applications are only appropriate for slurry bioreactors or compost systems noting that the culture was isolated from a compost pile. Using the EPA 8082 analysis the total Arochlor levels in the bioreactor were reduced 57% in five days (k = .28 per day; half-life 2.4 days). The results of the compost experiments, with less intimate contact, showed reductions of 44% over five days (k = .11 per day; half-life 6.3 days). Further there is preliminary evidence that dried cell mass extract is active enzymatically which opens up other intriguing treatment possibilities since that would be a temperature independent process. With respect to 1,4-dioxane, noting that *G. midousuji* can cleave the aryl ether linkage, the results of packed column studies demonstrated a degradation rate of 7% at a residence time of one minute. We also will report on work with cell extracts that as noted can maintain enzymatic activity. Again, because of the thermophilic nature of the organism it can not be introduced directly into the environment, so the main application will likely be in pump and treat BioGAC systems noting this strategy has worked with MTBE which is another GAC-recalcitrant ether.

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Presenter: Stephen Koenigsberg
Characterizing Preferential Flow Paths in Fractured Bedrock and Complex Hydrogeology

Leif J. Law

Many contaminated sites are challenged with complex heterogeneous transport flow paths leading to difficult or impossible understanding of the fate and transport of the target contaminates. Willowstick Technologies has developed a unique geophysical approach that locates groundwater flow paths in almost any geological setting including the most challenging for remediation practitioners such as fractured bedrock, Karst and dissolution systems, and low permeability clay with stringers. Willowstick provides accurate and detailed maps with 2D and 3D models of how groundwater connects in the subsurface. As the signature electric current flows between strategically placed electrodes it concentrates in the more conductive zones (i.e., in areas of highest saturation and transport porosity) where groundwater preferentially flows through the subsurface. Magnetic fields generated from the distribution of electric current are used to identify preferential electric current flow paths. The concentration and distribution of electric current is then interpreted and modeled to characterize how and where groundwater preferentially infiltrates and flows through the sites

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Passive Electrochemical Remote Sensing

Scott R. Burge and Russell G. Burge

The fate and transport of organic carbon through the aquifer are important components in understanding the hydrogeobiochemical structure and functioning of complex subsurface systems over relevant spatial and temporal scales. Most methodologies estimating microbial activity require the collection of soil/water samples followed by the incubation of the samples.

The development of a microbial fuel cell by Lovley et. al. for anaerobic systems indicated a correlation between concentration of substrates and electrical current generated. The proposed monitoring system is a non-chemically based electron acceptor capable of measuring microbial activity in the subsurface. The electrode system consists of four components:

1) A graphite electrode (anode) is located in the sediment or aquifer. In anaerobic environments, the surface of the anode becomes populated with native bacteria (i.e. Geobacter sp.) capable of oxidizing the dissolved organic compounds in the groundwater (acetate, other organic acids, etc.). Bacteria transfers electrons produced during the oxidation of organic substrates to the graphite electrode (electron acceptor).

2) An insulated wire conducts the electrons from the anode to the cathode.

3) A cathode is located at the surface where the electrons are transferred to the ultimate electron acceptor (i.e. reduction of oxygen).

4) A measurement system determines the flow of electrons (current) through the insulated wire connecting the anode and cathode.

The paper reports on the efforts to correlate the current measured with the rate of degradation of organic substrates in the subsurface. The monitoring system under development is envisioned to be capable of real-time monitoring of contaminated sites with data transferred through web-based communications to remote users.

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Presenting Author: Scott R. Burge
Reducing Environmental Liabilities and Preserving Sustainable Water Supplies through Automation

Mark Kram, Hugo Loaiciga, Clifford Frescura, and Michael Lamar

Environmental conditions can be dynamic. As such, traditional groundwater, vadose zone and air quality monitoring and data starved modeling approaches can result in inaccurate conclusions. For instance, vapor intrusion risks are typically characterized using point-in-time and time-weighted vapor sampling methods. Using continuous and high-frequency monitoring techniques, practitioners have demonstrated that traditional methods can yield false negative conclusions because they are not capable of capturing the entire range of exposure concentrations. Although traditional methodology shortcomings have been acknowledged at the federal level, since continuous monitoring techniques capable of measuring worst case scenarios for real property due diligence and compliance are not yet required, undetected environmental liabilities may exist and vapor intrusion assessments can therefore underestimate risks. Automated continuous monitoring and response approaches can be implemented to better characterize and address vapor intrusion risks, and to more conclusively document when risks are minimal or non-existent.

In the case of water supply management, the most commonly used modeling packages were not designed to answer critical questions regarding maximum sustainable groundwater extraction rates. For instance, transport models are used to determine groundwater basin yield estimates based on simulations that require infiltration estimates because of the model platform constraints, thereby biasing the overall conclusions. In addition, interactions between surface water and groundwater are poorly represented in most simulations because the models selected do not adequately address hyporheic dynamics. As with environmental liability management, continuous automated monitoring, data processing and response systems can be used to immediately determine when unsustainable groundwater extraction conditions exist or are pending (e.g., resulting in basin overdraft, seawater intrusion, or stream depletion beyond a safe ecological threshold), and to automate responses. This presentation will cover cases where automated liability and sustainability management platforms provide documented support for appropriate assessment, management decisions, and related water supply and environmental legal challenges.

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Reduction, Adsorption, and Precipitation of Heavy Metals by Elemental Iron, Iron Sulfides, and Related Reactive Minerals

Alan Seech and Paul G. Tratnyek

_In situ_ chemical reduction (ISCR) has increasingly been applied to treatment of soil and groundwater contaminated with chlorinated organics. The mechanisms involved in such applications are now fairly well understood and widely recognized in the environmental remediation community. ISCR can be broadly defined as a category of _in situ_ soil and groundwater remediation technologies in which treatment occurs primarily by chemical reduction of contaminants, mediated mainly by abiotic processes. It is also recognized that ISCR mechanisms of contaminant reduction can be stimulated by microbial activity (e.g., carbon fermentation), and even created solely by the activity of microorganisms (e.g., biogenic reactive minerals). The major groups of reductants operative in ISCR treatment of soil and groundwater can be broken into four groups including (a) elemental iron such as ZVI powder, (b) minerals that derive their reducing power from Fe\(^{2+}\) such as magnetite and ferruginous clays, (c) minerals that derive their reducing power from reduced S\(^{-}\) or S\(^{2-}\) either alone or in combination with Fe\(^{2+}\) such as pyrite, and (d) organic matter containing redox-active functional groups such as quinones. All the mechanisms involved in ISCR degradation of chlorinated organics are now understood to be related to the transfer of electrons from a reducing agent (the electron donor) to an oxidized species (the electron acceptor). The same cannot, however, be said for the application of ISCR to treatment of heavy metals. The authors will present a survey of ISCR materials and mechanisms as applied to treatment of heavy metals in soil and groundwater.

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VAPOUR INTRUSION

Site-Specific Groundwater Standards for the Vapor Intrusion Pathway
Helen Dawson, Geosyntec Consultants, Falls Church, VA

New Tools Address Risk, Liability, and Uncertainties Related to Vapor Intrusion & Provide Fast Track to Site Closure
David Gillay, Barnes & Thornburg LLP, Indianapolis, IN

Results from Continuous Monitoring of Chlorinated Solvent Vapors: Ramifications on Soil Gas, Sub-Slab Soil Gas and Indoor Air Sampling
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Application of Passive Sorbent Techniques to the Measurement of Naphthalene in Indoor Air
Heidi Hayes, Eurofins Air Toxics, Inc., Folsom, CA

The Hybrid Option for On-going Protection from Short-Term Risks with Episodic Chemical Vapor Intrusion
Henry Schuver, USEPA - ORCR, Washington, DC

Sampling Media, Analytical Methods, and Instrumentation used to Screen, Investigate, and Close Vapor Intrusion Sites – What is reliable and accurate?
Robert Uppencamp, ARCADIS U.S., Inc., Indianapolis, IN
Site-Specific Groundwater Standards for the Vapor Intrusion Pathway

Helen Dawson and Jeff Kurtz

For the first time in Colorado, the Colorado Water Quality Control Commission (WQCC) established site-specific groundwater standards for a man-made pollutant, trichloroethene (TCE), protective of the vapor intrusion (VI) pathway in residential areas overlying a shallow TCE plume adjacent to the former Lowry Air Force Base (LAFB). The groundwater standards were developed due to technical impracticability of further remediation, and considered multiple rounds of empirical groundwater, soil vapor, sub-slab vapor, and indoor air data. VI risks to residences overlying the off-site TCE plume were estimated using the EPA spreadsheet version of the Johnson & Ettinger (J&E) model. Paired groundwater, soil vapor, sub-slab vapor and indoor air sampling over the highest concentration portion of the off-site TCE plume, in multiple winter-heating season events over a ten year time frame, allowed for “calibration” of the J&E Model to site-specific conditions. Agreement between measured and modeled results was very good (within a factor of approximately five). In order to extrapolate the results from the sampled area to the remainder of the residential area overlying the mile-long off-site plume where no indoor air data were available, detailed lithology for 16 off-site exposure units was compiled from boring logs and used as input to the J&E model. The most recent toxicology data for TCE was used to estimate VI risks. All calculated risks were shown to be below the Colorado Department of Public Health and Environment (CDPHE) $10^{-5}$ (or HI=1) action level for indoor air, but were above a $10^{-6}$ risk level. In accord with Colorado groundwater policy, the Water Quality Control Division of the CDPHE recommended to the WQCC that site-specific groundwater standards for TCE be set equivalent to a $10^{-6}$ risk level for residential vapor intrusion, which corresponds to a groundwater TCE concentration of 12 ug/L in this instance.

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Presenting Author: Helen Dawson
New Tools Address Risk, Liability, and Uncertainties Related to Vapor Intrusion & Provide Fast Track to Site Closure

David Gillay and Kyle Hoylman

The vapor intrusion ("VI") pathway continues to present significant obstacles to obtain closure. The science has evolved and continues to evolve at a rapid pace. Last year (2014) was a critical year for stakeholders involved with managing the VI pathway with an emphasis on pre-emptive mitigation and the potential spatial, temporal, and related uncertainties with assessing VI.

Finding a cost effective path around these obstacles is a daunting and challenging task. Successful closure strategies begin with the end in mind and can profoundly affect the costs and time frame to reach an endpoint. This presentation discusses two new tools to manage and control future risk, liability, and the uncertainties related to the VI pathway.

The first tool is a new, patented remote monitoring platform for VI mitigation systems. This new technology will be discussed in detail and provide a real-time demonstration of its key features. The second tool is a Stewardship Agreement that centers on US EPA’s national institutional control policy. This so-called "Stewardship" Agreement provides the legal foundation for stakeholders to manage risk, liability, and address uncertainties with the VI pathway. This Agreement provides the architecture to design a site-specific and tailored approach for your particular site or situation. The presenters are both actively engaged and have leadership roles on the AARST/ANSI committee charged with drafting new guidance for VI mitigation systems and operation, maintenance, and monitoring (OM&M) protocols. When implemented appropriately, these new tools address the uncertainties and risks related to the VI pathway, instill confidence with regulators and other stakeholders, and provide a fast track to site closure.

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Presenting Author: David Gillay
Continuous monitoring of chlorinated volatile organic compounds (TCE & PCE) has been performed at five sites over the past seven years. Three of the sites were EPA-ORD (NERL) research sites with the goals on studying temporal variations in indoor air, soil gas and sub-slab soil gas concentrations. The other two sites monitored were commercial structures with active business operations.

The results from the EPA studies have significant ramifications on soil gas sampling, sub-slab sampling and indoor air sampling strategies. The temporal studies show little variation is soil gas and sub-slab soil gas concentrations over periods as long as 100 days in the dead of winter. Indoor air variations over this same time-period were infrequent and of short duration, but did vary in concentration by 5 to 20 times. Ramifications on soil gas and indoor air sampling strategies from these data sets will be discussed, as well as ramification on the utility of sub-slab data for assessing the vapor intrusion pathway.

The results from the two commercial sites demonstrate the potential benefits of continuously monitoring indoor air concentrations over time. At one site, the monitoring data were used to determine if shutting off an active mitigation system had any effect on the indoor air. At the second site, the monitoring data were used to determine if the indoor air PCE concentrations were from indoor sources or from the subsurface. Data from both of these sites will be presented and discussed for the first time in any public forum.

The ramifications from these studies on indoor air sampling, particularly regarding short-term (24-hour) exposure to trichloroethylene (TCE) will be discussed.
Application of Passive Sorbent Techniques to the Measurement of Naphthalene in Indoor Air

Heidi Hayes and Diane Benton

Naphthalene is often a chemical of concern at vapor intrusion sites affected by petroleum-contaminated soil and/or groundwater. To evaluate human health risks due to migration of naphthalene into nearby buildings and homes, indoor air measurements may be required. While passive sorbent samplers are gaining interest as an alternative to EPA Method TO-15 for measuring volatile organic compounds (VOCs) in indoor air, naphthalene performance using passive sorbent methods has not been fully assessed.

To evaluate passive sorbent techniques for monitoring naphthalene in indoor air, passive sorbent samplers were deployed in an environmental chamber and exposed to known concentrations of naphthalene generated using a permeation device. The environmental chamber was configured so that temperature, humidity, and air flow were controlled so as to mimic typical indoor air conditions. Sampling rates were determined for several passive sampler configurations including a permeation-style sampler as well as tube, badge, and radial sampler geometries. Each of these sampler styles was paired with the appropriate sorbent material for thermal desorption. After determining sampling rates, the samplers were exposed to trace level naphthalene concentrations in the environmental chambers to evaluate accuracy and precision near risk-based screening levels. To compare passive sorbent performance to conventional indoor air methods, concurrent TO-15 Summa canisters and TO-17 sorbent tubes were collected from the chambers and analyzed for naphthalene.

Recommendations on passive sampler configurations, sampling techniques, and analytical parameters for achieving naphthalene indoor air screening levels are presented. Additionally, considerations for the selection of appropriate air method to meet data quality objectives are discussed.

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Presenting Author: Heidi Hayes
The Hybrid Option for On-going Protection from Short-Term Risks with Episodic Chemical Vapor Intrusion

Henry J. Schuver

This explores three evidence-based options for on-going-screening/monitoring a specific scenario of Chemical Vapor Intrusion (CVI); i.e., uncontrolled CVI with relatively-low baseline levels but episodic peaks of chemicals associated with risks from short-term-exposures. The strengths and weaknesses of ‘Ideal’, ‘Conventional’, and ‘Hybrid’ options are compared for a number of characteristics. The Hybrid option involves trade-offs to approach ‘Ideal’ characteristics, while remaining at-least-as sensitive, specific, and more cost-effective, than the ‘Conventional’ option. The Hybrid option uses indoor-radon levels as a tracer/surrogate/indicator of building-specific susceptibility to the intrusion of nearby soil-gas. When combined with confirmed chemical contamination in near-building soil gas, elevated indoor radon levels indicate a probability for some chemical intrusion/short-term risks. Finding these conditions, further on-going-screening/monitoring could involve indoor air samples analyzed for CVI-chemicals and collected: 1) at an on-going-frequency appropriate for the shortest exposure period of concern, or; 2) less frequently, when combined with intrusion-reducing controls and ‘continuous’ indoor-radon monitoring.

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Presenting Author: Henry J. Schuver
Sampling Media, Analytical Methods, and Instrumentation Used to Screen, Investigate, and Close Vapor Intrusion Sites – What Is Reliable and Accurate?

Robert Uppencamp, Brian Cosky, Brian Schumacher, Christopher Lutes, John Zimmerman, Robert Truesdale and Robert Norberg

The field of vapor intrusion (VI) is constantly evolving, and accepted procedures to investigate VI have continued to change. A significant number of sampling and analytical methods and media, instruments, models, and supplemental tools are at the practitioner’s disposal to screen, investigate, and close VI sites. Multiple ambient air analytical methods exist that have been modified for soil gas, sub-slab vapor, and indoor air sampling. Passive sampling has been gaining traction for investigating VI; however, some regulatory agencies and clients are still skeptical. Radon is often used to determine site-specific attenuation factors and investigate VI entry points. With so many options, it is often unclear which media options, analytical methods, and instruments are reliable for decision making.

In this presentation, various types of sampling media, analytical methods, and instrumentation will be discussed with regard to their function and reliability, with a focus on passive/absorbent sampling media and radon measurement options. Using data collected from several sites including data from a vacant duplex intended to simulate residential conditions, recommendations on samplers and detection devices for VOCs and radon, including passive/absorbent media (tested over long periods of time), field gas chromatographs, and real-time radon detectors will be presented and discussed. At some sites, cross-comparisons between many samplers and devices were performed to assess their relative efficiency and reliability. This presentation will evaluate this data from long-term and short term detailed studies. Devices available to the domestic consumer were also assessed for comparison with regard to potential use in VI assessments by environmental practitioners. Understanding these issues is critical for VI practitioners to choose reliable media for VOC and radon sampling.

This presentation will provide evidence that some media, methods, and instrumentation may be better than others for certain vapor intrusion applications and discuss the pros and cons of each tool.

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Presenting Author: Robert Uppencamp
POSTER PRESENTATIONS

(in alphabetical order by presenting author)
Utilization of Phosphogypsum to Reduce Greenhouse Gases Emissions on the Kingdom of Saudi Arabia

Saud AL Oud and Fahad Al Barakah

Some Industrial plants have certain by-products that should be wisely disposed in a friendly way to sustain a healthy environment. Recycling of these by-products in a useful way will be more convenient for both the factory and the environment. Some of these by-products could be likely handled again with respect of their chemical and physical constituents either directly or after some technical treatments which could maximize its benefit to certain conditions in the environment. World widely, there are several billions of tons of phosphogypsum (PG) by-products of phosphate fertilizer industry solid waste, and the annual production is estimated to be 100–200 million tons. In Saudi Arabia, sedimentary phosphate rock was identified in 1965 in the Northern region of Saudi Arabia and its location is about 70 km East of Turaif. In addition, the Al Jalamid deposit was also found in Northern Saudi Arabia. The Al-Jalamid phosphate has a measured ore reserve of 500 Mt and indicated resources that could extend the life of Ma’aden company project beyond the planned 20 years. Ma’aden proposes to produce about 4.5 Mt/yr of phosphate rock to supply its fertilizer plant, which will have production capacity of 2.9 Mt/yr of DAP. In this study, the visibility of utilization PG by product of fertilizers industries in Saudi Arabia will be examined to preserve the balanced environment and reduce greenhouse gases emissions form liquid and solid wastes. An experimental approaches will be carried out under laboratory and greenhouse and field conditions. Phosphogypsum will be collected from PG stack at the The Al-Jalamid phosphate site, which is located in the Northern region Saudi Arabia at a location about 150 km East Turaif city. Chemical and physical characterizations of PG will be measured. This project was supported by NSTIP strategic technologies program number (12-ENV2917) in the Kingdom of Saudi Arabia

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Impact of Phosphate Mining Activities, on Airborne Particulate Concentration in North Saudi Arabia

Abdulaziz B. Alharbi

The main track for airborne particulates to entry human body is respiratory system, while airborne particulate concentration impact on the respiratory system depend on particle size, shape, density, and most of particles smaller than PM$_{10}$ (10 microns) can reach the human lungs. In this study, the mass concentrations of three particulate matter fractions (PM$_1$, PM$_{2.5}$, and PM$_{10}$), were monitored simultaneously outdoor in three location for different periods, at the Al Jalamid phosphate mine, in the North of Saudi Arabia. The results show that Phosphate Mining activities made in the investigated locations are a significant factor affecting particles concentration of PM$_{10}$, and PM$_{2.5}$. However, the influence of Phosphate Mining activities on PM$_1$ was not strong. The impact of Phosphate rock grinding was significant for PM$_1$, PM$_{2.5}$, and PM$_{10}$.

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Green House Gases (GHGs) Management in Kuwait Oil Company (KOC)


Kuwait Oil Company (KOC) is one of the major oil and gas production companies in the region and the industry has the major operation facilities like Gathering Centers, Booster Stations and Oil Wells and these are all spread over West, South-East and North Kuwait fields. As per KOC 2030 strategy, the domestic oil production will be increased to 4 million barrels/day that may also burden the air pollution through the emission of Greenhouse Gases. Considering the current and future challenges on air pollution, numerous steps were taken by the industry in order to assess and minimize the GHGs. Gas Flaring Reduction and Air Compliance Management Program is a major one that currently progressing for reducing the source emissions of GHGs in all over KOC facilities. As GHGs emissions is a Global issue, KOC voluntarily committed to reduce the Six GHGs [Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydro Fluorocarbons (HFCs), Per Fluorocarbons (PFCs) and Sulphur Hexafluoride (SF6)] that are covered under Kyoto Protocol. Additionally, the GHGs emission calculation tools are explored from IPCC/ IPIECA/ API WBCSD/WRI GHGs Protocol for direct and indirect emission sources in order to estimate CO2 equivalent for KOC operations.

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Model Development for Predicting Temporal Characteristics of Leachate from LNAPL Contaminated Soil

Mohammad Al-Suwaiyan

Accidental spills and leaks of petroleum products eventually result in a zone in the subsurface with residual amounts of the light nonaqueous phase liquid (LNAPL) held by capillary forces in the unsaturated zone. This zone contains three phases, namely: air, water and LNAPL and in most cases it acts as a source of continuous contamination of the surrounding groundwater. Removal of the residual LNAPL is a very important aspect of any subsurface remediation project. In pump-and-treat technology or soil extraction treatment of a contaminated zone, the residual LNAPL is essentially leached slowly into the flowing water or air eventually leading to the reduction and hopefully depletion of the residual LNAPL mass. Since common organics including gasoline and crude oil are actually mixtures of many individual organic products that have different physical and chemical properties that influence their partitioning into the various phases, their concentration in the leachate will vary with time as a result of the change in the LNAPL composition. An outline for the development of a compositional model is presented with the objective of coming up with the concentration of the various components in a leachate through uniform soil contaminated by crude oil. The model will be able to clearly demonstrate the difference in behavior of the various compounds of the LNAPL. The model will demonstrate that the concentrations of some compounds will decrease continuously with time while other compounds would exhibit a totally different behavior. The model can be used to examine the influence of critical chemical properties of the LNAPL compounds on their leaching aqueous concentration with time. Such model can also be useful for assessing the progress of the remediation process and its degree of effeteness as well an environmental forensic tool to perhaps determine the source and nature of spills that happened several years back.

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Removal of As (III) Present in Aqueous Matrices Models Using Binary Composites of Montmorillonite-nZVI Type: Effects of the Coating Degree

Pamela Sepúlveda, Daniela Muñoz, Jonathan Suazo, Karen Manquián, Nicolás Arancibia-Miranda and María Angélica Rubio

The development of industry and economics has clearly affected the ecosystem during the last centuries. In particular, the water resources have been constantly contaminated by several trace elements such as Pb$^{2+}$, Cu$^{2+}$, Cd$^{2+}$, CrO$_4^{2-}$, As$^{III}$ and As$^{V}$ [1-3], that appear as residues from different economic activities [1]. In particular, high arsenic concentrations from groundwater sources have been detected in Chile, USA, India and Mexico, among others [3]. In this context, the sorption of arsenic has been examined by considering several chemical. The iron nanoparticles (nZVI) are widely used for the removal of these pollutants, where their structural and surface characteristics such as surface area, size and surface charge favor the sorption processes [1,2]. However, due to the processes of aggregation and passivation, which significantly affect the sorption capacity of nZVI. Porous materials such as clays increase the stability of nZVI, allowing it to work under extreme conditions of pH and temperature as well as improving the sorption process [3].

In the present work two types of binary composites were prepared: montmorillonite-nZVI, with varying degrees of nZVI coating (coating mass 5% (C1) and 20% (C2)). The characterization of these materials was made by X-ray diffraction (XRD) and scanning electron microscopy (SEM). Sorption studies showed that the As(III) sorption kinetics was adequately described by the pseudo-second order model, achieving maximum As (III) adsorption ($q_m$) after 40 minutes of reaction, and C2 was the composite that had the highest sorption capacity, 32.7 and 61.9 mg/g, for C1 and C2 respectively, indicating that the degree of coating is a critical factor in the removal of As. The adsorption capacity of C2 was significantly higher than those of C1, while C1 is higher affinity than C2. The data presented suggest that the C2 nanocomposite had a higher adsorption of As(III) in water matrices compared with C1, and it may be widely used for the decontamination of anions in aqueous systems.

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Presenting Author: Nicolás Arancibia Miranda
Highly Successful ERD Pilot Study in Residual DNAPL Utilizing a Simple Additive Delivery Approach

Kent Armstrong and I. Richard Schaffner

Groundwater at a manufacturing facility in east central Ohio contains trichloroethylene (TCE) at concentrations nearly 30% of its solubility limit, implying the presence of DNAPL. Enhanced reductive dechlorination was selected as the site remedy using ERDenhanced™, a patented carbohydrate-based additive formulated with macro-micro nutrients to stimulate native soil bacteria and enhance the destruction of chlorinated alkene source mass. A remedial pilot study was implemented to collect pre-design data for the full-scale remedy.

ERDenhanced™ was amended to the well bore of three monitoring wells utilizing Passive Release Sock (PRS) technology. Overall, there was an 80% Reduction to >99.9% Reduction in TCE concentrations at the three wells over 12 months. At one of the wells, there was a 99.9% Reduction in cis-1,2-dichloroethene (cis-1,2-DCE) and a 98% Reduction in vinyl chloride (VC), consistent with abiotic dechlorination. At the two other wells, there was an >186% Increase in cis-1,2-DCE and as high as a 500% Increase in VC.

The significant reduction in TCE concurrent with increased cis-1,2-DCE and VC is consistent with biotic dechlorination. Indicator parameter data were generally consistent with the development of anaerobic, chemically reducing conditions proceeding down to at least sulfate reduction at all three wells into which PRSs were deployed.

Conditions at a background well remained generally aerobic, chemically oxidizing throughout the plot study. CENSUS Bio-Trap data were collected at the wells into which PRSs were deployed and at a background well following ten months of PRS deployment. Each of the three Bio-Traps deployed at wells equipped with PRSs had positive indicator values (i.e., tceA Reductase, BAV1 VC Reductase, VC Reductase) up to 10^4 cells/bead whereas the one Bio-Trap deployed at the background well was non-detect.

A remedial design is under development to advance the site towards regulatory closure.

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Groundwater Quality Assessment: A Case Study from Kolar Gold Fields, Karnataka, South India

Nagaraju Arveti and Sunil Kumar Kondeti

The Kolar Gold Fields (KGF) in Karnataka was a premier gold mining area in India and is situated about 15 km east of Bangarpet. At present, the mines were closed in 2000 and have a recorded history of nearly 200 years of operation. The groundwater is a vital source of water for domestic and agricultural activities in this Kolar area and due to the lack of surface water resources, groundwater quality and its suitability for drinking and agricultural usage was evaluated. In this study, 40 groundwater samples were analyzed for distribution of chemical elements Ca, Mg, Na, K, HCO₃, F, CO₃, Cl, and SO₄. The parameters include total hardness, alkalinity, total dissolved solids, electrical conductivity and pH. The measured pH values for analyzed waters are in the range of 7.05 – 8.48. TDS values measured in the tested waters range from a minimum value of 787 mg/l to a maximum value of 3907 mg/l. Their specified hardness is in the range from 128 to 1440 μmhos/cm. The scope of certain concentrations of alkalinity ranges from 125 mg/l to a maximum 472 mg/l. Chlorides are determined in a concentration range of minimum 29 mg/l up to a maximum of 761 mg/l. The concentrations of sulphates in the examined waters range from minimum 42 mg/l to a maximum 310 mg/l. Trace metals like have accumulated in waters about 7.9 ppb of gold, 402 ppb of lead and 523 ppb of zinc. The parameters like sodium adsorption ratio, percent sodium, potential salinity, residual sodium carbonate, non carbonate hardness, Kelly’s ratio, magnesium ratio, permeability index, indices of base exchange and Gibbs ratio was calculated. This study has concluded that the chemical analysis forms the basis of interpretation of the quality of water in relation to source, geology, climate, and use.

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This study investigated the effect of the application of vermicompost on the growth and biomass accumulation of *Chromolaena odorata* and its uptake of heavy metals from contaminated soil in a greenhouse. The heavy metals, Cd, Cu, Pb, Ni and Zn were used to amend the soil to give final concentrations 0, 10, 50, 80 and 100 mg kg\(^{-1}\). The soil was mixed with vermicompost in a ratio of 3:1 in plastic soil pots and six weeks old *Chromolaena odorata* propagated from stem cuttings were transplanted into the contaminated soil and kept in the greenhouse for twelve weeks. Soil pH, electrical conductivity and respiration of soil organisms were measured. Microbial diversity in the soil was determined. Soil pH decrease in the experimental soil and EC increase significantly. The growth of *Chromolaena odorata* was not significantly inhibited by concentrations of the heavy metals below 50 mg kg\(^{-1}\). Microbial diversity was significantly larger in the treated experiments than in the control experiments. The application of vermicompost enhanced the growth of *Chromolaena odorata* and the uptake of heavy metals. Overall, the uptake of metals was increased by the application of vermicompost; however, the effect was least evident in the Cd amended treatments while the Zn treated experiments showed more uptake.

**Keywords:** *Chromolaena odorata*, heavy metals, phytoremediation, vermicompost.

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Nanotechnology is becoming an advanced form of groundwater pollutant removal. The tiny size of the particles allows for a larger level of particle removal at a reduced cost than the use of larger technologies. These particles are separated, in singular form and can bond with more of the pollutant materials than larger, bonded particles that cost more to create. The technology is also able to filter out more types of pollutants than other technologies because many of the pollutants are too small for the other technologies to be efficient. This paper will highlight the way that nanotechnologies are able to perform their duties of efficiently cleaning groundwater, report on the currently rising problem with the salination of groundwater sources, and explain some of the innovative nano-technological designs that are proving efficient for the desalination of these water sources. Finally, the paper will introduce a table illustrating the wide array of nano-technological designs used in the removal of groundwater pollutants; including what contaminants these designs are able to remove and what mechanisms these designs use in order to remove them. The table will be handed out as reference to participants.

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Presenting Author: Bonnie Aylor
Modeling Potential Volcanic Occurrences for Implementing Its Resources to Maximum Use and Curtail Eruptions

Bonnie Aylor

Currently, California’s mountain ranges fall in line so that the geographical structures such as geysers and springs fall in line with the mountainous structures that reach as far up as the ANWR region. It has been shown that the natural gas resources also run underground along these currents. In recent times, geysers have been tapped into ever more often because the underground pressure is allowing for an increased use of the resource. Furthermore, the occurrence of earthquakes have increased, and gas extraction leaks have become more prevalent in that region. For the past few decades, microscopic water species that support other layers of species have begun to die off as water temperatures increase. Many forests fires have burned out of hand, increasing the capability of the surface to feed nutrients into underground reservoirs that provide resources for flowing oil reserves. This paper will seek to provide a scientific system in which environmental modeling can predict the fate of mountainous structures as they evolve from basic faults in the tectonic plate designs into steaming hot, exploding volcanos. This modeling data can be used to predict different measures that can be implemented to ease the ability of the structures to emit lava and to use this fantastical occurrence as a resource for other things. Basically, the presentation will provide an overview of the many innovations that can solve regular societal problems and energize volcanic structures to good use while treating the structures so that pressures release and mixtures slow, essentially containing the volcanic reaction altogether.

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Coming of Age: Phytoremediation as an Aesthetic Trend

Bonnie Aylor

As the age of the Industrial Revolution finally expires and businesses are coming to grips with the new movement towards green industry, CEO’s are realizing increasingly the amount of damage that has been produced through historic processes. These companies are looking to change out their methods to ensure that they reduce their harm to the environment as much as possible. They are also looking to retire old site, and clean them up so that they are no longer harmful. Many times these sites are left abandoned, even after they have been cleaned up, because there isn’t a lot of use left for them. However, a catching trend in remediation is to take the property and regenerate it into a housing development or a park. Some have even gone so far as to turn the property back into a wilderness area. This is done through a careful selection of phytoremediation technologies, coupled with structures used for different types of sites. While phytoremediation maybe a slow processes, it has many values. The first value regards its price, the others are in the continued opportunities of use of the land. This paper will provide an overview of some common uses for a phytoremediation program. It will also attempt to introduce some basic phytoremediation technologies, how they what, what types of remediation projects they are good for, and if there will need to be any other types of technologies required to catalyze the initial process. The paper will conclude with some recommended projects for the remediation of groundwater according the contamination level and type. It will also demonstrate some money making opportunities that can some from a view variations of phytoremediation technologies.

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This study determined effect of different levels of composted market waste on the growth, yield and heavy metal content of sunflower in a textile effluent polluted soil. Soil samples were collected from the vicinity of a textile company in Nigeria. Twelve-liter plastic pots were filled with 10 kg soil. Composted market waste was applied at 0 (control), 40, 60, 80, and 100 Kg N ha⁻¹. N.P.K (20:10:10) fertilizer was applied at recommended rate of 60 Kg N ha⁻¹. The pots were arranged in Completely Randomized Design and replicated three times. Growth parameters (number of leaf, stem diameter and plant height) were taken. Plants were harvested 12 weeks after sowing and separated into leaf, stem and root. Lead (Pb), chromium (Cr), cadmium (Cd) and zinc (Zn) levels in plant and soil were determined using Atomic Absorption Spectrophotometer. Data were analyzed using descriptive statistics and analysis of variance. Composted market waste significantly (p < 0.05) enhanced the growth and yield of sunflower compared to N: P: K fertilizer. Increase in the quantity of composted market waste applied significantly reduced the uptake of heavy metal. Higher concentrations of Pb (1.75 mg kg⁻¹), Cr (1.00 mg kg⁻¹), Zn (67.48 mg kg⁻¹) and Cd (0.13 mg kg⁻¹) were observed in the stem at 60 Kg N ha⁻¹ of N.P.K (20:10:10) fertilizer.

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Presenting Author: Babatunde Saheed Bada
Knock Off Blind Wells – An Innovative Method to Complete Single Ended Horizontal Environmental Wells

David Bardsley and Dan Ombalski

Background/Objectives. Horizontal well installation technology has been utilized since the 1980’s for a wide variety of monitoring and remediation activities. The installation method consists of two types of well configurations. (1) Continuous or double ended wells – wells completed using methods similar to utility installations having an entry and exit location, with the well materials pulled into the borehole in tension. (2) Single ended or blind wells – completions with only an entry location, with the well materials pushed into the borehole in compression. Blind wells have distinct advantages in applications where surface constraints limit the availability of an exit location. However, maintaining an open borehole in certain types of geology (gravels, cobbles, poorly consolidated sands, swelling clays) while pushing well materials into the bore is risky for the contactor. Additionally, well materials utilized in the vertical well industry are not designed for the compressive stresses generated from pushing the screen and casing into the horizontal borehole. The increased costs and risk of failure have limited blind well installations within the environmental horizontal well industry. A new methodology had to be developed to reduce the risks and costs of blind well construction.

Approach/Activities. Early blind well completions included the installation of surface casing set through the curved section of the borehole. The surface casing significantly reduced the friction on the well materials as they were pushed through curved section of the borehole. However issues with borehole stability and friction during the well installation process through the horizontal section still limited the success of blind well completions. One way to reduce the risk of failure during installation of blind wells is to utilize steel/stainless steel well screen and casing. The steel well materials are able to withstand the compressive stresses during installation, however this is a significant cost increase over PVC and HDPE well materials. A new method for completing wells in single ended/blind boreholes has been developed using large diameter (5” inside diameter) drill pipe. Utilizing this large diameter drill pipe and a specially designed drill bit assembly, three inch (3”) and four inch (4”) well screen and casing can be installed inside of the drill pipe. The well materials “lock into” the drill bit, which detaches from the drill pipe and anchors the screen and casing into the end of the borehole. The drill pipe is then pulled from the subsurface, leaving the screen and casing in contact with the formation. This innovated installation technique is called the “Knock Off” blind well installation method.

Results. The Knock Off installation method allows for the successful completion of blind horizontal wells by inserting the well screen and casing inside of large diameter drill pipe. The Knock Off method reduces the risk of blind well completions and has an added benefit of reducing the overall well cost because PVC and HDPE well materials can now be utilized to complete long, single ended wells.

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Presenting Author: David Bardsley, P.G.
Horizontal Environmental Drilling 101 – An Introduction to the Means and Methods for Horizontal Environmental Well Installation

David Bardsley and Michael Lubrecht

Horizontal well installation technology has been utilized since the late 1980’s for a wide variety of monitoring and remediation activities. Consultants and site owners may be intimidated with the equipment, nomenclature and perceived high cost of these innovative well installation methods. This presentation will provide an overview of the following important aspects of horizontal environmental wells:

- History of horizontal environmental wells
- Applications and advantages of horizontal wells
- Horizontal drilling and well installation nomenclature
- Drilling, installation and development fundamentals
- Drilling Fluids
- Well materials
- Drilling equipment
- Potential problems and challenges to successful installations

The data presented will be useful for both seasoned and relatively new environmental professionals.

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Presenting Author: David Bardsley
Effect of Hydrogel Amendment on Growth and Survival of Plants in Two Types of Soils

Isam Bashour, Jessica El Asmar, Hadi Jaafar and Mohammad Farran

The effect of Hydrogel, a Super Absorbent Polymer (SAP) (STOCKOSORB® 660, a crosslinked Potassium salt Polyacrylic acid) on water holding capacity and survival rates of plants in clay (C) and sandy clay (SC) soils was tested. Two greenhouse experiments (testing the effect of hydrogel on corn growth and survival rate of pine trees); one field experiment (testing its effect on survival of Carob trees, Ceratonia siliqua, South European flowering ash, Fraxinus ornus, and Juda’s tree, Cercis siliquastrum); and one laboratory study (investigating its effect on water holding capacity of the soils) were conducted.

The rates of hydrogel used in the investigations were 0, 0.5, 1, 2, 3 and 4 g hydrogel/kg soil. The application methods were banding (a single layer under the root zone) and complete mixing with the soil. Results showed that hydrogel significantly increased water holding capacity of sandy clay soil. The use of hydrogel did not significantly benefit tree survival in the field experiment. However, the corn pot experiment indicated that banding hydrogel was more efficient than mixing it with the soil. The second pot experiment showed that at the rate of 4 g/kg, hydrogel significantly helped prolong the life span of pine seedlings from 19 weeks to 25 when mixed and to 31 when banded.

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Presenting Author: Isam Bashour
Remediation of Chlorinated Solvents in Groundwater and Soil Gases Using Site-wide Pseudo-convective Transport Processes

Edward Council and Christopher Council

The study site is a former dry cleaner with elevated levels of chlorinated solvents in its groundwater. During earlier demolition activities, almost all native vadose zone soils were removed along with VOC source areas within them. Prior to October 2013, VOCs in the soil gases were predominantly at low levels (>5 ppbv), except within a cluster of phytoremedial TreeWells® located at the center of groundwater contamination. After the installation of 40 small diameter BVE™ Treatment System probes and conversion of the cased phytoremedial TreeWells® into large diameter GVE™ vents, the temporal and spatial soil gas pressures/distribution patterns radically changed across the entire Site. Soil gas VOC levels increased orders of magnitude (up to 3,100 ppmv) and became very mobile, with velocities exceeding 80 feet/day. Due to the elevated Henry’s constants for the chlorinated solvents, the contaminants that degassed into the vadose zone appeared to periodically dissolve back into groundwater elsewhere as they migrated toward the GVE™ vents. This flux appears to be similar to landfill processes previously identified by Morris (1994). A combination of soil gas/barometric pressures and the developed preferential pathways of the BVE™/GVE™ Treatment Systems were the driving factors for this “Green” groundwater remediation system. The large data set generated during this study “strongly indicates” 1) single event SOV surveys may have a negligible value in correctly identifying contaminated source area(s) or VI issues; 2) small but important contaminated groundwater areas are not likely to be detected during conventional field studies, but their continual input will significantly extend remediation timeframes/cost; and 3) contaminants-degassing from groundwater may occur when convective routes of transport are inadvertently created during assessments and/or construction activities. Due to the uncertainty associated with most data collection activities, low-cost/high density mitigation measures should be university considered to break the pathway(s) between contaminant sources and nearby receptors.

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Photovoltaic Solar Cooling in Regions With High Solar Irradiation: A Case Study

Muhammed Emin Tolu and Mehmet Numan Kaya

Turkey is one of the luckiest countries in the world, receiving high levels of solar radiation. This encourages individuals to use solar power for various applications including space cooling since the demand for cooling of indoor air is growing due to increasing comfort expectations. Today, cooling systems dominate the energy consumption in most of office buildings and solar power can be used to cover this demand. In this study, a photovoltaic solar cooling system is designed to meet the cooling requirement of the office rooms of Karamanoglu Mehmetbey University located in Karaman, Turkey. By using the calculated cooling load, the system components are selected and the economic feasibility of the system is evaluated under the climatic conditions of Karaman. Long-term solar irradiation measurements of Turkish State Meteorological Service are used for calculations in this study.

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Heavy Metals Transport in Depth and Chemical Forms Distribution in Volcanic Soils Treated With Sewage Sludge

Mauricio Escudey, Nicolas Arancibia and Carmen Pizarro

Sewage sludge (SS) is the end product of municipal wastewater treatment processes worldwide. For disposal, the SS may be land applied because contains organic matter and essential plant nutrients, but also heavy metals (HM). The study of transport and chemical speciation of HM in two soils derived from volcanic materials (Ultisols), are the objectives of this paper.

Testing columns, of 25cm depth, were prepared at each soil bulk density; 30g of SS or 18g of sewage sludge ash (SSA, obtained by heating the SS at 500°C for two hours), was added at the top and irrigated, adding one pore volume of water every week, during 12 weeks. Control columns were prepared and treated similarly. At the end of the leaching experiment, each soil column was cut open lengthwise and then sectioned into five equal length segments for analysis of the HM contents. A chemical fractionation of HM was carried out to each section by a sequential extraction (KNO₃, distilled water, NaOH, EDTA, and HNO₃), allows to estimate the exchangeable, sorbed, organic, carbonate and residual fractions of HM. Analysis of Cu, Zn, Pb, Al, Fe, Ni, Cr, Mn, Mo and Cd were carried out by ICP-OES.

In general, more than 99% of the total HM input with SS remains into the soil column with the exception of Pb (~97%), Mo (~89%) and Mn (~44%); the addition of SSA increases even more the HM soil retention. Organic and carbonates HM chemical forms significantly increase with the addition of SS and carbonates forms with the addition of SSA when compared to control. The 0-5 cm depth section concentrates the most important amount of HM. The importance of soil pH (5.4-6.4) on HM speciation is more significant than soil adsorption processes.

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Efficiency of Zeolite-Nanomagnetite Composites in the Arsenate Remotion from Aqueous Solutions

Carmen Pizarro, Daniela Muñoz, María Angélica Rubio and Mauricio Escudey

The increasing level of arsenic on the Earth surface has been leading not only to serious environmental problems, but these are also the cause of high concerns about their direct effects on individuals, either those living in remote small communities or in densely populated urban areas of big cities. In northern Chile, the occurrence of arsenic in superficial and ground fresh waters is steadily increasing, as a consequence of the intensive mining activities. In this work, composites based on optimized content of nanosized particles of magnetite supported on a natural zeolite were prepared and the arsenate adsorption efficiency was evaluated considering the kinetic of the adsorption process, and the real availability of the theoretical maximum adsorption sites. Different composite:solution ratio were considered, equilibria involving 0.5, 5.0 and 16.0 g of composites suspended in one liter of aqueous solution containing 100 mg L⁻¹ of arsenate were studied. The arsenate adsorption follows the pseudo first order kinetic model and the maximum of adsorption is achieved after 30 minutes of equilibrium, no matter the solid:solution ratio considered. Adsorption isotherms can be described by the Langmuir model, giving an arsenate maximum adsorption of 3.81 mg g⁻¹. At all the composite:solution ratio studied, from 98 to 100% of the composites maximum theoretical adsorption sites were occupied, making easy to estimate the amount of composite required to remove arsenate. In terms of efficiency, acidic conditions improve arsenate remotion.

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In-situ Chemical Oxidation and Bioremediation of Groundwater in Challenging Lithologic and Groundwater Conditions

Jude T Francis

This paper presents the results of two in-situ injection-based pilot tests of chemical oxidation and bioremediation in challenging site lithologic and groundwater conditions in southern California. One pilot test involved ISCO remediation using alkaline-activated persulfate oxidation to address petroleum hydrocarbons and MTBE in a low permeability silt/clay formation. A second pilot test involved in-situ anaerobic bioremediation (ISB) and chemical reduction (ISCR) testing using a lecithin substrate with ferrous iron at one location and an emulsified vegetable oil substrate at another to address deep groundwater (150 feet bgs) impacts in a low permeability formation.

The first case study is at an actively operated fire station that is impacted with relatively high concentrations of TPH as gasoline (120,000 g/L), MTBE (130,000 g/L) and TBA (120,000 g/L) in a low permeability silt/clay formation in the water table zone (25 to 40 feet bgs). A bench test was conducted comparing various oxidant chemistries that resulted in the selection of caustic-activated persulfate (Klozur) for the pilot test. The pilot test involved direct push injection in the 25 to 40-foot zone in 2-foot intervals in 16 injection points and associated post-injection groundwater monitoring. This poster will present the remedial goals, implementation approach, dosage and results of the pilot test that show the effectiveness of this ISCO technology in low permeability formations.

The second case study is a site that is impacted with TCE (1,500 g/L) and hexavalent chromium (140,000 g/L) that originates from an adjacent site in the water table zone (150 to 180 feet bgs). Given the depth of the groundwater impacts, the preferred remedy was an in-situ injection based technology that required the amendment to be injected through wells to address only the TCE with a reactive barrier. Two technologies (ISCR/ISB) were selected for field pilot testing with both including bioaugmentation with a microbial culture. This included a lecithin-based substrate with ferrous iron (EHC-L, Peroxychem) that is a combined ISB/ISCR approach and an emulsified vegetable oil substrate (SRS-SD, Terra Systems) that is just bioremediation. This poster will present the remedial objectives, the implementation approach, dosage and results of the pilot test that show that despite high chromium concentrations and unfavorable oxidizing background conditions dechlorination of TCE is occurring.

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Presenting Author: Jude Francis
Investigation & Evaluation of Subsurface Anthropogenic Preferential Pathways

Aaron P. Friedrich

The evaluation of preferential pathways poses significant difficulties when developing a conceptual site model (CSM). The problem becomes significantly more complex when the preferential pathway has relevance to potential vapor intrusion (VI) concerns at sites where groundwater or soil contamination is present.

Typical preferential pathway assessments include an evaluation of vapor or groundwater in higher permeability material around the outside of a sewer. Current VI (e.g. US EPA 2002/2011, ITRC 2007/2014, etc.) and conceptual site model (CSM) guidance documents present a generalized approach to evaluating preferential pathways. However, there is very limited descriptive guidance on the appropriate screening and sampling methods to evaluate preferential pathways. In addition, there is little guidance on the evaluation of volatile organic compounds (VOC) impacts migrating inside a sewer and the corresponding migration and exposure pathways. Preliminary VI screening mechanisms, such as those based on the proximity to the source or attenuation only comprise a small set of the multiple lines of evidence (MLOE) that must be considered.

The purpose of this presentation is to summarize various investigation methods and approaches utilized to evaluate anthropogenic preferential pathways. In addition, this work presents a step-wise pathway evaluation approach consistent with the acceptable MLOE methods for VI. This step-wise approach to evaluating preferential pathways focusses on groundwater, sewer water, sewer gas, and soil gas and the corresponding interrelationship these media have on the CSM. This work and future work will include an evaluation of i) the mechanisms that may influence VOC migration associated with preferential pathways, ii) the applicability of attenuation factors for preferential pathways, and iii) decision making framework for remediation when contamination is identified in a preferential pathway.

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Presenting Author: Aaron Friedrich
How Do You Get Out of the Product Recovery Loop? Naturally Sustainable LNAPL Source Control

James Gonzales, Erica Whiting and Steven Gaito

In the late 1960’s, an inadvertent release of gasoline was reported from a pipeline located in the Colorado Desert Region of Southern California. Approximately 50,000 gallons of light non-aqueous phase liquid (LNAPL) were recovered from the surface around the release area during pipeline repair. An additional 14,000 gallons of LNAPL were recovered during dual-phase recovery conducted from 1988 through 2004. Approximately 400 gallons of LNAPL was removed by way of periodic bailing from 2006 to 2013. Currently, the LNAPL and dissolved-phase plumes are stable. However, because measureable LNAPL continues to accumulate in monitoring wells located near the original release area, the site has languished under the current regulatory metrics for LNAPL recovery, i.e., de minimis LNAPL thickness in monitoring wells. Because LNAPL recovery is no longer effective, an alternative long-term LNAPL management plan, including the quantification of natural degradation processes to demonstrate continued source reduction is proposed for this site consistent with California’s Low Threat Underground Storage Tank Case Closure policy.

Natural source zone depletion (NSZD) represents natural processes that reduce the mass of LNAPL through chemical redistribution of LNAPL constituents (i.e., dissolution, volatilization, and sorption) and through biodegradation by microbial and/or enzymatic activity.

NSZD rates were quantified through the comparison of dissolved-phase geochemical and gasoline constituents across the source zone and by measuring carbon dioxide emissions from the subsurface that are attributable to biological degradation of LNAPL constituents. Radioisotope analysis of the carbon dioxide captured by traps was used to distinguish between carbon dioxide flux generated from the degradation of petroleum hydrocarbons and carbon dioxide flux related to naturally occurring soil respiration processes.

NSZD was demonstrated to be a viable LNAPL management strategy that meets goals for mitigation of risk pathways, long-term LNAPL body stability, and sustainability. The NSZD remedial option is shown to result in LNAPL reduction rates an order of magnitude higher than those attainable through traditional LNAPL recovery strategies.

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Presenting Author: Steven Gaito
Demonstrating Natural Source Zone Depletion of LNAPL as a Remedial Alternative

Erica Whiting, Steven Gaito and Elizabeth Cohen

A common assumption is that removal of all light non-aqueous phase liquid (LNAPL) to the maximum extent practicable means achieving de minimis LNAPL thickness in compliance wells. Changes in best practices and regulation and greater acceptance of risk-based remedial alternatives have caused a shift in this approach. In cases where LNAPL is not a significant source of risk and is neither migrating nor practicably recoverable, an LNAPL management strategy that leaves LNAPL in place where it continues to be depleted through natural processes is a cost effective and sustainable option.

Natural source zone depletion (NSZD) is a combination of natural processes that reduces the mass of LNAPL through dissolution, volatilization, and sorption and subsequent biodegradation. In the saturated zone, LNAPL depletion is quantified by groundwater flux and changes in groundwater quality across the LNAPL body. In the unsaturated zone, characterization of diffusive gas transport processes to quantify carbon dioxide emissions are used to estimate rates of LNAPL depletion.

The selection of NSZD as part of a remedial strategy is illustrated for a site with an existing LNAPL body. The investigative process and methodologies used to provide a defensible demonstration of NSZD are described. The NSZD rate measured in the vadose zone is generally one to two orders of magnitude greater than in the saturated zone; therefore, the assessment uses only the vadose zone analysis to determine NSZD rates. An estimate of overall project lifecycle cost savings for this remedy compared traditional alternatives is presented.

NSZD as a remedial option has particular relevance for those sites which exhibit low risk or where engineered remedial alternatives are impractical. Successful demonstration of NSZD can be completed using cost effective methods and a streamlined process resulting in potentially significant project life-cycle cost savings.

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Presenting Author: Steven Gaito
Natural Source Zone Depletion Evaluations at a Capped Site: Limitations in Current Quantification Methods

Steven Gaito, Brad Koons, Grant Trigger

Historical operations at the former General Motors Buick City manufacturing complex resulted in subsurface light nonaqueous phase liquid (LNAPL) impacts. The Buick City facility is located in Flint, Michigan adjacent to the Flint River. Multiple petroleum types have been found across 15 distinct LNAPL plumes bodies that are present at the facility. Manufacturing operations have ceased and the factory buildings at the 452-acre facility have been demolished. However, the building slabs and parking surfaces were generally left in place and the bulk of the site is covered by asphalt or concrete.

Site assessment activities were conducted to determine the natural depletion rate of petroleum LNAPLs at multiple site locations. The two dominant methods to quantify natural source zone depletion (NSZD) are the gradient method, which utilizes multi-level soil gas probes to estimate LNAPL losses in the vadose zone via diffusive gas transport processes (ITRC 2009) and measurement of carbon dioxide (CO₂) emissions from the subsurface attributable to biological degradation of LNAPL constituents through deployment of CO₂ traps.

Site conditions were not ideal for the current methods for quantifying NSZD rates. Installation of multi-level soil gas probes was difficult due to shallow groundwater in some locations (approximately five feet below ground). The petroleum LNAPLs are predominately located under concrete slabs that impede soil gas transport and measurement of CO₂ emissions from the subsurface.

The heterogeneous soils, shallow groundwater, and concrete cap exposed limitations in industry standard methods for NSZD rate determination. The gradient method provided vertical soil gas profile and soil diffusivity data, but construction requirements for multi-level soil gas probes limit applicability. Comparative CO₂ trap deployment identified that CO₂ observed in traps installed through the concrete were dominated by advective flow rather than diffusive transport. These observations contribute to the growing understanding of how to make accurate measurements of NSZD, so that it can be successfully applied as a more common benchmark of site progress.

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Sustainable Reuse of Treated Soil after Ex Situ Gas Thermal Remediation: Implications for TPH Impacted Sludge or Soils

Grant Geckeler, Lowell Kessel and Carol Winell

Background/Objectives. An operating farm in Central Valley California had a tank spill of diesel fuel resulting in fuel-saturated soils requiring timely treatment and resolution. Based on the site conditions and localized area of impact, soil excavation was conducted in April 2012 to remove soil impacts at the source area. Soil samples were collected from the excavation pit and revealed TPH-d concentrations of 2,340 mg/kg. A total of approximately 20,000 cubic yards of diesel impacted soil were removed from the vadose zone to a depth of 5 feet bgs and stockpiled approximately 100 feet north of the source area above a non-permeable and non-reactive Visqueen barrier. The pile footprint measured approximately 124 feet by 38 feet with an average height of 14 feet. The angle of repose measured approximately 40 degrees.

Approach. The identified remediation solution was determined to be Ex Situ Gas Thermal Remediation (GTR™) in order to heat the soil and TPH to the point of volatilization and thermal destruction. Thirty-six GTR™-type thermal conduction heating wells were installed into the side of the soil pile during construction of the Ex-Situ GTR™ pile. Baseline soil samples were collected at time of pile construction revealing a maximum TPH-d concentration of 31,900 mg/kg and an average TPH-d concentration of 9,645 mg/kg.

Results. Soil heating and LNAPL condensate recovery continued for an average duration of forty-five days achieving an average target treatment temperature of 200°C. Post treatment soil sampling of 16 soil samples confirmed a maximum concentration of 570 mg/kg TPH-d and an average concentration of 106.5 mg/kg TPH-d verifying a 99.7% reduction in concentration from baseline sampling. The project achieved remedial goals without disruption of site activities, was granted a No Further Action notice, and was approved for reuse of treated soils onsite as dirt road cover.

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Presenting Author: Grant Geckeler
Ozone Sparging for Large Scale Remedial Design

Kevin Gomes

Background:

There are many remedial technologies that are available today when approaching hydrocarbon and chlorinated solvent site contamination. In the case of a particular former petroleum and chemical storage terminal, the combined use of soil vapor extraction (SVE) with ozone has quickly and effectively reduced the source zone and removed a majority of contaminants within the area of influence.

Approach/Activities:

H2O Engineering bid and won the ozone sparge system for a former tank farm site in New Jersey, the largest ozone sparging system in the contiguous United States. There were many design challenges involved with this former tank farm including concentration levels in excess of 400,000 ug/L, multiple recalcitrant chlorinated COC’s (PCE,TCE, 1,2-DCA, Carbon Tet, and Chloroform), thickness of the saturated source zone was 60-80 ft. bgs and finally over 100 acres near the Delaware River.

H2O Engineering Inc. was contracted to design and construct an ozone sparge unit able to produce up to 180 lbs. per day at a flow rate 28 scfm of ozone at up to a 10% concentration amount. This system was capable of delivering ozone to 416 sparge wells at 4 staged depths. The ozone unit was pared with a 1500 scfm SVE blower to 42 vapor extraction wells. The result was a dramatic decrease in contaminant concentration in the effected source area after only six months of operation, on track to finish earlier than expected.

Results:

Dramatic decrease in contaminant concentration in the effected source area after only six months of operation, on track to finish earlier than expected.

H2O Engineering, Inc. makes the goal of reliable ozone performance a reality for each one of its customers and can do so for you.

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Presenting Author: Kevin Gomes
Case Study – Passive TO-17 Indoor Air Sample Results Compared to TO-15 Indoor Air Summa Canister Sample Results Over a 6 Month Time Period

Megan Hamilton, Grace Randall and Travis Garrett

Method TO-15 using Summa canisters has been the standard method of measuring contaminant concentrations in indoor air since the Vapor Intrusion (VI) pathway emerged over 20 years ago. Several State VI Regulatory Guidance documents recommend using Summa canisters to characterize the VI pathway over other methods. Passive indoor air sampling techniques using Method TO-17 offer many benefits over Summa canisters, including the capability of measuring average indoor air contaminant concentrations over longer exposure durations. Given the variability in indoor air concentrations that have been demonstrated through several studies over the past years, measurements over longer exposure durations have been gaining traction within the regulatory community. A handful of studies comparing the results of passive sampling techniques to TO-15 have been conducted in an attempt to demonstrate the effectiveness of using passive sampling methods to measure indoor air contaminants.

This case study involves measuring tetrachloroethene (PCE) and trichloroethene (TCE) concentrations in the indoor air of a commercial structure in Indiana over a six month period of time. A passive sampler will be deployed inside the building over a period of two weeks. Summa canisters fitted with 72 hour flow controllers will also be deployed over the same two week period to account for temporal variability. This process will be repeated once a month for a period of six months. The study is designed to span across three different seasons in order to capture temporal variability and possibly determine whether a “worst-case” scenario involving a period of time during the year actually exists. At the end of the six month study, the data will be compiled and presented in order to determine the effectiveness of passive sampling techniques compared to Method TO-15 using Summa canisters. Patterns for worst-case scenarios will also be observed and presented.

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Presenting Author: Megan Hamilton
Evaluation of Observed VI Attenuation Factors and Exposure for 50 Commercial Facilities in the Midwest

Megan Hamilton and Jeffrey Carnahan

Much effort has been expended by environmental regulators and researchers in attempts to develop a generic approach for identifying structures where vapor intrusion (VI) assessment is, or may be necessary near subsurface releases of VOCs. Guidance on VI assessments from many agencies promotes the screening of structures based on conservative, generic attenuation factors (AFs) derived from statistical analysis of past sampling data at other structures (i.e. the U.S. EPA Database). The majority of available data used to derive these AFs has been compiled from residential structures. Larger commercial buildings may exhibit characteristics that differ from residential structures and can affect the attenuation of contaminants from the subsurface into the indoor air, effectively lowering the AF. Although there is a lack of compiled data to support this theory, several state VI Guidance documents have incorporated an adjustment to the generic attenuation factors for larger commercial structures. This study presents the analysis of AFs derived from a combination of soil gas, sub-slab vapor and indoor air data for commercial structures at and surrounding 50 different dry cleaner sites where subsurface releases of PCE have occurred. Each site was evaluated using the prescribed default screening approach. An analysis of the compiled data is presented and compared with observed trends from the U.S. EPA VI database. The result of this study provides a ground truthing of how the generic screening approach and default AFs compare for commercial structures, and whether there is a basis for an adjustment factor for commercial structures.

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Presenting Author: Megan Hamilton
Lifecycle of the CDOT Materials Testing Laboratory Remediation Project: An Example of Adaptive Remediial Design and Optimization

Craig Divine, Kim Heinze, Scott Andrews, Jesse Manley and Theresa Santangelo-Dreiling

More than two decades ago, preliminary subsurface characterization activities identified significant contamination associated with two former underground storage tanks (USTs) located at the Colorado Department of Transportation’s (CDOT’s) Materials Testing Laboratory (MTL) facility in Denver Colorado. Further investigations identified the presence of dense non-aqueous phase liquid (DNAPL) and total concentrations of 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1,-DCE), trichloroethene (TCE), and other compounds in excess of 100 milligrams per liter on site. The associated shallow groundwater plume extended more than 2,000 feet off-site in a fractured bedrock aquifer, flowing under numerous single-and multi-family residents. For approximately 13 years (1998-2011), a source zone and downgradient groundwater plume actively treated utilizing a variety of technologies. Specifically, pump-and-treat, soil vapor extraction (SVE), enhanced aerobic bioremediation (AB), and enhanced reductive dechlorination (ERD) were employed in different areas of site and in various phases of the remedial lifecycle.

Overall, the remediation actions have been very successful; approximately 90% of the VOC mass in the off-site plume has been destroyed, and active remediation was stopped in the off-site area in 2013, and no significant rebound has been observed. On site, contaminant concentrations across much of the source area have been reduced by several orders of magnitude and currently are in the parts per billion range at some locations. Consequently, contaminant mass flux has been dramatically reduced and the source-zone hydraulic capture system was shut down in 2011. Source-zone contaminant concentrations are continuing to decrease and it is anticipated that active treatment in the source area and across the entire site will then be considered complete within the next year or two. The overall lifecycle of this project highlights the importance of actively optimizing full-scale remedies, and adapting the remedial strategy based on observed remedial performance, new site information, and developments in remediation technologies.

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Presenting Author: Kim Heinze
Turning a Brownfield into a Health Center

Jessica Yeager, Frank Vetere, Russell Parkman and Kathleen Kerigan

A Health Center is constructing a clinic on a brownfields site in the Greater Boston Area. A requirement of the project and agency’s landlord was the remediation of the site to closure under the Massachusetts Contingency Plan (MCP). GZA has been assisting the client in navigating the complicated world of the MCP by generating reports that included a Remedial Action Plan and a Remedial Implementation Plan where we performed pilot testing of a remedial system to mitigate a chlorinated solvent plume on the property. GZA will be implementing a three-part remedial action. High Vacuum Extraction (HVE) will be used to mitigate elevated groundwater concentrations in the source area to below upper concentration levels (UCLs) to allow for permanent closure of the site with an activity and use limitation (AUL). Enhanced reductive dechlorination (ERD) will be used to treat the dissolved phase plume down gradient of the source area. Vapor intrusion will be mitigated by installing a sub slab membrane system (SSMS) under the slab of the new building. This project has involved work with many different design disciplines and contractors, including stakeholders, the agency’s landlord, architects, general contractors, civil engineers, and HVAC engineers.

GZA also provided licensed site professional (LSP) and remedial services, geotechnical engineering and field oversight, asbestos and hazardous materials survey and abatement oversight, and construction phase health and safety monitoring. Remediation is occurring in conjunction with the building construction. The site will achieve permanent closure, and the building will receive LEED certification. The Health Center plans to apply for Brownfield funding.

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GZA is using a mobility-based approach for permanent closure at a large light non-aqueous phase liquid (LNAPL) remediation site in eastern Massachusetts. GZA operated an extensive dual-phase extraction system on site for approximately 3.5 years and, though recovery has reached asymptotic conditions, LNAPL thicknesses in wells are still as high as several feet in isolated locations.

In support of a Permanent Solution, GZA implemented an innovative field program that included laser-induced fluorescence (LIF) screening, ultra-violet fluorescence (UVF) screening, LNAPL sampling for fluid properties, and soil sampling to analyze for LNAPL initial and residual saturation; laboratory testing for physical soil characteristics such as porosity, capillary drainage, and hydraulic conductivity; and laboratory analyses for volatile and extractable petroleum hydrocarbons in soil, groundwater, soil gas, and indoor air.

Laboratory analytical results demonstrated that residual LNAPL is largely immobile, with less than 15% of samples indicating mobility potential. The soil, groundwater, and indoor air data were evaluated in a Method 3 Risk Assessment in support of a Permanent Solution With Conditions under the MCP.

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Hot Soil Vapor Sampling and Analysis - Post-ISTT

Jessica Yeager, Maryann Sapanara, Albert Ricciardelli, Patrick Sheehan and Kathleen Kerigan

The timing of confirmatory soil vapor sampling, after remediating the subsurface via in-situ thermal remediation (ISTT), has historically been affected by elevated soil temperatures and the complications associated with accurately correcting the reported concentrations to reflect ambient-temperature conditions. Following the implementation of ISTT at a solvent-impacted site, GZA developed regulator-approved protocols for collecting hot soil vapor samples and correcting the elevated-temperature data. This process permitted the collection of soil vapor samples several years before the soils were anticipated to return to ambient temperatures and the application of temperature corrections to the soil vapor data set that yielded soil vapor results suitable for use in the site risk assessment.

The temperature correction procedure employed specialized hot soil vapor sampling techniques and partitioning calculations. Over 160 soil vapor samples were collected over the 2.7 acre site. The soil vapor required cooling before its constituents could be analyzed by GC/MS using an on-site mobile laboratory. To cool the soil vapor and collect any condensate that was generated during the cooling process, GZA designed a sampling apparatus that included a stainless steel cooling coil in an ice bath. GZA collected the soil vapor samples in accordance with soil gas guidance. To perform temperature-correction for trichloroethene, tetrachloroethene, and vinyl chloride, GZA employed three-phase partitioning modeling and mass conservation principles.

GZA received approval from the regulator to implement the soil vapor sampling and temperature-correction protocol at the Site and ultimately the regulator issued a notification of project completion. Given that soil vapor data are key input parameters in risk assessment evaluations, the development and implementation of this innovative sampling and temperature-correction technique and subsequent regulatory acceptance, allowed the Site to receive regulatory completion years before it would otherwise have been possible.

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Pharmaceuticals and Personal Care Products in Reclaimed Waste Water

William Luksemburg, Martha Maier, Andrew Patterson and Allison Clarke

Like many areas, California is turning to the use of treated waste water for residential and commercial landscape irrigation. While irrigation is the most common use of recycled water, it may also be used for other nonpotable purposes such as feeding water features (fountains, etc.) or fighting fires. Pharmaceuticals and personal care products (PCPPs) in waste water are an emerging issue. Potential risk to aquatic organisms due to exposure to PPCPs in the environment has been identified as a primary concern given that aquatic organisms may be continually exposed to chemicals, including multi-generational exposures. There is also concern for subtle effects on ecological receptors when exposed to low concentrations over a long period of time. For humans, consumption of potable water which may contain trace concentrations (in the part per trillion to part per billion range) of various PPCPs has been identified as one of the primary potential routes of exposure. Pharmaceuticals, personal care products, hormones and sterols in reclaimed water used for irrigation, final effluent from the wastewater treatment plant and drinking water.

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Assessing the Environmental Impacts of Agricultural Subsidy in the Mississippi Delta Region Using GIS

Edmund Merem, Peter Isokephi, Joan Wesley, Shayron Thomas, Yaw Twumasi, Siddig Fageir and Marshand Crisler

The Mississippi delta region as a major agricultural hub is one of the most heavily farmed areas in the country and the state of Mississippi with continual federal transfer payments and other forms of subsidies to sustain farming. Accordingly, in the last several years, subsidies related to farming continue to rise among counties in the Mississippi delta region. At the same time, the larger agricultural structure of the region has been experiencing various forms of changes including declining land base, rise in water use, wide spread applications of fertilizers and agro-chemicals and a mounting threat to the surrounding ecology and water resources.

With much of the subsidies directed at crop insurance, commodities, conservation and disasters, very little has been done in the literature to assess the changing impacts of subsidies and current efforts to mitigate the problems. While subsidy impacts in the Mississippi delta do not operate in a vacuum, recent studies show they are attributed to a host of socio-economic and policy elements located within the larger agricultural structure. Considering the level of changes inherent in the region along with a host of issues, the impacts of agricultural subsidy in the study area merit a geo based analysis.

This paper adopts a GIS based method and primary data to analyze subsidy use in selected counties of the Mississippi Delta region. There is a focus on the issues, factors, mitigation efforts and future line of actions. The preliminary results show widespread dependence on subsidies and growing impacts in the form of environmental quality declines, changes in land areas and land use elements coupled with the geographic manifestation of the impacts and trends. While the impacts stem from various socio-economic and policy elements, the paper suggests the need for education, environmental considerations, policy changes and regular use of geo based analysis.

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The effects of cadmium (100, 1000 μM concentrations) and copper stress (10, 50 mM concentrations) on metallothionein type 2 isoform 1 (Mt2Pg isoform 1), 2 (Mt2Pg) and 3 (Mt3Pg) in Prosopis glandulosa was examined under hydroponic conditions for 4, 8, 12 and 24 h. Degenerate Mt’s primers were synthesized based on amino acid and nucleotide alignment sequences reported for Mt’s in other plant species found in GenBank. Gene expression of Mt´s were evaluated using reverse transcriptase-polymerase chain reaction (RT-PCR) amplification technique. Three major fragments of 450 bp (Mt2Pg isoform 1), 300 bp (Mt2Pg) and 541 bp (Mt3Pg) were identified by BLAST search (www.ncbi.nlm.nih.gov/BLAST/). The results showed that high doses Cu induced high levels of Mt2Pg isoform 1. In contrast Mt2Pg and Mt3Pg transcript showed low expression levels with respect at exposure time. On the other hand, the embryos exposed to Cd showed a diminution in the levels of expression of Mt2Pg isoform 1, Mt2Pg and Mt3Pg during the first 4 hours of exposure with respect to levels expression of these genes observed in the treatments with copper. Further research is need to define the mechanism involved in the P. glandulosa capability for tolerate the heavy metals through Mt´s detoxification. The participation of phytochelatins is not discarded.
Virus and Trace Organic Compound Treatment Using Ozone in Potable Water

Robert Moncrief

Ozonation has been found as an approved technology for drinking water treatment by the U.S. Environmental Protection Agency and has been extensively recognized as an effective method of treating drinking water to enhance taste and safety for municipalities, small communities, and residences. The use of ozone (O\(_3\)) for recycled water treatment has previously been approved by the California Department of Public Health (CDPH). Per Title 22 regulations, a minimum CT of 1.0 mg-min/L was recommended and approved by the CDPH to achieve less than 2.2 MPN/100 mL total coliform and full virus removal credit in this previous approval.

As part of WateReuse Research Foundation Grant 11-02, co-funded by H2O Engineering, Inc. (H2O) out of San Luis Obispo (CA), Carollo Engineers (Carollo) and Trussell Technologies bench scale tests and pilot ozone (O\(_3\)) disinfection tests on filtered secondary effluent (both media filtered and membrane filtered) were performed. The results of these tests served two purposes. First, it better educated the industry on reclaimed water disinfection kinetics with O\(_3\). Second, it allowed H2O Engineering to gain “conditional acceptance” for the H2O TOrCsOX® O3 reactor from the California Department of Public Health (CDPH).

Bioassay tests were completed to evaluate virus and coliform disinfection performance over a range of operational conditions such as O\(_3\) dose to total organic carbon (TOC) ratio (O\(_3\)/TOC), and CT values (product of O\(_3\) residual and contact time). Tracer testing was performed at two locations, Site A and Site B, over a range of flows to determine O\(_3\) contact times and hydraulic residence times for sampling.

H2O Engineering’s TOrCsOX® technology has completed technology validation by Carollo Engineers and is pending CDPH Title 22 certification.

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Presenting Author: Robert Moncrief
Using Solar-Powered Mixing Devices to Enhance the Raw Water Quality of a Lake

April Nabors

Previous research performed by the Birmingham Water Works Board (BWWB) suggested that Lake Purdy, a drinking water reservoir for the Birmingham area, was undergoing a process known as stratification particularly during the warm summer months of the year. Therefore, eutrophication of the lake would lead to severe loss in dissolved oxygen and the creation of hydrogen sulfide at low levels of the lake. For obvious reasons this is an extremely undesired process especially when considering water used as a drinking water supply. To alleviate the stratification issues during the hot summer month’s fourteen solar-powered mixing devices were installed in Lake Purdy during April 2011. This paper will discuss the results since installation. Water quality parameters that will be evaluated are temperature, pH, turbidity, TOC and its resulting chlorine demand.

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Assessment of Water Quality by determining the Diversity and Abundance of Benthic Macro-Invertebrates in The Nima Creek in Ghana

Jingyu Huang, Hederick Rosevelt Dankwa and Linda Akosua Nuamah

Biological monitoring and assessing the quality of fresh waters has been one of the environmental concerns for many countries of which Ghana is not exempted. This study was undertaken in the Nima creek in Ghana to assess the abundance, composition and diversity of the benthic macro-invertebrate fauna. It also aimed at determining the quality of water in the creek, based on the type of macro-invertebrates found in the creek. Samples were collected at 8 different riffles with surber sampler. The benthic macroinvertebrate sampled consisted of 6 taxa and 5891 individuals belonging to 4 classes namely Nematoda, Oligochaeta, Gastropoda and Insecta. Chironomini were the predominant group with 99.04% on the average, followed by Psychoda sp (0.44%), Rhabitidae (0.26%) and Tubifex (0.26%) at the upstream stretch of the creek. The downstream was dominated by Chironomini forming 97.30% on the average, followed by Tubifex (1.52%), Rhabitidae (1.08%) and Psychoda sp (0.05%). The estimated diversity of the sampling area for both upstream and downstream was assessed by using the Simpson Diversity Index and was found to be 0.53; indicative of fairly diversified community structure. The Family Biotic Index (FBI) was used to determine the water quality of the creek and found to be 9.92 which indicate severely polluted water. The distribution and occurrences of taxa in the upstream and downstream showed that the macro-invertebrates appeared in both reaches with the exception of Melanoides tuberculata which occurred only at the downstream reach due to low current, the formation of rocky substratum and the absence of riparian vegetation making it a suitable habitat.

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Renewable Energy Powered Rural Irrigation: Feasibility Comparison of Solar and Wind Based Water Pumping Systems In Turkey

Mehmet Numan Kaya and Faruk Köse

Renewable energy sources are being used in a wide range of applications including water pumping for rural irrigation all over the world. Turkey is one of the developing countries supporting investments in renewable energy technologies with various incentive programs. In this study, the feasibilities of wind and solar power systems to cover the energy need of irrigation pumps for rural irrigation are compared for a small town, Alibeyhuyugu, which is located in Konya, Turkey. According to the real energy consumption data, investment cost of both systems are calculated and an economic analysis was performed. In addition, reduction in CO₂ emissions afforded by the use of the renewable energy systems are calculated and environmental effects are discussed.

Keywords: Solar, wind, water pumping, irrigation, feasibility

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While remedial assessment of LNAPL sites in developed countries has improved significantly in recent years with the application of improved delineation technologies facilitating the rapid assessment of LNAPL recoverability and mobility, in many areas of the world these assessment technologies are not available or prohibitively expensive. The typical environmental investigation performed in developing countries consists of the installations of discontinuously sampled borings, monitoring wells, and laboratory analysis of site soils and groundwater. While these are useful and necessary assessment steps at any environmental site the development of a useful conceptual model and the understanding of the recoverability, mobility, and the remedial alternatives of LNAPL using this data alone is often limited. Using existing site data and the recently published ASTM Standard E2856 – 11e1 Standard Guide for Estimation of LNAPL Transmissivity AECOM has developed an assessment methodology which can quickly, quantitatively, and defensibly determine LNAPL recoverability and migration potential at sites where only the most basic site assessment can be performed. The assessment methodology relies on three site assumptions: 1) existing delineation of LNAPL at a site using typical methods, 2) confirmation of the absence of any possibility additional source releases, and 3) the identification of environmentally sensitive receptors. With these three assumptions met the methodology involves the development of existing sites wells adjacent to suspected LNAPL impacts (e.g., visual, analytical, or gauging data) using surge block techniques, allowing fluid levels in wells to equilibrate, performing either LNAPL baildown or manual skimming mobility testing, and the collection of hydraulic slug testing data. After initiating the program the data is collected, analyzed, and reported resulting in both quantitative (potential migration rates, LNAPL recovery rates, and LNAPL transmissivity), qualitative conclusions (potential impact to receptors, potential benefits/limits of remediation, and experience at sites with similar impacts), and recommendations concerning the LNAPL recoverability and mobility potential.
Comparison of Various Regulatory Approaches for Human Health Risk Assessment of Total Petroleum Hydrocarbons in Soil

Kanan Patel-Coleman

Using a sample data set, the authors calculated multiple human health risks based on various approaches for residential receptors exposed to total petroleum hydrocarbons (TPH) in soil. Risks were estimated for aliphatic and aromatic fractions for each of three carbon ranges—light, medium, and heavy. Various regulatory approaches that employ fractionated data—including USEPA, California Department of Toxic Substances Control (DTSC), and Massachusetts Department of Environmental Protection (MassDEP)—were used to compare the outcomes. The authors present a critical review of the findings and discuss how they may affect decision-making at a site.

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Contour Maps, Preparation, Interpretation, Forensic Perspective

Mehmet Pehlivan

This paper presents an outline of common pitfalls that most engineers and scientists encounter when preparing contour maps. Review of several public databases and reports indicated that a discussion about the contouring and interpretation is necessary. Even though most professionals prepare contour maps, it was noticed that some basic points have frequently missed and unintended interpretations are presented without making any reference of their implications. Several cases and examples of contour maps were compiled from public databases and case files. These cases will be presented anonymously. All names, site addresses and company logos will be removed from presentation. A special emphasis will be given in preparation and interpretation of groundwater elevation contours and chemical concentration contours. Presentation will also include a brief discussion on: how to recognize geological anomalies using the contour maps and preparation of logarithmic/exponential contour maps.

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Presenting Author: Mehmet Pehlivan
Lipid Tracers for Organic Matter in Surface Soils from Riyadh City, Saudi Arabia

Ahmed Rushdi, Khalid Al-Mutlaq, Aarif El-Mubarak, Mohammed Al-Saleh, Mubarak El-Otaibi and Bernd Simoneit

Soil particles contain a variety of anthropogenic and natural organic components, and in urban areas can be considered as collectors of pollutants. Surface soil samples were taken from ten areas in Riyadh during early winter of 2007. After air drying they were sieved to fine particles (<125mm), extracted with dichloromethane-methanol mixture and the extracts analyzed by gas chromatography-mass spectrometry. The major compounds were UCM (unresolved complex mixture, 9588±26033 ng g⁻¹), plasticizers (2493±2404 ng g⁻¹), n-alkanes (1534±1518 ng g⁻¹ from petroleum and 108±91 ng g⁻¹ from plant wax), carbohydrates (729±763 ng g⁻¹), n-alkanoic acids (701±686 ng g⁻¹), hopanes (465±1084 ng g⁻¹), n-alkanols (172±123 ng g⁻¹), and sterols (102±112 ng g⁻¹). Both anthropogenic and natural biogenic inputs were the major sources of the organic compounds and varied dramatically across the sampling area. Discarded plastics and vehicular emission products were the major anthropogenic sources in the soil particles, ranging from 5.9% to 38.9% and from 31.4 to 91.1%, respectively. Their tracers were UCM, plasticizers, n-alkanes, hopanes and traces of steranes. Vegetation detritus was the major natural source of organic compounds (1.5 to 46%) in samples from areas with less human activities and included n-alkanes, n-alkanoic acids, n-alkanols, sterols and carbohydrates.

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Continued Decline in Volatile Organic Compound Concentrations in Groundwater Following Electrical Resistance Heating Remediation

John Sankey and Tom Powell

ABSTRACT: Electrical Resistance Heating (ERH) is a proven in situ thermal remediation technology for rapid contaminant source area cleanup in soil and groundwater including DNAPL and LNAPL. In addition to volatilization and recovery of VOCs, it has been demonstrated on several ERH remediations that in situ contaminant destruction through both biotic and/or abiotic mechanisms occurs during and after ERH. Results are confirming the beneficial, long term effects following ERH with continued decline in contaminant concentrations in groundwater.

Seldom are trends in contaminant concentrations in groundwater post-ERH available because the property is quickly redeveloped and monitoring wells are abandoned or removed soon after the remediation is completed. Following more than a decade of performing ERH remediation on more than 80 project sites, field data following remediation consistently demonstrates that contaminant concentrations in groundwater continue to decline, in several cases by orders of magnitude, during time periods ranging from 6 to 24 months, post-ERH. These observations support the previous hypothesis that contaminant rebound does not occur following ERH remediation.

The presentation will focus on project results that illustrate continued decline in contaminant concentrations in groundwater from several ERH projects, including:

· TCE remediation, Pemaco Superfund Site, Maywood, CA

· Remediation of total VOCs, Los Angeles, CA

· TCE remediation, East Gate Disposal Yard Superfund Site, Fort Lewis, WA

· Methylene chloride remediation, northwest Atlanta, GA

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High concentrations of heavy metals are found in many soil and sediment environments. At very high concentrations, heavy metals can be acutely toxic to microorganisms. Treatment approaches that rely on microbial processes may not function well in such acutely toxic environments because processes important to their efficacy, such as carbon fermentation, oxygen consumption, and biological sulfate reduction, can be significantly slowed or even completely inhibited. Hence, in such toxic environments, metals treatment reagents that are not dependent on microbial activity but rather combine reduction with adsorption and precipitation of heavy metals can be advantageous. MetaFix™ reagents represent an entirely new family of reagents for treatment of soil, sediment, industrial wastes, and groundwater contaminated with heavy metals. Their treatment mechanisms are based on iron, iron sulfides, and other iron-bearing minerals and therefore result in heavy metal precipitates that include iron. These iron-bearing heavy metal precipitates generally have lower solubility and greater stability than precipitates that do not incorporate iron (i.e., heavy metal sulfides or heavy metal hydroxides). The new reagents are composed of mixtures of reducing agents (ZVI, iron sulfides), processed reactive minerals (iron oxides, iron oxyhydroxides), pH modifiers, silicates, and catalysts. This new approach is insensitive to toxicity and will perform well even in environments that have high metals concentrations, high concentrations of organic contaminants such as chlorinated solvents, high salt content, or pH levels (high or low) that would inhibit carbon fermentation and sulfate reduction. Surface soils and industrial wastes can be treated with MetaFix using direct soil mixing and in situ reactive zones can be constructed to prevent migration of heavy metals into sediments or surface water. Performance data including reductions in leaching of heavy metals as well as cost information will be presented.

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Dissipation of Cypermethrin, Dichlorvos and Pirimiphos-Methyl under Ultrasonication in Aqueous Systems

Rufus Sha’ato, Felix Olukayode Oketunde and Nnadozie N. Nkpa

Aqueous solutions of cypermethrin, dichlorvos and pirimiphos-methyl were subjected to ultrasonication (40kHz) and their dissipation monitored spectrophotometrically at 265nm, 265nm and 250nm, respectively. First-order kinetics treatment of the dissipation data enabled calculation of the process rate constants and attendant half-lives for each pesticide undergoing ultrasonic degradation is in the order 1.9 hrs < 3.85 hrs < 5.8 hrs for pirimiphos-methyl, dichlorvos and cypermethrin, respectively. This order of degradative response to ultrasound is attributed to the structural makeup of the pesticides. It is concluded that ultrasound can be employed for the rapid clean-up of water that is contaminated with these pesticides.

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Abiotic Degradation of Diazinon (O-O-diethyl-O-[2-isopropyl-6-methyl-4-pyrimidinyl] phosphorothioate) and Monocrotophos (dimethyl phosphate of 3-hydroxy-n-methyl-cis-crotonamide) in an Aqueous Medium under Solar Irradiation

Rufus Sha'ato, Ikenna Onyido and Verylin Asmau Umoru

This research describes the abiotic degradation of diazinon (O-O-Diethyl-O-[2-isopropyl-6-methyl-4-pyrimidinyl] phosphorothioate) and monocrotophos (dimethyl phosphate of 3-hydroxy-N-methyl-cis-crotonamide) in aqueous medium under natural solar irradiation. While the degradation periods varied from 7.64 to 84 days for diazinon and 1.71 to 16.3 days for monocrotophos, the process for each substance followed first-order kinetics. The mechanism of the degradation process appears to be similar in both cases to mechanism of hydrolysis since the degradation products are similar to those obtained from their hydrolysis.

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Presenting Author: Rufus Sha'ato
Microbial Profiling: Essential for Technology Selection, Remediation Evaluation/Troubleshooting

Jack Sheldon

Microbial profiling tools have evolved over the last decade to where they now are routinely used to support remediation technology selection, evaluation of remediation performance, and as troubleshooting tools in soil and groundwater projects. This is critical as microbiology is often a forgotten component in remediation. Collectively, the present day tools are referred to as molecular biological tools or MBTs. For decades, standard plate counts and Most Probable Number methods were the industry standard with challenges in obtaining an accurate microbial profile from samples. The new methods will be compared and contrasted with the old methods. Now, quantitative polymerase chain reaction (qPCR), phospholipid fatty acid (PLFA), and hybrid micro-array(Quant-Arrays) analyses have become the norm. These methods are coupled with more accurate sampling techniques that show a broader spectrum of microbiology in a sample, often over an extended period of sampling time. These new methods allow identification of types and groups of microorganisms, genetic functions that code for specific degradation of chemical compounds, and can even concurrently assess aerobic, anaerobic, and cometabolic mechanisms. Examples of each method will be presented and a description of their application to a specific project will be made to demonstrate how broadly they can be used in the remediation world. A start to finish approach will be outlined that begins at sample collection and results in specific report types with lessons learned highlighted.

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Comparison of Abiotic and Biotic Degradation of TCP in Microcosm Studies

Michael Sieczkowski and Donovan Smith

1,2,3-Trichloropropane (TCP) is a xenobiotic halogenated alkane that has recently received interest as an emerging contaminant. Like chlorinated ethenes such as perchloroethene (PCE), TCP is not typically readily biologically degraded in groundwater under natural conditions. Common remedial methods such as mechanical removal and in situ chemical oxidation may be somewhat effective in remediating TCP but these processes exhibit the same limitations and challenges as those associated with the remediation of chlorinated ethenes. Biological degradation of TCP under conditions similar to those demonstrated to be effective for chlorinated ethenes could be a significant advancement in TCP management.

Recent advances in microbial testing have led to the identification of a number of microbial populations important to the degradation various compounds including PCE and TCP. One of these groups, Dehalogenimonas (Dhg), has been demonstrated to degrade TCP and is a closely related phylogenetic relative of Dehalococcoides (Dhc). Dhc has been long identified as an important organism in the complete reductive dechlorination of ethenes. The apparent similarities between the organisms capable of degrading of PCE and TCP suggests that proven remedial processes used to degrade PCE may be applicable to remediate TCP. Similarly, the abiotic degradation of TCP by zero valent iron (ZVI) under anaerobic conditions may also follow processes already demonstrated for PCE.

In order to demonstrate that TCP can be degraded through abiotic and biotic processes similar to those for PCE, JRW commissioned a series of laboratory microcosms mimicking in situ conditions using different substrates that have demonstrated performance characteristics at chlorinated ethene sites. Comparisons of the degradation kinetics of both TCE and TCP were evaluated for a soluble substrate, WILCLEAR Plus®, a slowly soluble substrate, LactOil® soy microemulsion, and a microemulsion containing iron. In addition, degradation kinetics were evaluated for PCE degrading microbial cultures and TCP degrading microbial cultures.

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Non-aqueous phase liquid (NAPL) is the source of groundwater and soil contamination at many sites and is a technically challenging problem to address in the subsurface. Oxidizing bulk NAPL plumes requires substantial amounts of oxidant to meet cleanup goals. Typical ISCO implementations are limited because oxidation only takes place in the aqueous phase. Conventional pump-and-treat approaches tend to exhibit diminishing yields and become ineffective over time.

Surfactant Enhanced Product Recovery (SEPR) and Surfactant-enhanced In Situ Chemical oxidation (S-ISCO) are patented, innovative, green-chemistry technologies, developed by VeruTEK Technologies and marketed by EthicalChem that address the source of contamination and effectively treat tightly sorbed, hydrophobic, and free phase contaminants. SEPR is implemented for bulk NAPL removal by extraction, where plant-based surfactant blends are injected with low doses of hydrogen peroxide. The surfactants work to desorb and emulsify the NAPL while the peroxide decomposition produces oxygen gas bubbles which physically help facilitate desorption and movement of the NAPL toward extraction wells. S-ISCO is implemented to address residual NAPL and tightly sorbed contaminants, where plant-based surfactants are simultaneously injected with an activated oxidant (typically persulfate). The combined injection of activated oxidant and surfactants will provide surfactant-generated desorption and emulsification of the contaminants making them available in the aqueous phase with greatly increased surface area for easy destruction by the oxidants. Following the complete, or near complete, oxidation of contaminants, the stable surfactants are eliminated by either remaining oxidant or biodegradation reactions.

A combination of field and laboratory data will be presented demonstrating the significant advantage of surfactant use for in-situ remediation. Field results will cover the enhanced NAPL extraction and significant contaminant mass reductions achieved using SEPR and S-ISCO technologies. Additionally, laboratory results will be presented to provide further insight into reactions between oxidants and surfactants and their simultaneous use in S-ISCO applications.

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Surfactant-Enhanced Product Recovery (SEPR™) for Creosote Remediation

Dan Socci, Geeta Dahal and George Hoag

EthicalChem’s patented Surfactant-Enhanced Product Recovery (SEPR) technology was implemented at a former wood treatment facility in Delaware at which creosote waste and condensate water had been released into an unlined lagoon. Pre-treatment site investigations revealed extensive DNAPL impacts throughout the soil matrix, with only minimal product accumulation in monitoring wells—evidence of the limited mobility of the highly viscous creosote oil. During this pilot test, the chemical formulation of the surfactant and co-solvent mixture was customized to enhance its effectiveness at emulsifying and thereby breaking apart the creosote oil into easily extractable globules. In addition the pilot trial examined the relationship of SEPR to the subsequent S-ISCO polishing phase, to determine the most efficient and effective treatment sequence.

SEPR involves the simultaneous injection of VeruSOL®, customized mixtures of plant-based surfactants and co-solvents, and low concentrations of peroxide to emulsify DNAPL free product for subsequent extraction. SEPR can be used as a cost-effective measure to enhance the performance of site recovery systems and as a pre-treatment for Surfactant-Enhanced In Situ chemical Oxidation (S-ISCO®) remediation, a treatment that involves injections of VeruSOL to emulsify NAPL into aqueous phase for oxidative destruction by simultaneously injected oxidants.

The case study of this pilot test will be presented, including an analysis of the optimal surfactant composition, and the innovative design of the injection and extraction system for efficient and effective process implementation. Data will also be presented about the relationship between SEPR and S-ISCO. The results of this pilot trial will shed light on the viability of combined SEPR and S-ISCO remedies for treatment of sites with extensive DNAPL free product, particularly related to creosote and No. 6 fuel oil.

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Case Examples of Targeted, Cost Effective Remediation From High Resolution Site Characterization

John Sohl

In the past, many remediation efforts have proven to be unsuccessful in achieving remediation success due to insufficient site characterization and/or over-generalized and misleading conceptual site models. Currently, many previous remedial technologies are being reexamined, improved and in many cases, replaced by advancing, remedial technologies or a combination of technologies. However, the redesign of these technologies does not always create a cost-effective orientation to conduct business.

The demand for total mass characterization including sorbed, dissolved, free-phase liquid and vapor phase site data, prior to application of the remedial technologies is essential to project success. Furthermore, an effective, efficient remediation strategy necessitates a comprehensive and extensive assessment of the post-treatment to depict the reduction in contamination and to establish if any additional treatments are necessary. Utilizing effective, efficient high resolution site characterization allows you to optimize the delineation of total mass characterization and target remediation treatments. While using vertical profiling tools to gather thousands of data points and collect information over a short period of time, one is able to successfully develop a more accurate high resolution site characterization.

High resolution site characterization saves lots of time and is cost-effective in providing a much more realistic assessment of subsurface conditions than a limited number of monitoring wells or discrete samples spread throughout the application area. John will be able to present some case examples that highlight the importance of multiple collaborative lines of evidence when making management and remediation decisions involving LNAPL. The importance of interactive, real-time decision making to identify and close gaps in order to improve effectiveness and lower cost will also be presented.

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Health Impact Assessment: an Emerging Trend for Oil and Gas Projects in the US?

Kathleen Souweine, Dr. Mary Mcdaniel, Lindsay McCallum, Dr. Chris Ollson and Bart Koppe

Projects across many sectors have the potential to influence population health. Health Impact Assessment (HIA) seeks to identify and estimate the magnitude and distribution of health effects from policies or projects on a population. An HIA is based on the principle that health, as defined by the World Health Organization is “a state of complete physical, mental, and social well-being and not merely the absence of disease”. In many countries, HIA is often required or incorporated into best practices in the oil and gas industry. In the United States, Alaska’s HIA program seeks to ensure that large oil development projects are designed to maximize the positive health benefits and minimize the negative health impacts to local communities. Outside of Alaska, very few HIAs have been conducted in the US oil and gas sector. However, HIAs in the US are increasingly being promoted by a number of organizations, including the Centers for Disease Control and Prevention, the National Research Council, and many State and County public health departments. This presentation discusses the emergence of HIA as a systematic part of the decision making process for the approval of oil and gas development projects. We predict that HIAs will become increasingly common as controversial oil and gas practices like hydraulic fracturing (commonly referred to as “fracking”) raise public concerns.

A case study will be presented of an HIA recently conducted for an oil development project on a 1.3-acre site within 100 feet of businesses, 150 feet of residential areas, and 55 feet of a park in Hermosa Beach, California. The City agreed to conduct an HIA to supplement the required Environmental Impact Report and to inform decision-makers about potential health impacts. Lessons learned from this HIA will inform strategies to successfully complete HIAs for other oil and gas development projects.

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Presenting Author: Kathleen Souweine
A Kaleidoscopic Investigation: How Seven Fluorescent Tracers Were Used to Determine Connectivity between Aquifers

Craig Divine, Ben Stanphill, Robert Ruscitto and Jeff Mcdonough

Abstract: Conventional tracer studies in support of in situ remediation are based around establishing a volume-to-distribution relationship and a quantitative approximation of the groundwater velocity. A unique tracer application was developed to characterize the extent of transport between a perched and semi-confined aquifer in Southern California. An innovative analytical technique comparing the natural fluorescence of site groundwater known as background fluorescence analysis (BFA) provided a basis from which six tracer well groupings were selected. The subsequent tracer study included the injection of separate tracers into the vadose zone (sulforhodamine G) and a subset of wells within each grouping in the perched aquifer (sulforhodamine B, uranine, eosine, sodium naphthionate, rhodamine WT, and pyranine). Post injection monitoring was performed to evaluate the degree of vertical and horizontal connectivity among and within the three separate hydrostratigraphic zones (vadose zone, perched aquifer, and upper aquifer). The results of this tracer study were used to evaluate the potential transport risk of transient geochemistry from remediation implemented in the perched aquifer.

A novel interlocked, automated tracer delivery system was designed to maintain a protective injection pressure during unmanned operation. During tracer delivery, the level of solution in each well was maintained approximately fifty feet below ground surface, and delivery was automatically halted when target injection volumes were reached. This configuration enabled economic implementation with high technical quality in spite of a relatively less permeable lithology.

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An Innovative Bioremediation Strategy for Treating Chlorinated VOCs in Low-Permeability Saturated Soils Using Specialized Jetting Techniques

Bill Walsh, Mei-Chin Yei, Ed Alperin and Susumu Uesawa

EOS Remediation, LLC (EOS Remediation) and Chemical Grout Co. Ltd (CGC) are working together to bring bioremediation in low permeability saturated soils to the next level. The team combined a CGC-developed specialized construction technique with a specially engineered, all natural, sustainable substrate to promote in situ bioremediation in low permeability soils impacted by chlorinated volatile organic compounds (cVOCs). The goal was to create a more effective remediation approach that would decrease the remedial timeframe in a cost-effective manner when compared with other technologies.

A former dry cleaning site located in Tokyo, Japan was selected for this demonstration. The contaminants of concern include perchloroethylene (PCE) and trichloroethylene (TCE), as well as the associated degradation daughter products. The objectives of the field demonstration were to: 1) to increase immediate contact between contaminants, EOS® substrate, and microbes to accelerate biodegradation in low permeability soil matrices, and 2) to decrease the distance that hydrogen gas generated by fermentation must diffuse through the saturated soil to stimulate reductive dechlorination, thereby decreasing the remedial time frame and cleanup costs.

The results gathered from this collaboration demonstrate that CGC’s jetting technique effectively delivered an engineered emulsified oil substrate into low permeability zones resulting in enhanced reductive dechlorination of target cVOCs. Two years after injection, cVOC concentrations were reduced as much as 99% and 95% in some groundwater and soil leachate samples, respectively. Chlorine number calculations on the molar concentrations of cVOCs in groundwater reflected the degradation of TCE (Cl# =3.2) to less chlorinated daughter products (Cl# =1.9), which supported biodegradation as the mechanism for removal. However, bioremediation of soil leachate is a relatively slow process and additional time will be required to meet several of the soil cleanup criteria. This presentation will describe additional background information and results of this collaborative solution to this common, worldwide problem.

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Presenting Author: Bill Walsh
Building a Vapor Intrusion Case: Use of Multiple Lines of Evidence to Support a Site Conceptual Model for TCE Migration under a Residential Neighborhood

Nadine Weinberg, Katherine Eyre and Darren Scillieri

Draft guidance released by U.S. Environmental Protection Agency (USEPA) has the potential to extend vapor intrusion (VI) investigations indefinitely due to perceived uncertainties in the data sets generated to evaluate this exposure pathway. At this site, a multiple lines of evidence (MLE) approach was used to evaluate VI from a large trichloroethylene (TCE) plume. TCE concentrations were historically up to 15 milligrams per liter (mg/L) in groundwater on the source property and determined to be present under several residential and commercial buildings. An initial, local Agency investigation of VI did not identify any immediate concern.

TCE concentrations in shallow groundwater were later determined to be significantly lower (< 0.050 mg/L but still exceeding USEPA VI screening levels) than concentrations at deeper depths. Thus, additional VI investigation was requested, in part due to vadose zone lithology of well-sorted fine to medium grained sand. A MLE was developed to focus the data collection and analysis, and obtain USEPA approval on the scope. The MLE started with nested soil gas samples from 17 locations downgradient from the source area. These data confirmed that TCE was not present in the vadose zone above reporting limits, providing clear evidence that TCE was not migrating into residential homes.

Per the MLE and agreement with USEPA, direct measurements (i.e., sub-slab soil gas and indoor air) were required because the Agency continued to express concern that the VI pathway was complete for residences overlying the TCE plume. With regulatory concurrence on the MLE work plan, data were collected from 21 residences and a commercial building that demonstrated that TCE was not present in sub-slab soil gas or indoor air above conservative screening levels. Thus, the data confirmed the findings of the comprehensive soil gas study in which data were collected over and close to the TCE groundwater plume.

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Treatment of Arsenic by Chemical Fixation/Stabilization

Alan Weston, Christa Bucior, Sophia Dore and Donald Pope

Treatment of arsenic in groundwater can be complex due to the different forms of arsenic that can be present. The form of As and therefore its mobility in the environment depends on the groundwater pH and redox conditions. As can be mobilized over the entire pH range under suitable physical and chemical conditions.

Chemical fixation/stabilization in-place is a conventional treatment method, which involves the immobilization of the contaminants such as As within the soil or sediment medium.

A site in New Jersey (Site) produced arsenical fungicides and herbicides leaving the groundwater and soil heavily impacted with As. AsIII is present in the shallow aquifer at the former source area and at depth downgradient of the source area, and AsV is the dominant form of As in the shallow aquifer immediately downgradient of the source area.

The existing pump and treat system is not cost effective and in situ As immobilization was proposed as a potential remedy to reduce costs of groundwater treatment.

A treatability study was performed to investigate the potential for As precipitation from groundwater by chemical fixation and to determine the optimum reagent and dose for precipitation of the As. Since the Site contained both aerobic and anaerobic areas and the solubility of arsenic is highly dependent upon redox state, different precipitation reagents were tested for the different areas. Once the optimum chemistry for the precipitation of arsenic in each area had been identified, commercially available media that would be suitable for full scale treatment were tested. The results of the study were used to identify products that would be effective and cost effective options for the precipitation of the groundwater at the Site. This presentation will discuss the design and results of the treatability study.

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