



April 28-30 and May 1, 2008 Poster Presentations

LOCATION: TRADE SHOW AREA – APRIL 29 & 30
GRAND BALLROOM A/B/C/D – MAY 1

In-Situ Remediation: Stabilization of Lead-Contaminated Groundwater Using APATITE II™

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The Havre St. Pierre Airport is a federally owned property managed by the municipality of Havre-Saint-Pierre. This project is the first project of lead stabilization carried out in the northern region using the APATITE II™ technology. The poster presented at the 2006 Federal Contaminated Sites National Workshop reported the establishment of the reactive zone using APATITE II™ to immobilize lead. The overall goal of the project is to reduce dissolved lead concentrations to a level below the Ministère du Développement durable, Environnement et Parcs (MDDEP) criterion for drinking water (10 µg/L).

The present work shows the results of groundwater monitoring. One year after the reactive zone was established, the lead concentrations ranged from 5 µg/L to 490 µg/L. The monitoring results for November 2006 showed a marked improvement, with a mean decrease of 89% in lead concentrations. Although the reaction time was longer than expected, the results indicate that the reactive zone stabilized and reduced the lead contamination. The results suggest that the low groundwater temperature and the absence of surface infiltration influenced the reaction time. Monitoring is still ongoing in 2007. APATITE II™ is a promising technology because it is easy to implement and does not require the use of cumbersome treatment or maintenance infrastructure.

Spill Response and Soil Remediation of Biodiesel

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Biologically-based fuels offer many advantages over petroleum-derived fuels: life-cycle reductions in greenhouse gas emissions; improved air quality; and, a sustainable energy supply. To promote their use, targets have been set for adding biofuels, such as biodiesel, to traditional petroleum fuels. As an unfortunate, but inevitable consequence, spills of pure and blended biofuels will increase along with demand. Well-developed spill response and remediation technologies for biofuels will be critical to support the development, promotion, and uptake of biofuels. Due to the differences in physical, chemical, and toxicological properties of biodiesel, in comparison to petrodiesel, conventional spill response and remediation technologies may not be as effective on biodiesel and biodiesel-petrodiesel blends. Testing of existing mechanical containment and recovery techniques is currently being undertaken to determine their effectiveness for cleanup of a biodiesel spill. In addition, although biodiesel is widely considered to be readily biodegradable and non-toxic, anecdotal field evidence for vegetable oil indicates that vegetable oil, and perhaps biodiesel, can persist in the subsurface for decades. Thus, bench-scale testing is also underway to assess biodegradation of biodiesel under subsurface conditions and the effectiveness of in-situ chemical oxidation of biodiesel for soil remediation.



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Removal of Cyanide and Ammonia in Zone 2 Pit Lake at Colomac, NWT

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This poster will illustrate the removal of cyanide and ammonia from a water filled mine pit at Colomac, an abandoned gold mine located in the remote boreal forest 220 km northeast of Yellowknife, Northwest Territories. An emergency transfer of water to the Zone 2 Pit (the main ore excavation site) was conducted when a nearby tailings lake first reached its capacity limit. This resulted in elevated concentrations of cyanide complexes and related degradation compounds (thiocyanate and ammonia) in the pit-lake.

Both the tailings lake and Zone 2 Pit were treated with phosphate fertilizer to enhance the natural rate of degradation of cyanide, thiocyanate and ammonia to acceptable water quality levels. This enhanced natural removal (ENR) treatment was successful in reducing contaminant levels in the tailings lake well in advance of original predictions.

However, data collected from the deeper Zone 2 Pit indicated that the pit-lake did not fully circulate. The depth of mixing was limited to the top 25 m of the 110 m deep lake. Below this surface layer, the water column was devoid of dissolved oxygen. As a result, the effectiveness of the ENR treatment at reducing the concentration of thiocyanate and ammonia was limited to the surface layer and the reduction of the total inventory had not proceeded at the same rate as the tailings lake.

Based on the predicted water quality at this time, a decision was made in 2005 to install a destratification system to circulate the water body and increase the concentrations of dissolved oxygen to accelerate the removal of thiocyanate and ammonia. The destratification system was run through the summer of 2006. Within nine days of aeration, the entire water column was mixed and, by the end of summer, thiocyanate was below detection and the load of ammonia reduced. The aeration system is being run again in summer of 2007 to further reduce ammonia levels. The destratification system and its effects will be demonstrated.

Development of a Human Health Soil Quality Guideline for n-Hexane

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During the five-year review of the Canada-wide Standard for Petroleum Hydrocarbons, concerns were raised by Equilibrium Environmental Inc. regarding the unique toxicity of n-hexane. It was concluded that, if n-hexane comprised a significant portion of the C₆-C₈ aliphatic hydrocarbons, the soil quality objectives in the standard may not be protective. To address this issue, Health Canada commissioned Meridian Environmental Inc. and Equilibrium Environmental Inc. to develop a human health soil quality guideline for n-hexane, allowing this substance to be assessed separately.

The development of the soil quality guideline included a review of sources of n-hexane in the environment and potential background human exposures, an evaluation of fate and transport of n-hexane, development of new toxicity reference values, and calculation of soil quality guidelines for agricultural, residential, commercial and industrial land based on the Canadian Council of Ministers of the Environment (CCME) protocol.

Secondary Impacts of In-Situ Treatment Technologies on Groundwater Quality

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A literature review financed by Health Canada's Contaminated Sites Division was performed in order to examine possible secondary impacts on groundwater quality due to in-situ remediation (permeable reactive barriers [PRBs] or air sparging) of sites contaminated with chlorinated solvents. A secondary impact would be a change in a water quality parameter other than the reduction of the concentrations of contaminants of concern and their degradation by-products. The reactive media targeted in this study were granular and nanoscale zero-valent iron (ZVI) barriers and those involving enhanced biodegradation via injection of hydrogen, oxygen, carbon and ZVI sources. The empirical data available from the literature on air sparging and PRBs are currently insufficient to quantify secondary impacts on groundwater quality. However, technical reports regarding installation of ZVI PRBs at seven American sites did provide evidence of changes in certain physicochemical parameters (i.e., pH, temperature, specific conductivity, oxidation-reduction potential (ORP), dissolved oxygen



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(DO), cations and anions). Monitoring of these parameters was essentially designed to examine the performance and longevity of the reactive media within treatment cells. A reduction in DO in the media was seen to result in increased pH, which in turn slowed degradation of the trichloroethylene (TCE) and/or reduced the reactive potential of iron due to precipitate formation. Very little information was available either upgradient or downgradient of the treatment zone. It was therefore difficult to identify any secondary impacts on a larger scale. There is an urgent need to develop remediation installations with surveillance systems distributed on a spatial and temporal scale better adapted to groundwater quality monitoring. Such improvements would provide data for a more adequate assessment of the full range of environmental impacts of the remediation technologies, as required for federal sites under the *Canadian Environmental Assessment Act*.

Mutagenic Hazard and Carcinogenic Risk of Complex PAH Mixtures in Contaminated Soils Measured Using an In-vitro Mammalian System

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The objective of this study was to validate the risk assessment paradigm for estimating the mutagenic and carcinogenic risk of complex polycyclic aromatic hydrocarbon (PAH) mixtures using an in-vitro mammalian system. Organic components of PAH-contaminated soils were extracted and separated into polar aromatic and non-polar neutral fractions. Synthetic mixtures containing priority PAHs were prepared using the results of chemical analyses. The mutagenic activities of the soil fractions, corresponding PAH mixtures, and individual priority PAH were evaluated using the *lacZ* mutation assay in FE1 Muta™ Mouse cells. Significant increases in *lacZ* mutations were observed upon exposure to each of the soil fractions, PAH mixtures, and five priority PAHs. In most cases, the mutagenic activity of the synthetic mixtures, and the sum of the contributions from each PAH, overestimated the observed mutagenic activity of the non-polar soil fractions. The excess lifetime cancer risk of each of the soils was estimated using the traditional risk assessment method and a novel mutagenic potency ratio (MPR) method. In most cases, the MPR method yielded lower estimates of risk than the traditional, targeted approach. The results indicate that risk assessments that focus on priority PAHs alone will likely provide conservative predictions of mutagenic (or carcinogenic) activity; however, routine assessments cannot account for risks associated with unidentified polar compounds in soils.

Zeolite for Reclamation of Contaminated Sites and Other Environmental Benefits

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Natural zeolite is well suited, and very cost effective, for the treatment of water, agriculture wastes, and reclamation of soils.

Zeolite is a natural occurring mineral with several 100 chemical variations and many more artificially produced variants. Natural zeolites are crystalline, hydrated aluminosilicates composed of hydrogen, oxygen, aluminum and silicon. The cavities and channels within the framework hold water molecules and exchangeable cations. It is formed from the reaction of fine-grained volcanic ash with water of high pH and high salt content.

Natural zeolites have extraordinary ion exchange and molecular sieving capabilities, high porosity and permeability, and a large reactive and adsorptive surface area. The interconnecting channels in the framework impart molecular-sieve properties to zeolite. Molecules larger than the internal cavities are excluded from the internal surfaces, while smaller cations are free to enter. Zeolites also have unique dehydration-rehydration properties, being able to lose and gain water reversibly.

This poster will look at the use of zeolite in a compost-amendment for the in-situ-immobilization of metals in soils, while bringing plant cover back to health through a built-in “time release” mechanism that make nutrients and water available to plants as needed.

Readily Available Additional Funding for Innovative Remediation Projects

Lorne James¹, Bob Arnold²

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We are often unable to complete various stages of remediation programs due to shortfalls in funding. This poster will describe an opportunity for additional funding where some innovation occurs within the project or demonstration of a new technology.

Canada Revenue Agency provides incentive for research and development (R&D) projects to tax paying entities via their Scientific Research and Experimental Development Program (SR&ED). This is not competitive fund, but rather provides recovery of funds spent testing/demonstrating a technology.

While a government agency would not directly qualify for this program, their projects may when they would have the involvement with a tax paying corporation/entity. This



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could be either a third party partner (for example a First Nations corporation) or a consultant/contractor. In the case of the third party partner, an agreement with the third party requesting them to apply for SR&ED credits, which, when received, would be applied to the project. In the case of a contractor/consultant, a contract provided by the agency would require them to seek SR&ED funding, which again, would be applied to the project. The SR&ED program has a pre-approval program that would assure that the funding for an eligible project would occur if the details were provided beforehand, and the project followed the work plan.

Some form of innovation would be required (i.e., beyond standard practice or baseline data collection). A smaller company could receive cash equaling 78% of the project costs for a single year project or more dollars for multiple year projects (28% overhead is allowed for each year even without additional spending by the proponent).

An Extended Case Study of Vapour Intrusion by Chlorinated VOCs

Gillian Daly, John Goodin, Theresa Repaso-Subang
Golder Associates Ltd.

Contaminated groundwater can impact basements, buildings and other enclosed spaces through the migration of volatile chemicals through the subsurface.

At an industrial site in Ontario, concentrations of trichloroethylene (TCE), cis-1,2 dichloroethylene (cDCE), trans-1,2-dichloroethylene (tDCE), 1,1-dichloroethylene (1,1-DCE) and vinyl chloride (VC) were measured in indoor air, soil vapour, outdoor air and groundwater every six months over a four-year period. Concentrations of many of the chlorinated volatile organic compounds (VOCs) in the groundwater exceeded the Ontario Ministry of the Environment (MOE) non-potable groundwater criteria (i.e., Table 3 Standards in Ontario Regulation 153/04), while indoor air concentrations and soil vapour concentrations are well below relevant American Conference of Governmental Industrial Hygienists (ACGIH), Ontario Ministry of Labour and MOE standards. The Johnson and Ettinger vapour intrusion model has been used to predict indoor air concentrations based on soil vapour and groundwater concentrations. These projected indoor air concentrations can be compared to the measured indoor air concentrations to assess the contribution of groundwater to the indoor environment. A sensitivity analysis was completed to evaluate which model input parameters have had the greatest impact on the projected indoor air concentrations. The difference in model output from using default input parameters and site-specific parameters will be highlighted.

Case Study: The Excavation of MGP Residuals

in Soil Adjacent to an Active Rail Line and Within a Residential Community

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A remedial action was completed at a former manufactured gas plant (MGP) in New Jersey involving the installation of sheeting, active de-watering, and the deep excavation of 20,717 tons of soil. The former MGP encompassed a 0.2-acre property in a residential setting adjacent to an active rail line. The impacted soil was delineated at the site and two adjoining properties during remedial investigation activities. This required the excavation of soil to depths ranging from 2.5 to 34.5 feet below ground surface (bgs) to provide for future unrestricted use. Due to the small size of the work area, proximity to an active rail line and the presence of an active roadway that bisected the proposed excavation, the project posed several logistical challenges related to work zones, traffic controls, and how to approach the sheeting installation in close proximity to residential dwellings.

Several technical and physical challenges were encountered throughout this project. The excavation of soils to the top of a competent clay unit (approx. 34.5' bgs) required the depressurization of two highly permeable silt layers that exist within the top 20' of the extensive clay unit. The excavation was completed adjacent to the right-of-way of an active rail line at depths ranging from 2.5' to 25.5' bgs, which required the earth-support design to comply with requirements set forth by the railroad. The construction of an on-site groundwater treatment facility, with the capability of addressing MGP related impacts prior to discharge was also required.

Design and implementation challenges and outcomes regarding remediation of contaminated soils will be outlined in detail. Post excavation groundwater data is being evaluated as part of a proposed monitored natural attenuation remedy.

In-Situ Chemical Oxidation: Remediation of Chlorinated Solvents in Boulder Fill Conditions

Kristin Lang and Don Carey
Jacques Whitford Limited

Jacques Whitford Limited was retained by a confidential client to complete a pilot test and implement an in-situ chemical oxidation remediation program at a multi-tenant commercial property in Dartmouth, Nova Scotia. The site building historically contained a tenant which stored contaminated liquids in underground storage tanks. In 2001, the underground tanks were removed and an environmental assessment program was initiated which identified a large tetrachloroethene (PCE) plume on the property (including



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daughter products). The in-situ remediation program, with the use of hydrogen peroxide as an oxidant, was initiated in 2006 with the objective of remediating the property within a two year time period to the Ontario Ministry of the Environment's (MOE) *Soil, Groundwater and Sediment Standards for use under Part XV.1 of the Environmental Protection Act* Table 3 criteria. The work is currently on going and is expected to be completed in 2008.

The subsurface condition of the site consists of boulder fill. Environmental assessments at the property identified the subsurface material was inhomogeneous, with varying hydraulic conductivity and void spaces between boulders. Boulder fill conditions are difficult subsurface material for in-situ remediation and a flexible program was required to meet the remediation timelines. Ongoing monitoring and variations in remediation strategy were used to achieve promising results which, to date, indicate the remediation objective will be achieved in 2008.

The remediation approach was designed to achieve results within a relatively short timeframe. The pilot test identified areas of the site which accept higher volumes of the oxidation product (hydrogen peroxide) and areas which would not accept large volumes. Remediation was first implemented in areas that were more accepting of the hydrogen peroxide product. During the initial remediation stages, strategies specific to the site were developed to allow remediation in the more difficult areas of the site. Following the completion of the remediation in the initial areas, remediation continued at other areas of the site.

This poster will illustrate the deliberate approach of the remediation program and present the challenges and solutions relating to subsurface conditions, oxidation product, time and access restrictions and health and safety issues.

A Modified In-vitro Method to Assess the Bioaccessibility of Lead in Contaminated Soils

T.P. Morgan-Gray, J.D. Goodin, T. Repaso-Subang
Golder Associates Ltd.

The bioaccessibility of lead in soils was determined in support of a human health risk assessment being conducted for a site in Ontario. The objectives of the testing were to determine site-specific estimates of lead bioavailability that are more representative of exposure following ingestion of metals-contaminated soils from the site, and to validate a modified in-vitro method. The relative bioaccessibility leaching procedure (RBALP) developed by Drexler and Brattin (2007) and a modified version of the RBALP were used. The procedures differ primarily in the methods of mixing (end-over-end rotation in a temperature controlled water bath versus a see-saw motion in a temperature controlled oven). Lead bioaccessibility ranged from 14 to 141%

and from 19 to 134% using the standard and modified RBALPs, respectively. The results from the standard and modified RBALPs are linearly correlated ($p < 0.05$, $r = 0.95$). This indicates that the modified RBALP is adequately predictive of the bioavailability of lead in soil to animals as the results correlate with the results of the standard RBALP, which has been validated using the immature swine model. Use of the modified RBALP simplifies testing because it eliminates the use of a water bath, the test system occupies less space, and dish washing is minimized through the use of disposable bags rather than bottles.

The Mutagenic Activity of High-Energy Explosives: Contaminants of Concern at Military Training Sites

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Health Canada, Mutagenesis Section, Safe Environments Programme

The genotoxicity of energetic compounds (i.e., explosives) that commonly occur in contaminated soils at military training sites has not been rigorously tested. Thus, the *Salmonella* reverse mutation assay, and the MutaTMMouse in-vitro transgene mutation assay were employed to examine the mutagenic activity of selected energetic compounds including trinitrotoluene (TNT), tetryl, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX). *Salmonella* reverse mutation analyses employed TA98 (frameshift mutations), TA100 (base-pair mutations), as well as the metabolically enhanced YG1041 (TA98 background), with and without exogenous metabolic activation (S9). The results indicate that TNT is a direct-acting mutagen, eliciting significant positive responses without S9. *Salmonella* strains TA98, TA100, and YG1041 yielded mutagenic potencies of 0.84 ± 0.05 , 1.64 ± 0.10 , and 1.31 ± 0.08 revertants/ μgTNT , respectively. In contrast, tetryl elicited significant positive responses both with and without S9, exhibiting considerable mutagenic activity in all strains. Potencies ranged from 1.22 ± 0.09 to 13.50 ± 0.89 revertants/ $\mu\text{g}_{\text{tetryl}}$, with the highest value obtained using TA100 without S9. Initial testing of TNT and tetryl using the MutaTMMouse assay was inconclusive and the substances are currently being re-evaluated. Testing of RDX and HMX with both assays is underway. The significant mutagenic activity of TNT and tetryl indicates that testing of other energetic materials, as well as contaminated soil samples from military training sites (i.e., Canadian Forces Base Petawawa), is warranted in order to reliably estimate mutagenic hazard.



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Canadian House Dust Study: Study Design and Communication of Results

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Health Canada's federal contaminated sites program requires baseline indoor dust data to characterize contributions from contaminated sites. The Canadian House Dust Study is a four-year research study whose goal is to address this data gap in risk assessment by obtaining a statistically robust estimate of background levels of chemicals in urban household dust across Canada.

A sampling design was developed to obtain a random and representative sample of Canadian cities with populations greater than or equal to 100,000. Based on existing information on the variability of metal concentrations in Ottawa households, it was determined that sampling approximately 1,000 homes in 13 cities across Canada was required. Sampling methodologies include collection of a composite vacuum sample and settled dust wipe samples from living areas of the home. Vacuum dust samples are air-dried and sieved for subsequent determination of a wide range of inorganic and organic constituents.

Phase 1 sampling was completed in 282 southern Ontario homes in 2007. In the absence of published guidelines, a provisional, risk-based and tiered approach was developed to categorize the potential human health risk associated with chemical levels in dust. This risk-based approach was designed for communicating results to study participants and was deemed appropriately precautionary given the limited information regarding potential health risks of household dust.

Lauvina Woods Erosion and Sediment Control Plan (ESCP): Canadian Forces Base Gagetown, New Brunswick

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Canadian Forces Base Gagetown houses the second largest range and training area (RTA) in the British Commonwealth and is of primary importance to the Department of National Defense's training program. Thousands of soldiers train for a variety of military operations, including deployment areas involved in conflict. Housed in the RTA is the Lauvina Wood heavy equipment training area for Royal Canadian School of Military Engineering. This school

trains utilization of traditional construction equipment for operation in peacekeeping, disaster relief, as well as operations in areas of conflict.

The RTA was developed in the early 1990's and is adjacent to a significant tributary of the St. John River (Rockwell Stream). Training operations required that earth be moved regularly, eight months a year, creating what is effectively a perpetual or permanent heavy civil construction site. Extremely high sediment loads result in excess of 20,000 ppm and total suspended solids can be as high as one hundred times the regulatory guideline.

The 50 ha site, consisting of glacial tills with high silt contents (over 40%), had been identified as requiring immediate action. Remedial activities involved the creation of permanent sedimentation control measures to balance the needs of the training of soldiers with the needs of the environment and ecology. The chosen approach created individualized training areas or "sand boxes" which captured sediment from training and channeled it to large sedimentation ponds. This site utilized a balance of hard civil engineering solutions in conjunction with establishing vegetation, as well as chemical flocculants, thereby presenting a unique approach to sedimentation control.

Vapour Intrusion Guidance for Risk Assessment at Contaminated Sites: A Health Canada 2008 Update

Jo-Ann Aldridge¹, Heather Jones-Otazo¹, Meghan Roushorne¹,
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The transport of vapour phase organics from the sub-surface into buildings through vapour intrusion can pose a significant human health concern at federal contaminated sites. Health Canada has developed guidance to assess this pathway, consisting of written guidance and a spreadsheet tool.

Inherent in the spreadsheet tool are key distinctions which have been made between default assumptions deemed appropriate at the preliminary quantitative risk assessment (PQRA), as compared to the site specific risk assessment (SSRA) levels. This may impact remedial options available to federal custodians of contaminated sites.

The key tenet of the guidance is the derivation of semi site-specific attenuation factors using the Johnson and Ettinger model. It also establishes the minimum site investigation data needed to assess the vapour intrusion pathway while emphasizing the need for multiple lines of evidence, and delineates what site conditions are deemed to be precluding factors for the assessment of vapour intrusion using modeled attenuation factors.



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Existing data gaps in the science of vapour intrusion pose challenges to decision-making. For example, challenges still exist in modelling vapour intrusion, specifically relating to chlorinated solvents, biodegradation, and special environments, such as those in Canada's north. This Health Canada guidance addresses these data gaps in a conservative fashion.

Field Technical Workplans for the Demilitarization and Remediation of Sites Contaminated with Chemical Warfare Agents: Experimental Proving Grounds, Canadian Forces Base Suffield, Alberta

David Simpson, P.Eng., Golder Associates Ltd.

The experimental proving grounds (EPG) at Defence Research and Development Canada (DRDC) Suffield, located near the town of Ralston, Alberta, was established in 1941 to support a variety of military purposes, but most significantly for the testing, use, storage, disposal and destruction of chemical warfare agents (CWAs) such as mustard, lewisite and nerve agents during and subsequent to World War II. As a result of these activities, various locations within the EPG are known or suspected of being impacted by CWAs, CWA-related materials and equipment, and potential unexploded ordnance (UXO). The Department of National Defence is looking at options to reduce the risks associated with these sites within the EPG, including demilitarization and remediation.

Execution of this project involves reacting and adapting to uncertainties caused by the unknown extent and high-risk nature of the key contaminants of concern; gaps in documentation as to historical disposal practices; the amount of time that has passed since these activities were last carried out; and the historical disposal of various field testing and laboratory materials into pits and trenches which were subsequently backfilled and covered, potentially including CWA and/or UXO.

A general strategy has been developed to look at the remedial approach to reducing risk. The strategy begins with demilitarization to remove and destroy CWAs and UXOs within an excavation enclosure, followed by conventional remediation to remove residual contaminants such as metals, laboratory chemicals and CWA degradation products. The destruction or treatment of CWA impacted soil and materials will be achieved using a set of techniques including incineration augmented by chemical neutralization or stabilization to ensure safe handling and transportation, and ultimately disposal of treated soils and associated solid by-products (i.e., incinerator ash) to a suitable landfill. Any remediation work is expected to be carried out by a specialized team that includes DRDC Suffield personnel and private contractors. This will illustrate some of the key

uncertainties, challenges and possible solutions associated with this complex project.

Investigation of Buried Materials at a Former Residential School

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¹Franz Environmental Inc.

²Public Works and Government Services Canada

In the summer of 2007, Franz Environmental Inc. conducted a Phase III Environmental Site Assessment (ESA) of the former Lower Post Residential School, located on the grounds of the Daylu Dena First Nation Reserve in Lower Post, in northern British Columbia. The Phase III ESA was conducted for Public Works and Government Services Canada (PWGSC) on behalf of Indian and Northern Affairs Canada (INAC), and focused on assessing buried materials associated with the former residential school buildings.

In the late 1800s, in conjunction with various religious organizations, the federal government began to play a role in the development and administration of the residential school system to provide an education to Aboriginal people, as well as to assist with their integration into the broader Canadian society. These schools were located in almost every province and territory, including British Columbia. It is estimated that approximately 100,000 children attended these schools over the years in which they were in operation. Most residential schools ceased to operate by the mid-1970s. In recent years, individuals have come forward with personal and painful stories of physical and sexual abuse at residential schools. The history and legacy of residential schools is a special consideration in any environmental investigation of these types of sites.

The school buildings at Lower Post were destroyed during a fire that occurred in the late 1980s. Subsequent to the fire, portions of the school buildings were buried and left in the subsurface at the site. There is also an onsite bio-cell and four soil stockpiles at the site. During previous investigations, petroleum hydrocarbons (PHCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals were identified as contaminants of concern (COCs) in soils at a limited number of areas at the site. Asbestos-containing material had also been identified in buried building materials in the vicinity of the former school building.

The 2007 assessment program included a review of previous environmental reports and data gap analysis; consulting with local community members to understand their needs and to identify former structures; reviewing historic air photos; tracking down and reviewing the site plan circa 1955 identified by Library and Archives Canada; executing an investigation of over 25 test pits in and around the former residential school buildings; staking out the boundaries



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of the former school main building; surveying in the school building perimeter with a total station surveying unit; sieving mixed soil/debris samples to assess relative percentages of soil versus debris; and employing the use of polygons in defining areas of influence around each sampling location for detailed volume calculations.

This combination of local knowledge, historical research and innovative sampling and volume estimation techniques enabled development of defensible estimates of buried materials and impacted soils at the site. It is anticipated that this work will lead to a remedial action plan that cost effectively provides some closure from both a contaminated sites perspective, and more importantly, from a healing perspective for the local community.

How Innovative Project Management Ensured Success on the Axe Point Remediation Project

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This poster will illustrate the way in which project management planning and controlling processes were utilized to ensure that the Axe point remediation Project was completed ahead of schedule and within budget, while also meeting or exceeding client and stakeholder objectives. The poster will outline some of the unique project challenges in terms of the northern remote conditions, schedule constraints, and the ambitious socio-economic performance commitments made by the proponent. The poster will also show how the early project deliverables required by Public Works and Government Services Canada (PWGSC) and Indian and Northern Affairs Canada (INAC) as the project sponsors, and the contractors participation on finalizing design components were instrumental in ensuring that the remediation project was thoroughly planned such that execution could proceed within budget and schedule. In addition, the poster will describe how Quantum Murray LP engaged in extensive resource planning and collaboration with the Deh Gah Got'ie Dene Council to ensure that there was meaningful participation of the local Aboriginal community in the remediation project. An outline of the PWGSC weekly and monthly status reporting and internal Quantum earned value management metrics will be presented to demonstrate how such controlling processes were instrumental to ensure the baseline budget and schedule was maintained during project execution, and if deviations were observed, to ensure corrective action was taken.

Fracture Controlled Petroleum Hydrocarbon Releases: Steeves Lake Colomac Mine Site, NWT

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Colomac was an open pit gold mine that operated between 1990 and 1997. The site was abandoned and is currently the responsibility of the Indian and Northern Affairs Canada (INAC), Contaminants and Remediation Directorate (CARD). The site is located 220 km north of Yellowknife, in the Northwest Territories.

Significant uncontrolled releases of diesel and gasoline products occurred on the Colomac site during mine operations. Free phase petroleum product (free product) has been identified in the sub-surface of the former tank farm area. The Steeves Lake shoreline has been impacted with petroleum hydrocarbons (PHC) and hydrocarbon sheens have been observed at various locations along the shoreline. Hydrocarbon sheens are most notable as a result of precipitation events and wind-induced or wake-induced (boat) wave action. A floating lake boom, absorbent pads and socks are required during open water season to control the sheen.

A preliminary sediment survey was completed in 2005, and an enhanced sediment survey was completed in 2006 near the shoreline below the former tank farm area. The samples were analyzed for benzene, toluene, ethylbenzene and xylenes (BTEX) and F1-F4 fraction PHC and polycyclic aromatic hydrocarbons (PAHs). Wide spread PHC and PAH impacts were detected along the shoreline, with large areas impacted in excess of applicable guidelines.

Based on the sediment sampling, it became apparent that the distribution of PHC and PAH impacts were highly variable and were not only dependant on the location of upgradient sources, but by the bedrock fracture morphology, the presence of high velocity zones, channeling effects and type of sediment substrate (i.e., highly organic to waste rock).

The fracture controlled release environment was a significant challenge to developing an effective and robust delineation program.

An enhanced sampling plan was developed by INAC based on a grid pattern established along the lake's shoreline. Using 10 metre (m) intervals, sampling locations were established. At each marker placed along the shoreline, sampling was completed along a transect line at 2.5 m, 5.0 m, 7.5 m, and 10.0 m intervals.

The analysis of sediment samples was completed on a 'first-in-line' basis. All samples were submitted to the laboratory and only the first sample taken from each transects line was analyzed. When laboratory reports indicate that concen-



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trations of PHCs were below the applicable guideline, analysis of that line was terminated. The laboratory was then instructed to analyze the next samples in line through the lines that required further delineation. This process continued until concentrations below applicable standards were found in all lines.

This poster presents the challenges and approach of assessing contaminants in a fracture controlled environment, methodology and results of the sediment sampling.

The Clickable Map: User-Friendly Interactive Electronic Reporting

Tuula Talvila, Stephen Livingstone
Franz Environmental Inc.

The Clickable Map is an electronic, web browser-based, interactive report that was developed to demonstrate how a standard printed report might be viewed electronically, using standard HTML web page construction.

In contrast to a typical printed report, the interactive report is presented spatially by using maps as the starting point. Clickable map elements allow the client to investigate and access report sections relating to that spatial feature. For example, when clicked on, soil sampling locations open a PDF file of the relevant soil chemistry data. Similarly, photograph and video symbols open the photographs and video files that were taken at those locations.

While not as sophisticated as using a geographic information system (GIS) to present geospatial data, this web-based page method provides a relatively easy way to present components of a standard printed report electronically, in a convenient visual and interactive format. It requires no technical knowledge of the user, nor advanced software. All that is required is a web-browser (the electronic report is read directly from the user's hard drive) or a CD (it is not published on the Internet).

This poster presents an example of an electronic report, developed by Franz Environmental Inc.

1,4 Dioxane: An Emerging Contaminant in Groundwater

Stephen Livingstone, Thomas Franz
Franz Environmental Inc.

Though, as a society, we have taken the appropriate end-of-pipe measures to ensure protection of human health and the environment from contaminated sites, the issue of emerging chemicals pose significant challenges to managing and remediating contaminated sites, risk assessments and site monitoring. Emerging contaminants are chemicals that are presently unregulated, can have an unknown or

not fully understood effects on health and the environment and have public and/or regulatory interests.

In the U.S., 1,4 dioxane has been recently discovered at hundreds of contaminated sites. Records of Decision have been overturned based on the presence of 1,4 dioxane. As such, new and advance treatment systems need to be installed. The solvent stabilizer 1,4 dioxane has been discovered co-existing with other groundwater volatile organic compounds including TCE, TCA and PCE. It is more than likely that every significant chlorinated solvent plume (TCE, PCE, TCA) is co-existing with a 1,4 dioxane plume. In Canada, the Transport Canada, Gloucester Landfill site, Ottawa is an example of large-scale 1,4 dioxane plume. The site has been the centre of environmental assessment, remediation and risk assessment work over the past 20 years.

The main concerns with 1,4 dioxane is the fact that it is a likely carcinogen and is not subject to adsorption and is highly resistant to abiotic and biotic transformations. It is considered a solvent to water (dissolves water) and travels at the same velocity as groundwater. As such, conventional groundwater remediation treatment including carbon treatment and air stripping are not effective. The only effective treatments are ultraviolet light and chemical oxidation. Numerous public water supply wells in the United States have been shut down due to the presence of 1,4 dioxane.

1,4 dioxane is used primarily as a solvent in paints, varnishes, lacquers, cosmetics, deodorants, and is often used as a stabilizer and corrosion inhibitor with other chlorinated solvents.

Canada does not currently have any guidance for 1,4 dioxane. However, it is our understanding that Health Canada is pursuing a criteria while the Ontario Ministry of Environment's latest draft standards included a 1,4 dioxane groundwater standard for review and comment. In the United States, groundwater State Action levels range from 3 ppb in California to 85 ppb in Michigan.

This presentation will profile the occurrence, history, regulation and remedial response of the emerging contaminant 1,4 dioxane.

Performance Assessment and Design Considerations for In-Situ Remediation of TCE in Groundwater Using a Multi-Barrier Approach

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Prevailing subsurface conditions can affect performance of in-situ remediation technologies and going forward life cycle remediation costs. Besides the shear size of the impacted site, a few factors can have a profound affect on remedia-



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tion implementation and costs and, ultimately, technology selection and time to reach remediation goals. Among the most critical factors affecting remediation success are: depth of contaminants; hydraulic properties; temperature and treatment substrate contact with affected solid media; remediation objectives; and, proximity to infrastructure and receptors. The findings provide insights in assessing the feasibility of in-situ treatment methods for other groundwater remediation projects in northern and cold climates.

This poster illustrates results of pilot scale testing of a multi-barrier approach to in-situ trichloroethylene (TCE) remediation at Canadian Forces Base Valcartier (Valcartier). Valcartier's geological unit at the pilot test area is comprised of very coarse sand and gravel from near the surface to a bedrock confining unit at approximately 20-28 metres below ground surface (mbgs), groundwater is present at 10 mbgs with an average hydraulic conductivity of 7,2 E-4 m/s and temperatures that average 6°C. The prevailing conditions at this site represent a challenge to in-situ technologies which require delivery and mixing of air or substrates (air sparging, in-situ bioremediation or chemical oxidation), a passive flow through treatment system (permeable reactive barriers) or removal of water (pump and treat) or vapor (soil vapor extraction). At Valcartier, selected technologies used for pilot testing included: air sparging; a zero-valent iron (ZVI) permeable reactive barrier (PRB); and, a multiple technology solution that combined ZVI, bioremediation and air sparging. EHC® was introduced as a supplemental carbon source to stimulate bioremediation. To our knowledge, this was the first major pilot test to examine the potential synergistic effects of a combined ZVI/EHC® barrier.

The poster demonstrates the theoretical treatment mechanisms that can occur within the multi-reactive barrier relative to the observed test results and findings. Both biotic and abiotic pathways are examined. Pilot testing results suggest that groundwater TCE and cis-1,2-dichloroethene (cis-DCE) concentrations declined between 50% and 75% for the pilot test configuration used and depending on the location within the test zone. The greatest decline in chlorinated volatile organic compound (CVOC) concentrations occurred primarily in the ZVI/EHC® barrier. Concentrations of both TCE and cis-DCE declined despite the cold temperatures (5 to 8°C) and higher than anticipated groundwater flow rates. An evaluation of the ratio of TCE to cis-DCE shows little change in the distribution seen between upgradient wells and downgradient wells. This indicates that both TCE and cis-DCE are degrading at the same relative rate, suggesting that most of the degradation occurring is abiotic. These results suggest that EHC® carbon source did not play a significant role in CVOC degradation during the time period of the test. The requisite bacteria for reductive dechlorination, called halo-respiring microorganisms, were absent or at low populations and dissolved oxygen, as the primary electron acceptor in groundwater, was not depleted to the range required for effective treatment.

The dominant factors affecting success and estimated life cycle costs are examined as well as the implications of the pilot test on full-scale implementation and operation.

Pharmaceuticals and Personal Care Products (PPCPs) in the Environment: A Threat to our Water Resources?

Thomas Franz, Stephen Livingstone
Franz Environmental Inc.

In 2007, several federal and Ontario provincial politicians agreed to having blood samples taken and analyzed for a series of contaminants. The results created significant publicity in the media about the substances that were found and their origins, including carcinogenic compounds, neurotoxins, and hormone disruptors that may be found in pesticides, non-stick chemicals, flame retardants, plasticizers, pharmaceuticals, and personal care products.

This poster will summarize the current knowledge base of the occurrence of PPCPs or their metabolites in surface water and groundwater. Due to increased production and use of PPCPs, it has been found that such substances are finding their way into water supplies worldwide with increasing frequency. Their effects, at low concentrations in these media, on humans are currently not understood. However, studies on amphibians and fish have shown "feminization" of some species, indicating that genetic alterations can occur. At this time, no standards or guidelines exist in Canada for assessing soil, sediment, or water. A review of other jurisdictions (United States, Europe) will be presented to shed some light on the current status and expected future of regulatory involvement regarding PPCPs.

Human Health and Ecological Risk Assessment: An Integrative Approach

Geordie Clyde, Jody Berry, Larry Rapustka, David Rae,
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Risk assessment can be used effectively to evaluate options for dealing with contaminated sites. In many cases, it is necessary to evaluate the risks to both human and ecological receptors. Problems arise when the ecological and human health assessments are done separately as the end results do not always complement each other. By integrating the human health and ecological risk assessments into one process, holistic evaluation of the linkages and interactions between receptors and stressors becomes possible. The practice of risk assessment continually matures with an emphasis on increasing the "real world" representation. This poster will illustrate the use of probabilistic approaches embedded within an integrated human health and ecological



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risk assessment with varying degrees of complexity in terms of receptors and pathways. Using GoldSim® as a modeling environment, it is possible to translate the conceptual model of human and ecological pathways into a computational model. Assembling discrete modules and explicit linkages offers numerous advantages over spreadsheet approaches, including explicit association of units with numerical values and simplified navigation within the model. Conceptual planning for an integrated assessment and communicating its results benefits greatly from the use of graphical depictions of exposure pathways within the modeling environment, especially when moving between coarse and fine scales.

Dermal Cancer Risk Associated with Benzo[a]pyrene Soil Exposures Expressed on a Per Unit Surface Area Basis

Anthony L. Knafla, M.Sc. DABT, Equilibrium Environmental Inc.

At contaminated sites, humans are exposed via skin contact to B[a]P in soil. Exposure to B[a]P in mice has resulted in skin cancers, suggesting humans may similarly be at risk. No default protocol exists for estimating human skin cancer risks associated with B[a]P exposure since typical risk assessment protocols assess dermal exposures based on the absorbed dose that penetrates the skin and exerts an effect at internal tissue sites. The issue is further complicated by mouse skin painting cancer study protocols that involved application of B[a]P in acetone rather than bound to soil, which may have a significant influence on the proportion of the dose retained by the skin. An alternate approach was developed that could be used to estimate human skin cancer risks due to B[a]P in soil exposures at contaminated sites based on results from mouse skin painting studies and in-vitro data examining differential rates of skin retention between a B[a]P dose applied in acetone and soil. An environmental risk-based soil criterion for B[a]P of 2.0 mg/kg soil was calculated for the protection of humans from dermal cancer risk, which differs from criteria that have been developed for dermal exposure to B[a]P based on an absorbed dose.

Effects of Diesel Exposure on Survival, Growth, and Gene Expression in Rainbow Trout

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¹Hemmera

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Each day, nearly three billion gallons of oil are used in the world, of which 17,000 tonnes were spilled in 2005 alone. Many of the events were inland diesel spills which may have impacted freshwater ecosystems. In this study, a new

draft test method (diesel spike test) with juvenile rainbow trout (*Oncorhynchus mykiss*) was used to simulate exposure during a spill. Chemical analysis was used to identify individual components within the test solution. Survival was monitored over 7 and 14-day exposures to establish lethal concentrations. By utilizing the cGRASP 16,000k gene Salmonid microarray, trout livers were assessed for transcriptional changes that could indicate subtle toxic effects and identify mechanisms of action. Trout survival was affected at diesel exposures of 40-100 mg/L (33-100% mortality). Gene expression was altered at all doses tested (0.8-40 mg/L) but only at the highest dose clusters of genes were significantly up- and downregulated. Downregulated gene clusters included those involved in oxygen binding and transport, as well as other carrier proteins. Immune system and detoxification (metabolizing enzymes and electron carriers) genes were among the most abundantly upregulated genes. Furthermore, indications that diesel may serve as an endocrine disruptor were documented. Since relatively little is known about the toxic effects of diesel, this study provided an important first step in identifying the short- and long-term risks associated with diesel spills in freshwater ecosystems.

Cost Effective DNAPL Remediation Case Study: Contaminated Soils and Groundwater at a Refinery Site near Montreal, Canada, Using Ivey-sol® Surfactant Remediation Technology

George A. Ivey, B.Sc., CEC, CES, CESA, Ivey International Inc.

This poster will focus on the in-situ application of the Ivey-sol Surfactant Remediation Technology at an active refinery site near Montreal, Canada. The Ivey-sol technology was applied to improve the mass recovery of chlorinated contaminants from the soil and groundwater. The client had tried several remediation technologies at significant cost without success, before attempting site remediation with Ivey-sol. In brief, the Ivey-sol surfactant technology increased the rate of contaminant recover by greater than 800% to 1200%, permitting the rapid and cost effective reclamation of soil and ground DNAPL contamination that was posing a significant risk to a near-by municipal groundwater aquifer.

The case study provides an overview of site conditions, source and extents of contaminant plums, Ivey-sol system designed, installation, and the application process resulting in significant time and cost savings for the client.

A brief overview of the Ivey-sol technology along with several graphical Ivey-sol injection and contaminant recovery plots with the associated mass recovery for individual chlorinated compounds over time, are also details therein.