Enbridge Energy, Limited Partnership
333 S. Kalamazoo Ave.
Marshall, Michigan 49068
P. 269-781-1500
F. 269-789-9135

Rich Adams
Vice President, U.S. Operations

November 8, 2012

VIA EMAIL & OVERNIGHT DELIVERY

Richard Karl
Superfund Division Director
US EPA Region 5
77 W. Jackson Blvd.
Mail Code: S-6J
Chicago, IL 60604-3507

VIA EMAIL & HAND DELIVERY

Ralph Dollhopf
Federal On-Scene Coordinator and Incident Commander
U.S. Environmental Protection Agency
801 Garfield Avenue, #229
Traverse City, MI 49686

RE: In the Matter of Enbridge Energy Partners, L.P., *et al.*
Docket No. SWA 1321-5-10-001

Dear Mr. Karl and Mr. Dollhopf:

Enbridge Energy, Limited Partnership ("Enbridge") sets forth in the attached report views on the oil biodegradation study that was provided by EPA for our review on October 25, 2012. While we appreciate the opportunity to comment on the study, given the limited amount of time to comment made available, a fuller analysis of the study was not possible. Nonetheless, as is clear from the attached report, Enbridge has identified certain deficiencies in the biodegradation study and seeks further explanation of certain points.

We look forward to the opportunity to further discuss our views with you.

Sincerely,

ENBRIDGE ENERGY, LIMITED PARTNERSHIP
By Enbridge Pipelines (Lakehead) L.L.C.
Its General Partner

Richard L. Adams
Vice President, U.S. Field Operations

cc: Robert Kaplan, U.S. EPA, Region 5 (via email only)
Leslie Kirby-Miles, U.S. EPA, Region 5 (via email only)
Karen Peaceman, U.S. EPA, Region 5 (via email only)
Michelle DeLong, MDEQ (via email only)
Mark DuCharme, MDEQ (via email only)
William Creal, MDEQ (via email only)
Polly Synk, MDEQ (via email only)
John Sobojinski, Enbridge (via email only)
David Coburn, Steptoe & Johnson (via email only)

THIRD PARTY REVIEW OF EPA/ERT BIODEGRADABILITY STUDY OF ENBRIDGE RELEASE AT KALAMAZOO RIVER

At the request of Enbridge Energy, Limited Partnership (Enbridge), a third party review was conducted of the EPA/ERT Biodegradability Study (Study) on residual crude oil within the sediments of the Kalamazoo River in Michigan. The review panel consisted of independent consulting experts in the following fields: chemistry, geochemistry, geology and ecology and are identified at the conclusion of the report. The Study was conducted to evaluate if residual submerged oil could undergo biodegradation beyond the weathering and in-situ degradation which has already occurred following the July 25, 2010 spill event. The ERT Study consists of:

- Executive Summary,
- Introduction,
- Materials and Methods,
- Initial Oil Testing,
- Biodegradation Studies,
- Oil Sample Processing & Preparation for Biodegradation Study,
- Biodegradation Assessment Process,
- Data Interpretation & Conclusions,
- Appendix A – Summary of Samples
- Appendix B – Oil Fingerprint Report and Total Petroleum Hydrocarbon (TPH) Results
- Appendix C – Article "Chemical Fingerprints of Alberta Oil Sands and Related Petroleum Products"
- Appendix D – Checklists and Experimental Design for Activity Screening

The Study identifies itself as "a bench scale activity screening level oil biodegradation study." With this in mind, several observations are noted below that identify limitations in the "screening level" study. In addition, recommendations for further study are identified.

Synopsis of Study

The first phase of the Study was to obtain samples of oil remaining in Kalamazoo River sediments from the Line 6B release. Two 5-gallon buckets of oil-contaminated sediment were collected from a river side channel which is depositional at Mile Post (MP) 10.75. Mechanical oil recovery had occurred at this location; however, the location was reportedly re-oiled and was anticipated to contain representative residual oil. This location provided sediments typical of the Kalamazoo River depositional areas, though a single sample does not document the variability in the river system. The sediments were extracted and analyzed for total petroleum hydrocarbon (TPH) and oil fingerprint analysis (these results are referred to as Sample 0000). Per the Study, "The TPH concentrations in the sediments were considered insufficient to conduct meaningful biodegradation assessments." In addition to low TPH concentrations (less than 200 milligrams per kilogram), a majority of the TPH concentration was attributed to naturally occurring background organics that are not petroleum related.

In lieu of obtaining additional sediment for the collection of a sufficient volume of residual oil from Line 6B, oil was obtained from alternate sources including released oil that was recovered during initial response actions and was currently in storage (Sample 0003), residual oil obtained from a subsurface void during a bank excavation at MP 13.40 (Sample 0004), and oil collected directly from the pipeline (Samples 0005 and 0006). Additional detailed chemical analysis of the oil samples have been performed by Alpha Laboratory under a Quality Assurance Plan developed for the U.S. EPA. Attached Table 1 presents our

assumption for how the samples from the Study relate to the more detailed chemical analysis of the oil. The Study provided a gas chromatographic assessment of the various crude oil samples. The characterization of the components of the oil samples was conducted in an attempt to validate the selection of samples and assess which classes of compounds are more resistant to biodegradation and weathering. Samples of oil used for the biodegradation test consisted of the following:

- Sample 0003: A sample of released oil was obtained from a processing facility in Indiana that was storing oil recovered during the initial spill response. Based on its lower viscosity and physical characteristics, this oil sample was interpreted to represent "fresh crude" that not had undergone significant mechanical weathering.

- Sample 0004: A residual oil sample was found during a bank excavation at MP13.40 in a subsurface void. The sample was highly viscous and believed to be mechanically weathered. However, it was not biodegraded to the extent of the oil which was collected by disturbing the river sediment samples (Sample 0000).

The samples selected for the Study were evaluated by GC and GC/MS. The Study was run for a total of 28 days with samples being tested on Days 0, 14 and 28. Samples were analyzed by quantitative TPH analysis and gravimetric analysis. The Study assessed the extent of biodegradation solely on mass changes in the gravimetric analysis, and does not provide more detailed evaluation of specific alkylated polynuclear aromatic hydrocarbons or other classes of compound.

Missing Information

- No original laboratory analytical data are included in the report. The source data from which the chromatogram exhibits were created are not presented.

- The Study indicates that background organics are present in the sediment samples collected from location mile 10.75; however, background samples (i.e., Kalamazoo River sediment samples not impacted by Line 6B release) were not collected and analyzed for the purposes of this test.

- The report concludes that "*35-40% of the mass of the oil which remains from the Enbridge Oil Spill is not quantifiable using GC or GC/MS techniques,"* but the data to support this are not clearly identified. Table 3a of the Study presents data indicating the Day 0 value for total mg/flask calculated by GC/MS actually *exceeds* the gravimetric calculated mass in the same sample at Day 0. The stated premise of calibration with source oil 0003 for the TPH measurements would imply that the response factor is inherently adjusted for the un-chromatographable mass. It should be noted that the mass of oil not quantified by Gas Chromatogram methods is very dependent on the instrumentation and conditions. Differences in inlet temperature, injection technique, split timing, column, run time, and integration technique can change the apparent mass that is not quantifiable *if* the calibration is performed with reference materials that elute completely during the run. The referenced Standard Operating Procedure (SERAS GC/MS SOP 1841) and complete details of the calibration procedure and premise of TPH quantification should be provided to fully understand the basis of the report conclusions. It is not clear if silica gel or other cleanups were performed on the samples prior to analysis. These cleanups can remove polar organics such as biogenic natural organic matter, oil degradation metabolites, and highly polar oil components such as asphaltenes. The composition of the crude oil itself can also make a dramatic difference, and it is not clear in the Study exactly which of the oils analyzed this statement is based on. Weathered crude will yield a much higher relative percent mass that is not quantifiable by GC, than the "fresh crude" containing diluent.

- Inoculation for treatment is done using sediment that presumably contains hydrocarbon degrading microbes. The Study did not include an assessment of the potential degraders present on the sediments evaluated. Field sampling and storage can reduce the viability of microbes in the sediment and reduce the population available for biodegradation. It may take greater than 28 days for different types of degraders to establish.

Representativeness of Oil Samples

- The stated purpose of Study was to evaluate the biodegradation of residual oil within the Kalamazoo River sediments. The residual oil within the river sediment has undergone mechanical weathering including the loss of the condensate and an undetermined degree of biodegradation within the deposition and erosion zone. However, a sufficient volume of residual oil was not collected from the river sediment samples for the purposes of the degradation test. In lieu of obtaining additional sediment for the collection of a sufficient volume of residual product from sediments, oil was obtained from two different sources for the degradation test. The degradation test was conducted on a sample of "fresh crude" that was recovered during initial response actions and was in storage. The test was also conducted on a sample of oil that was found in a subsurface void during a bank excavation at MP13.40, which was described as being most similar to the oil recovered from river sediments. The characteristics of the oil used in the Study may be similar but are not fully representative of the mechanically weathered and biologically degraded oil remaining within the river sediments. It is anticipated that the globule

size of oil within the sediment is smaller and thus offers additional surface area for access by microbes.

Limitations of the Bench Scale Test

- The test does not comment on the degradation rate of oil within a geochemically dynamic system of changing redox conditions and aerobic/anaerobic cycling induced through rainwater infiltration, snow-melt, freeze-thaw cycle, bioturbation of soils and sediments, and other transient conditions not attainable in a laboratory setting. Under low dissolved oxygen concentrations, sulfate and nitrate reducing bacteria may further degrade residual oil. Peer reviewed studies have shown that recalcitrant polyaromatic hydrocarbon compounds such as phenanthrene are completely degraded by sulfate and nitrate reducing bacteria. Anaerobic and aerobic analysis would provide a more complete assessment of the overall potential for biodegradation. The Study notes that the sediments trapping the oils rapidly become anaerobic. The Study further notes that the lack of oxygen prevents further biodegradation. If ferric iron, sulfate, and nitrate are available in the sediments, these alternative electron acceptors can facilitate anaerobic biodegradation which can be more significant than aerobic biodegradation. However, anaerobic degradation was not considered in the study.

- The Study uses open culture broth to evaluate biodegradation with a small addition of sediment to inoculate the plate. The oil that is in the Kalamazoo River sediment will be in contact with sediment that contains a larger population of microbes and concentration of electron acceptors. Use of more sediment may limit the recovery of oils during extraction, but it will provide a more realistic assessment of how biodegradable the oils are in the environment.

TPH Data

- The report concludes that "*currently the TPH content of river sediments from the Kalamazoo River impacted by the oil spill can be dominated by compounds which have origins other than the Enbridge Oil Spill, both naturally generated compounds and contamination sources other than the Enbridge Oil Spill*" and later states "*[i]t was determined that the "oil" extracted from the sediment consists of mostly hydrocarbons from decaying organic material, possibly oil from "other" unknown sources, and pyrogenic PAHs from an unknown source-probably creosote. It can be accurately estimated that more than half of the measured TPH is not attributed to the spilled oil.*" The relative amounts of hydrocarbons from biogenic natural organic matter in the sediment, hydrocarbons from non-Line 6B crude oil, and pyrogenic PAHs from other non-Line 6B sources are very relevant to any biodegradation study designed to determine how much and how quickly any Line 6B oil present in the sediment will degrade. Third-party reviewers agree that hydrocarbons, including a majority of the petrogenic and pyrogenic hydrocarbons, in most Kalamazoo River sediments are not related to the Line 6B oil spill. However, more detailed quantitative information should be provided in the biodegradation study to support this conclusion since there may be very low contributions to the PAHs from Line 6B oil after natural, pyrogenic and other petrogenic PAH signatures are accounted for.

- Biodegradation was assessed using gravimetric and quantitative TPH analysis. The quantitative TPH analysis was not used to assess the extent of biodegradation because, according to the report, previous studies have shown that there is a discrepancy between quantitative TPH analysis and gravimetric analysis. The Study explains that "The gravimetric results correlate with literature sources (Attachment 04 – Yang et al, 2011) concerning asphaltene content and how it effects the actual "measured" TPH concentration compared to the gravimetric TPH concentration." The paper cited does not provide an assessment of a comparison between gravimetric and quantitative TPH measurements. It states that the TPH measurements represent

only a portion of the overall hydrocarbon mass and excludes asphaltene and those heavier hydrocarbons that were removed by silica-gel cleanup.

- Given that gravimetric analysis is the principal component used to assess the extent of biodegradation, the report should clarify whether gravimetric analysis samples were taken to constant weight after the solvent was evaporated. No description is provided of the methodology. This is the most important part of the degradation Study given that biodegradation is an assessment of mass lost during the incubation period.

- Extracted residual quantified by TPH analysis does provide a comparison of how much mass is lost over time in this fraction. Furthermore, the Study does not discuss the fact that silica gel cleanup for quantitative TPH analysis also removes polar organic compounds that represent the biodegradation byproducts which are presumably less toxic. Therefore, the gravimetric analysis may include partially polar biodegradation byproducts in the residual untreated mass. It may be more accurate to report the quantitative TPH measurement of mass removal and the gravimetric results as two different ranges of potential biodegradation occurring.

Forensic Evaluation of Petroleum Hydrocarbons

- The overall quality of the forensic evaluation and associated report is marginal for the following reasons:
    - The TPH and the GC/MS gas chromatograms are reduced at least three to six times, which makes it more difficult to evaluate and interpret the information.
    - An analytical standard is not provided for the chromatograms.
    - There is a lack of quantifying data and results given (in peak area or peak height).
    - The individual peaks on the GCs are not identified or labeled.
    - The first five minutes of the TPH fingerprints (GCs) and the first 25 minutes of the Hopane fingerprints (GCs) are not provided for review of the compounds that would emit earlier in these runs.
    - An indication was not provided on whether the samples were extracted for gas chromatography analysis.
    - Varying scales of the gas chromatograms with no reference to the changes causes difficulty in making comparisons.

- The Study concludes that "*The hopane fingerprints of EX01 and EX02 can be used as evidence that the line 6B oil is present in the sediment. There is a "partial match" of the sediment hopanes when compared to the spilled oil because of naturally occurring hopanes produced from organic plant debris that cannot be separated out*". The visual similarity of hopane and other terpane patterns alone cannot be used for confirmation of the presence of Line 6B oil because other crude oil sources may display very similar overall terpane patterns. Multiple diagnostic ratios of specific target analytes unique to Line 6B must be used to confirm the presence of Line 6B oil and the interferences of non-Line 6B petroleum sources, as well as pyrogenic hydrocarbons from other sources, must be quantitatively removed to calculate the actual allocation of Line 6B oil as a source to the sediment hydrocarbons. No specific diagnostic ratio data or target compound analysis is presented in the Study.

- Sample 0004 is presented to be a "mechanically' weathered version of Sample 0003. Based on the data presented in the report, the only fingerprint data are TPH chromatograms and hopane biomarker (ion 191) chromatograms. Given the site setting, third party reviewers concur that "*sample 0003 and 0004 are from the same source*". However, use of limited fingerprint data for source

determination is problematic. Hopane fingerprints can't be used as conclusive evidence for source determination as crudes of different sources can have very similar hopane fingerprints (see Wang *et al.*, "Petroleum biomarkers for oil spill characterization and source identification" in Wang and Stout "Oil Spill Environmental Forensics", Academic Press, 2007). In Wang, et al., 2007, a California crude and a Platform Elly crude were compared. As can be observed, the hopane fingerprints look very similar; but sterane fingerprints (ion 217) are distinctly different. Other biomarkers should be considered for analysis, especially steranes and aromatic steroids. Use of limited hopane data to conclude that samples taken from the site are from the Line 6B may overestimate the impact from the spill.

- The Study notes "*the oil extracted from the sediments collected from location 10.75 exhibited fingerprints that matched the line 6B oil, but the majority of hydrocarbons that are typically calculated as TPH are actually from naturally occurring background organic material. The hopane fingerprints of EXO1 and EX02 can be used as evidence that the line 6B oil is present in the sediment. There is a "partial match" of the sediment hopanes when compared to the spilled oil because of naturally occurring hopanes produced from organic plant debris that cannot be separated out.*" Hopane fingerprints can't be used as conclusive evidence (see the discussion above and Wang, et al., 2007 previous comments). Assigning all the hopane compounds to the Line-6B spill may include other sources, and, therefore, overestimate the impact. (Wang, et al., 2007)
- Evaluation of Genetic Relationship of Oil Samples by Third Party Reviewer: Plots of the isoprenoids IP-13, IP-14, IP-15, IP-16, IP-18 (pristane) and IP-20 (phytane) were created for Samples 0003 (pipeline crude), 0004 (bank crude), and 0000 (skimmed oil from sediments). Due to the absence of qualified data and the very reduced size of the gas chromatograms, the genetic relationships are only estimates. See **Attachment A** for plots of Isoprenoid Plot A and Isoprenoid Plot B. These plots appear to suggest that the oil in Samples 0003 and 0004 are more than likely from the same source/release, whereas, the oil in Sample 0000 may also be from the same source but may have been altered by other petroleum/hydrocarbon related sources (as the Study also states). Crude oil in Samples 0003 and 0004 appear to correlate to each other but the crude oil in Sample 0000 does not directly correlate, most likely due to naturally occurring hydrocarbons as well as non-Line 6b hydrocarbon sources.

- A case study example of a "similar oil" sample and resulting chromatographic signature is presented in EX06A as an analog for degradation of Line 6B oil over an 84 Day Degradation Study. However, the exhibit does not show the source of the oil or note whether the oil was original bitumen in this sample.

General Observations on Study Conclusions

- The Study concluded that residual oil related to the Line 6B release within the Kalamazoo River has the potential to undergo further degradation. The Study estimated that approximately 25 percent of the TPH was degraded within the first 14 days of the aerobic test. Biodegradation continued following Day 14 but the aerobic degradation rate declined. The report concludes that *"the absolute amount of oil which may be removed via degradation is limited to roughly 25% of the current residual oil mass*", but Table 7 data seems to indicate a removal rate between 57% and 65% on Day 14 of the study, which seems to contradict this conclusion. The detailed basis for the conclusion should be explained.

- Moreover, the degradation study based on solutions with added surfactant in flasks on an orbital shaker under oxic conditions at 30°C do not simulate the degradation of oil globules under anoxic conditions buried in Kalamazoo River sediment or the degradation of oil in the suspended sediment where no surfactant is present. The partially weathered oil in Sample 0004 used for the study is also significantly different than the highly weathered residual oil in Sample 0000 derived from real residual oil sheen/globules in Kalamazoo River sediment. The absence of dominant n-alkanes in Sample 0000 clearly indicates advanced biodegradation in sheen/globules derived from the sediment has already occurred, so the relevance of the study using much less weathered Sample 0004 is unclear. The report provides only an unquantified analogy with an unrelated oil resembling Sample 0000 in another study.

Contributors:

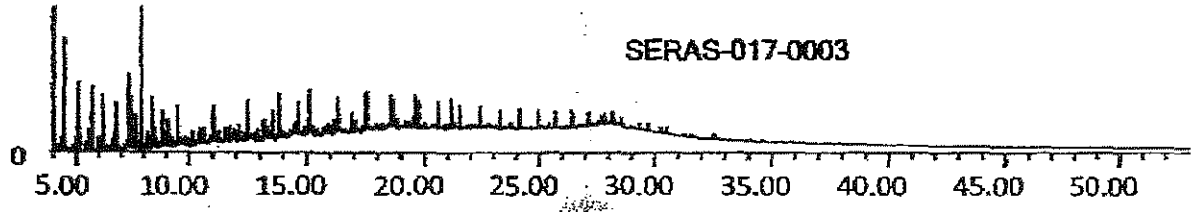
Paul Donovan, P.E., Leggette, Brashears & Graham, Inc.
Barry Harding, CPG, AECOM
Robert Kennedy, AECOM
Jun Lu, Ph.D., AECOM
Angus McGrath, Ph.D., Stantec
Gene W. Schmidt, CGWP & PHG, GW/S Environmental Consulting
Jennifer Shelton, P.E.; Leggette, Brashears & Graham, Inc.

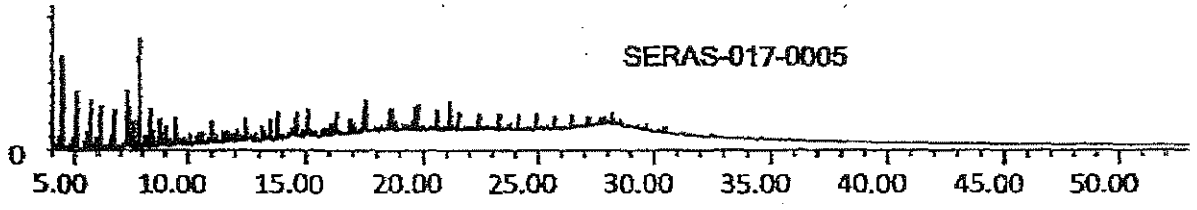
Table 1
Summary of ERT Oil Biodegradation Study Report Samples
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

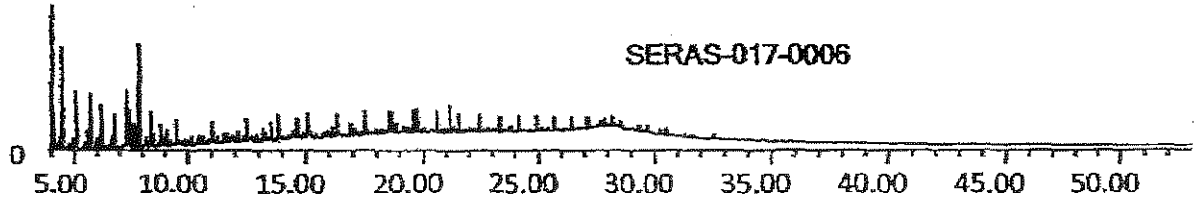
ERT Sample	Matrix	ERT Description from Report	Original Oil Sample Name	Synopsis of Relevant Findings
0000	Oil Skimmed from Bucket	In an effort to understand the composition of the residual oil within the sediments, the sediments within one of the buckets of sediment from 10.75 was disturbed and oil globules which migrated to the water surface were collected and analyzed by the oil fingerprinting techniques. This oil sample collected by ERT is referred to as SERAS-017-0000		Sediment contained < 200 mg/Kg of TPH. THP concentrations were deemed insufficient to conduct biodegradation assessment. TPH content of river sediments appears to be dominated with naturally generated compounds and contamination sources other than Line 6B release. Isoprenoid plots suggest that the oil in Sample 0000 may be from the same source as 0003 and 0004 but may have been altered by other petroleum/hydrocarbon sources. Estimated nC-17/Pr ratio of 0.11.
0001	Sediment	Two 5 gal buckets of oil contaminated sediment were collected by Region 5 START from location 10.75 and shipped to ERT in Edison NJ. FIRST BUCKET		
0002	Sediment	Two 5 gal buckets of oil contaminated sediment were collected by Region 5 START from location 10.75 and shipped to ERT in Edison NJ. SECOND BUCKET		
0003	Oil	During the initial response, released oil was recovered and sent to a processing facility in Indiana; at that facility, a portion of the recovered oil had been stored. A request was submitted to obtain a sample of this oil recovered from the initial oil spill response. This recovered oil is suspected to be "fresh crude" that had not undergone significant mechanical weathering as evidenced by the observed low viscosity and other physical characteristics.	OLXX recovered 2010	Isoprenoid plots suggest that the oil in Sample 0003 and 0004 are likely from the same release. Estimated nC-17/Pr ratio of 1.07
0004	Oil	An alternative Line 6B residual oil sample was found and obtained during a bank excavation at MP 13.40 in a subsurface void. This residual oil was highly viscous and believed to be mechanically weathered within the Kalamazoo River.	OLKR 1340L01	Isoprenoid plots suggest that the oil in Sample 0003 and 0004 are likely from the same release. Estimated nC-17/Pr ratio of 0.73
0005	Oil	Corresponds to Sample No. WCS-68-072223-092910-JPS-KA-002-20. Two bottles received with custody seal # 701795.	WCS-6B-072223-092910-JPS-KA-002-20	Sample collected directly from Line 6B
0006	Oil	Corresponds to Sample No. CL-68-072223-09271O-JPS-KA-001-33. Two bottles received with custody seal # 701688.	CL-6B-072223-092710-JPS-KA-001-33	Sample collected directly from Line 6B
Not Used	Oil	Not Used	DS02 MARSHALL OIL RESPONSE	DS02 MARSHALL OIL RESPONSE

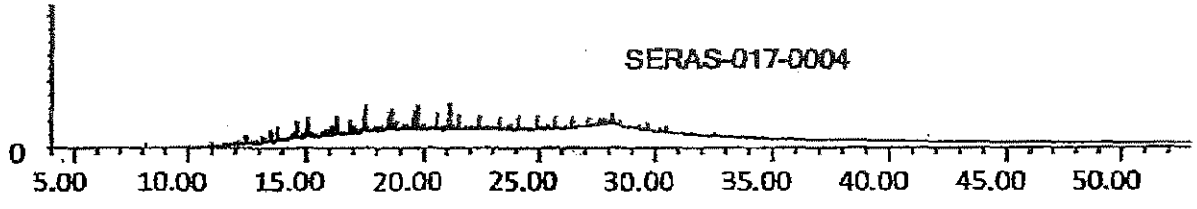
ATTACHMENT A

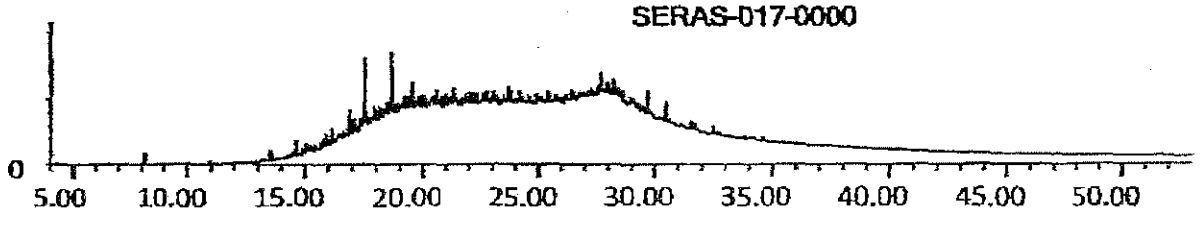
EX03: TPH Fingerprints







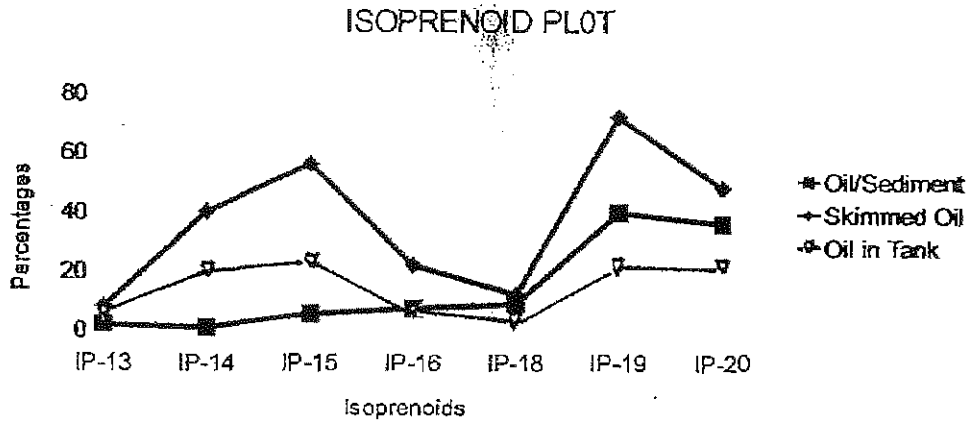




Sheet1

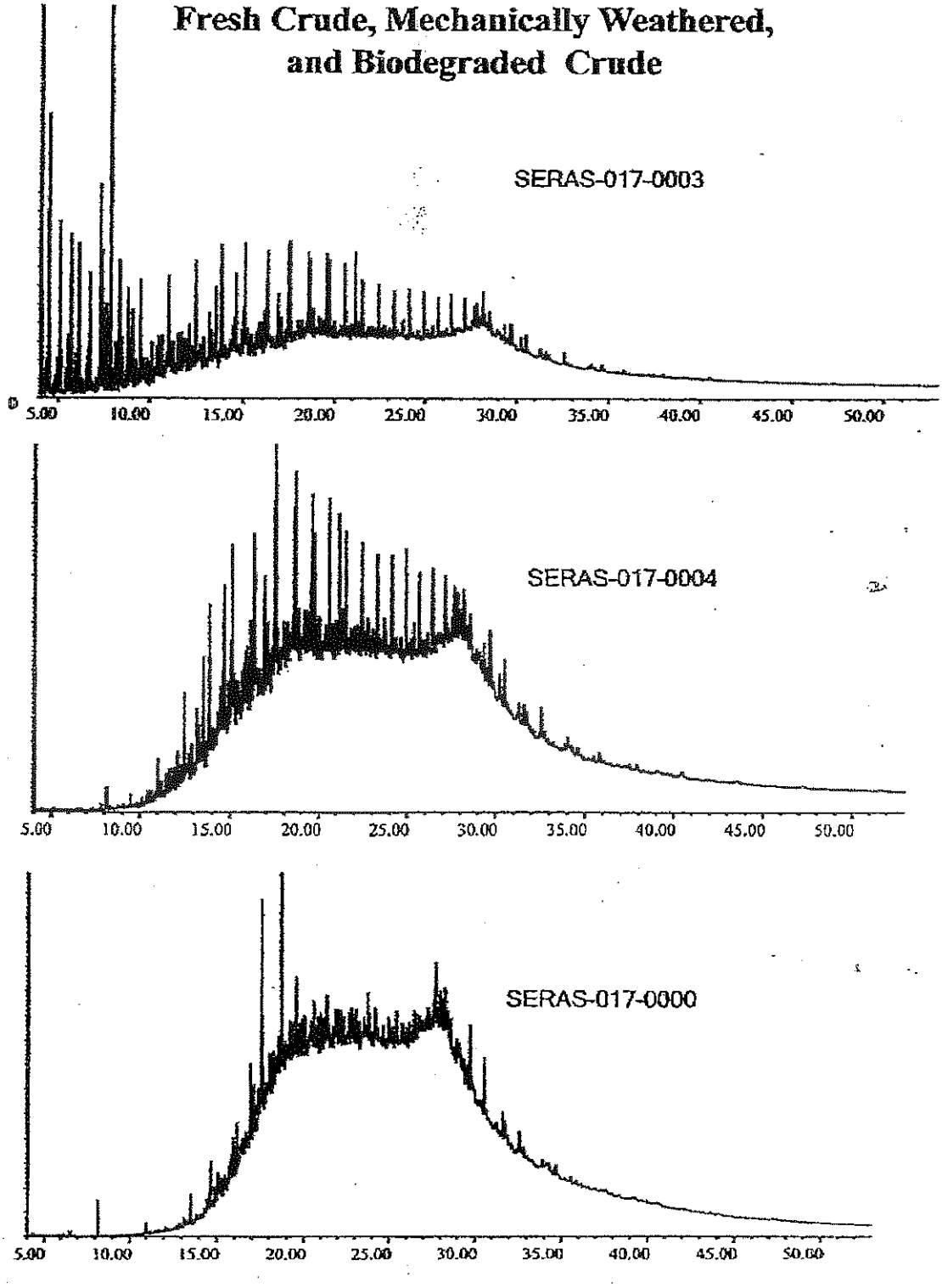
PLOT A

	Oil/Sediment	Skimmed Oil	Oil in Tank
IP-13	1.8	8	5.7
IP-14	0.9	40	20
IP-15	5.4	56	22.9
IP-16	7.2	22	5.7
IP-18	9	12	2.9
IP-19	39.6	72	21.4
IP-20	36	48	21.4



Oil in Tank is SERAS-017-0003
Skimmed Oil is SERAS-016-0004
Oil/Sediment is SERAS-017-0000

EX05: TPH Fingerprints Illustrating Fresh Crude, Mechanically Weathered, and Biodegraded Crude

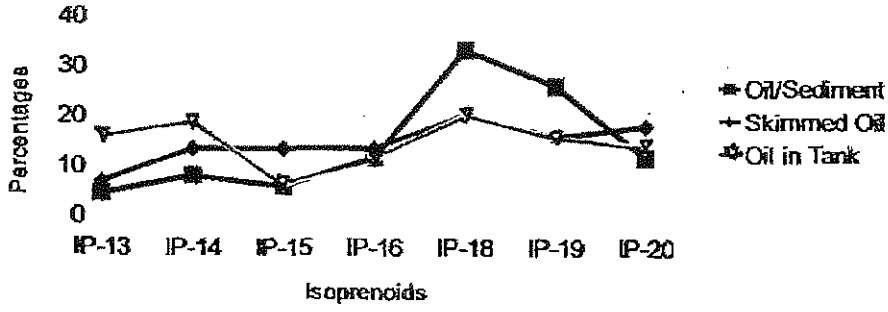


Sheet1

	Oil/Sediment	Skimmed Oil	Oil in Tank
IP-13	4.3	6.7	15.4
IP-14	7.9	13.3	18.5
IP-15	5.8	13.3	6.2
IP-16	11.5	13.3	10.8
IP-18	33.1	20	20
IP-19	25.9	15.6	15.4
IP-20	11.5	17.8	13.8

PLOT B

ISOPRENOID PLOTS



Oil in Tank is SERAS-017-0003
Skimmed Oil is SERAS-017-0004
Oil/Sediment is SERAS-017-0000

Paul B. Donovan has over seventeen years of environmental engineering and project management experience associated with the investigation and mitigation of numerous environmental impact sites, including: retail fuel facilities; chemical storage and transfer facilities; bulk petroleum terminals; agricultural chemical facilities; brownfield redevelopment sites; commercial and industrial properties; and residential and/or commercial properties impacted by adjacent facilities. He has a strong and diverse foundation of field experience, and has managed many projects from inception to closure. He has completed comprehensive feasibility studies, cost-benefit analyses, remedial designs and specifications, installations, operations, and project close-outs. He has evaluated and closed many sites based on risk analyses. He has corresponded and negotiated with state regulatory agencies to develop and implement work plans for completing remedial investigations and analyses to satisfy agency concerns at reasonable costs to clients. He has completed work following requirements to maintain client eligibility in reimbursement programs when applicable.

Paul's remedial design experience includes multi-phase extraction (MPE), soil-vapor extraction (SVE), air sparging (AS), dissolved oxygen injection (DOI), groundwater pump-and-treat, density driven convection (DDC), free-product recovery, and remedial excavations. He has experience in programmable logic control (PLC), Supervisory Control and Data Acquisition (SCADA) system, and Human Machine Interface (HMI) system programming to allow for remote monitoring and control of installed systems.

EDUCATION

B.S. in Environmental Engineering Technology, Summa Cum Laude, 1992, Temple University, Philadelphia, Pennsylvania

M.S. in Environmental Engineering, 1994, University of Notre Dame, South Bend, Indiana

REGISTRATION

Registered Professional Engineer – Minnesota #25867

SUMMARY OF PROFESSIONAL EXPERIENCE

2011 to present:
Associate with Leggette, Brashears & Graham, Inc., St. Paul, Minnesota

2001 to 2011:
Senior Environmental Engineer with Leggette, Brashears & Graham, Inc.,
St. Paul, Minnesota

2000 to 2001:
Environmental Engineer with SERVICE Environmental & Engineering, Inc.,
St. Paul, Minnesota

1995 to 2000:
Environmental Engineer, with Summit Envirosolutions, Inc., St. Paul, Minnesota

1991 to 1992:
Environmental Engineer, with Camp, Dresser & McKee Federal Programs,
Wayne, Pennsylvania

SPECIFIC EXPERIENCE IN FEASIBILITY STUDIES AND COST-BENEFIT ANALYSES

LBG's Liability Sharing/Risk Transfer Program
Reviewed a number of sites and prepared best case, most-likely, and worst case project plans and cost scenarios to evaluate liability and risk.

Kansas City, Kansas
Prepared a detailed and media-specific feasibility study and cost-benefit analysis to analyze multiple remedial options for an active petroleum terminal with over 22 acres of free product observed at the water table. Evaluated the site risks and considered the regulatory environment to develop a realistic remedial goal that was practical, economically feasible, and acceptable within the regulatory framework established by Kansas. Analyzed remedial alternatives based on their ability to target and treat the most heavily impacted environmental media identified by a mass-distribution analysis. Appropriate models were used to estimate the time to-, and degree of remediation for specific remedial alternatives. Prepared detailed cost estimates for design, installation, operation and maintenance for each specific alternative, and conducted a present value analysis using the estimated time to remediation derived from modeling for each alternative. The cost-benefit analysis completed indicated that the client would save over $1,000,000 in present value over the life of the project by implementing a specific combination of remedial technologies over several of the proposed remedial alternatives.

Cottonwood, Minnesota
Prepared a feasibility study and cost benefit analysis to determine the most cost effective approach to mitigate a significant pipeline release of gasoline and diesel. Remedial alternatives analyzed included excavation, landfarming, landfilling, in-situ biopile, ex-situ biopile, soil vapor extraction, multi-phase extraction, pump-and-treat, ex-situ thermal treatment, phyto-remediation, and free-product recovery. LBG was awarded the project as a result of the cost-saving, innovative approach recommended to remediate the site based on the feasibility study/cost-benefit analyses.

Joplin, Missouri
Reviewed the feasibility of multiple remedial technologies to mitigate volatile organic compound impacts to low permeability soils overlying fractured bedrock. Remedial technologies analyzed included steam injection and extraction, MPE, SVE, excavation, and six-phase heating.

SPECIFIC EXPERIENCE IN INDOOR AIR QUALITY ASSESSMENT AND MITIGATION

Anoka, Minnesota

Project Engineer for an indoor air quality evaluation and sub-slab ventilation system project at a former manufacturing facility now occupied by school district offices and kindergarten and pre-school classrooms. Chlorinated volatile organic compounds (cVOCs) from previous manufacturing activities had impacted soil and shallow groundwater at the site. The presence of sensitive populations prompted the Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Health (MDH) to require evaluation of indoor air quality at the facility, and to implement measures to eliminate potential exposure to sub-slab vapors. Designed, installed, and tested a facility-wide sub-slab ventilation system to maintain a negative pressure below the building slab. Prepared an operation and maintenance manual for the sub-slab vent system for the current property owners. Testing of the system was witnessed by the MPCA and MDH, and site closure status with the MPCA was received shortly thereafter.

Kansas City, Kansas

Project Engineer for the remediation of a large active bulk petroleum storage terminal and transfer station. Historical petroleum impacts to soil and groundwater resulted in indoor air quality issues at the site. A previous explosion on the facility was attributed to subsurface vapor migration to an existing electrical structure. Evaluated indoor air quality and sub-slab vapors, and proposed, designed and implemented engineering controls, including: sub-slab ventilation systems and positive pressure HVAC to eliminate vapor migration and exposure in affected occupied structures; and vapor monitoring systems to constantly monitor the indoor air quality. Partnered with Hygieneering, Inc. to draft procedures to be followed in the event that petroleum vapors were detected in an occupied structure. Prepared a full scale remediation system design to remove the source of the vapors in the subsurface.

Minnetonka, Minnesota

Project engineer for a land redevelopment project. Responsibilities included coordination with contractors, excavation oversight and excavation monitoring of PCE impacted soil. Designed a passive soil venting system to remedy MPCA concerns of cVOCs impacting a future apartment complex. Recommended the installation of a vapor barrier as added protection for any future site structure.

Mandan, North Dakota

Engineer of Record for the remediation of a large diesel fuel plume beneath several city blocks of a downtown business district. An estimated 3 million gallons of diesel fuel was released from suspected fuel transmission lines associated with a nearby rail yard, and indoor air impacts have been observed at several locations. Designed, installed and started one of the largest remediation systems in the State of North Dakota. Forty-one remediation wells were installed in the basements of structures located above the diesel plume to mitigate potential impacts to indoor vapors.

.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION

Huntsville, Alabama
Project Manager and Engineer for a remediation project at a former electronic component manufacturing facility. The site is regulated by the Alabama Department of Environmental Management (ADEM). The compounds of concern at the site are trichloroethane and its degradation products. Initial responsibilities included providing installation oversight of a large MPE/SVE system with modifications to an existing groundwater remediation system, facilitating communications with client, contractors, vendors, potential bidders and consultants, developing bid documents for system operation and maintenance activities, reviewing and debugging system PLC programs, and developing a system O&M manual. Follow-up responsibilities included management of junior staff to operate and maintain the system, preparing and reviewing reports including the preparation of a comprehensive risk assessment completed under the direction of the then, newly drafted ADEM Risk Manual, managing the project budget, and communicating with the client and regulator.

Newark, Delaware
Project Engineer for the remediation of solvent impacts at a former automotive assembly plant. Responsibilities included troubleshooting, modification and optimization of a MPE/SVE system with an electric catalytic oxidizer unit for air treatment.

Des Moines, Iowa
Project engineer for a remediation project at an aviation fueling facility. The site was utilized as a bulk fuel storage facility for jet fuel and aviation gas. Free product was observed adjacent to the tank basin. Performed SVE pilot testing activities, completed air permitting to install temporary SVE system, designed and implemented the SVE system, provided drilling oversight, supervised well installation activities, observed excavation and removal of underground storage tanks, and completed ground-water activities. Assisted in completing risk based corrective action (RBCA) Tier I, and Tier II modeling to demonstrate that the site petroleum hydrocarbon impacts posed a low risk to human health and the environment.

Des Moines, Iowa
Project manager for a jet fuel leak site at a former aviation fueling facility. The site was a former bulk fuel storage and loading area. The compounds of concern included benzene, toluene, ethylbenzene, xylenes, and total petroleum hydrocarbons as diesel. Responsibilities included review of previous investigation activities, negotiating with the Iowa Department of Natural Resources (IDNR), developing work plans and completing additional site investigation activities, completing airport access permits, and completing RBCA Tier I, and Tier II reports to show modeling to demonstrate that the site petroleum hydrocarbon impacts posed a low risk to human health and the environment. Negotiations with the IDNR provided site closure pending an off-site well abandonment.

Early, Iowa
Project Engineer for a remediation project at an agricultural chemical transfer facility. The facility was operated by two separate companies. The compound of concern at the site was ammonia. Responsibilities included design support, installation services, and monitoring of a soil-vapor extraction (SVE) system. System data was used to support reduced client financial responsibility for site remediation activities.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

Thornton, Iowa

Project Engineer for a pipeline release clean-up effort adjacent to a residential property. Directed the excavation and off-site disposal of impacted soil around the pipeline. Collected soil and groundwater samples for verification of cleanup analyses, and for forensic analyses to determine the age of the release. Data obtained verified that the petroleum impacts observed were related to a much older release under different management of the pipeline. Prepared a summary report of the work activities and results for the IDNR, and subsequently received a "no further action" letter from the State.

Kansas City, Kansas

Project Engineer for the remediation of a large active bulk petroleum storage terminal and transfer station with an estimated 1.5 million gallons of released gasoline and diesel fuel. A free product plume over 22 acres in size was delineated. Prepared a comprehensive feasibility study and cost-benefit analysis to determine the most cost-effective approach to remediation. Designed and directed MPE, SVE, air sparge, and density-driven convection pilot testing activities. Completed all design layouts, structure, calculations, specifications and permits for a large scale MPE/SVE/air-sparge system to be implemented over a 5-year period. Directed installation, start-up and operation of the initial design phase. The initial phase of the design included two 50 horsepower SVE systems, four 30 horsepower air sparge systems, four 7.5 horsepower MPE systems, a groundwater treatment system, a state-of-the-art air treatment system (a Flame Oxidizer) and over 40 remediation wells. This phase was completed in October 2005, and removed the equivalent of approximately 112,000 gallons of petroleum in the first 5.5 months of operation.

Kansas City, Kansas

Project Engineer for the remediation of cVOCs in groundwater at a former adhesive manufacturing facility. The site was entered into the Voluntary Cleanup and Property Redevelopment Program (VCPRP) of the Kansas Department of Health and Environment (KDHE). Under a very limited budget, Voluntary Clean-Up Proposal and Voluntary Clean-Up Plans were submitted to- and approved by the KDHE in 2007. The Voluntary Clean-Up Plan included the design of a flexible soil-vapor extraction/air-sparge system to remediate the cVOC impacts to shallow and intermediate depth groundwater. The design allows for easy injection of an electron donor (such as sodium lactate and soybean oil) for enhanced reductive dechlorination as a final polishing step, if required. The system was installed in 2008, and in less than 1 year of operation, reduced the concentrations of cVOCs to below KDHE Tier II clean-up values.

Minnesota

Project manager, project engineer, and field supervisor for a number of leaking underground storage tank sites in Minnesota. Sites were regulated by the MPCA and eligible for reimbursement funds through the MDC Petrofund. Responsibilities included completing client, contractor, MPCA and MDC communications and negotiations, cost estimates and work plan development, remedial investigations, risk assessments, reporting, and modeling. A majority of the sites managed received closure status from the MPCA and 90 percent reimbursement from the MDC.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

Chaska, Minnesota
Project Engineer for a land redevelopment project. Responsibilities included excavation oversight and monitoring of PAH and petroleum hydrocarbon impacted soils. Supervised the removal of petroleum hydrocarbon impacted soil during the installation of a storm sewer.

Cottonwood, Minnesota
Project Manager and Engineer for a 700-barrel gasoline/diesel pipeline release project regulated under the Minnesota Pollution Control Agency (MPCA). The site was located in the middle of farmland, and access to utilities was limited. To compound the difficulty of the cleanup efforts, the site was centered on a topographic high, and the geology consisted of a complex glacial till. Design, installed and operated a unique multi-phase extraction/soil-vapor extraction, pump-and-treat, and groundwater treatment system. Treated groundwater was either spray-irrigated or discharged to a local drainage ditch under SDS and NPDES permits. Remedial efforts were closely monitored and optimized to expedite clean-up. Within 3 years of system operations, approximately 14,000 gallons of gasoline was removed and free product was no longer observed in site wells. The site received closure status from the MPCA in 2006, and efficient cleanup efforts and project management saved the project over $100,000.

Duluth, Minnesota
Provided sediment drilling oversight, sediment sampling, vane shear testing of sediments, and slug testing and analysis, for a Superfund site impacted with polynuclear aromatic hydrocarbons (PAH). Reviewed and compared old dock design plans with current information to develop an updated design schematic.

Fridley, Minnesota
Project manager for underground storage tank leak site involving transmission fluid at a commercial facility. The site was regulated under the MPCA. Observed excavation activities, completed a remedial investigation, analyzed risks associated with the release, and prepared a report for site closure. The MDC Petrofund initially would not allow reimbursement for the tank excavation and remedial investigation costs because the contamination was hydraulic fluid, and not petroleum fuel. Through product research and negotiations with the MDC, the client was awarded reimbursement funds.

Minneapolis, Minnesota
Project engineer/manager for a remediation project at an aviation fueling facility. The MPCA regulated the site. Past releases of Jet Fuel produced a layer of free product in surficial ground water observed in till. A SVE system was installed at the site. A passive product collector was also installed in a site monitoring well. Responsibilities included providing system monitoring, operation and maintenance, developing and implementing system modifications, and reporting. Through negotiations with the MPCA, the system was shutdown. Follow-up monitoring demonstrated that free product did not re-appear. The MPCA granted site closure.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

Minneapolis, Minnesota
Project engineer for a brownfield redevelopment project funded by the Minnesota Community Development Agency (MCDA). Responsibilities included excavation oversight of PCB, lead, cadmium, PAH and petroleum hydrocarbon impacted soils. Observed stabilization of lead impacted soils.

Pine City, Minnesota
Project Engineer for an agricultural co-op facility regulated under the Minnesota Pollution Control Agency (MPCA). The site was a former fueling facility for the co-op, and separate leaks were discovered from underground storage tanks containing kerosene, diesel, and gasoline in separate tank basins. Co-mingled free product plumes of diesel and gasoline were observed on and off site in a saturated lense of sandy material in an otherwise clayey till. Responsibilities included review of previous remedial investigation (RI) and pilot testing data, preparation of work plans and implementation of additional pilot tests, development of corrective action design (CAD), coordination with state and local officials to analyze discharge options and develop discharge criteria, implementation of CAD, and operation, maintenance, monitoring, and evaluation of CAD. All work was implemented following MPCA and Minnesota Department of Commerce (MDC) Petrofund guidelines to maintain client eligibility for 90 percent state reimbursement of clean-up costs. The CAD consisted of vacuum-enhanced groundwater and product extraction to remove free product, and mitigate the soil and ground-water impacted by petroleum hydrocarbons. During less than 2 years operation, the system has removed over 3,000 gallons of free product and over 4,000 pounds of VOCs. A human-machine interface (HMI) system utilizing Intellution FIX supervisory control and data acquisition (SCADA) software was programmed and implemented to provide remote operation and monitoring of the system. A system query link (SQL) was also developed to capture a snapshot of system operation data and place the data into a preformatted database through open database connectivity (ODBC). The database was used as a system operations record.

Princeton, Minnesota
Project technician for a herbicide fate and transport research study conducted for a major agricultural chemical manufacturer. Responsibilities included, soil and groundwater sampling utilizing good laboratory practices (GLPs), coordination of field efforts, installation oversight of monitoring wells and piezometers, construction of lysimeters, and maintenance of installed weather station.

White Bear Lake, Minnesota
Project engineer for a remediation project at a retail fuel facility. Conducted SVE and air sparging pilot tests. Evaluated data and provided recommendations for system installation.

Willow River, Minnesota
Project manager/engineer for a remediation project at a retail fuel facility. Developed work plans and performed remedial investigation activities, developed, designed, and implemented CAD. Large free product plume also prompted installation of active free product recovery systems. The site was regulated by the MPCA. Negotiations with the MDC increased reimbursement payment percentage to client despite previous reductions for tank leak detection violation.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

Wrenshall, Minnesota
Project Manager and Engineer for a petroleum release cleanup project at an unmanned pipeline pump station in Wrenshall, Minnesota. Conducted the remedial investigation and designed, installed and operated a SVE system to mitigate impacts to soil. The project received closure status from the MPCA in 2005.

Reno, Nevada
Field engineer for a transformer oil survey at remote utility locations. Coordinated efforts with client personnel, sampled and analyzed various transformers for polychlorinated biphenyl (PCB) oils, and completed a project summary report.

Denville, New Jersey
Project Engineer for the remediation of cVOC impacts to a resource aquifer from a former rocket motor manufacturing facility. Responsibilities include operating, maintaining, troubleshooting, modifying and optimizing an existing pump-and-treat and SVE system, and maintaining compliance with permits and Federal and State reporting requirements.

Paulsboro, New Jersey
Project engineer for a remediation project at a bulk petroleum terminal facility with public relations issues. An existing 250-gallon per minute ground-water pump-and-treat system was evaluated, instrumented and modified to provide more efficient capture of a petroleum hydrocarbon-impacted groundwater plume. A SCADA system was installed to allow greater system monitoring capabilities and control. Fixed and mobile remote transfer units (RTUs) equipped with pressure (water depth level), temperature, conductivity, and dissolved oxygen sensors were installed and linked with the SCADA system. The system was to be designed for future public viewing of real-time system data via the Internet, database storage of system data to be used to constantly calibrate a groundwater model and to determine most efficient use and operation of recovery wells. Responsibilities included assisting in SCADA system design, specifying and procuring system equipment and sensors, coordinating installation efforts with client, three contractors, and two consultants, providing system installation services and oversight, and developing a system O&M Manual. Data generated by the system convinced the State to allow for the abandonment of a recovery well that produced the bulk of system iron-fouling problems.

Rockaway Borough, New Jersey
Project Engineer for the remediation of cVOC impacts to a resource aquifer from a former rocket motor manufacturing facility. Responsibilities include operating, maintaining, troubleshooting, modifying and optimizing an existing pump-and-treat system, and maintaining compliance with permits and Federal and State reporting requirements.

Mandan, North Dakota
Engineer of Record for the remediation of a large diesel fuel plume beneath several city blocks in the center of downtown Mandan. An estimated 3 million gallons of diesel fuel were released from a pipeline adjacent to a railyard. Due to the location of the diesel plume, the North Dakota Department of Health (NDDH) required an expedited construction phase with minimum impact to local businesses. Designed, installed and started one of the largest remediation systems in the State of North Dakota in less than 1.5 years of construction and

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

with practically no disruption to local businesses. The work included pilot testing, preparing designs and specifications, task bidding, coordinating contractors, lining up vendors, securing access agreements, maintaining public relations, and installing: three remediation buildings, 16 remote manifolds, 300 remediation wells, 27 miles of remediation pipe and conduit, multiple MPE and SVE systems, water and air treatment systems, and an integrated control system; and conducting start-up activities. Forty-one remediation wells were installed in the basements of structures located above the diesel plume to mitigate potential impacts to indoor vapors. In less than a year of operation the system has significantly reduced the size of the diesel free product plume.

Sioux Falls, South Dakota

Project Engineer for an asphalt remediation project at a former bulk petroleum storage facility. Historic petroleum hydrocarbon impacts to soil and groundwater were being mitigated by an air-sparge/SVE system, but a property transfer deal was being hindered by the presence of free product. Evaluated and pilot tested a multi-phase extraction system to remove observed recoverable free product from the site. Evaluated and optimized the existing air-sparge and SVE system.

Watertown, South Dakota

Project Engineer for the remediation of a large bulk petroleum storage and transfer facility. A large dissolved-phase petroleum hydrocarbon plume encompassed the site and extends off-site. Previous remedial strategies by others failed to mitigate the plume. Modified existing systems and expanded the operation of a large scale dissolved oxygen injection system. The system practically eliminated the on-site plume and significantly reduced the off-site plume in less than 2 years of operation. Follow-up monitoring of groundwater confirmed the success of the remediation system, and the site was granted closure status by the South Dakota Department of Environment and Natural Resources.

Colfax, Wisconsin

Project Engineer for a remediation project at a cooperative and retail fueling facility. Performed operation, maintenance, and monitoring activities for an existing SVE and air sparging system. Completed system operation reports to demonstrate system effectiveness at removing subsurface VOC impacts. The site was granted closure by the Wisconsin Department of Natural Resources (WDNR). Observed and completed SVE and air sparging abandonment activities.

Osceola, Wisconsin

Project Engineer for a combined agricultural chemical and petroleum hydrocarbon leak site. Site lithology consisted of sandy clay overlying shallow sandstone bedrock. Supervised remedial soil excavation of diesel, ammonia, pesticide, and herbicide impacted soil, performed on-site sample analysis, supervised installation of monitoring wells, and completed surface and ground-water monitoring activities.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER REMEDIATION (continued)

Wausau, Wisconsin
Project Engineer for an emergency response to a 30,000-gallon+ release of gasoline at a terminal located adjacent to a residential area. Historical leaks at the site that previously impacted groundwater in the residential areas resulted in past litigation and numerous claims which were very costly to the client. For this reason, containing contaminants on-site was absolutely imperative. Designed, installed and operated a combination SVE, AS, DDC, DOI, product recovery and pump-and-treat system that recovered the bulk of the release in less than 1 year of operation, and contained all the impacts on-site. Nearly all of the equipment used, including controls, were selected from client's existing stock at sites managed by LBG where equipment was no longer being used – significantly reducing capital costs to client. Use of the existing equipment also allowed immediate construction and operation of systems, avoiding ordering, stocking, and shipping turnaround time delays.

SPECIFIC EXPERIENCE IN SPCC AND CONTACT WATER TREATMENT

Richmond, California
Project Manager and Engineer for the design and installation of a new contact water treatment system at a marine petroleum terminal facility. Work involved coordinating with and acquiring permits from numerous agencies. Secondary containment structures meeting SPCC requirements were designed and constructed for treatment equipment. The client was extremely pleased with the design and functionality of the system, and may apply to receive a Green Business award from the City.

Roseville, Minnesota
Project Engineer for a project involving SPCC upgrades to an existing truck and rail car ethanol unloading/loading area. Provided technical support for review of storm water drainage structure design and containment storage volumes. Evaluated proposed designs and researched optional designs for a spill containment area for the truck ethanol unloading area. Prepared a design and cost summary document for the client.

Minneapolis, Minnesota
Project engineer for a spill containment system design project at an aviation fueling facility. The system was designed to divert potential spills from fuel truck loading activities to temporary underground storage tanks. Provided system design support, specification review, contractor coordination, and installation oversight.

Mandan, North Dakota
Engineer of Record for the design, operation and maintenance of one of the largest remediation systems installed in North Dakota. The system includes three separate remediation buildings that each extract both groundwater and diesel fuel from the sub-surface. Secondary containment systems and structures have been incorporated into the remedial design. Use of tanks to store recovered diesel fuel required the implementation of an SPCC plan.

SPECIFIC EXPERIENCE IN WATER SUPPLY

Eden Prairie, Minnesota

Project engineer for a municipal well field operating system. The system was designed to allow operators to monitor and control the wellfield. Specific sensors were installed to monitor pump motor power consumption and motor vibration, flow rate, and depth to water. Provided SCADA programming utilizing Intellution FIX, acquired system equipment and sensors, provided system installation oversight and system support. Provided programming to allow periodic downloading of wellfield data to a Microsoft Access database. The data collected is used to optimize wellfield operation, and to model ground-water flow for a Wellhead Protection Area (WHPA). Coordinated efforts to program ArcView GIS to provide three-dimensional rendering of the aquifer surface using data from the Access database

Washoe County, Nevada

Provided a technical review of an existing municipal wellfield control system. Developed recommendations and an engineering cost estimate to modify existing SCADA to allow for database population of ground-water elevation data. The data was to be used for future well sitting and development of a WHPA.

BIBLIOGRAPHY

Donovan, P. and Peramaki, M.P. 2003. *Remedial Goal Driven, Media-Specific Method for Conducting A Cost Benefit Analysis of Multiple Remedial Approaches.* Presented at a National Ground Water Association Conference in New Orleans, Louisiana, September 2003.

Peramaki, M.P., L. Alm, **P. Donovan**, and B. Granley. 2003. *Multi-Phase Extraction Drop Tube Design for LNAPL Recovery.* The Seventh Annual In-Situ and On-Site Bioreclaimation Symposium, Orlando, FL, June 2-5, 2003.

Barry J. Harding CPG
Senior Professional Geologist

Professional History

Education

MS, Geology, Bowling Green State University, Ohio, 1989
BS, Geobiology, Saint Joseph's College, Indiana, 1987

Years of Experience

With AECOM 10
With other firms 13

Registrations

Certified Professional Geologist, National, #10832 (AIPG), 2004, expires Not Specified

Mr. Harding has over 20 years of experience as a project manager, technical leader and consulting scientist. His areas of expertise include phytoremediaition, vapor intrusion investigations, DNAPL and LNAPL investigations, methane investigations, soil-gas studies, environmental assessments, remedial investigations, geological and hydrogeological investigations, sediment and aquatic investigations, environmental forensics, and field techniques. Mr. Harding has provided senior technical guidance during the investigation and site characterization phases at projects contaminated with fuels; crude oils; aromatic hydrocarbons (BTEX); Trimethylbenzene isomers, MTBE; other petroleum hydrocarbon fractions (light, middle distillate, heavier fractions, lubricants); PAHs; chlorinated aliphatic hydrocarbons (TCE, PCE and associated compounds); PCBs, PBBs, dioxins, furans; phenolics; chlorides; nitrates and phosphates; selenium; endocrine-disrupting compounds (EDCs); lead and organo-lead; mercury, including methylated mercury; hexavalent and total chromium; and nickel. His areas of expertise also include design and monitoring of applied phytoremediation treatment strategies. He is experienced with non-conventional field investigation techniques, including soil-gas, geo-botanical surveying, cone-penetrometer testing (CPT), vibra-core and sonic drilling methods, near-surface geochemistry and biogeochemistry, and aerial photographic interpretation. He has also provided technical support related to bio-hazard safety, including venomous animals, vectors and noxious plants (excluding pathogens and biochemical hazards).

Mr. Harding is Earth Tech’s corporate technical leader in the fields of soil investigations and pore-water investigations. He is also a senior technical resource on both vapor intrusion and soil-gas sampling strategies and vapor intrusion mitigation. Mr. Harding’s graduate research in 1988 included performing a shallow soil-gas survey trending across the Albion-Scipio Oil Field, in South Central Michigan. Target analytes were methane, propane, ethylene and ethane, as part of an unconventional petroleum exploration strategy using near surface geochemistry and geobotany.

In 2008, Mr. Harding was recipient of Earth Tech's (a heritage AECOM

company) Presidential Gold Award for Technical Excellence on an Environmental Project.

Experience

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site Phytodegradation Study, Kalamazoo, Michigan. Senior scientist for an enhanced phytodegradation (phytoremediation) study using native prairie grasses to treat LNAPL and VOC-impacted soils at a brownfields site prior to redevelopment as the Davis Creek Business Park. Work included both conceptual and final design of soil treatment cells using indigenous Midwestern prairie grasses, selection of plant species, development of sampling and monitoring schedule, evaluation of remedial end-point goals, and preparation of a report of findings.

Glenn Springs Holdings, Inc., EPA-Approved Technical Impracticability Waiver, Montague, Michigan. Senior geologist responsible for all aspects of the development of a technical impracticability (TI) waiver for an aquifer impacted with dense non aqueous phase liquid (DNAPL). Responsible for description of TI Zone for aquifer impacted with carbon tetrachloride, tetrachloroethene, hexachloroethane, hexachlorobutadiene, and hexachlorocyclopentadiene. Developed presentation of conceptual model that supported the TI waiver that included groundwater flow, DNAPL impact, evaluation of discharge to surface waters, and risk exposure pathways. Also lead effort to develop estimates of cleanup time frame for continuing existing pump and treat system and also for alternate scenarios. Deployed considerable research skills to benchmark against other TI waivers. Lead scientist on development of DNAPL architecture model.

City of Ann Arbor, Broadway Village at Lowertown Site Redevelopment, Ann Arbor, Michigan. Technical leader for consulting services for a $40 million Brownfield redevelopment of a former dry-cleaning site to new office space, condominiums, and parking garage, where the contaminant of concern is PCE. Providing review and comments on the developer's remediation plan. [04/2007 - 04/2008]

TDY Industries, Vapor Intrusion Investigation, Muskegon, Michigan. Technical leader on soil-gas/vapor intrusion investigation at a 1-million-square-foot manufacturing facility. Work included development of conceptual scope, work plan, field quality assurance protocol, sampling methodologies, interface with regulatory personnel, technical client lead related to soil-gas investigation, and regulatory compliance review. Contaminants of concern are primarily chlorinated volatile organic compounds (CVOC).

TDY Industries, LNAPL Investigation, Muskegon, Michigan. Technical leader on identification and remediation of light-nonaqueous phase liquid (LNAPL) identified at site. Work included forensic chemical analysis and differentiation of LNAPL samples, correlation to known product use at the facility, performance of product bail-down testing; assessment of product recovery measures; evaluation of product recovery techniques, including skimming, manual bailing, petro-trap techniques, and use of sorbents.

TDY Industries, LNAPL Investigation, Muskegon, Michigan. Lead geologist for a purge well and groundwater capture system evaluation. Provided technical support on optimization of groundwater capture system installed to provide containment of volatile organic contaminants and transition metals identified as risks to surface water bodies. Work included performing slug-tests to determine hydraulic conductivity of soils targeted for placement of purge wells. Work included development alternative pumping containment scenarios. Wrote a purge well construction report, with modification of existing containment system.

Michigan Department of Environmental Quality, Adrian Dry Cleaners Site Vapor Intrusion Investigation, Adrian, Michigan. Developed scope of work and served as technical leader on a vapor intrusion/soil-gas investigation at an active dry cleaning facility where tetrachlorethene (PCE or perchloroethylene) was contaminant of concern. Scope of work included preparing a work plan and sampling plan addressing MDEQ-RRD Draft Operational Memorandum 4, Attachment 4 (Soil-Gas and Indoor Air). Applied field activities included installing several soil-gas sampling points, soil-gas sampling using summa canisters, evaluation of gas migration pathways and preparation of a feasibility study addressing vapor mitigation in a residential area. Contaminants of concern include terachlorethene and other chlorinated aliphatic compounds.

Michigan Department of Environmental Quality, Armen Cleaners Site, Ann Arbor, Michigan. Lead scientist on DNAPL investigation at an active dry cleaning facility where tetrachlorethene (PCE or perchloroethylene) was contaminant of concern. Remedial Site Investigation lead. Pre-Design Investigation Lead. Delineated DNAPL situated in shallow sand and silt aquifer underlying residential neighborhood. Extensive soil vapor and vapor intrusion investigation. Development of computer generated extent of contamination model. Lead scientist of feasibility study.

Miscellaneous Basin Infiltration Testing Projects. Developed scope of work for basin infiltration resting (USACOE specifications) for discharge of treated wastewater to target rapid infiltration beds (RIBS). Evaluation of phosphorus loading to infiltration beds. Development of field protocol. Client lead on technical deployment of field services.

US Army Corps of Engineers - Detroit District, Sampling, Great Lakes. Managed USACOE A-E indefinite delivery contracts for sampling on Federal Harbors of the Great Lakes. Work included proposal and cost-estimation preparation; contractor selection; coordination with contractors and venders; selection of technical strategy or approach; implementation of field sampling activities, using a wide range of sampling methods; preparation of health and safety plans (ACOE, Work from Floating Platform); technical document review; preparation of final reports, invoices and final deliverables.

US Army Corps of Engineers - Detroit District, Sediment Sampling, Wisconsin. Performed sediment sampling using experimental box-core sampling device at Milwaukee Harbor and Kinnickinnic River, on Research Vessel *Neeskay,* Center for Great Lakes Studies, University of Wisconsin at Milwaukee. Work was performed in support of EPA Testing and Evaluation Laboratory treatability study for PCBs, PAHs and other recalcitrant compounds in sediment along the Kinnickinnic River.

US Army Corps of Engineers - Detroit District, Sediment Sampling, Sturgeon Bay, Wisconsin. Performed sediment sampling using gravity core and Ponar dredge sampler, in anticipation of sediment characterization prior to dredge work along harbor. Work included collection of sediment samples and elutriate samples from floating platform (boat) in Sturgeon Bay; GPS mapping; GIS platform development, using ArcView software; preparation of final report of findings.

US Army Corps of Engineers - Pittsburgh District, Environmental Assessment, Pennsylvania. Completed an environmental assessment at Lock and Dam No. 4, Monongahela River, near Pittsburgh. Work included drill rig oversight, geological USCS logging of soils, collection of soil samples, construction of monitoring wells, groundwater sampling; surface soil sampling for metals and organics; data QA/QC; preparation of a report of findings.

US Army Corps of Engineers - Detroit District, GIS, Great Lakes. Performed GIS applications at various Federal Harbors of the Great Lakes. ArcView applications to sediment sampling locations, using NOAA Nautical Chart viewer extension and image viewing software.

Michigan Consolidated Gas Company (MichCon), Taggart Compressor Station, Six Lakes, Michigan. Senior scientist during a total and methylated mercury investigation in a woodland wetland. Coordinated field sampling using low-level mercury sampling techniques; developed sampling strategy, including innovative sample/analysis methodology using low-level (EPA 1631) analysis of SPLP leachate, coupled with acid volatile sulfide (AVS) / sequentially extracted metals (SEM) to determine mobility of mercury in varying sediments (humus and sandy deposits).

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site Source Area Removal Pre-Design Investigation, Kalamazoo, Michigan. Senior geologist responsible for coordinating predesign investigation for removal of petroleum hydrocarbon LNAPL impacted soils in a former refining area at the refinery. Work entailed installation of 20 groundwater monitoring piezometers, advancement of 40 sonic boreholes, vertical profiling of soils using Sudan IV test kits, soil sampling and evaluation of horizontal and vertical extent of contamination. Derived contaminant information was used to develop proposed excavation areas for design drawings and specifications. [2008]

Michigan Department of Environmental Quality - RRD, Dry Cleaner Site Investigations, Michigan. Lead geologist on three dry cleaner projects: Armen Dry Cleaners (Ann Arbor), Adrian Dry Cleaners (Adrian) and Marcy's Cleaners (Howell). Assessed site conditions and evaluated remedial options, including SVE, in-situ chemical oxidation (ISCO), dual-phase extraction, source removal, SSDS, and monitored natural attenuation. [2008]

Michigan Department of Environmental Quality - RRD, Former Sav U Gasoline Retail Facility Site Investigation, Owosso, Michigan. Lead geologist on extent of contamination investigation at a former UST site. Work included vertical aquifer profiling, using Geoprobe tooling, soil and groundwater sampling. Developed a conceptual model for extent of contamination. Prepared report of findings. Provided senior QA/QC. [2008]

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site Phytodegradation Study, Kalamazoo, Michigan. Senior scientist for an enhanced phytodegradation study using native prairie grasses to treat LNAPL- and VOC-impacted soils at a brownfields site prior to redevelopment as the Davis Creek Business Park.

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site Ground-based Infrared Groundwater Mapping Study, Kalamazoo, Michigan. Senior scientist on nontraditional groundwater-to-surface water mapping techniques using thermal imaging methods and image processing techniques.

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site Chemical Oxidation of Soil, Kalamazoo, Michigan. Senior scientist for a project using BIOX reagent to treat LNAPL- and VOC-impacted soils.

Michigan Department of Environmental Quality - RRD, Former Lakeside Refinery Site, Kalamazoo, Michigan. Senior scientist for a project using land-farming and enhanced SVE to treat LNAPL- and VOC-impacted soils.

Michigan Department of Environmental Quality - RRD, Remedial Investigation at the Former Lakeside Refinery Site, Kalamazoo, Michigan. Senior scientist for sediment sampling, pore-water sampling, surface water sampling; sonic drilling, HSA-auger drilling, near-surface direct current geophysics (ER/IP), CPT and Geoprobe investigation techniques.

Michigan Department of Environmental Quality - RRD, TENORM Survey and Low-Level Radioactive Waste Management at the Former Lakeside Refinery Site, Kalamazoo, Michigan. Senior scientist.

Michigan Department of Environmental Quality - RRD, Groundwater to Surface Water (GSI) Investigation of Methylated Mercury in Water and Sediments at the Former Lakeside Refinery Site, Kalamazoo, Michigan. Senior scientist for pore-water, groundwater, surface water and sediment sampling.

Michigan Department of Environmental Quality - RRD (Superfund Sections), Remedial Investigation at the Grand Traverse Overall Supply Site, Greilickville, Michigan. Senior scientist for delineation of a dissolved PCE/TCE plume venting to Lake Michigan. Work included profiling plume over time, contaminant transport modeling, and fate estimation.

Michigan Department of Environmental Quality - RRD, Source Investigation at the Hard Chrome Plating Site, Grand Rapids, Michigan. Senior scientist for development of contaminant transport model by determining chromium geochemistry using Scanning Electron Microscopy, coupled with XRF to determine chromium mineralogy in sub-surface soils.

Michigan Department of Environmental Quality - RRD, Potassium Permanganate Pilot Study, Portside Cleaners, Elk Rapids, Michigan. Senior scientist for a chemical oxidation treatment study for soil contaminated with PCE and TCE DNAPL.

Michigan Department of Environmental Quality - RRD, Remedial Investigation & Feasibility Study at Dickman Road Landfill, Springfield, Michigan. Senior scientist for a chlorinated aliphatic hydrocarbon investigation. Drum burial investigation with co-solvency LNAPL/DNAPL.

Michigan Department of Environmental Quality - RRD, Remedial Investigation, Parma Wells (Bedrock) Site, Parma, Michigan. Senior scientist for a mud rotary drilling into bedrock formation as part of a chlorinated compound investigation. Work included use of tritium dating of groundwater to differentiate groundwater in quaternary sediments from Marshall sandstone aquifer. TCE investigation.

Michigan Department of Environmental Quality - RRD, Magnetek Facility, Owosso, Michigan. Senior scientist for a remedial investigation of TCE and PCE impact to soils and groundwater.

Michigan Department of Environmental Quality - RRD, Hydrogeologic Evaluation, Former Rockwell International Site, Allegan, Michigan. Senior scientist for investigation of PCBs, dioxin, heavy metals and cyanide.

Michigan Department of Environmental Quality - RRD, Landfill Containment Evaluation, Gratiot County Landfill, Michigan. Senior scientist for a polybrominated biphenyl PBB investigation.

Michigan Department of Environmental Quality - RRD, Cap and Slurry Wall Assessment, Gratiot County Landfill, Michigan. Senior scientist using CME continuous sampling core to evaluate bentonite slurry wall integrity and landfill cap competence.

Michigan Department of Environmental Quality - RRD, Fort Gratiot Landfill Containment Evaluation, Port Huron, Michigan. Senior scientist for a UXO investigation.

Michigan Department of Environmental Quality - RRD, Black River Impoundment Bridge-Scour Evaluation, Bangor, Michigan. Senior scientist for an ACOE investigation of erosion at footing/piles of bridge involving chromium and chromium VI.

Michigan Department of Environmental Quality - RRD, Black River Impoundment Sediment Sampling, Bangor, Michigan. Senior scientist for a CrIII and CrVI investigation.

Michigan Department of Environmental Quality - RRD, Tannery Bay Vibra-Core Sampling, White Lake, Michigan. Senior scientist for sediment sampling prior to dredge activities. Contaminants included chromium, hexavalent chromium, PAHs and various other metals.

Michigan Department of Environmental Quality - RRD, Feister Oil Bulk Facility LNAPL Provenance Determination, Wetland, Michigan. Senior scientist for a forensic investigation to determine liable parties bases on fuel geochemistry, fuel oxygenate use and marker components of refined fuel products. LNAPL Investigation.

Michigan Department of Environmental Quality - RRD, Gratiot County Landfill Receptor Survey, St. Louis, Michigan. Senior scientist.

Michigan Department of Environmental Quality - RRD, Crystal Oil Field, Areas of Concern Delineation, Northern Michigan Oil Field Sites, Michigan. Senior scientist for ArcView GIS mapping of chloride-impacted areas and crude oil spills.

Michigan Department of Environmental Quality - RRD, Raisin River Sediment Sampling, Monroe Harbor, Michigan. Senior scientist for navigational chart conversions to ArcView GIS.

Publications

Barry Harding, "Nikola Tesla: Architect of Sustainability," Battelle Conference on Remediation of Recalcitrant Compounds, Monterey, California, May 2010.

Barry J. Harding and Jeffrey D. Spruit, "Occurrence of Overland LNAPL Migration with Sub-Aerial Exposure at a Former Petroleum Refinery ." Battelle Conference on Remediation of Recalcitrant Compounds, Monterey, California, May 2010.

Barry Harding, Jeffrey Spruit, and Daniel Cassidy, "200 Weeks Later: Rhizodegradation of Trimethylbenzenes in Soil at a Former Refinery," (poster) Battelle Sixth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, May 19-22, 2008.

Barry J. Harding and Jeffrey Spruit, "Occurrence of Methane at an Abandoned Oil Refinery," AIPG Annual Meeting, Traverse City, Michigan, Oral Presentation October 2007.

Barry J. Harding and Jeffrey Spruit, "Ground-Based Infrared-Guided Sampling: A Tool for Mapping the GSI," AIPG Annual Meeting, poster presentation, Lexington, Kentucky, October 2005.

Barry J. Harding, "Nikola Tesla: Victorian Age Environmentalist?" AIPG Annual Meeting, Lexington, Kentucky, October 2005

Barry J. Harding, "Nikola Tesla: Victorian Age Environmentalist?" poster presentation, Soil and Groundwater Conservation Society Convention, Rochester, New York, July 2005.

Barry J. Harding, "The PBB Incident and the GCL," Michigan Department of Environmental Quality, Superfund Section, March 2002.

Barry J. Harding, "Soil Removal Action at the Petoskey Petrolane Site," Michigan Department of Environmental Quality, Environmental Response Division, January 2002.

Barry J. Harding, "Remedial Activities at the Black River Impoundment," MDEQ-ERD/Village of Bangor, Michigan, May 2001.

Barry J. Harding, Research Grant: "Chromium Uptake and Biogeochemistry of Cat-tail (Genus Typhus) at the Black River Impoundment," Bangor, MI. MDEQ-RRD, Kalamazoo District.

Presentations

Barry Harding, "Nikola Tesla: Architect of Sustainability," Battelle Conference on Remediation of Recalcitrant Compounds, Monterey, California, May 2010.

Barry J. Harding and Jeffrey D. Spruit, "Occurrence of Overland LNAPL Migration with Sub-Aerial Exposure at a Former Petroleum Refinery ." Battelle Conference on Remediation of Recalcitrant Compounds, Monterey, California, May 2010.

Barry Harding, Jeffrey Spruit, and Daniel Cassidy, "200 Weeks Later: Rhizodegradation of Trimethylbenzene Isomers in Soil at a Former Refinery," accepted for Conference Proceedings, Battelle Conference on Remediation of Recalcitrant Compounds, Monterey, California, May 2008.

Barry J. Harding and Jeffrey Spruit, "Oil-in-Soil Volume Estimation using Three Different Techniques at an Abandoned Petroleum Refinery in South-Central Michigan."

Barry J. Harding and Jeffrey Spruit "Plant-Assisted Bioremediation of Trimethylbenzene Isomers in Soil at a Former Petroleum Oil Refinery, South-Central Michigan," AAPG Annual Meeting, Columbus, Ohio 2004.

Barry J. Harding, "Nikola Tesla's Contributions to Geophysics," *GSA Abstracts with Programs,* Vol. 24, No. 7, 1991.

Barry J. Harding and J. Parrish, "Effects of Light Hydrocarbons on Tree Morphology: Albion-Scipio Oil Trend," *GSA Abstracts with Programs,* Vol. 21, No. 6, 1989.

Robert K. Kennedy
Senior Project Chemist

Professional History

Education

BA, Chemistry, Wichita State University

Years of Experience

With AECOM 6
With other firms 23

Technical Specialties

Laboratory Auditing
Laboratory Data Review and Validation
Data Usability Assessment
Regulatory and Technical Support
Chemical Analytical Methodology
Wastewater Analysis
Solid and Hazardous Waste Analysis
Quality Assurance/Quality Control

Professional Affiliations

American Chemical Society

Mr. Kennedy is a Senior Project Chemist in the Quality Assurance group of the Specialty and Emerging Technologies Department in the Westford, MA office of AECOM Environment. He is currently responsible for supervising data validation and laboratory services to AECOM projects in the Northeast and other regions. He serves as consulting chemist on projects throughout AECOM, providing assistance in analytical program design, laboratory auditing for program compliance, and interpreting chemical data for industrial and government clients. Mr. Kennedy has 29 years of experience in environmental analytical chemistry, including 23 years in laboratories generating, reviewing, and interpreting chemical data. He is familiar with a wide range of both organic and inorganic methods, including new methods for emerging contaminants, the associated QA/QC procedures, and data quality assessment from a regulatory perspective. Particular areas of expertise include (1) PCB analysis both as Aroclors and congeners by GC/ECD and congeners and homologs by GC/LRMS and GC/HRMS techniques; (2) volatile organics by GC/MS, GC/PID, and GC/FID; (3) semivolatile organics by GC/LRMS, GC/HRMS, and GC/FID; (4) pesticides by GC/ECD, GC/LRMS, and GC/HRMS; and (5) petroleum hydrocarbons by GC/FID and GC/LRMS with forensic interpretation. Past responsibilities have included those of analyst, supervisor, QA officer, technical director, laboratory director, project manager, and consulting senior chemist

Experience

Environmental Laboratory Auditing and Assessment, Multiple Facilities. Lead auditor for project specific assessments of laboratory performance involving reviews of all relevant laboratory Standard Operating Procedures, review of performance evaluation of blind sample performance testing results, review of laboratory Quality Assurance Manuals for compliance with NELAC and project corrective action requirements, on-site interviews with analysts, supervisors, and quality assurance managers to verify method QA/QC compliance and corrective action effectiveness. Responsible for auditing compliance with RCRA, CERCLA, and NPDES program quality requirements in multiple states and EPA regions.

Tronox, Environmental Conditions Assessment, Henderson Facility, Henderson, Nevada. Senior project chemist for ECA at BMI complex where manganese dioxide, boron, boron halides, sodium chlorate, ammonium perchlorate chlorinated solvents, organophosphorous intermediates, and chlorinated pesticides were produced. Responsible for analysis of site related chemicals list and planning of analytical protocols, modification of QA Project Plan, laboratory coordination, laboratory technical oversight, laboratory auditing, and data validation management. SRCs include natural radionuclides, metals, anions including perchlorate, TPH, fuel alcohols, organochlorine pesticides, organophosphorous pesticides, PCBs (both Aroclor and congener specific), volatiles, semivolatiles, chlorinated dioxins/furans, asbestos by elutriator method, and formaldehyde. Responsible for database and reporting compliance with site specific risk assessment driven regulatory requirements by state agency.

Confidential PRP Group, Remedial Investigations/Feasibility Study, NY/NJ Area River Project. Senior project chemist for water and sediment sampling and analysis program. Responsible for project specific laboratory SOP modifications, analyte list refinements, method selection and planning of analytical protocols, on-site laboratory audits, UFP QAPP creation, laboratory coordination, and technical data evaluation. COPECs include radionuclides used for sediment dating, metals, AVS/SEM, TOC, nutrients, DRO, GRO, pesticides by both GC/ECD and HRMS, PCB congeners by HRMS, PCBs as Aroclors by GC/ECD, volatiles, semivolatiles, PAHs by isotope dilution LRMS, chlorinated herbicides, and chlorinated dioxins/furans. Responsible for analytical design of chemical water column monitoring program including high volume sampling for ultratrace level hydrophobic organic contaminants, completion of equilibrium partitioning study of PCB congeners between pore water and sediment , as well as evaluating impact of methodological differences between current, historical, and split sample datasets.

Confidential PRP Group, Remedial Investigations/Feasibility Study, NY Area Waterway Technical assistance for project specific laboratory SOP modifications, analyte list refinements, method selection and planning of analytical protocols, UFP QAPP creation, laboratory selection, and technical data evaluation. COPECs include radionuclides used for sediment dating, metals, AVS/SEM, TOC, nutrients, DRO, GRO, pesticides by both GC/ECD and HRMS, PCB congeners by HRMS, PCBs as Aroclors by GC/ECD, volatiles, semivolatiles, PAHs by isotope dilution LRMS, SHC and geochemical biomarkers

Pepco Holdings Inc, Transformer Oil Spill Shoreline Assessment, Potomac River Substation Coordinating lab services for soil, sediment, surface water, and pore water analysis for PCBs by HRMS, PAHs by isotope dilution LRMS, geochemical biomarker analysis, VOCs, SVOCs, and metals. Responsible for method selection, specification of QA/QC requirements, data validation oversight, and interpretation of forensic data.

Enbridge Energy, Line6B Spill Site, Marshall, Michigan
Coordinating lab and data validation services for emergency response soil, sediment, groundwater, surface water, and drinking water analysis for crude oil related VOCs, SVOCs, and metals. Responsible for QAPP revision, laboratory audits, and split sample problem investigation with corrective action. Analysis of forensic data for saturated hydrocarbons, alkylated PAHs, geochemical biomarkers to assess oil sources.

BNSF, KRY, Kalispell, Montana Review of historical data problems and design of method modifications to correct problems with extraction efficiency, leaching efficiency (SPLP), and analytical accuracy for pentachlorophenol analysis in correlation study.

Confidential Industrial Client, Mill Pond in Connecticut. Project chemist for sediment, surface water, and tissue analysis of PCBs (congener specific and Aroclor based), low-level mercury and methyl mercury, AVS/SEM, and metals. Responsible for workplan selection of analytical methods, specification of QA/QC requirements per CT DEP RCP, auditing of HRMS laboratory for compliance and performance, review and evaluation of analytical results including comparability of PCB methods and interpretation of PCB data patterns.

Forensic evaluation of hydrocarbon data for major petroleum refiner in South America and a major gas pipeline and cogeneration energy supplier in North America. Analyzed chromatographic patterns to assign product identifications and define potential sources in contaminated soil and groundwater. Coordinated lab services for specialized forensic methods. Review and comparison of biomarker, fuel additive, sulfur concentration, and pyrogenic/petrogenic PAH patterns to estimate date of product release and source relationships.

Reilly Tar & Chemical Superfund Site, City of St.Louis Park, Minnesota. QA chemist responsible for generating UFP QAPPs governing groundwater analyses and soil vapor intrusion studies for complex mixture of PAHs and heterocyclic compounds at ultra low detection limits by modified EPA methods. Responsible for routine on-site laboratory audits and oversight of QA/QC based corrective actions.

Dow Chemical, Comparable Fuels Study. QA chemist for analytical data to support comparable fuels exemption for waste combustion at polymer manufacturing facility. Negotiated alternate method choices with EPA when standard methods produced false positive for target analytes.

InEnTec, Syngas Fuel Study. QA chemist for analytical program development to support Appendix VIII analysis demonstrating syngas fuel exclusion requirements for plasma enhanced melter technology. Responsible for method selection plus data review and validation.

Garvey Elevator, Remedial Investigations/Feasibility Study, Garvey Elevator Superfund Site, Hastings, Nebraska. Project chemist responsible for QAPP revisions to include mobile lab, revision of site specific SOPs, and coordination of on-site and CLP lab services. Contaminants of concern are grain fumigant volatile organic compounds.

Other Experience

Role: Laboratory Director **Dates:** 2005 **Company:** AMRO Environmental Laboratories

Role: Senior Scientist **Dates:** 1997-2004 **Company:** AMRO Environmental Laboratories

Role: Group Leader **Dates:** 1996-1997 **Company:** NEI-GTEL Environmental Laboratories

Role: National Technical Director **Dates:** 1993-1995 **Company:** GTEL Environmental Laboratories

Role: Senior Environmental Scientist **Dates:** 1987-1993 **Company:** GTEL Environmental Laboratories

Role: Senior Chemist **Dates:** 1983-1987 **Company:** Mid West Analytical Laboratories

Jun Lu Ph.D.
Principal Technical Specialist

Professional History

Education

Ph.D., Geochemistry, Virginia Tech
MS, Geology, Virginia Tech
BS, Geology, Hefei Polytechnic University, China

Years of Experience

With AECOM 11
With other firms 16

Registrations

Professional Geologist, CA
Certified Hydrogeologist, CA
Certified Engineering Geologist, CA

Dr. Lu held a Ph.D degree in geochemistry and is a California professional geologist, certified Hydrogeologist and certified Engineering Geologist. As he has been involved to various environmentally related disciplines over 27 years of his professional career, he is in a unique position to most effectively integrate the multiple key disciplines for site characterization and forensic investigation. He has provided technical support for legal teams for environmental liability related projects as both a principal forensic chemist and a hydrogeologist. For the past ten years, he has been extensively involved with petroleum site characterization and forensics projects at various sites including marine and inland surface oil spill sites, petroleum refineries, terminals and pipelines, underground storage tanks, oil fields, MGPs, chlorinated solvents, and various other industrial facilities. He has been invited to give and to chair the presentations on forensics subjects at national and international conferences and published numerous papers and book chapters within disciplines of geology and petroleum forensics.

Experience

Plan and management of source oil samples and laboratory analyses, Gulf of Mexico. Dr. Lu was hired as a petroleum forensic chemist by a confidential client to assist planning and management of samples and laboratory analyses of source oils from a catastrophic spill on Gulf of Mexico. Various laboratory analyses are conducted to characterize the oil from multiple areas of interest and data are analyzed and organized into categories including fingerprints (PAHs and biomarkers), toxicology, and petroleum production, transportation and refining. A customized EQUIS database is being developed to facilitate data requests and to provide appropriate source oil data to requestors based on their needs.

Forensic investigation of petroleum spill source(s) in a water channel of a large metropolitan area, California. Gasoline-like products and crude oil were found seeping into a large open flood channel in a metropolitan area. As the area is underlain by a complicated network of pipelines, potential responsible parties were ordered by the oversight

agency to investigate for the sources. Dr. Lu was retained by a confidential client to plan for forensic sampling and to interpret the forensic data, to review forensic data collected by other parties and to negotiate with the oversight agency on behalf of the client.

Plan and implementation of LNAPL Forensics Program at a large petroleum refinery, California. Dr. Lu developed and integrated approach for release detection program using LNAPL forensics for a large active refinery in the U.S under an "Expert Consultant Retainer Agreement". The program consists of five major steps: 1) prioritizing wells for sampling, 2) choosing an adequate sampling frequency, 3) selecting appropriate analytical parameters, 4) building a database to efficiently manage data, and 5) interpreting data and recommending remedial follow-up actions. The program proved to be successful in predicting the release and/or migration of existing LNAPL and contributed greatly to both the Prevention Program and the Remediation Program.

Diesel fuel fingerprinting, Illinois. At a railyard in a small town near Chicago, weathered fuel oil has been present in several monitoring wells. Pumping and skimming have been employed to remove the product as the released fuel is believed or assumed to be caused by railroad operation. As apparently similar diesel fuel was found in a trench near the site recently, a forensic study was conducted to determine source relationship between the product found in the trench and those in the monitoring wells. Various forensic techniques were employed to reveal fingerprints of the products. Conclusion was made that the product found in the trench was from another source and therefore relieved the Client from financial burden for remediation.

LNAPL forensics at a petroleum product terminal, California. A major petroleum terminal in southern California has been in operation since 1920's. The terminal handles various types of petroleum-related products. On a number of occasions, petroleum product has been discovered in the vicinity of terminal and regulatory agencies have required the owner of the property to investigate and remediate the impacted media (soil and groundwater). Dr. Lu conducted numerous environmental forensics analyses to differentiate product types which lead identification of other sources and minimized the client's liability.

Petroleum hydrocarbon fingerprinting, Trinidad. At a pipeline site in Trinidad, a leak was detected in an underground pipeline system owned by a large oil company. The impacted material was excavated and the pipeline was repaired. Two years later, a crude oil spill occurred and was believed to be from the neighboring petroleum operation. As the type of material spilled previously was not known, the potential of future disputes exists in the event that the later crude spill poses impact to the environment. To rule out the source connection of the later spill with the earlier spill, a detailed forensic study was conducted, involving selection of sampling locations and depths, forensic laboratory analyses and data interpretation. Based on the findings from forensic analysis, a conclusion was drawn that the two types of crude are distinctly different.

Source identification and delineation of footprint of petroleum release in soil, California. At an active refinery in California, a petroleum pipeline release occurred in an area with historical releases. Dr. Lu

conducted a detailed forensic study on the hydrocarbon samples from the source and from recently and historically impacted soils to differentiate current from historical releases. The study was conducted with a tiered approach for sampling and laboratory analyses for cost saving. As a result, the current release was found to be in a limited area both horizontally and vertically. The findings helped the oversight agency understand the nature and extent of the release and therefore expedited the cleanup process.

LNAPL forensics at UST sites, Principal Technical Specialist. Numerous UST sites in California and across the Country were assessed from a forensic perspective. Impacted soils, free product and/or contaminated groundwater from monitoring wells were sampled and analyzed for forensic data including chromatograms, diagnostic and/or biomarker compounds, lead speciation and carbon isotope analyses. Statistical methods were used to enhance data analysis. The analysis was of great value for liability management, as well as beneficial for site characterization. All work was conducted under "Attorney-Client Privilege".

Environmental forensics of historical petroleum impacted soil, Principal Technical Specialist, Washington. Dr. Lu completed an "impact-based" forensic analysis to resolve a dispute over responsibility for petroleum contaminated soil. Since the contaminated soil was previously excavated and disposed of, the forensic analysis had to rely on various techniques for "impact based" chemical data to fingerprint the hydrocarbons. As a result, multiple products were identified and the findings opened door for the Client to renegotiate for compensation. The work was conducted for an energy company under "Attorney-Client Privilege".

PAH forensics of an industrial site, Washington, Principal Technical Specialist, Washington. Historical operations at the site include a manufactured gas plant, wood treatment plant and a railroad. Storm water and industrial discharges also contributed contaminants to the soil and sediments. An independent forensic study was conducted to differentiate PAH sources and revealed that preliminary conclusions drawn from previous consultants were not correct due to inappropriate assumptions and approach. The new findings/conclusions relieved our Client from unnecessary liabilities.

Use of parent PAHs to attribute PAH sources, Minnesota. Forensic evaluation of sources of PAHs in sediments has typically relied on the use of the "expanded PAH" analysis in which parent and alkylated members of each homologous series are quantified and reported. However these forensic data are often not collected during routine environmental site investigations. Various studies were conducted using only parent PAHs present in the environmental media and demonstrated that forensic analysis can be conducted to determine source(s) and therefore helps to enhance conceptual site model, which can be used for site characterization and optimal remediation design.

Determination of Monitored Natural Attenuation (MNA) Using Compound Specific Isotope Analysis (CSIA), California. At a large petroleum refinery facility, contaminants of concern (benzene and

oxygenates) migrated offsite from shallow aquifers to deep aquifers. Based on plume trends and geochemical indicators, biodegradation appears to occur. To provide more defensible evidence to support the MNA initiative, two rounds of site wide sampling were conducted to determine if reduction of contaminants of concern is related to biodegradation or other mechanisms such as dispersion. Detailed examination of the data revealed that biodegradation was primarily responsible for the reduction in concentration of the contaminants of concern. CSIA proved to be a very effective technical approach to demonstrate MNA of contaminants of concern.

Delineation of oxygenate plume(s), California. MTBE migrated off the property at an active refinery. Dr. Lu was the senior technical advisor supporting the delineation of the plume(s). The work included installation of 37 monitoring wells using a triad approach over a six year period (2003 through 2008). The wells were drilled with mud rotary and sonic techniques. All pilot boreholes were sampled for soil and groundwater (with SimulProbe) in 5-10 feet intervals. Most of the wells were completed as nested wells screened at various depths of Gage, Lynwood and Siverado Aquifers with total depths from 130 feet to 450 feet. The potential for cross contamination was addressed using previous lithology information, pilot testing, and installation of conductor casing, and monitored by sampling and analyzing drilling mud before and after simulprobe samples.

Groundwater Flow Model, West Coast Basin, California. Dr. Lu developed groundwater flow model to better understand the complex hydrogeological issues related to three-dimensional groundwater flow and capture, quantities of water entering or leaving aquifers, direction of flow, time of travel, and potential impacts on and off site for an active refinery in Southern California. The study area was approximately 150 square miles. Particle tracking capabilities of the model were used to assist in making Environmental Indicator (EI) determinations regarding groundwater control.

MGP gas purifier waste characterization, Washington, Principal Technical Specialist. Cyanide species have been observed in soil and groundwater at manufactured gas plant sites throughout the United States. At a MGP site in Washington, Prussian Blue or ferric-ferrocyanide (FFC), one of the most prominent species, was observed in soil. As groundwater impacts can occur as a result of leaching from spent oxide box residuals, which are potential sources of cyanide, a study was conducted using site-specific geochemical information to develop semi-quantitative predications of cyanide concentrations in groundwater within or near source material.

Compound-specific isotope analysis (CSIA) of chlorinated solvents, various Air Force bases, Technical Leader. At several Air Force bases nationwide, groundwater was contaminated with chlorinated solvents tetrachloroethene [PCE] trichloroethene [TCE] and/or cis-1,2-dichloroethene [DCE]). Carbon and hydrogen CSIA was performed to determine if biodegradation has played a significant role in attenuation of the chlorinated contaminants. As neighboring facilities historically used similar chemicals, CSIA data were also used to determine if off-site sources contributed similar contaminants to the site. Interpretation of data

was conducted by integrating multiple disciplines including isotopic geochemistry, contaminant hydrogeology, environmental forensics and statistics. Findings from the analysis were critical for the Client to make their cases to reduce investigation scope and therefore cost from remediation.

Isotopic fingerprinting of 1,2-DCE at a railroad site, Michigan, Technical Leader. At a railroad site, groundwater was contaminated with 1,2-DCE. Based on site history and hydrogeologic conditions, the 1,2-DCE at the far downgradient location is potentially from offsite source(s). To provide additional line of evidence, compound specific isotopic analyses (carbon and chlorine) were performed. Findings from the analysis provided justifications for the Client to modify their monitoring programs and to collect additional data to address the issue.

Identification of sources and pathways of MTBE using compound specific isotope analysis (CSIA), Principal Technical Specialist. The history of petroleum-related activities in an active refinery and its vicinity is extensive and complex. The general area includes numerous former and existing petroleum refineries, associated tank farms, reservoirs and pipelines that have refined, stored and/or transported various products over many decades going back to the early 1900s. The various land properties are owned by a multitude of different parties. One of the concerns is that MTBE is migrating offsite. As the plume is diving and offsite MTBE sources potentially comingle with onsite sources, differentiation of sources and determination of pathways are critical for our client. Two rounds of compound specific isotope analysis were conducted (2008 and 2011). Carbon isotopes were analyzed for both methyl tert butyl ether (MBTE) and tertiary butyl alcohol (TBA). A comparison of the 2011 data to the 2008 data suggests an increased rate of MTBE biodegradation between 2008 and 2011, but most importantly provides an additional line of evidence for a potential offsite source. A better understanding of the plume pathways was also achieved with the CSIA data.

Review of a CFEST Model, Sr. Hydrogeologist. Dr. Lu reviewed and assisted to refine a CFEST groundwater model developed to evaluate the remedial alternatives for the Interim-Action Feasibility Study of an Operable Unit being conducted as part of the Remedial Investigation/ Feasibility Study to characterize a 3-mile-long TCE plume. An analytical fate and transport model was developed to validate model results.

Environmental forensics of historical petroleum impacted soil, Principal Technical Specialist, Snohomish County, Washington. Dr. Lu completed an “impact-based” forensic analysis to resolve a dispute over responsibility for petroleum contaminated soil. Since the contaminated soil was previously excavated and disposed of, the forensic analysis had to rely on various techniques for “impact based” chemical data to fingerprint the hydrocarbons. As a result, multiple products were identified and the findings opened door for the Client to renegotiate for compensation. The work was conducted for an energy company under “Attorney-Client Privilege”.

Geochemistry of mineral deposits – Research Geologist. Dr. Lu investigated numerous ore deposits to determine genesis of the ores

including gold, silver, copper, lead, zinc, and iron. Project areas included China, U.S., Canada and Indonesia.

Publications and Presentations

Lu, J., GEOLOGY OF THE CANTIN CREEK AREA, QUESNEL RIVER, BRITISH COLUMBIA, Geological Fieldwork, British Columbia Ministry of Energy, Mines and Petroleum Resources, 1988

Lu, J., CHALLENGES OF INFORMATION REVOLUTION ON GEOLOGY AND MINING INDUSTRY, Metallurgical Geological Economy, vol., 20, 1990

Lu, J., APPLICATIONS OF NEW TECHNOLOGIES ON CANADIAN GEOLOGY AND EXPLORATION OF NATURAL RESOURCES, Geology and Prospecting, vol., 26, 1990

Lu, J., A PRACTICAL SOFTWARE FOR GEOLOGY AND PROSPECTING – PC-XPLOR, Geology and Prospecting, vol., 27, 1990

Chen, Z. L., **Lu, J.,** GEOLOGICAL FEATURES OF LIUFENSHAN COPPER DEPOSIT, A NEW TYPE, Geology and Prospecting, vol., 26, 1991

Lu, J., and CRAIG, James R. Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24601, ZINC MINERALIZATION AND PARAGENESIS AT THE IDOL MINE, COPPER RIDGE DISTRICT, EAST TENNESSEE, Geological Society of America Abstracts with Programs, vol. 24, 1992

Lu, J., INORGANIC AND ORGANIC GEOCHEMISTRY OF THE ZINC ORES OF THE IDOL MINE, EAST TENNESSEE: Unpublished M.S. thesis, Blacksburg, Virginia Polytechnic Institute and State University, 1993

Lu, J., HARICH, K., CRAIG, James R., and WHITE, R., Department of Geological Science and Department of Biochemistry, Virginia Polytechnic Institute and State University, VA 24601, PRELIMINARY INVESTIGATION OF ORGANIC COMPOUNDS IN SPHALERITE IN THE IDOL MINE COPPER RIDGE DISTRICT, EAST TENNESSEE, Geological Society of America Abstracts with Programs, vol. 25, 1993

CRAIG, James., **Lu, J.,** and SOLBERG, Todd N., Dept. Geological Sciences, VirginiaPolytechnic Institute and State University, Blacksburg, VA 24061, SPHALERITE GROWTH BANDING, COMPOSITION AND CORRELATION IN THE ZINC ORES OF THE IDOL MINE, TENNESSEE, Geological Society of America Abstracts with Programs, vol. 25, 1993

Lu, J., and Craig, J.R., Dept. Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061 PETROLEUM COKE SLAGS: CHARACTERIZATION AND CHEMISTRY OF PHASES, Preprints of Papers Presented at the 208th ACS National Meeting, Washington, D.C., August 21-25, 1994. Vol. 34, No.2.

Lu, J., Craig, James R. and Rimstidt , J. Donald, Dept. Geological

Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, PARAGENESIS AND GEOCHEMISTRY OF THE IDOL MINE ZINC DEPOSITS, TENNESSEE,, Economical Geology, vol. 90, 1995

Silverman, M, **Lu, J.** and Riley, M., A Case Study of Leak Detection At BP Carson Refinery, BP Center of Excellence (CoE) Conference, Houston, 2002

Lu, J., Sparks, G., Johnson, M. and Chaudhari, K., Integrated Approach for LNAPL Forensics, BP CoE conference, Dusseldorf, Germany, 2003

Sparks, G., **Lu, J.,** Johnson, M. and Chaudhari, K., Prevention Program Approach at Carson Refinery, BP CoE conference, New Port Beach, 2004

Lu, J., Johnson, M., Chaudhari, K., Chung, S. and Sparks. G., LNAPL Profile Sampling and Analysis at the BP Carson Refinery, BP CoE conference, New Port Beach, 2004

Johnson, M., **Lu, J.,** Sparks, G., Luka, K., Gogosha, S., Use of Hydrocarbon Forensics Analysis to Support Release Prevention Program at the Carson Refinery, BP CoE Conference, Calgary, Canada, 2005

Lu, J. and Johnson, M, LNAPL Profile Characterization, BP CoE conference, Calgary, Canada, 2005

Lu, J., Innovative Hydrogeological Study for Spring Source Certification, The 34th Conference of International Association of Hydrologists, Beijing, China, 2006

Lu, J., Destruction of A Large Water Supply Well with An Innovative Approach, The 34th Conference of International Association of Hydrologists, Beijing, China, 2006

Lu, J., Johnson, M., and Beckmann, D., LNAPL Profile Characterization, Association of Environmental Health and Science, San Diego, 2007

Lu, J., Chemical Fingerprinting of Petroleum Hydrocarbons and Applications, Conference of Southern California Chinese American Environmental Protection Association, April, 2008

Lu, J., Luka, K., Use of Hydrocarbon Forensics Analysis to Support Release Prevention at a Petroleum Refinery, International Society of Environmental Forensics, Qindao, China, May, 2008

Lu, J., Kirkman A., Wang, S., and Luka, K., Use of LNAPL fingerprint chemical data to enhance understanding of LNAPL mobility, Association of Environmental Health and Science, San Diego, 2009

Lu, J., Cluster analysis of forensic data of petroleum hydrocarbons, International Network of Environmental Forensics, August 30-September 1, 2009, Calgary, Canada

Lu, J., Characterization of petroleum contaminants in soil and groundwater: a forensic approach, Wuhan International Conference on

the Environment (WICE), October 17, 2009

Mohler, R., and **Lu, J.,** Use of statistic tools to improve confidence in analytical conclusions, Environmental Forensics: Proceedings of 2009 Annual Conference, Royal Society of Chemistry Special Publication No. 327

Kirkman, A. and **Lu, J.,** Improved metrics for recovery of light non-aqueous phase liquid (LNAPL), Global Environmental Forum, Shanghai, China, May 5-7, 2010

Lu, J., Applications of forensic techniques in petroleum hydrocarbon site characterization, Battelle Conference, May 24-27, 2010

Lu, J., Application of statistics in environmental forensics of fingerprinting light non-aqueous phase liquid data analysis – Chapter 8 in *Practical Applications of Environmental Statistics and Data Analysis* by ILM Publications, June 2011

Lu, J., Use of environmental forensic techniques to enhance site characterization for petroleum impacted sites, 18th International Petroleum and Biofuels Environmental Conference, Nov 8-10, 2011, Houston.

Lu, J., Resolution of a comingled LNAPL plume to address potential MtBE release(s), Environmental Forensics: Proceedings of 2011 Annual Conference, Royal Society of Chemistry Special Publication

Lu, J., Collection of forensic information in a site investigation, A chapter in *Introduction to Environmental Forensics*, 3rd edition by Elsevier/Academic Press (in progress)

Angus E McGrath Ph.D

Principal

Dr. McGrath has 13 years of experience in the environmental consulting field as an Applied Chemist in both organic and inorganic chemistry and 19 years in both environmental research chemistry and. as a laboratory researcher, both in academia and industry where he has helped develop fully recyclable paper machine oils and patented remediation methods. This experience has included project management, technical support, litigation support and field supervision of soil and groundwater remediation projects, and toxic trace element investigations. Projects he has managed have pertained to both soil and aquatic chemistry, including natural attenuation of chlorinated volatile organic compounds (VOCs) and MTBE/petroleum hydrocarbons, geochemical modeling of mine waters, acid mine drainage, treatment of acid soils, in situ alkaline stabilization of heavy metals, ex situ hazardous waste treatment, chemical oxidation of VOCs, chemical reduction of VOCs, adsorption of benzene, heavy metal remediation in groundwater, toxic trace element speciation in soils and waters, colloidal silica barrier stability, municipal waste discharges, and wastewater treatment and testing. He is currently working on projects involving the natural attenuation of chlorinated VOCs (CVOCs), hexavalent chromium, and petroleum hydrocarbons, biostimulation of CVOC reductive dehalogenation, Cr (VI) and perchlorate reduction in groundwater, chemical oxidation of petroleum and chlorinated VOCs, treatability of metal- and organic-bearing wastes, and modeling metal mobility and fate in aquifer materials.

EDUCATION

Ph.D., University of California, Berkeley, California, 1994

BA, Chemistry, Hamilton College, Clinton, New York, 1985

MEMBERSHIPS

Member, American Geophysical Union

Member, American Chemical Society

AWARDS

1993 Carolyn Meek Fellowship, UCB

1993 Graduate Student Award in Environmental Chemistry, American Chemical Society

PROJECT EXPERIENCE

Aboveground and Underground Storage Tank Investigation

Remediation of Petroleum Hydrocarbons and Fuel Oxygenates, Texas (Consulting Geochemist)

Angues served as a consulting geochemist on a project evaluating the potential for natural attenuation for a regional plume sourced by an underground propane bulk storage facility. He was responsible for evaluating the geochemistry of the plume to determine the applicability of natural attenuation as a remedial alternative for the containment of a propane and petroleum hydrocarbon plume. Additionally, he evaluated the transport and natural attenuation of a plume 200 to 300 feet below ground surface (bgs) and performing the work for a multinational corporation in Texas.

Assessment, Health Risk Evaluation, and Remediation of soil vapor

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Angus served as consulting Geochemist for a commercial property company that owns hundreds of shopping malls across California and the United States. He designed and implemented soil vapor extraction (SVE) system to remove CVOC from former dry cleaner contamination. He worked successfully with the dry cleaning operator and cleaned up CVOC concentrations using SVE and limited excavation. Additionally, Angus prepared reports to document remediation completed to date and letter for request for closure.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Electrical Commissioning and System Testing

Remediation and Assessment of Chlorinated Solvents, Springfield, Missouri (Consulting Geochemist)

Angus served as the consulting geochemist on an Electrical Resistance Heating (ERH) project in a karst system. Stantec implemented an ERH pilot study to test the technology in an onsite source area. Angus oversaw feasibility and bench scale testing, as well as design development for the ERH pilot study, ISCO bench scale studies, and 1,4-dioxane stripping efficiency. The pilot study was effective at cleaning up the 2,000-square-foot source area. The full-scale project is currently in the planning stages.

Remediation and Assessment of Chlorinated Solvents, El Centro, California (Consulting Geochemist)

Angus served as consulting Geochemist on an Electrical Resistance Heating (ERH) project. He planned and reviewed feasibility tests at a chlorinated solvent site to select the remedy, served as a technical reviewer for ISCO testing and ERH evaluations, and implemented ERH treatment in the remaining source area.

Environmental Assessments

International and Miscellaneous Projects, Sao Paolo, Brazil (Consulting Geochemist)

Angus served as consulting geochemist for automobile parts manufacturer. He conducted assessments of geochemical contamination issues at four equipment manufacturing facilities including plating, painting, battery production, and general equipment assembly. He recommended remedial approaches and processes to limit additional contamination.

Environmental Health & Safety

International and Miscellaneous Projects (Consulting Geochemist)

Angus served as a consulting geochemist for the training of staff and consultants of a Brazilian subsidiary of a multi-national oil company. He prepared and presented presentations in Portuguese for Brazilian staff and consultants. Additionally, Angus coordinated with Brazilian equipment providers to conduct presentations on health and safety and best work practices.

Environmental Site Assessments Phase I, II, III

International and Miscellaneous Projects, Curritiba, Brazil (Consulting Geochemist)

Angus served as the consulting geochemist on a Phase I and Phase II assessment of refrigeration system manufacturer and installer. He traveled to Brazil to establish a teaming relationship with the Brazilian consulting firm. This firm would be conducting a Phase I assessment and subsequent Phase II soil borings to determine the extent of groundwater contamination. Angus developed an understanding of the CETESB rules for environmental investigation in Sao Paolo, Brazil. He conducted the work on behalf of a multi-national air conditioning and refrigeration equipment manufacturer.

Remediation of Petroleum Hydrocarbons and Fuel Oxygenates, Northern California (Consulting Geochemist)

Angus served as the consulting geochemist on a project evaluating the potential for the application of a natural attenuation remedy at a chlorinated VOC site in northern California. He developed and reviewed data collected using the approved Air Force Center for Environmental Excellence (AFCEE) protocol to determine the applicability of natural attenuation at the site. He conducted bioaugmentation/biostimulation bench scale study to evaluate the potential for the enhancement of natural attenuation using simple carbon food sources with and without microbial (Dehaloccoides ethogenes) amendments. Currently, Angus is conducting a field biostimulation pilot study using a proprietary remedial mixture and performing the work for a multi-national corporation.

Environmental Site Remediation

Remediation of Petroleum Hydrocarbons and Fuel Oxygenates, Northern California (Consulting Geochemist)

Angus served as the consulting geochemist on a project evaluating the impact of oxygen infusion technologies for the augmentation of fuel oxygenate biodegradation. He was responsible for performing a remediation technology comparison for the in-situ remediation of methyl tertiary butyl ether (MTBE) at a fuel terminal for a major oil company.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Remediation and Petroleum Hydrocarbons and Fuel Oxygenates (Consulting Geochemist)

Angus served as the consulting geochemist on an investigation pertaining to liability of gas station operator with regard to groundwater contamination from historic and present-day gasoline spills. He evaluated site and composition of gasoline spills to assess sources of spills as a function of aging and MtBE concentrations. Additionally, Angus performed work for two environmental engineering and consulting firms.

Groundwater and Geochemical Modeling

International and Miscellaneous Projects (Research Geochemist)

Angus served as a research geochemist on an investigation of the pesticide persistence and stability in forested watersheds of Northern California federal government land. He developed analytical capabilities and degradation studies on atrazine, picloram, and triclopyr in a broadcast-spraying operation for shrub control during plantation growth. He performed his work for a U.S. government agency.

Remediation of Petroleum Hydrocarbons and Fuel Oxygenates (Consulting Geochemist)

Angus served as the consulting geochemist on a project evaluating the biodegradation of tertbutyl alcohol (TBA) by organisms removed from granular activated carbon (GAC) in a pump and treat system. He was responsible for evaluating the potential for GAC inoculation with TBA degrading organisms to remove TBA from extracted groundwater prior to discharge to the storm drain or publicly-owned treatment works (POTW).

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Angus served as the consulting geochemist for a full-scale application of potassium permanganate treatment for chlorinated alkene VOC remediation. He was responsible for developing a reactive barrier to remove CVOCs and prevent off-site migration of contaminants. All work was based on a bench-scale comparison of chemical oxidants screened for this site. Pilot study results indicated that the initial remedial treatment could remove chlorinated VOCs in the treatment area for up to nine months before new flow from upgradient transported more contaminants into the treatment area.

Remediation and Assessment of Chlorinated Solvents, Northern California (Consulting Geochemist)

Angus served as the consulting geochemist for the selection and testing of chemical oxidants for the oxidation of chlorinated VOCs at a site. Developed laboratory and field pilot protocol. He tested the oxidant selected through laboratory testing in the field. Chemical indicators revealed that the treatment was effective at degrading the compounds of concern, however hydrogeologic limitations prevent effective field application of the treatment.

Remediation and Assessment of Chlorinated Solvents, New Jersey (Consulting Geochemist)

Serving as the consulting geochemist on the review of the applicability of different remedial alternatives for the destruction of CVOCs in a fractured bedrock aquifer, Angus evaluated chemical treatment, natural attenuation, and physical methods for efficacy in treating the chlorinated VOC plume. He performed the work for a multinational personal hygiene products manufacturer.

Groundwater monitoring and reporting

Landfill, Mining and Heavy Metal, Northern California (Consulting Geochemist)

Angus served as the consulting geochemist for the evaluation of remedial alternatives pilot tested at a nationally recognized groundwater hexavalent chromium contamination site. He provided expert advice on the effectiveness of proposed remedial alternatives and the meaning of pilot test results.

Groundwater Treatment

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Served as consulting Geochemist for a pilot study of Fenton's reagent degradation of chlorinated solvents in groundwater. Conducted a laboratory batch and column study to determine the efficiency of Fenton's reagent degradation of trichloroethene (TCE) and dichloroethene (DCE) in contaminated aquifer material with a moderate to low permeability. Conducted a field pilot study of the technology based on successful bench-scale testing. Performed work for an electronics manufacturer in Northern California.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Served as consulting Geochemist for a pilot-scale testing of Fenton's reagent treatment of a contaminated aquifer, using vertical mixing well technology. Conducted technology and site assessment for a listed site contaminated with VOCs and dense non-aqueous phase liquid (DNAPL). Obtained regulatory approval for novel technology testing. Performed work for a multinational corporation at a site in Rhode Island.

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Served as consulting Geochemist on a project for the remediation of hexavalent chromium in groundwater beneath a municipal park. Designed and implemented chemical reduction treatment of sediments within excavations at park applying potassium dithionite to site sediments to provide a ten-year geochemical reactive barrier to influent hexavalent chromium. Currently overseeing groundwater treatment for VOCs during final phase of park construction. Performing the work for a Northern California municipality.

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Serving as consulting Geochemist and project manager for a CVOC plume at a state superfund site in northern California for a major microchip manufacturer. Bench and field tested and implemented on a full-scale groundwater treatment for CVOCs using ozone sparging. Implemented ozone sparging using Calcon equipment after difficulty with other equipment manufacturers. Remediated the central portion of the source area and in the process of completing treatment in down gradient source areas

Landfill, Mining and Heavy Metal (Consulting Geochemist)

A pilot-scale project for in situ stabilization of nickel and reductive precipitation of chromate in groundwater. Developed an alkaline treatment to precipitate nickel in groundwater and vadose zone soil at one of the largest historical plating facilities in the world in Indiana. Developed a remedial approach for treatment of hexavalent chromium using ferrous iron.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

The treatment of extracted groundwater impacted with hexavalent chromium. Designed and operated a flow through treatment system for the reduction and precipitation of hexavalent chromium in groundwater removed during dewatering of an excavation. Performed the work for a municipality in Northern California.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

A remediation project reducing and precipitating Cr (VI) site wide in vadose zone soils and groundwater using ferrous iron treatment. Reduced groundwater hexavalent chromium concentrations in situ site-wide at an active aeronautics plant using a method SECOR developed and received United States Environmental Protection Agency (USEPA) approval for. Currently evaluating the effectiveness of groundwater treatment, awaiting soil closure, and applying for site closure. Performing work for an industrial client in Southern California.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

Served as a consulting Geochemist on a project where a hexavalent chromium plume is threatening a series of domestic drinking water wells. Evaluated the geochemistry of the aquifer, the remedial options for in situ and ex situ treatment, the stressors on the aquifer and modeled groundwater movement. Installed a more effective groundwater extraction system, an above ground chemical treatment system for hexavalent chromium and an in situ pilot biological hexavalent chromium treatment system. Reduced overall costs for groundwater disposal by approximately $500,000 per annum. Performing work for a major oil company in West Texas.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Healthcare

Confidential - Former NASA Industrial Facility, Hospital and MOB Redevelopment, Downey, California

Mr. McGrath participated on the team that conducted a combined environmental and geotechnical evaluation of a former NASA industrial plant that was to be demolished and redeveloped as a hospital and medical office building complex. The NASA facility was utilized for Gemini, Apollo, and Space Shuttle testing, and included an airfield, hazardous material storage, and cryogenic and physical testing areas. The project involved historical research to locate former hazardous material usage and storage areas; drilling and sampling of soil, soil vapor, and groundwater to evaluate impacts; combining the geotechnical and environmental sampling for efficiency and cost savings; assessment and health risk (PEA) reports for evaluation of worker and site user health risk and for submission to the California DTSC; asbestos and hazardous material abatement reports for demolition purposes; geotechnical reports for site grading, foundation, pile, and liner design, and backfill requirements; construction oversight; and participation with client legal counsel in negotiations with state regulatory agencies. Remedial oversight was also conducted, and we coordinated with the client, contractor, adjacent landowners, the City, and regulatory agencies.

In Situ Biomonitoring

Remediation of Petroleum Hydrocarbons and Fuel Oxygenates (Consulting Geochemist)

Served as consulting Geochemist for the development of a guidance document for the implementation of in situ biotreatment of petroleum hydrocarbons and fuel oxygenates in groundwater. Contracted by the American Petroleum Institute (API) to research and compile literature on in situ biobarriers and develop a guidance document for the implementation of aerobic biobarriers. The publication is currently in review with API.

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Served as consulting Geochemist for the evaluation of commingled CVOC plumes using compound-specific stable isotope techniques and treated the source are with in situ chemical oxidation (ISCO) at a marine terminal. Evaluated the stable isotope signatures of source and reductive dehalogenation breakdown daughter products both on-site and from other upgradient sources. Developed an opinion for the client regarding the isotopic signature observed. Tested and implemented potassium permanganate treatment of CVOCs for the source area. Completed source area treatment and developed plan for site wide remediation.

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)

Serving as consulting Geochemist for the development of a guidance document for the implementation of in situ biotreatment of petroleum hydrocarbons and fuel oxygenates in groundwater. Researched and compiled literature on in situ biobarriers and developed a guidance document for the implementation of aerobic biobarriers on behalf of the American Petroleum Institute. The publication is currently in review with API.

Mixed-Use

Port of San Diego Rohr Facility, Chula Vista, California

Mr. McGrath participated in a detailed subsurface assessment of the Rohr facility. The intent of the assessment was to evaluate the 40-acre former aircraft part manufacturing facility for acquisition by the Port of San Diego for redevelopment into a business park and entertainment complex. The assessment identified the presence of soil, soil vapor, and groundwater impacts by petroleum hydrocarbons, VOCs, heavy metals, PCBs, and semi-volatile organic compounds. He utilized many sampling techniques to assess the limits and concentrations of contaminants in the subsurface. Ultimately, the team was able to develop a cost estimate for potential remedial action cost associated to corrective action to allow redevelopment.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Remedial System Installation
Remediation and Assessment of Clorinated Solvents (Consulting Geochemist)
Serving as consulting Geochemist selecting and installing a site-wide remedial system to degrade chlorinated VOCs and petroleum hydrocarbons at a former circuit board fabrication facility. Evaluated and implemented the installation of an ozone sparging and soil vapor extraction system to remove and oxidize VOCs in groundwater below the proposed multinational corporate headquarters. Performing the work for a multinational electronics manufacturer in Northern California.

Site Management and Remediation
Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)
Serving as consulting Geochemist for a project where the client purchased cost cap insurance and transferred long-term responsibility for remediation and remedial operations to SECOR. Operated pump and treat system until asymptotic and followed with limited ISCO using potassium permanganate to treat chlorinated ethenes. ISCO dramatically reduced CVOC concentrations across the site.

Soil and Groundwater Remediation Systems
Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)
Served as consulting Geochemist on the review of the applicability of different remedial alternatives for the destruction of CVOCs and petroleum hydrocarbons in groundwater at a site in Scotland, UK. Evaluated the geochemistry and the hydrogeology to determine which remedial alternative available would be most suitable for remediation of the site. Performed the work for a multinational electronics manufacturer in Northern California.

Remediation and Assessment of Chlorinated Solvents (Consulting Geochemist)
Serving as consulting Geochemist on a natural attenuation project for hexavalent chromium contamination in groundwater at a landfill for a brick manufacturer. Conducted geochemical analyses of soil and groundwater, evaluated the feasibility of remedial alternatives, and implemented natural attenuation based on geochemical indicators and risk evaluations. Performing work for a Southern California brick manufacturer.

Landfill, Mining and Heavy Metal (Consulting Geochemist)
Served as a consulting Geochemist on a project evaluating the acid generating potential of soils and drilling spoils from oil exploration in pristine wilderness in Venezuela. Modeled the acid generating potential of drilling spoils and evaluated the acid neutralizing capacity of the surficial soils and receiving waters. Evaluated the potential to maintain anoxic conditions to prevent acid generation. Conducted the work for a multi-national oil exploration firm.

Soil and Water Quality Assessments
International and Miscellaneous Projects (Geochemist)
Served as Geochemist on a project studying the use of colloidal silica barriers for actinide and mixed-waste containment. Responsible for developing studies on soil characterization and interactions between colloidal silica and soil matrices, and measuring water retention properties of soils. Performed work for a U.S. Government agency.

Soil Quality Assessment
Landfill, Mining and Heavy Metal (Consulting Geochemist)
Served as a consulting Geochemist for the stabilization of acid impacted soils from metal and asphaltic sludges. Evaluated that acid neutralizing requirement for soils and sludges for in situ stabilization. Conducted field stabilization pilot study to demonstrate remedial strategy effectiveness. Conducted the work for a multi-national oil company.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

Steel & Metals

Interim Measures Implementation Summary, Santa Ana, California

Mr. McGrath was responsible for an Initial Study and Negative Declaration prepared pursuant to CEQA with the purpose to reduce concentrations of contaminants of concern (COC) beneath the chromium plating building, as well as to isolate the areas most impacted. In addition, the IMWP addresses treatment downgradient along the southern property boundary to prevent hexavalent chromium and perchlorate migration onto the neighboring property and into their proposed groundwater VOC treatment system. We evaluated several alternatives and conducted a six-month pilot study of the proposed remedial technology and submitted a Pilot Study Report in 2006 to the DTSC. Based on the pilot study, we proposed full-scale implementation of the in situ treatment using a network of injection wells. The treatment includes weekly injections of substrate into the network of wells using a below-grade piping network connected to an automated dosing. Dosing in the downgradient southern property boundary wells is performed manually on a weekly basis. An Interim Measures Installation and Implementation Report (IMIIR) is currently being developed.

Stormwater Management

International and Miscellaneous Projects

Served as consulting Geochemist on the design and model parameters for a wastewater/storm water outfall in the Carquinez Strait of San Francisco Bay. Developed a database for water temperature and solution parameters to determine the proper design requirements for a deep-water discharge. Performed work for an environmental engineering firm.

Waste Management

Landfill, Mining and Heavy Metal (Consulting Geochemist)

Served as a consulting Geochemist for the column testing of stabilization processes for chromite ore process residue COPR wastes. Developing remedial treatments for hexavalent chromium in COPR wastes and conducting a column test to determine the leachability of the stabilized wastes.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

For metal waste stabilization for hazardous waste landfills across the country developing treatment methods for different waste streams such as chromite ore process residue (COPR). Currently on retainer to design evaluate treatability tests for a hazardous landfill operator.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

To recycle zinc from metal hazardous wastes for a solid waste landfill. Evaluated pyrometallurgical and hydrometallurgical processes for recycling zinc from metal wastes. Developed a summary of available technologies and feasible processes.

Wastewater Treatment

International and Miscellaneous Projects (Consulting Geochemist)

Served as consulting Geochemist on treatability studies for wastewater treatment and testing for a freeway reconstruction project in Northern California. The project included ongoing review and development of wastewater treatment technologies for heavy metals (Hg, Cd, Ag, Pb, As, Ag, Cr), trace elements, and synthetic organic contamination projects (BTEX and VOCs). Prepared client for expert witness testimony. Performed work for two companies in Berkeley, California. Developed a high-volume treatment system for arsenic removal from groundwater using an aboveground treatment plant in combination with heavy metal removal.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

A plating and precision machining company evaluating wastewater treatment alternatives and working with vendors to implement the identified technology. Also evaluating remedial alternatives for treatment of hexavalent chromium, perchlorate, and chlorinated VOC (CVOC) in a commingled groundwater plume at the site. Testing in situ biologically mediated reductive treatment for hexavalent chromium, perchlorate and CVOCs. Performing work for a Southern California plating and precision machining company.

Water Treatment

International and Miscellaneous Projects (Consulting Soil and Aquatic Chemist)

Served as consulting Soil and Aquatic Chemist on studies to determine the cause and remedial action required for plugging of rapid infiltration disposal beds for municipal waste discharges. Assessed the impact of redox conditions, algal cell growth, and water table fluctuations on the permeability of treatment beds, and proposed new treatment designs for a pilot study. Performed work for a city in Northern California and an engineering firm.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

International and Miscellaneous Projects (Geochemist)

Served as Geochemist on a multidisciplinary project related to selenium contamination and cycling in the San Francisco Bay, California. Responsible for work plan development, and design of field and laboratory activities, including sampling of water, sediments, algae, and plants, and refining analytical capabilities for trace metal quantification. Responsible for data evaluation and conceptual model development. Performed work for the area Regional Water Quality Control Board (RWQCB) and a U.S. Government national laboratory.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

Served as a consulting Geochemist on a project to remove trace level antimony and arsenic contamination from drinking water for a water supply system in Utah. Developed a water treatment technology that was able to decrease antimony from 20 micrograms per liter (µg/L) to less than 2 µg/L in order to meet USEPA water quality requirements. Tested and implemented the technology on a pilot scale. Changes in regulatory requirements have reduced the pressure on full-scale implementation. Performed the work for a small municipality in one of the Salt Lake City ski valleys.

Landfill, Mining and Heavy Metal (Consulting Geochemist)

Mine closure to evaluate and model the geochemistry of mine water quality. Conducted geochemical simulations of mine water quality to determine what natural controls were present to prevent heavy metal dissolution and total dissolved solids from increasing in mine drainage water. Demonstrated that natural precipitation processes control heavy metal and total dissolved solids (TDS) concentrations without additional controls. Performed work for a mining client in Alaska.

** denotes projects completed with other firms*

Angus E McGrath Ph.D

Principal

PUBLICATIONS

Evaluation and Mitigation of Landfill Gas Impacts on Cadmium Leaching from Native Soils. *Groundwater Monitoring and Remediation*, 2007.

Bench Scale Evaluation of Ex Situ and In Situ Cr (VI) Remedial Methods. *In Chromium (VI) Handbook*, 2004.

Microbubble Oxidation of MtBE and BTEX. *Contaminated Soil Sediment and Water*, 2001.

Selenium Cycling in Estuarine Wetlands: Overview and New Results from the San Francisco Bay. *Environmental Chemistry of Selenium*, 1999.

Degradation of 2, 4-dichlorophenoxyacetics Acid by Birnessite Catalysis. *Physiochemical and Engineering Aspects*, 1996.

Selenium Fractionation and Cycling in the Intertidal Zone of the Carquinez Strait. *LBNL Annual Report*, 1996.

A Design Study for the Isolation of the 281-3H Retention Basin at the Savannah River Site using Viscous Liquid Barrier Technology. *LBNL Annual Report*, 1996.

Soil Sci. Soc. of Amer., 59:1723-1731. *Spectroscopic Characteristics of Forest Floor Aqueous Extracts II: Effects of Fertilization and Herbicides*, 1995.

Soil Sci. Soc. of Amer. 59:1715-1722. *Spectroscopic Characteristics of Forest Floor Aqueous Extracts I: Pine and Understory Litter*, 1995.

Ph.D. Thesis, UCB. *Adsorption and Abiotic Degradation of Aromatic Amines on Birnessite and Ferrihydrite: Impact on Soils*, 1994.

In: Proc. of the 13th Annual Forest Vegetation Management Conference, Eureka, California, pp. 45-53. *Soil Reactions with Natural and Synthetic Organic Compounds*, 1992.

Curriculum Vitae

Gene W. Schmidt

Present: Groundwater/Soils Environmental Consulting
11619 S. Hudson Place
Tulsa, OK 74137-8532
Residence: (918)298-9849
Email: envirodog@aol.com

Education:

M.S. Geochemistry, University of Tulsa, May 1971 (Hydrogeochemistry of Gulf Coast Sands and Shales)

M.S. Chemistry, Fort Hays Kansas State University, August 1962 (Aqueous Chemistry)

B.S. Chemistry, Fort Hays Kansas State University, June 1961 (Analytical and Organic Chemistry)

A.B. Geology, University of Missouri, January 1955

Professional Skills:

Professional Experience:

1992-Present: GW/S (Groundwater/Soils) Environmental Consulting (owner) Specializing in hydrocarbon contamination of groundwater and soils and petroleum hydrocarbon fingerprinting and age dating. Retired from Amoco Corporation September 1, 1992.

1992: Amoco Corporation, Senior Technical Consultant:
Senior Technical consultant, Groundwater/Soils, Environmental Affairs and Safety Department

1983 to 1992: Amoco Corporation
Director, Groundwater/Soils Management Services, Environmental Affairs and Safety Department. Under my stewardship as Director, several thousand subsurface investigation, assessment and remediation projects were completed.

1973 to 1980: Consulting to Corporation on Environmental groundwater-related matters

1973 to 1980:	Consulting to Corporation on Environmental groundwater-related matters
1964 to 1980:	Amoco Production Company Research Associate - In charge of Formation Water Research, Geologic Research Division, Geochemistry Department, Amoco Production Company Research Center, Tulsa OK (use of chemistry and physics of subsurface petroleum and formation water to enhance the exploration and production of petroleum and other valuable minerals)
1957-1964:	Kansas Board of Health District Geologist, Oil Field Section Water pollution control work for the State of Kansas, Department of Health

Professional Organizations:

Certified Professional Hydrogeologist, American Institute of Hydrology #429, 1984

Certified Ground Water Professional, The Association of Groundwater Scientists and Engineers, #168, 1986.

Professional Geologist (Hydrogeology), south Carolina State Board of Registration for Geologists, #499, 1987.

Elected to the 1992 Who's Who Environmental Registry for achievements of Gene W. Schmidt in the environmental industry.

Trade Associations:

American Petroleum Institute, Past Chairman, Groundwater/Soils Technical Task Force (see attached list for the task force's publications and charter research projects during my stewardship) as Chairman (four years) and Task Force member (15 years).

Environmental Assessment Experience:

Under my stewardship as Director, Groundwater Management, Environmental Affairs and Safety Department, Amoco Corporation, over 3000 projects were completed. These projects involved application of all state-of-the-art environmental technologies.

Publications and Patents:

Chemical Analysis of Groundwaters, Rooks County, Kansas, Kansas Academy of Science, V.64, No.1, 1961.

Brine Effected Soil Studies, Potwin County, Kansas, 1966, Kansas State Department of Health, Environmental Health Services, Topeka, Kansas, May 1966.

Geochemistry of Interstitial Waters of Deep Sands and Shales of the Gulf Coast, American Association of Petroleum Geologists Bulletin, Vol.57, No.2, February 1973, pp.321.337.

U.S. Patent, Geochemical Prospecting Methods – Use of Dissolved Aromatic Hydrocarbons in Formation Waters, August 1970.

Hydrogeology and Groundwater Pollution as Related to Tulsa County, Oklahoma. Tulsa's Physical Environment, Tulsa Geological Society Digest, Vol.37, 1972.

Corrosion Aspects of Some Groundwaters in Tulsa County, Oklahoma, Tulsa's Physical Environment, Tulsa Geological Society Digest, Vol. 37, 1972.

Discussions, Interstitial Water Composition Geochemistry of Deep Gulf Coast Shale and Sandstone, AAPG Bulletin, Vol.59/4, April, 1975.

Underground Cleanup Manual, American Petroleum Institute, API Publication 1628. June 1980 (member of committee who authored manual).

Proceedings: Sampling and Analytical Methods for Determining Petroleum Hydrocarbons in Groundwater and Soil, R. Babcock, D.D. Conway, W. Deever, and G. Schmidt, American Petroleum Institute Workshop, November 1984.

Petroleum on the Groundwater Table – Aquifer Restoration Concerns, Hydrological Science and Technology: Short Papers, Vol.1, No.1, September 1985, American Institute of Hydrology, pp. 49-51.

Benzene in Florida Groundwater – An Assessment of the Significance to Human Health, Florida Petroleum Council, a division of the American Petroleum Institute, Washington, DC, October 1986, pp.1-161 (member of steering committee for publication).

The Use of PVC Casing and Screen in the Presence of Gasoline on the Ground Water Table, Discussion. Groundwater monitoring Review, Spring, 1987, pp.94-95.

Cleanup Lessons Learned – An Industry Perspective, Conference Proceedings, the 1987 Washington Conference on Underground Tanks, Inside IPA Weekly Report and The Center for Energy and Environmental Management, July 1987.

Active Control-Interceptor Trenches, Refinery Groundwater Conference/Workshop, National Petroleum Refiners Association, Toronto, Canada, April 1988.

New Field Method Providing for In-Field Extraction of Volatile Petroleum Hydrocarbons in Groundwater Samples, G.W. Schmidt and P.F. Fairbanks, Third Outdoor Action conference (NWWA), May 1989.

The National Groundwater Research Act of 1989 in the Matter of H.R. 2734, Testimony of Gene W. Schmidt before the U.S. House of Representatives Subcommittee on Natural Resources, Agriculture Research and Environment, Washington, DC, August 1989.

Field-Freon Extraction of Dissolved Hydrocarbons in the Groundwater, T.G. Miller and G.W. Schmidt, Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration, (NWWA) November 1991.

Remediation of Underground Storage Tank Releases Needs a Kiss, G.W. Schmidt, Underground Storage Tanks. 1992 Environmental Technology Exposition and Conference, Washington, DC, April 1992.

Remediation of Petroleum Hydrocarbon Releases Needs a Kiss, G.W. Schmidt, Oklahoma's Water and Sustainable Development Conference, Governor's Coordinating Committee on Water Resources Research, Oklahoma City, OK , February 1993.

Hydrocarbon Fingerprinting for Application in Forensic Geology: Review with Case Studies, L.G. Bruce and G.W. Schmidt. The American Association of Petroleum Geologists Bulletin, V.78, No.11, November 1994, pp.1692-1710.

Hydrocarbon Fingerprinting Techniques: Case Studies in Subsurface Environments, G.W. Schmidt, National Institute on Hydrocarbon Fingerprinting Conference, The College of Engineering, University of Wisconsin, Albuquerque, NM, March 1955 (course instructor).

The Effect of Petroleum Weathering on Pattern Recognition, Gene W. Schmidt, A Workshop on Technical Fingerprinting Methods and Case Studies, The College of Engineering, University of Wisconsin, Seattle, Washington, October 1995 (course instructor).

Forensic Geochemistry for Hydrocarbon Releases, Gene W. Schmidt, 1996 Petroleum Hydrocarbons and Organic Compounds in Ground Water: Prevention, Detection, and Remediation Conference, November 1996.

The Effect of Petroleum Weathering of Pattern Recognition and Dating, Gene W. Schmidt, An International Workshop on Hydrocarbon Pattern Recognition and Dating Conference, The College of Engineering, University of Wisconsin, Port of Spain, Trinidad and Tobago, March 1997.

Forensic Petroleum Hydrocarbon Fingerprinting and Age of Release Developments, Gene W. Schmidt, The 4th International Petroleum Environmental Conference, The University of Tulsa, San Antonio, Texas, September, 1997.

The Effect of Petroleum Weathering on Pattern Recognition and Dating, Gene W. Schmidt, Hydrocarbon Pattern Recognition and Dating Conference, The College of Engineering, University of Wisconsin, Philadelphia, Pennsylvania, November 17-18, 1997 (course instructor).

Case Studies and Workshop on Forensic Fingerprinting, Gene W. Schmidt, Hydrocarbon Pattern Recognition and Dating Conference, Department of Engineering Development, University of Wisconsin, Philadelphia, Pennsylvania, November 17-18, 1997 (course instructor).

The Effect of Petroleum Weathering on Pattern Recognition and Dating, Gene W. Schmidt, Hydrocarbon Pattern Recognition and Dating Conference, The College of Engineering, University of Wisconsin, Houston, Texas, June 24-26, 1998 (course instructor).

Case Studies and Workshop on Forensic Fingerprinting, Gene W. Schmidt, Hydrocarbon Pattern Recognition and Dating Conference, Department of Engineering Development, University of Wisconsin, Houston, Texas, June 24-26, 1998 (course instructor).

The Effect of Petroleum Weathering on Pattern Recognition and Dating, Gene W. Schmidt, Environmental Forensics Conference, International Business Communications Forum, Houston, Texas, September 24-25, 1998 (course instructor).

The Effect of Petroleum Weathering on Pattern Recognition and Dating/ Case and Workshop on Forensic Fingerprinting, Gene W. Schmidt, Hydrocarbon Pattern Recognition and Dating Conference, Department of Engineering Professional Development, University of Wisconsin/Wyoming Department of Environmental Quality, Cheyenne, Wyoming, October 28-30, 1998 (course instructor).

Advances in Correlation and Age Dating of Petroleum Products Released to Soils and Groundwater, Gene W. Schmidt, Dennis D. Beckmann and Bruce E. Torkelson, The 6th International Petroleum Environmental Conference, The University of Tulsa, Houston, Texas, November 1999.

Special Cases: Interesting Techniques and Gas Chromatograms from Environmental Forensic Subsurface Investigations, Gene W. Schmidt, Dennis D. Beckmann and Bruce E. Torkelson. The 7th International Petroleum Environmental Conference, The University of Tulsa, Houston, Texas, November, 2000.

Schmidt, G., Beckmann, D., Torkelson, B., *Gas Chromatography Technique for Estimating the Octane Rating of Fresh and Weathered Gasolines Released to Soils and Groundwater*. Journal of Environmental forensics, 2003, 4, pp. 75-80.

Schmidt, G., Beckmann, D., Torkelson, B., *A Technique for Estimating the Age of Regular/Mid-grade Gasolines Released to the Subsurface Since the Early 1970s.* Journal of Environmental Forensics, 2002, 3. pp. 145-162.

Schmidt, G., *Invited Commentary on Dr. Isaac Kaplan's Paper "Age Dating of Environmental Organic Residues"*, Journal of Environmental Forensics, 2003 4, p. 153.

Hurst, R. W., and Schmidt, G.W., *Short Term Chronometers in the Earth Sciences,* Chapter 6, Degradation of Organic Compounds, Geological Sciences 570, University of California State, copyright February, 2004.

Hurst, R. W., and Schmidt, G.W., Age Significance of nC17/Pr Ratios in Forensic Investigations of Refined Products and Crude Oil Releases. Journal of Environmental Geosciences, 2005, Vol. 12, Issue 3, pp. 177-192.

Schmidt, G.W. and Hurst, R.W., *Use of nC17/Pristane Ratios for Age Dating Refined Products and Crude Oil Releases in Forensic Investigations*, Special Goldschmidt Volume of Applied Geochemistry, Elsevier, accepted for publication, 2007.

Hurst, R. W. and Schmidt, G. W., Oudjik and Wade: "On the Subject of Age-Dating Distillate Fuels: A Commentary on the Methods of Hurst & Schmidt (2005) and Galperin & Kaplan (2008)". Environmental Forensics, 12:5-6, 2011.

Jennifer Shelton has project management as well as technical experience in many aspects of environmental engineering. She has designed various in-situ and ex-situ remediation systems for sites contaminated with petroleum hydrocarbons and chlorinated solvents. Innovative groundwater technologies that Jennifer has implemented include underground injection of highly oxygenated water with nutrient amendments and density-driven convection. She has designed remedial actions involving multi-phase extraction, groundwater recovery and treatment, air sparging (AS), soil vapor extraction (SVE), phytoremediation, bioventing, free product recovery, and various engineered barriers. Jennifer has conducted feasibility studies and risk evaluations, designed and implemented pilot test procedures, prepared specifications, plans and bidding documents for successful system installations, and has managed projects through to site closure. She has experience in the preparation of site assessments and environmental monitoring plans (i.e. Spill Prevention, Control, and Countermeasure Plans and Storm Water Pollution Prevention plans).

Jennifer's field experience includes conducting environmental site assessments, pilot tests, supervising and inspecting construction activities, initiating remediation system start-up activities, investigating sites for insurance claim reviews, and conducting remediation system troubleshooting activities.

EDUCATION

B.S. in Civil and Environmental Engineering, Magna Cum Laude, 1994, Marquette University, Milwaukee, Wisconsin.

REGISTRATION

Registered Professional Engineer in Wisconsin, Illinois, Ohio and Georgia

State of Wisconsin Registration to Participate in PECFA

Certified Construction Documents Technologist by the Construction Specifications Institute

1998 Wisconsin Society of Professional Engineers Young Engineer of the Year Award Recipient

TECHNICAL SOCIETIES

Wisconsin Society of Professional Engineers: Member; Former Vice President of the Southwest Chapter.

American Society of Civil Engineers: Member; Former Environmental Technical Committee Chairperson for the Wisconsin Section

Dane County Environmental Council: Former Council Chairperson.

Wisconsin Department of Natural Resources Remediation and Redevelopment Technical Focus Group: Member.

SUMMARY OF PROFESSIONAL EXPERIENCE

2012 to present:
Associate with Leggette, Brashears & Graham, Inc., Madison, Wisconsin

2000 to 2011:
Senior Environmental Engineer with Leggette, Brashears & Graham, Inc., Madison, Wisconsin

1994 to 1999:
Environmental Engineer with Leggette, Brashears & Graham, Inc., Madison, Wisconsin

1991 to 1993:
Co-op Engineer with HNTB Corporation, Milwaukee, Wisconsin

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER CONTAMINATION

Sag Harbor, New York

Designed a groundwater pump and treat system for a Superfund site impacted with chlorinated solvents. The groundwater recovery system consisted of nine recovery wells, which were located within a plume that stretched over a mile in length throughout a residential neighborhood. The treatment system was designed to operate at 650 gallons per minute and included a filtration system, tower air stripper, vapor-phase carbon units to treat stripper off-gases, and an acid back-wash system. Conducted a comprehensive evaluation of system operational parameters following system start-up. Prepared an exhaustive soils remediation closure evaluation for an SVE system within the site's former drum storage area.

Watertown, South Dakota

Prepared USEPA permit applications and a pilot test work plan for underground injection of oxygenated water amended with nutrients to remediate the shallow aquifer. Partnered with bioremediation specialist to design oxygenation system for active terminal where releases of

gasoline, diesel, ethanol, fuel oil and fertilizer have impacted site soils and groundwater.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER CONTAMINATION (continued)

Roca, Nebraska

Designed an expansion to a remediation system consisting of groundwater pump and treat, AS and SVE. The groundwater recovery system depresses the water table to optimize the recovery of petroleum compounds by the SVE system at an active terminal. The system consists of ten recovery/SVE wells and 13 AS wells. Conducts routine evaluations of system operational parameters to ensure compliance with air and surface water discharge requirements and to maximize system effectiveness.

Spartanburg, South Carolina

Manages a groundwater remediation system consisting of groundwater pump and treat and AS technologies to mitigate impacts to ground water and the adjacent surface water body. The AS system targets a localized plume near the active truck loading rack and the groundwater pump and treat system captures impacted ground water migrating onto the site from an upgradient and co-mingled petroleum plume.

Doraville, Georgia

Manages a remediation system consisting of dual-phase extraction and SVE at an active terminal. The fluid recovery system transports free-phase petroleum product and ground water to a treatment system consisting of an oil/water separator, air stripper, and filtration equipment. The system consists of 25 recovery/SVE wells. Conducts routine evaluations of system operational parameters to ensure compliance with air and surface water discharge requirements and to maximize system effectiveness.

Mosinee, Wisconsin

Designed an in-situ density-driven convection (DDC) system with Wasatch Environmental, Inc. to quickly remediate petroleum impacted groundwater at an active terminal. Downgradient potable supply wells within a subdivision were impacted. Site closure was approved by Wisconsin Department of Natural Resources.

Dubuque, Iowa

Overseeing remedial actions at an active petroleum terminal where approximately 150 barrels of fuel oil leaked from a buried product pipeline. Other historical petroleum impacts also exist on site. Due to the presence of a surficial clay layer, source excavation activities will be implemented. A biovent system was installed to create and maintain an oxygenated environment in the unsaturated weathered bedrock.

Ellenboro, Wisconsin

Designed and implemented a soil vapor extraction system to remediate soils at a Wisconsin Department of Natural Resources' state-lead site. Petroleum contamination from a leaking underground storage tank impacted numerous downgradient residential wells.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER CONTAMINATION (continued)

Vega Alta, Puerto Rico
Prepared detailed specifications for the installation of an SVE system at a site consisting of an industrial park adjacent to groundwater supply well fields. Chlorinated solvents were the contaminants of concern.

Hartland, Wisconsin
Manages project through long-term groundwater monitoring phase following active source area remediation involving in situ vaporization with humidification. Source area contained gross chlorinated solvent contamination in soil and ground water.

Rock Falls, Illinois
Pursuing site closure through the IEPA Site Remediation Program at a site where a leaking petroleum pipeline impacted soils and ground water within a residential neighborhood. Site remedial efforts included recovery trenches, an SVE system, an AS system, and point-of-entry carbon treatment systems at adjacent residences with private water supply wells. Select shallow supply wells have been replaced with wells completed to 100 feet or more below grade.

Waukesha, Wisconsin
Conducted SVE and air sparge pilot tests at a site impacted with petroleum compounds. Designed off-site groundwater recovery system to contain a 400-foot plume and minimize risk to residential supply wells. Designed an air sparge system coupled with an SVE system to remediate the source.

Watertown, Wisconsin
Supervised and inspected the installation of SVE, groundwater recovery, and AS systems for chlorinated solvent contamination at an unregulated disposal site. Monitored the operation of 17 till and bedrock recovery wells, 13 SVE well clusters, and 8 AS wells. Recovered water was treated in aeration basins and by air strippers, and the vapor was treated by catalytic oxidation and vapor-phase carbon units.

Tomah, Wisconsin
Designed a groundwater recovery and treatment system which consisted of 13 recovery wells located throughout an eight-acre site. The petroleum contaminated water was treated by iron removal filters, a tray air stripper, pressure filters, and polished by a carbon unit prior to being discharged to surface water. Designed an SVE system which consists of horizontal screens and vacuum enhancement to several recovery wells.

Ashton, Illinois
Managed remedial actions at a petroleum metering station where a relief valve failed causing

impacts to soil and shallow groundwater. An air sparge system consisting of 23 sparge points was installed. Trenches were constructed through the surficial clay layer to allow an avenue for injected air to vent to the atmosphere.

SPECIFIC EXPERIENCE IN SOIL AND GROUNDWATER CONTAMINATION (continued)

Manitowoc, Wisconsin
Designed remediation system to remove product from the water table and treat impacted ground water. System consisted of a pneumatic pump installed within a recovery well, an oil/water separator, chemical treatment, and liquid-phase carbon. Remedial action also consisted of SVE and vacuum enhanced pumping.

Oconomowoc, Wisconsin
Designed groundwater recovery, air sparge, and SVE system for a site impacted by a petroleum release. The system consisted of a groundwater recovery well, horizontal SVE wells, and AS wells. The design was fast-tracked so that installation activities could coincide with tank upgrade activities.

Stratford, Connecticut
Designed a groundwater treatment system for construction dewatering activities associated with the installation of bridge pilings. Treatment system consisted of a hopper barge retrofitted with weirs to construct sedimentation basins, heavy-duty submersible pumps, and a mixed-sand filter skid unit. Calculations were conducted to ensure that the capacity of the barge was not exceeded for this application.

SPECIFIC EXPERIENCE IN SOLID WASTE

Middleton, Wisconsin
Project manager for the operation and maintenance of a closed landfill with an active gas recovery and combustion system and a leachate recovery system. Gas recovery/combustion system consists of 13 gas recovery wells and an enclosed flare. Leachate recovery system consists of nine pneumatic leachate recovery pumps.

Troy Area Landfill, East Troy, Wisconsin
Prepared a Plan Modification Request addendum for decommissioning the active gas extraction system and converting the site into a “Green” site through the use of innovative technology and solar power. An evaluation was conducted in regards to compliance with Wisconsin Department of Natural Resources (WDNR) air regulations based on current conditions at the landfill and how compliance would be affected by the operation of a solar vacuum flare.

Edgerton, Wisconsin
Designed an SVE system and a geomembrane vapor barrier at a former solvent disposal site. The SVE system, which was installed at a State Superfund site, consisted of sixteen

wells which produced approximately 1,000 standard cubic feet per minute. Supervised the installation of the SVE system and vapor barrier. Conducted a feasibility study for free product recovery alternatives and implemented the installation of a belt skimmer.

SPECIFIC EXPERIENCE IN SOLID WASTE
(continued)

Toledo, Ohio
Prepared Remedial Design/Remedial Action Work Plan and Request for Bid to implement remedial actions at a former landfill. Remedial actions selected to minimize risk to potential receptors within an urbanized area included a soil cover over the Ohio EPA Superfund Site, slope revetment along a river bank to minimize the risk of direct contact with seeps, and phytoremediation. Provided technical support and construction oversight services during the implementation of the remedial action.

SPECIFIC EXPERIENCE IN ENVIRONMENTAL COMPLIANCE PLANS

Onalaska, Wisconsin
Prepared a Spill Prevention, Control and Countermeasure Plan (SPCC Plan) for a manufacturer of hunting-related equipment. The 24-acre manufacturing facility stores up to 7,000 gallons of gun cleaning oil or its raw components in six aboveground storage tanks. The SPCC Plan addressed each applicable section of 40 CFR § 112 as promulgated in the Federal Register, Volume 39 FR 34165, dated December 11, 1973, amended on July 17, 2002.

Michigan, Wisconsin, Illinois, Indiana
Prepared twelve SPCC Plans for a petroleum pipeline company with terminals and pumping stations located throughout the Upper Midwest. Oversaw personnel conducting the field investigations, evaluated site information, and prepared text and procedures for the plans.

LACT Facilities in North Dakota
Prepared SPCC Plans for Lease Automatic Custody Transfer (LACT) facilities in Alexander, Stanley, and Beaver Lodge.

Manteno, Illinois
Certified a SPCC Plan for a warehouse distribution center located on a 162-acre parcel. Oil used at the facility includes diesel fuel, sorter oil, gear oil, hydraulic oil, and SAE-30 oil. A waste oil storage area is also present. The SPCC plan provides procedures for handling and storing product, training oil handling personnel, and responding to and containing spills so that releases do not impact the 6-acre detention pond or municipal water sewer system.

Alma Center, Wisconsin

Prepared a Storm Water Pollution Prevention Plan (SWPP Plan) for a livestock rendering and hide curing facility. The 47-acre facility generally consists of a main receiving building (Rendering Building), an office building, a hides operation and storage facility, and a maintenance shop. The SWPP Plan identified potential sources of pollutants, applicable best management practices, and record keeping protocols.