

**Resumes of Beazer's Technical Consultants and Experts  
Involved in Feasibility Study, Risk Assessment, and Remedy Selection Discussions**

**Education:**

M.S., Geology, Arizona State University, Tempe, Arizona, 1986  
B.A., Geology, Smith College, Northampton, Massachusetts, 1984

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**Professional Experience:**

GeoTrans, Inc., Sacramento, California, (2000-Present), *Associate/ Senior Hydrogeologist*  
GeoTrans, Inc., Sacramento, California, (1994-2000), *Senior Hydrogeologist*  
McLaren/Hart Environmental Engineering, Rancho Cordova, California, (1986-1994), *Senior Geoscientist*

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Ms. Abrahams is an Associate and Senior Hydrogeologist specializing in nonaqueous phase liquids (NAPLs) remediation and remediation of CERCLA and RCRA sites. She has over 24 years of experience in groundwater analysis and remediation, and has successfully negotiated a Technical Impracticability Waiver at a CERCLA DNAPL site. Ms. Abrahams has extensive experience in the development of innovative and cost-effective remedies for free-phase and dissolved-phase organic contaminants such as creosote constituents, polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol, and organic solvents. Over the past 10 years Ms. Abrahams' work has concentrated on the use of enhanced *in situ* aerobic degradation of organics and groundwater containment remedies. Ms. Abrahams' work at wood-treating sites includes guiding the regulators through the completion of site characterization and into site remediation that includes using innovative technologies such as *in situ* chemical stabilization of residual NAPLs, enhanced aerobic degradation, monitored natural attenuation, and TI Waivers.

**Relevant Project Experience:**

Superfund Site, California - Project Manager for wood-treating CERCLA facility. Remedial Action programs include enhancement of *in situ* groundwater bioremediation, passive recovery of DNAPL, and dynamic streamlining of quarterly groundwater monitoring. Developed Data Quality Objectives (DQOs) used to substantiate suspension of operation of off-property groundwater treatment plant. Developed and maintained groundwater database for site. Prepared Technical Impracticability (TI) evaluation of groundwater restoration of a portion of the site, due to the presence of one million gallons of DNAPL. USEPA granted the TI waiver and modified the Consent Decree to incorporate the TI waiver, and include monitored natural attenuation as a groundwater remedy. Successfully transitioned off-property groundwater from enhancing bioremediation to beginning remedy attainment sampling.

Superfund Lumber Facility, California - Assisted with a comprehensive characterization program at an active wood-treatment facility. Activities included technical support and interaction with client (consisting of multiple responsible parties), USEPA, and California Department of Toxic Substances Control (DTSC). Provided scopes of work for additional phases of characterization to refine extent of contamination, including a previously unidentified deeper aquifer. Developed and directed the implementation of a focused Interim Remedial Measure. Work was conducted on a fast-track schedule to comply with the requirements of a USEPA 106 order.

Superfund Site, Florida – Task Manager for preparing a Feasibility Study (FS) for an active wood-preserving facility in Gainesville, Florida. Groundwater beneath the site is impacted with residual-phase creosote NAPLs, dissolved-phase creosote compounds and arsenic. Creosote impacts extend approximately 150 feet below land surface to the Upper Floridan Aquifer, a regional source for drinking water. The FS is a collaborative effort between the responsible party, USEPA, and Florida Department of Environmental Protection, as the site is located approximately 2 miles from a 26-MGD well field. The FS develops and evaluates remedial alternatives to achieve the site remedial action objectives (RAOs). The FS takes a comprehensive approach to ensure the best combination of actions will be taken for all impacted media and hydrologic units.

Wood Treating Facility, Mississippi - Project Manager for active wood-treating RCRA facility. Identified and collected data needed to perform a site risk assessment, including dioxin sampling in response to a USEPA request. Prepared RCRA Facility Investigation (RFI) Report presenting information for 17 SWMUs. Interim Measures designed and implemented at the site include installing a sheet-pile barrier wall to prevent migration of creosote DNAPL, excavation of DNAPL impacted sediments from a drainage across the site, and construction of an impoundment for the impacted sediments. RFI accepted 16 years after investigations began at the site. Prepared the CMS Workplan that identified

MNA as a possible corrective measure; implemented baseline MNA sampling workplan to provide data to support the potential corrective measure for the site. Managed a significant off-site soil sampling event required by EPA (and with direct EPA oversight) in response to community complaints.

Wood Treating Facility, Colorado - Inter-company team coordinator for active wood-treating RCRA facility. Coordinated a team of four consulting firms and seamlessly integrated text from all members to produce an integrated Interim Measure (IM) Report for the site. The IM will: prevent migration of creosote DNAPL, remediate the dissolved phase groundwater plume and achieve a containment/in situ remedy. The IM remedy was approved by the state and USEPA, and replaces the pump-and-treat remedy initially preferred by regulators.

Wood Treating Facility, Alabama – Project Manager for former wood-treating RCRA facility. Developed site strategy to facilitate transitioning the site to the CMS and prepared the CMS which was accepted by ADEM. Requested RCRA Permit modifications to significantly reduce required groundwater monitoring, based on revised site objectives pursuant to the implementation of the IM (sheet-pile wall). Prepared the CMI Plan that identifies the corrective measures of *in situ* biogeochemical stabilization through injection of permanganate and MNA sampling. ADEM accepted the CMI Plan and drafted a new Consent Order that will replace the RCRA Permit. Injected sodium permanganate into free-phase and residual creosote to reduce the aquifer permeability and form an encrustation around the aquifer material and NAPL droplets.

Superfund Site, North Carolina – Project Manager for former wood treating facility. Prepared and implemented pilot study to enhance the existing groundwater remedy (P&T) for pentachlorophenol plume in fractured bedrock. Enhancement includes injecting base-catalyzed persulfate into weathered bedrock.

Wood Treating Facility, Pennsylvania - Assisted with Site Remediation Assessment at facility where current owners are not legally responsible for environmental cleanup. Investigation indicated that groundwater treatment system installed by client had remediated site impacts caused by client. Remaining site impacts due to continuing sources to groundwater, caused by current owner operations. Results of the Site Remediation Assessment led to the current owners settling with the former owners.

Aerospace Superfund Site, California - Managed evaluation of potential sources of organic chemicals in production water wells adjacent to an 8,700-acre site. Identified potential responsible parties downgradient of the Superfund site and upgradient of production wells. Monitor wells installed in PRP vicinity confirmed PRP organic chemical contribution to aquifer. Scope of work included modeling groundwater flow and solute transport. Model was calibrated using regional groundwater elevations and known Superfund site source areas and concentrations.

Aerospace Superfund Sites, California - Project Manager for developing and building a database that archives technical, legal, and regulatory information for more than 950 PRPs around two aerospace superfund sites. The relational database includes summaries of all the archived records and also includes portable data format (pdf) files of the archived records. The record review and database development encompassed 4000 person hours and was completed in 8 months.

Aerospace Superfund Site, California - Project Manager for developing a focused feasibility study and technical impracticability evaluation for the restoration of groundwater at a 550-acre site. Site impacted with TCE DNAPL and perchlorate in fractured crystalline bedrock. Established professional relationship with federal and state regulators facilitated award of this contract.

Defense Contractor Facility - Evaluated effectiveness of groundwater extraction treatment systems as containment measures for solvent plumes at an 8,700-acre site. Developed and implemented additional extraction points to improve plume containment.

Petroleum Industry Service Stations - California, Colorado, New Mexico, and Texas. Project coordinator and project manager for characterization and remediation at sites that manufactured and serviced rod sucker pumps. The manufacturing sites have chromium, VOC and petroleum hydrocarbon impacts to soil and groundwater. The service station sites have petroleum hydrocarbon impacts to soil and groundwater and naturally occurring radioactive material impacts to surface soils. Received NFA on two California rod sucker pump service station sites; one site required removal of 3,000 yd<sup>3</sup> of impacted soils, and minor amounts of VOC impacts remained in site groundwater.

Paint Manufacturing Facility, California. - Project Manager for an active paint manufacturing facility in the Los Angeles vicinity with VOC impacted soils. Successfully negotiated the shutdown of a VES that operated 10 years and was removing 300 to 500 pounds of VOCs per month. The site remediation was transitioned to passive *in situ* enhanced bioremediation. Provided documentation to the local enforcement agency that the residual impacts in site soils did not pose a threat to humans by direct contact, did not pose a potential threat to groundwater, and did not pose a potential threat to humans by vapor intrusion into on-site buildings. The local enforcement agency granted closure of the site.

Superfund Site, California - Prepared a Feasibility Study for a 38-acre site that contains petroleum refining waste materials in the midst of residential developments. The FS presents remedial alternatives that provide appropriate remedial response for site sources, pathways, and receptors identified as posing a potential risk to public health and environment at the site.

Defense Contractor's Shipbuilding Facility - Prepared site characterization report summarizing soil and groundwater investigations. Site investigations included underground tanks, soils at potential source areas, storm sewers, groundwater quality and aquifer properties, and geotechnical and chemical properties of the nearshore sediments.

FMC, Modesto, California - Project Manager for former barium and strontium chemical producing facility. Site soils and groundwater are impacted with TDS, sulfate, nitrate, nitrite, and arsenic. Managed implementing tasks identified in the Voluntary Cleanup Agreement, established between FMC and DTSC, including completing the characterization of site impacts and preparing a Public Participation Plan. City of Modesto holds an option to purchase the site after the nature and extent of soil remediation activities have been established. Comprehensive Remedial Investigation Report was accepted by both DTSC and RWQCB. Implemented Interim Removal Action Workplan, which included excavating, transporting and disposing off-site over 20,000 tons of soil with site impacts at concentrations above site-specific target levels. Feasibility Study to remediate soils and groundwater addressed potential impacts of the RWQCB establishing a Total Maximum Daily Load for salinity, that may impact the discharge options of the current site groundwater extraction and treatment plant. FS was accepted by both the DTSC and RWQCB. Prepared a Remedial Action Plan for Soil and Groundwater that identifies covering the remaining soil impacts with an industrial/commercial development.

FMC, Newark, California – Project Manager for a former EDB manufacturing facility. NAPLs consisting of EDB and 1,2-DCA are present in site soils and groundwater. Implementation of pilot-scale six-phase heating with SVE and dual-phase extraction (DPE) with steam-enhanced injection technologies both failed at the site due to the harsh site environment of tight clayey soils and saline groundwater. Prepared a Revised Curtailment Report and Feasibility Study to request: curtailment of the DPE system, continued operation of the groundwater extraction and treatment system, covering soils with concentrations above the site-specific target levels, and implementing land use restrictions.

FMC, San Jose, California - Project Manager for VOC-impacted facility. Evaluated the occurrence of natural attenuation at site as a part of a remedial alternative analysis. Investigations included soil and groundwater sampling performed in accordance with AFCEE protocol. Implemented full scale application of Hydrogen Releasing Compounds to low permeability sediments, to remediate soil and shallow groundwater at the site.

United Defense, San Jose, California - Developed sampling plan to document dual phase extraction with pneumatic fracturing cleanup of site soils impacted with volatile organic compounds (mainly trichloroethylene). The State of California Regional Water Quality Control Board (RWQCB) accepted the cleanup verification plan that calculates the 95% upper confidence limit to determine whether the site cleanup standard has been met. Documented system operation to RWQCB to meet cleanup order requirements.

Large Automobile Manufacturing Facility - Assisted in site use history-based investigation of potential source areas of soil and groundwater contamination. Assisted with successful negotiations with regulatory agency to obtain approval to close over 200 sumps and pits without remediation, based on results of investigative work. Insured compliance with NPDES permit.

Confidential Aerospace Client, Southern California - Performed site characterization and investigation defining solvent contamination plumes for a 950-acre site. The project involved over 20 suspected chemical discharge source areas where solvents, heavy metals, and petroleum products were detected in soils and groundwater. RI/FS documentation indicated that site remediation required implementation of an oil recovery system and multiple-extraction well

groundwater control system.

Several Semiconductor Facilities, Santa Clara Valley, California - Prepared remedial investigations and implemented remedial actions for solvent contamination of soil and groundwater. Remediation included installation of vapor extraction systems and air stripping towers.

Confidential Client - Managed and implemented the startup of a 250-gpm air stripping tower for removal of solvents from groundwater at a semiconductor site. Assessed the effectiveness of the groundwater treatment system.

Major Aerospace Firm and Semiconductor Firms - Prepared numerous technical reports documenting investigations and remediation of solvent and heavy metal contamination. Reports included feasibility studies, remedial action reports, detailed workplans, sample plans, and Bay Area Air Quality Management and Regional Water Quality Control Board reports.

Class I Hazardous Waste Landfill, Benicia, California - Prepared EIR Project Description for closure of 200-acre site. Reviewed and assessed various environmental setting sections for completeness, technical quality, and legal applicability. Preparation included significant negotiations between California Department of Toxic Substances Control, the lead agency, and multiple responsible agencies. Closure of the landfill has been a politically sensitive issue for all involved agencies and local city and county governments, and has been an ongoing process from 1986 through 1994.

Sawmill Facility - Project Manager for environmental assessment and initial soil and groundwater environmental sampling at a 38-acre site with contamination from wood-treatment chemicals.

Aerospace Facility - Supervised and conducted onsite investigation of environmental assessment for 110-acre site with two million square feet of building space in operation for over 60 years. Investigation included negotiating initial sample locations with the Regional Water Quality Control Board to assess the status of identified areas of potential environmental concern.

Major Aerospace Corporation - Performed numerous onsite investigation, regulatory agency review, and report preparation for environmental assessments.

Corps of Engineers, Cold Region Research Engineering Laboratory, Hanover, New Hampshire - Researched sorption/desorption properties of heavy metals in soils.

Confidential Client - Installed and evaluated the effectiveness of *in situ* vapor extraction system for vadose zone soil contamination. Treatment of soil permitted regulatory agency site closure.

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### **Professional Certification:**

Professional Geologist, #6380, CA  
Registered Environmental Assessor, #04807, CA  
Professional Geologist, #1116, AL

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### **Professional Affiliations:**

Sigma Xi  
Geological Society of America  
Groundwater Resources Association of California  
Association of Women Geoscientists

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### **Publications:**

1. Abrahams, J.A., A.A. Kopania, and M.D. Tischuk. 2000. Technical Impracticability Evaluation of Groundwater

Restoration at Creosote-Impacted Site, 2<sup>nd</sup> International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22-25, Monterey, California.

2. Abrahams, J.A., A.A. Kopania, J.G. Mueller, and M.D. Tischuk. 2003. DNAPL Management at a Creosote-Impacted Site, Seventh International Symposium on In Situ and On-Site Bioremediation, June 2-5, Orlando, Florida.
3. Abrahams, J.A., A.A. Kopania, and M.D. Tischuk. 2004. Boron Remediation at Creosote-Impacted Site, Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 24-27, 2004, Monterey, California.
4. Abrahams, J.A., A.A. Kopania, J.G. Bold, M.D. Tischuk, and M.W. Bollinger, 2004. Costs to Remediate a Creosote-Impacted CERCLA Site, National Ground Water Association Conference on Remediation: Site Closure and the Total Cost of Cleanup, November 15-16, New Orleans, Louisiana.
5. King, M., R. Anderson, K. Paschl, M. Bollinger, M. Brouman, M. Helbling, J. Abrahams, and R. Bauer, 2006. Optimization of Long-Term Monitoring at Wood-Treating Sites, Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22-25, 2006, Monterey, California.

## Education

Postdoctoral Fellowship,  
Interdisciplinary Programs in  
Health, Harvard School of  
Public Health  
Postdoctoral Fellowship,  
Biology Department, Harvard  
University  
PhD, Biology, Harvard  
University, 1983  
MA, Biology, Harvard  
University, 1981  
BA, Biology, Boston University,  
1978

## Years of Experience

Total - 25  
With ARCADIS - 1

## Professional Associations

American Association for  
Advancement of Science  
(AAAS)  
American Chemical Society  
Ecological Society of America  
Society of Environmental  
Toxicology and Chemistry  
Water Environment Federation  
(WEF)

## Paul D. Anderson, PhD

### Vice President/Principal Scientist

Dr. Anderson has over 25 years of experience in human health and ecological risk assessment. He has been involved in evaluating the potential effects of pharmaceuticals in the environment as well as constituents of emerging concern (CEC). His work has also included investigation and assessment of PAHs and metals in sediments and he has done a significant amount of work on the assessment of human health and ecological risks posed by dioxins/furans.

Dr. Anderson has performed numerous multimedia, multichemical and multipathway risk assessments for federal and state superfund sites throughout the United States including operating and abandoned chemical and manufacturing facilities, landfills, former woodtreating sites, and pulp and paper mills. Dr. Anderson has managed the development of a watershed based model that predicts environmental concentrations of pharmaceuticals and related compounds in United States surface waters and oversees a database containing all the information available in the peer-reviewed literature on the aquatic toxicity, fate and removal of active pharmaceutical ingredients in surface waters. In addition, he has conducted human health and ecological risk assessments in support of the air and water permitting required for large industrial facilities and has prepared comments on the scientific basis of many Federal and State regulations such as the Great Lakes Water Quality Initiative and EPA's Combustion Initiative. Much of this work has been at sites and facilities where extensive negotiations with regulatory agencies have been critical for the successful completion of projects. Dr. Anderson is a leading advocate of advanced risk assessment techniques such as Monte Carlo analysis, has written over 20 papers and lectured widely on ecological and human health risk assessment, and has testified throughout the United States on the potential risks posed by dioxin and other chemicals. Dr. Anderson is also currently an Adjunct Assistant Professor in the Center for Energy and Environmental Studies at Boston University.

### Ecological Risk Assessment

Dr. Anderson has conducted and overseen a wide range of ecological risk assessments, from focused assessments on a single species in a local setting to whole ecosystems potentially affected by sites to endangered or threatened species in a large geographical area. Media of concern at these sites have typically been, soils, surface waters and sediments. At many of these sites dioxins, PAHs, PCBs and metals have been constituents of concern. Dr. Anderson has been an active proponent of rational assessment and management of sediment contamination in North America. Dr. Anderson has also lectured widely, as well as taught courses on ecological risk assessment.



**Human Health Risk Assessment**

Dr. Anderson has completed numerous human health risk assessments over the past 15 years. These have ranged from simple screening assessments to complex multi-pathway, multi-media, multi-chemical risk assessments. In many of these risk assessments the focus has been on the potential risks associated with bioaccumulative chemicals such as dioxins and PCBs, as well as polynuclear aromatic hydrocarbons (PAHs) and metals. Dr. Anderson has also been a leading advocate of the need to incorporate probabilistic techniques in risk assessment as well as of balancing the risks from exposure to the chemical of concern against the risks associated with the proposed action to reduce the potential exposure. Dr. Anderson developed and teaches a graduate level risk assessment course at Boston University as well as short courses in various cities in the United States.

**Litigation Support**

Dr. Anderson has provided expert support to attorneys as they prepare other witnesses for testimony in addition to providing expert testimony himself in both criminal and civil proceedings. Dr. Anderson has testified in front of juries, administrative law judges and state environmental boards as well as at public meetings.

**Regulatory Review**

Dr. Anderson has, on a regular basis, been called upon to review proposed State and Federal regulatory initiatives by a variety of organizations. Dr. Anderson has reviewed and provided comment on general human health and ecological risk assessment guidance, on proposed toxicity factors for several chemicals, on proposed methods to develop surface water quality criteria, on proposed criteria for specific chemicals, and on the Great Lakes water quality guidance, among other regulations.

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**Project Experience****Development of Watershed-Based Exposure Model for Human-Use Pharmaceutical Compounds**

PhRMA, Washington, D.C

Served as project manager for the development of a fate, transport, and toxicity model for products in the environment. This project required expertise in toxicology, health risk data analysis, programming, and GIS analysis. The first phase of the project was to evaluate an existing risk assessment model. Based upon the evaluation of that model, the research team agreed that development of a new model would best meet client objectives. Dr. Anderson oversaw development of that model for use as a predictive tool to estimate environmental concentrations of pharmaceuticals and personal care products in drinking water, surface water and fish. The model predicts concentrations of the selected compounds in the drinking water of people served by surface water-based Drinking Water Treatment Systems located within 12 watersheds in the US and in river reach segments within those 12 watersheds as well as fish



living in those segments. The GIS work included the compilation, evaluation, and editing of national GIS data sets for hydrography, permit compliance, wastewater facilities, drinking water supplies, and population. The study involved flow-route modeling and event sequence modeling on a watershed approach. The model has been published in Environmental Science and Technology.

#### **Trace Organic Compounds in Wastewater**

Water Environment Research Foundation, Washington, DC

Principal-in-charge and lead investigator for preparation of a Technical Brief on Trace Organic Compounds and Implications for Wastewater Treatment. The goal of this project was to update and expand the 2005 Technical Brief on endocrine disrupting compounds to include the full range of organic compounds that may occur at trace levels in wastewater treatment plant effluents. Topics covered by the brief included: a review of the different sources and categories of trace organic compounds; how they are measured; their removal in treatment plants; an introduction to the potential ecological and human health effects associated with trace organics in treated wastewater, reclaimed water, and receiving streams; and, an overview of current research needs including a summary of web-links describing major current research initiatives.

#### **Database of Aquatic Toxicity and Environmental Fate Information for Pharmaceutical Compounds**

PhRMA, Washington, D.C

Principal in charge for the development and maintenance of a database that summarizes information from all of the English language peer-reviewed literature on the aquatic toxicity, environmental fate and treatment plant removal of pharmaceutical compounds in surface waters. The database is designed to make all historical information easily accessible to users as well as providing them with up-to-date information (the database is updated quarterly). The user-interface is currently undergoing modification to make it easier for users to search the database and identify relationships between different compounds, therapeutic classes, test species, toxicity endpoints, and other parameters that affect the aquatic toxicity and fate on active pharmaceutical ingredients.

#### **Derivation of Risk-based Guidelines for Drinking Water Consumption of Two Pharmaceuticals, Remediation Strategy and Design**

Farchemia, Milan, Italy

Assisted in the derivation of human health risk-based guidelines for drinking water consumption for two pharmaceuticals using standard risk assessment methods and procedures. At a manufacturing facility in Italy, the off-Site plume of carbamazepine and dimetridazole was estimated to be over 20 kilometers. No Tolerable Daily Intake (TDI) or Acceptable Daily Intake (ADI) values were available in the published literature leading the regulatory agency to select very low target levels of 0.1 and 0.3 ppb for carbamazepine and dimetridazole, respectively. We researched the published toxicology literature, summarized the literature on adverse effects and

the dose levels at which they occurred, and derived a TDI using the methods and procedures that are in normal use by regulatory agencies. From the TDIs, groundwater remedial goals for the two pharmaceuticals were derived and documented. These values significantly reduced the extent of the groundwater plume that was of a potential health concern enabling Farmchemia to move forward with evaluating more cost-effective remediation alternatives than would otherwise be required.

**Development of a Predicted No Adverse Effect Level of Ethinyl Estradiol for Surface Water**  
PhRMA, Washington, D.C

Member of a research team comprised of scientists from several pharmaceutical companies and academic institutes charged with compiling and reviewing all available information on the aquatic toxicity of ethinyl estradiol, and then deriving a predicted no effect concentration (PNEC). Following the compilation of all available data, we selected the most sensitive endpoint (reproduction) and taxa (fish) to develop a species sensitivity distribution using studies in fish investigating reproductive effects to derive a PNEC of 0.35 ng/l. The results were published in Environmental Science and Technology in 2008.

**Review of the Comprehensive Exposure Assessment of Estrogens in the United States**  
Confidential Client, U.S

Served as principal in charge for a study that evaluated potential human exposures to estrogens through environmental sources and dietary intake. This study incorporated a comprehensive literature survey to quantify contributions of endogenous and prescribed hormones from humans and livestock to environmental media as well as exposure through dietary intake. Dr. Anderson reviewed available literature on the production of these hormones by humans and livestock and on measured concentrations of natural and synthetic estrogens in surface water, drinking water, ground water, and soil. Data on the concentrations of these hormones as well as phytoestrogens in foodstuffs have also been gathered. A weight of evidence evaluation was conducted by comparing predicted concentrations of estrogens in drinking water to several independent benchmarks. The study found that concentrations of prescribed estrogens in drinking water are several orders of magnitude below the various benchmarks suggesting estrogens in drinking water are not associated with adverse effects in humans.

**Review and Comparison of Predicted and Measured Concentrations of Ethinyl Estradiol in Surface Waters Throughout the World**

PhRMA, Washington, D.C

Member of a research team comprised of scientists from several pharmaceutical companies and academic institutes charged with determining the range of concentrations of ethinyl estradiol that might be present in surface waters. The research team identified, compiled and reviewed all peer-reviewed papers reporting on the occurrence of ethinyl estradiol in surface water anywhere in the world. The range of measured concentrations was compared to the results of conservative mass balance models as well as more sophisticated geographic information system models to

identify an upper limit on expected concentrations. Several of the measured concentrations were found to exceed the highest modeled concentrations. Further review of the measured concentrations revealed that some of the analytical methods had the potential to report concentrations that were biased high and that several of the commonly cited concentrations of ethinyl estradiol are not representative of typical concentrations in surface water. The findings of this analysis have been submitted for publication.

#### **Review of the State-of-the-Science of Endocrine Disrupting Compounds and Implications for Wastewater Treatment**

Water Environment Research Foundation, Washington, DC

Principal-in-charge and lead investigator of a monograph describing the sources of endocrine disrupting compounds (EDCs) in wastewater, their fate in wastewater treatment processes, and impacts in the environment as a result of discharges. The results of this research effort were published in 2005 as the Technical Brief: Endocrine Disrupting Compounds and Implications for Wastewater Treatment.

#### **Sensitivity Analysis of Remediation Drivers at a RCRA Site**

Confidential Client, Guthrie, Kentucky

Completed a sensitivity analysis of potential human and ecological risk assessment receptors at a RCRA site in Kentucky with offsite sediment issues downstream from an operating facility. By identifying the potential exposures that drive site risks, site investigation activities avoided possible pitfalls, such as agency-required sampling efforts based on presumptions about what's driving risk at the site, when in fact, those presumptions may be incorrect. Historical evaluations of the downstream reaches suggested that potential ecological risks were likely to drive the need for sediment remediation. Existing sediment data were compared to screening sediment quality guidelines to identify the segments of the stream that could possibly require remediation. Final determination of whether remediation was required in any of these reaches was determined by additional site-specific ecological field investigations. However, because the stream flows through residential areas with no access limitations, a sensitivity analysis of both human health and ecological risks was conducted prior to undertaking extensive site-specific ecological field work to confirm that ecological risk was the driver. The sensitivity analysis showed the use of default agency exposure parameters resulted in human health risks due to exposure to sediments. Subsequently, more realistic site-specific exposure assumptions were proposed. Because the agency was unwilling to accept alternative site-specific human health exposure parameters, a more practical approach of identifying and removing depositional areas was agreed to. The sensitivity analysis enabled the client to identify that the potential human health risks were the most sensitive endpoint and possibly avoid a more extensive ecological field investigation in the readily accessible reaches of the stream. Collection of site-specific benthic macroinvertebrate community data in the more pristine areas of the stream, as well as analysis of fish and flying insect from the flood plain areas, demonstrated that potential ecological risks were as much as 1,000 times lower than were estimated by a screening ecological evaluation. The more realistic

evaluation of potential ecological risk allowed the Kentucky Department of Environmental Protection to conclude that remediation of sediments in non-residential portions of the stream was not required even though polynuclear aromatic hydrocarbon concentrations exceeded screening benchmarks by more than 10-fold.

#### **Derivation of a Clean-Up Goal for PAH in Sediments**

Confidential Client, Follansbee, West Virginia

Historical releases from a facility on the bank of the Ohio River resulted in the presence of elevated levels of coal tar-derived PAH in sediments. To determine the limits of remediation, US EPA was requesting either use of typical conservative sediment screening benchmarks or site-specific toxicity tests. Dr. Anderson proposed compiling sediment toxicity testing information from several other wood treating sites, showing that these results are relevant and applicable to the Follansbee facility, and using the results from the other sites to derive a defensible PAH clean-up goal without having to conduct site-specific toxicity tests. US EPA concurred with this approach. Results from the other sites indicated that at total PAH concentrations of less than 100 parts per million, as long as the PAH are of pyrogenic and not petrogenic origin, adverse effects would not be expected. In fact, adverse effects are unlikely at total PAH concentrations of less than 250 parts per million. These total PAH concentrations are about 100-fold higher than typical sediment screening benchmarks. US EPA agreed that sediment with less than 100 parts per million total PAH could remain in place and not require additional testing or remediation, thereby saving the client substantial investigation resources and reducing the time to design and implement a remedy.

#### **RFI Negotiations, Risk Assessment and EI 725 Determination**

Confidential Client, Florence, South Carolina

Used a geostatistical analysis to determine that existing data were insufficient to conduct a realistic human health and ecological risk assessment as well as to identify locations where additional samples were required. Developed an excellent working relationship with risk assessment staff at the South Carolina Department of Health and Environmental Control Entered through extensive negotiations to scope the details of the human health and ecological risk assessment. Constituents of concern included, pentachlorophenol, dioxin, metals, and polynuclear aromatic hydrocarbons. Use of bootstrapping and spatial geostatistics led to the development of representative exposure point concentrations. Those representative concentrations combined with a range of assumptions regarding potential exposure and absorption of constituents of concern led to the development a range of conservative but representative potential risks. Estimated potential risks fell within EPA's range of allowable risk and remediation of on-site soils was not required. The risk assessment was also used to supplement the EI determination to show that potential human exposures are under control.

#### **Demonstrating Protectiveness of a Technical Impracticability Waiver**

Confidential Client, Westboro, Massachusetts

As part of a Technical Impracticability Waiver, worked cooperatively with U.S. EPA and Massachusetts DEP to develop a program to evaluate the potential adverse effects to a pond ecosystem associated with the discharge of a dissolved PAH groundwater plume. The program included developing site-specific EqP-based sediment quality goals (SQGs) substantially higher than benchmarks commonly used by U.S. EPA and MA DEP to evaluate sediments. Site-specific toxicity tests and benthic community evaluations were completed to document the protectiveness of the site-specific SQGs. In addition, long-term monitoring of PAH sediment concentrations is being conducted to document that the extent and magnitude of the groundwater plume is stable and the pond ecosystem is not at risk.

#### **RCRA Site**

Confidential Client, Montgomery, Alabama

A confidential client requested that Dr. Anderson assist in the review of the proposed ecological and human health risk assessment protocol at an active woodtreating plant located on a river. The existing protocol called for a detailed human health and ecological risk assessment based upon data collected immediately adjacent to the facility. Because the river had many upstream sources of the chemicals of concern, the existing protocol would not be able to discriminate between facility-related risks and risk from upstream sources. In addition, remedial solutions for the SWMUs had already been determined. Proposed a risk assessment protocol that used risk assessment and fate and transport modelling to demonstrate that once the remedial solutions are implemented, facility-related risks will be at or below acceptable levels. This solution met our clients technical and regulatory needs and saved the client money because neither additional sampling in the river nor a baseline risk assessment was needed.

#### **Biological Assessment for Listed Salmonids**

Potlatch Corporation, Lewiston, Idaho

Managed, and conducted portions of, the Biological Assessment of the NPDES permit renewal for Potlatch Corporation's bleach kraft mill in Lewiston Idaho at the confluence of the Snake and Clearwater Rivers. The Biological Assessment included an evaluation of all the permit parameters (e.g., dioxin, AOX, chloroform, chlorinated phenolics, temperature, biological oxygen demand, turbidity) on each of the listed salmonids (e.g., sockeye salmon, spring/summer run chinook salmon, fall run chinook salmon, steelhead, cutthroat trout, bull trout). A combination of data from the literature, monitoring data from the river, toxicity testing with the effluent and modeling of the effluent in the river was used to complete the Biological Assessment. The Biological Assessment concluded that the effluent is not likely to adversely effect the listed salmonids and that stricter NPDES permit limits are therefore not required.

#### **Comments on the Scientific Basis of the Great Lakes Water Quality Initiative**

NCASI, Kalamazoo, Michigan

Managed the intensive review of the key parameters that determine the water quality criteria proposed in the Great Lakes Water Quality Initiative (GLI). Chemicals reviewed included: PCB,

mercury, dioxin, pentachlorophenol and phenol. Other key aspects of the project included: a detailed critique of the U.S. EPA proposed food chain multiplier methodology used to estimate bioaccumulation; a review of the development of criteria protective of aquatic life; the use of Monte Carlo techniques to develop both human and wildlife criteria for PCB, mercury and dioxin; and a comprehensive review of the fate, transport and accumulation of mercury and PCB in the Great Lakes and other environments. under control.

#### **Fish Consumption Advisory Lifted**

Buckeye Cellulose, Inc. (formerly Proctor and Gamble), Perry, Florida

Assisted Buckeye Cellulose mill in collaborating with the Florida Department of Health (DOH) to lift an advisory banning consumption of fish from the Fenholloway River in Taylor County. The advisory warned the public against eating fish from the river, which at the time had high levels of dioxin contamination. The ban included the area of Fenholloway River located from the discharge point of the Buckeye Cellulose, Inc. (the former Proctor and Gamble) pulp mill to the mouth of the river. Samples of fish collected from three points in the river now show much lower dioxin levels in both types of fish likely to show dioxin contamination throughout the area previously covered by the advisory.

#### **Bailly Generating Station**

NiSource, Chesterton, Indiana

Provided strategic ecological risk assessment oversight for a coal-fired power generating station in northwest Indiana. The Site is located on the shore of Lake Michigan and borders the Indiana Dunes National Lakeshore (IDNL). Proximity to both Lake Michigan and the IDNL heighten focus on potential ecological effects and has required initiating field studies to evaluate potential effects to plants and amphibians, in addition to the more typical ecological risk assessment evaluations.

#### **Genesee River Dredging**

CSX Transportation, Rochester, New York

Conducted a screening level risk assessment to estimate the potential effects of methylene chloride concentrations down-stream of a proposed sediment dredging area and assess the potential impact of dissolved methylene chloride on ecological and human receptors.

#### **Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption**

Selected to be a member of the research team and one of the authors for this cooperative agreement between TERA and U.S. EPA. The project assessed the potential risks and benefits of eating contaminated fish. First some of the well-documented benefits of eating fish were summarized followed by an evaluation of the potential cancer and non-cancer risks associated with contaminants in fish. A framework was then created that expressed both the benefits and risks on a common scale allowing for comparison of benefits to risk. To demonstrate the framework's utility, the final report used it to compare the coronary heart disease, stroke and arthritis benefits of eating fish to the potential risks from chlordane and methyl mercury in a

hypothetical example as well as two case studies. At low to moderate consumption rates (up to about 50 grams per person per day, about two meals a week) benefits outweighed total (cancer and non-cancer) potential risks. At essentially all consumption rates benefits outweighed cancer risks, suggesting cancer risk should not be used to set fish consumption advisories.

#### **Relative Exposure Approach for Setting Fish Consumption Advisories**

Florida Pulp and Paper Association, Tallahassee, Florida

Developed an approach to setting fish consumption advisories that estimates the potential exposure to a chemical from several dietary sources, including recreational fish consumption, and then determines the need for an advisory by comparing exposures from different dietary sources. When a proposed advisory would substantially reduce overall exposure, the relative exposure approach suggests the advisory may be warranted. When the proposed advisory would not change overall exposure, the advisory may not be warranted. Case studies using methyl mercury and PCB suggested concentrations currently used to set existing advisories may be appropriate because they do limit overall exposure. However, for dioxin, some of U.S. EPA's proposed concentration limits are not appropriate because they will not result in any measurable change in overall dioxin exposure.

#### **Review of a Draft Biological Opinion for Bald Eagles in Maine**

Pierce Atwood Attorneys, Portland, Maine

Reviewed the scientific basis for the conclusions reached by a draft Biological Opinion released in February 2000 by the U.S. Fish and Wildlife Service. That draft Opinion concluded that even after compliance with Cluster Rule NPDES permit limits, the concentrations of dioxins in fish downstream of bleach kraft mills in Maine will result in an incidental take (i.e. cause harm) of eagles. The review showed that the conclusion of the draft Opinion was not supported by eagle productivity data near mills. The review also showed that the hazard model used by U.S. Fish and Wildlife Service to justify the "take statement" in the draft Opinion contained several incorrect assumptions and that when more appropriate assumptions are employed no adverse effect is predicted by the model. Finally, the review also found evidence that other factors, such as weather, have been associated with adverse effects to eagles in Maine. The review concluded that the best scientific evidence available today indicates that current levels of dioxin in fish in Maine do not cause adverse effects in eagles.

#### **Evaluation of State-wide Water Quality Criteria Development**

Florida Pulp and Paper Association, Tallahassee, Florida

On behalf of the association participated in the development of a methodology to derive state-wide water quality criteria for potentially toxic chemicals. Assisted in the interpretation and application of the results of a state-wide fish consumption survey, the use of probabilistic methods to derive water quality criteria, the development of inputs and assumptions used in the methodology (including duration of residence, absorption adjustment factors and bioconcentration factors).



**Evaluation of Potential Ecological Risks From Dioxins**

Buckeye Cellulose, Inc. (formerly Proctor and Gamble), Perry, Florida

Conducted a screening-level evaluation of potential risks to birds, mammals and fish living along and in the Fenholloway River whose flow for much of the time is dominated by effluent from a bleach kraft mill in Perry Florida. The study was precipitated by the U.S. EPA findings on elevated levels of dioxins (as high as 85 parts per trillion) in river sediments. The risk assessment employed a screening-level approach (i.e, toxicity quotients) combined with site-specific observations about sediments and the biota in the river to demonstrate that unacceptable risks were not expected. The risk assessment was presented to, and submitted to, U.S. EPA. At this time U.S. EPA has not requested that the mill do any additional studies or evaluations in the river.

**Nationwide Dioxin Risk Assessment Using Monte Carlo Analysis**

NCASI, Raleigh, North Carolina

Used Monte Carlo Analysis to perform a national exposure and risk assessment of the potential risks associated with consumption of fish containing 2,3,7,8 TCDD downstream of bleach kraft mills for the National Council of the Paper Industry for Air and Stream Improvement. The assessment showed that the U.S. EPA had in an earlier risk assessment overestimated potential exposures and risks by as much as 1000 fold. This result suggests that reducing the levels of dioxin in the effluent of bleach kraft mills may not be a public health priority on either a national or local level.

**Development of a Foodchain Bioaccumulation Model for Dioxins**

NCASI, New York, New York

Served as principal in charge and managed all aspects of the development of a computerized model to predict levels of dioxin in river water and fish and predict potential exposure and risk to humans for the National Council of the Paper Industry for Air and Stream Improvement. The procedure uses dynamic modeling of rivers and food chains to predict realistic and site specific levels of dioxin bioaccumulation in fish. The procedure estimates potential exposures via four exposure pathways (fish consumption, swimming, mother's milk, and drinking water) and assesses potential cancer risk using both threshold and non threshold approaches. The model has been used by pulp and paper mills to calculate realistic, achievable, health protective, and cost effective dioxin effluent limits. Managed the development of and implemented a workshop on the dioxin modeling procedure. The workshop was presented on the East and West Coasts and the Midwest to industry representatives, as well as to the U.S. EPA headquarters and U.S. EPA Region I.

**Review of U.S. EPA Dioxin Exposure Document**

Prepared peer review comments on the U.S. EPA document entitled "Estimating Exposures to Dioxin Like Compounds" (August 1992) for the National Council of the Paper Industry for Air and Stream Improvement. Written and oral comments stressed the need to use site specific data

whenever possible when estimating exposures to dioxin through foodchain pathways. Comments also stressed the need for the document to incorporate Monte Carlo Analysis in subsequent revisions. The existing draft does not represent the best science available.

#### **Development of Alternative Dioxin Water Quality Standards**

Developed scientifically defensible alternative dioxin water quality standards based on a critical review of the assumptions used in the US EPA Ambient Water Quality Criteria; demonstrated current science does not support several of the US EPA assumptions; and developed alternative assumptions based on more recent scientific and site specific information. Presented those alternatives to federal and state regulators, legislators, and the public through private meetings, public meetings, informational workshops, and expert testimony in: Alabama, Arkansas, Florida, Georgia, Maine, Michigan, Mississippi, New Hampshire, North Carolina, Pennsylvania, South Carolina, Tennessee and Texas. Several states have now adopted the alternative dioxin standards.

#### **Monte Carlo Analysis Based Water Quality Standards**

Completed a statewide Monte Carlo Analysis in support of the existing dioxin Water Quality Standard and presented the results in an administrative hearing for the Alabama Pulp and Paper Mills. The analysis showed that the existing Standard provided ample protection for even people who eat much greater amounts of fish than assumed by the Standard. Demonstrated that the potential risk to the average Alabama resident is much lower than the level of risk assumed to be allowable by the dioxin Standard. Based upon the evidence presented in the hearing, the judge ruled to retain the existing standard.

#### **Sediment and Benthic Biota Sampling**

W.R. Grace, Baltimore, Maryland

At a manufacturing facility with historic, and possibly ongoing, releases of metals to Baltimore Harbor, supervised the development and implementation of a sediment characterization plan. The highlight of the plan was ponar sampling of benthic macroinvertebrates for community analysis at several stations along the perimeter of the site and also at reference stations. Collocated porewater and bulk sediment samples were also collected and analyzed for chemistry and physicochemical properties (metals, pH, Eh, grain size, TOC, etc.). Though some site-related metals exceeded screening benchmarks in either porewater or bulk sediments, the macroinvertebrate community evaluation revealed no adverse effect associated with metals in sediments.

#### **Evaluation of Proposed Sediment Remedy**

Arnold and Porter, Jersey City, New Jersey

Appointed to an expert blue ribbon panel convened to review the protectiveness of a proposed remedy for sediments contaminated with chromium. Reviewed the human health and ecological risk assessments. Provided suggestions for additional study to demonstrate the absence of

oxidation of chromium III to chromium VI following sediment disturbance during extreme storm events. Conducted probabilistic evaluations to better document the protectiveness of the proposed sediment clean up goal.

#### **RCRA Site**

Confidential Client, Georgia

Conducted an ecological evaluation of a stream and wetland of an active CCA production facility and assisted in developing the strategy for the human health risk assessment. Because of regulatory deadlines the risk assessment and any additional investigation driven by the risk assessment, needed to be completed in less than six weeks time. Added to those constraints was that Georgia EPD required that the risk assessment be acceptable upon delivery. Dr. Anderson worked closely with the client and Georgia EPD staff to develop an acceptable risk assessment protocol. Part of this protocol concluded that on-site portions of the stream did not constitute critical habitat and did not require quantitative evaluation in the ecological risk assessment. The offsite portions were deemed to be important and potentially affected by releases from the facility. Comparison of analytical data from downstream sediments indicated that arsenic, chromium and copper were above sediment screening criteria, though not necessarily local background; however, sediment toxicity testing indicated no increase in mortality above that found in reference locations. A screening evaluation of potential wildlife also found no adverse effects. The work was completed within the six week time frame and was acceptable to the Georgia EPD.

#### **Evaluation of Risks from Carbonless Copy Paper Constituents in Effluent**

Confidential Client, Chillicothe, Ohio

Ohio EPA was renewing the NPDES permit for a bleach Kraft mill that manufactures carbonless copy paper. Earlier interactions with Ohio EPA indicated that the agency was concerned that the capsules in which the colorformers were contained, the colorformers themselves, and the capsules and colorformers in combination, may pose a potential risk to humans and the environment. In response to those concerns, we reviewed of all available data regarding the potential toxicity of the various constituents and developed responses to the agency's concerns. Based upon that review, prepared responses to the agency's concerns. The responses indicated that potential risks to humans and the environment were not expected and that permit limits for some of the constituents were not necessary.

#### **Review of Risk Assessment for Yaworski Disposal Site**

Connecticut

On behalf of PRP committee, reviewed agency risk assessment for a former disposal site in Connecticut. Showed that the exposure assumptions employed in the risk assessment were unrealistic. Use of more realistic assumptions lowered the potential risk substantially. The current negligible risk of adverse human health effects combined with potential ecological risks associated with remediation led to a recommendation that remedial alternatives that would disturb

the wastes not be undertaken. The agency concurred and ACLs are being developed that are protective of both humans and ecological receptors, but do not require disturbance of the waste.

#### **RCRA Site**

Confidential Client, Houston, Texas

Developed the strategy for a human health risk assessment at an active chemical storage facility. The facility had several previous owners, each with a unique set of chemicals. The strategy needed to comply with the Texas Natural Resource Conservation Commission Risk Reduction Rules and at the same time discriminate between the potential risks associated with chemicals our client had stored and those used by other owners of the facility.

#### **RCRA proposed Hazardous Waste Identification Rule**

Completed a review of, and submitted comments on, the RCRA proposed Hazardous Waste Identification Rule for the National Council of the Paper Industry for Air and Stream Improvement. Demonstrated that the rules used assumptions that led to action levels that were more stringent than needed to protect public health. Showed that the reference dose for methanol is exceeded by a factor two to four every time a child drinks a glass of juice. Showed that a more defensible reference dose for acetone is about two times greater than the existing reference dose.

#### **EI 725 Determination**

Confidential Client, Roanoke, Virginia

Conducted a risk assessment in support of an EI 725 Determination. The risk assessment was used to supplement the EI 725 form and demonstrated that even the concentrations of polynuclear aromatic hydrocarbons in soils on the site exceeded screening benchmarks, the more realistic evaluation of potential risk in the risk assessment found that risks were within acceptable levels established by EPA. The EI 725 determination concluded the potential human exposures are under control.

#### **RCRA Facility Investigation of a Dioxin Site**

Confidential Client, Denver, Colorado

Dr. Anderson conducted an ecological risk assessment at this operating manufacturing facility. The assessment was conducted in phases in order to focus on the chemicals (PAH and dioxin), environmental media (sediments and surface soil) and receptors (birds) of greatest potential concern thereby also conserving resources. The assessment used a foodweb model to estimate the potential exposure of migratory birds to site-related chemicals and found that potential exposures, even using typical default exposure assumptions, were unlikely to reach levels of potential exposure that would pose a potential concern.

#### **Solar Turbines**

San Diego, California

Developed cleanup levels for several organic compounds and metals for two RCRA sites in California. Used California Guidance for Multimedia Risk Assessments (July 1992) for all compounds except lead. Derived cleanup levels for lead using California uptake and toxicity model. For industrial scenarios, where contact with soil by children is minimal, the California model predicts lead soil cleanup levels in excess of 1000 ppm.

#### **RCRA Part B Compliance**

Reilly Tar and Chemical Co., Granite City, Illinois

Developed cleanup goals for compounds found at a site in Granite City, Illinois, for a RCRA Part B addendum. Critiqued the method used by the agency to derive cleanup goals for groundwater and soils at the site. Suggested use of more site specific fate and transport models and of a relative potency approach for evaluation of health risks associated with potentially carcinogenic PAH.

#### **Risk Assessment for a Former Landfill**

New Hampshire

Managed the risk assessment for a former landfill in New Hampshire. The assessment followed U.S. EPA methodology outlined in the Superfund Public Health Evaluation Manual. Selected indicator compounds after review of analytical soils and groundwater data. Profiled physical, toxicological and organoleptic properties of compounds found at the site. Identified potential risks from groundwater, soil, and surface water. Used fate and transport models to determine when constituents in groundwater underneath the site would reach offsite drinking water wells.

#### **CERCLA Site**

Confidential Client, South Carolina

Directed the ecological and human health risk assessments at a CERCLA site in South Carolina. Developed a surface and subsurface soil sampling protocol designed to obtain an unbiased estimate of chemical concentration and performed both a point estimate and Monte Carlo based assessment of potential human health risks. Oversaw ecological sampling, including: collection of biota, estuarine sediment and surface water samples; a survey of habitat use by wildlife; and, the conduct of sediment and elutriate toxicity tests, needed to perform a detailed ecological risk assessment.

#### **Massachusetts DEP**

New Bedford Harbor Superfund Site, Massachusetts

Served as the DEP's public health risk assessment expert for the New Bedford Harbor Superfund site. Reviewed and critiqued risk assessments for the proposed pilot feasibility study and for the remedial investigation.

#### **U.S. EPA PCB Spill Policy Review**

Reviewed the toxicological and scientific basis underlying the cleanup criteria presented in the U.S. EPA's new PCB spill cleanup policy.

#### **Ecological Risk Assessment for Proposed Coal-Fired Power Plant**

Jacksonville, Florida

Conducted the ecological risk assessment for emissions from a proposed coal-fired power plant located adjacent to the St. Johns River and near sensitive wetland areas in a wildlife refuge. Identified sentinel and endangered species and estimated the potential risk posed by emissions for several aquatic, avian and terrestrial species.

#### **PCB contaminated Soils**

Department of Environmental Protection, Massachusetts

Developed multimedia, health based cleanup levels for PCB contaminated soil throughout Massachusetts. Cleanup levels were set for three exposure scenarios (sites with unrestricted access, fenced sites, and capped sites) and varied from 1 ppm to 50 ppm.

#### **Municipal Solid Waste Incinerator Risk Assessment**

Pennsylvania

Performed a multiple exposure pathway, multiple compound, multiple media risk assessment for permitting a new incinerator in accordance with Pennsylvania and state of the art guidelines. Projected emissions dispersion and performed deposition modeling to provide ground level ambient concentrations and accumulation of emitted materials in solids, dusts and food chains. Although food chain exposures posed the largest potential risks, no unacceptable risks were identified by the assessment.

#### **Ecological Risk Assessment Course**

Confidential Client, Pittsburgh, Pennsylvania

Developed and presented a one day course on ecological risk assessment to ALCOA's corporate environmental and legal staff. The course presented the theoretical underpinnings of ecological risk assessment and examples of their application to waste disposal sites.

#### **Fish Consumption Rate Survey**

Louisiana

Directed the development and interpreted the results of a fish consumption rate survey designed to quantify the consumption rate of freshwater fish, shellfish, and saltwater fish from several parishes in Louisiana. The survey was unique in its ability to identify the relative contribution of different waterbodies to the overall consumption rate of the population and with regard to the rigorous methods used to establish the size of a fish meal, and area where little quantitative information had been available before.

#### **Remedial Investigation/Feasibility Study Review**

**Marathon Battery NPL Site, Cold Spring, New York**

Reviewed the remedial investigation/feasibility study report for this site in Cold Spring, New York. It was found that the human health and environmental risk of cadmium in a marsh at the site may have been overestimated. Considered the proposed remedial alternative for the site, dredging the marsh, to be potentially detrimental to the environment. It was therefore suggested that reassessment of health and environmental risk was required before it was possible to balance the risk of current site conditions versus the impact of the remedial activity.

**Cleanup Level Negotiation, CERCLA Site**

Saegertown, Pennsylvania

Negotiated cleanup levels for polynuclear aromatic hydrocarbons (PAH) in subsurface soils based upon realistic assumptions about potential exposure. The cleanup levels in the Record of Decision (ROD) had been based upon a risk assessment that assumed exposures typically associated with surface soils.

**Review of Freshwater Fish Consumption Rates**

Completed a review of all available information on the rate of freshwater fish consumption in the United States for the Pulp and Paper Industry. Established that the current fish consumption rate of 6.5 grams per day used in U.S. EPA Ambient Water Quality Criteria is scientifically defensible and that demands to change that level, and thus the Criteria, are not supported at this time.

**Risk Assessment**

Abandoned Manufacturing Site, Detroit, Michigan

Prepared risk assessment under Michigan Department of Natural Resources Rules that used available flexibility within the rules to demonstrate the potential soil ingestion risks did not exceed allowable regulatory levels. Also demonstrated that even though generic soil standards for the protection of groundwater were exceeded, when site specific hydrogeology is accounted for in a fate and transport model, potential risks from groundwater are within acceptable levels.

**Human Health and Ecological Risk Assessment**

NPL Site, North Carolina

Served as Principal in Charge, senior technical advisor and peer reviewer for a multipathway, multimedia human health and ecological risk assessment for a Superfund site. Developed realistic estimates of potential risk and realistic cleanup levels by employing exposure assumptions that characterized the site more accurately than U.S. EPA standard default assumptions. Because this substantially reduced the volume of soil containing dioxin and pentachlorophenol to be remediated, remediation costs could be reduced by several million dollars while at the same time protecting public health.

**Ecological Risk Assessment Lectures**

Boston University, Boston, Massachusetts



Developed and presented a series of three lectures on ecological risk assessment for the third year level environmental science course in Boston University's emerging environmental science curriculum. The lectures served as the students first introduction to the complexities of, and practical application of, ecological and human health risk assessment in the development of public health and environmental policy.

#### **Review of Regulatory Impact Analysis**

Reviewed and suggested changes to the Regulatory Impact Analysis published by U.S. EPA in support of the development of "Maximum Achievable Control Technology" (MACT) for effluents. The critique demonstrated that the risk assessment conducted by the EPA overestimated both the potential baseline and future risks associated with effluents. Use of an average, rather than an upperbound estimate of potential excess lifetime cancer risk, reduces the predicted health benefits associated with the proposed rule and increases its cost.

#### **CERCLA Risk Assessment**

Koppers Co., Texarkana, Texas

Identified compounds that were likely to pose the greatest risk to human health and the environment for a former wood treating site in Texarkana, Texas. Assessed chronic threshold and carcinogenic human health risks from contaminated groundwater, surface and subsurface soils, and surface waters to residents and workers. Potential inadvertent ingestion of PAH in surface soils posed the greatest risk; however, inclusion of biodegradation and physical breakdown of PAH resulted in a greater than 20 fold reduction in risk. Developed health based cleanup goals for soils.

#### **Site-specific Assessment**

Stone Container Corporation, Panama City, Florida

Completed a site specific assessment of the potential risks associated with dioxin in mill effluent. The assessment was based on site specific information about the fishery combined with a simple bioconcentration model. The results of the assessment indicated that fish potentially exposed to dioxin in the effluent do not pose a risk to humans, and thus supported an effluent limit that is both measurable and protective.

#### **Risk Assessment of Bleach Kraft Mills**

Boise Cascade, U.S.

Served as principal in charge and senior technical reviewer for a chloroform, chlorine, and chlorine dioxide risk assessment for all of Boise Cascade's bleach Kraft mills. The results were used by Boise Cascade to modify future mill expansions to reduce potential health risks and assist in community relations issues.

#### **Superfund Manual and Guidance Review**

Chemical Manufacturer's Association

Reviewed and compared EPA's 1986 Superfund Public Health Evaluation Manual and EPA's new 1989 Risk Assessment Guidance for Superfund. The new guidance provides for a more realistic evaluation of potential risks that should lead to substantially higher cleanup levels at most NPL sites.

#### **Risk Assessment of Former Disposal Site**

California

Provided risk assessment expertise for litigation purposes to the PRP committee for a Superfund site in California. Performed risk assessment and showed where agency had overestimated risk by using assumptions that consistently overestimated current and future exposures.

#### **UOP NPL Site Health Effects Assessment**

New Jersey

Performed health effects assessment of a former chemical manufacturing site using EPA guidance on health effects assessment. Provided design goals for remedial actions for a variety of site use scenarios and information for risk managers on appropriate use of the data.

#### **Environmental Risk Assessment Course**

Environmental Education Enterprises, U.S.

Participated in the development and teaching of a three day intensive risk assessment course for Federal and State regulators, industry representatives and other environmental professionals. The course combines a lecture and hands-on workgroup format that allows students to gain first hand knowledge of both the theoretical basis of risk assessment and of the difficult practical decisions and nuances associated with its application to day-to-day environmental problems.

#### **National Council of the Paper Industry for Air and Stream Improvement**

Estimated potential national exposure to dioxin from consumption of fish and drinking water based on available data from all U.S. bleach kraft mills and national fish consumption patterns.

#### **Municipal Solid Waste Disposal**

Harvard School of Public Health, Cambridge, Massachusetts

Evaluated several health risk assessments for municipal solid waste incinerators and developed a methodology for comprehensively assessing the associated health risks. Performed a multimedia comparison of the cancer risks associated with incinerating versus landfilling of municipal solid waste.

#### **Development of Acceptable Ambient Level for Dichloromethane**

New York

Evaluated the New York State Department of Environmental Conservation Acceptable Ambient Level (AAL) for dichloromethane (DCM) for a confidential manufacturer. After reviewing new

evidence regarding the pharmacokinetics of DCM, demonstrated that a nearly tenfold increase in the AAL would confer an identical degree of safety.

#### **Soil Risk Assessment and Agency Negotiations**

Confidential Client, St. Louis, Missouri

On behalf of a confidential client, negotiated with agency and developed soil cleanup levels protective of workers and local residents for a site in St. Louis, Missouri. Used up to date, scientifically defensible exposure assumptions which led to cleanup levels that did not require any excavation.

#### **Soil Gas Risk Assessment, Potential Development Site**

Minnesota

Assessed the long and short term health risks associated with groundwater and soil gas contamination at a potential development site in Minnesota. Potential risks associated with accumulation of contaminated soil gas in basements were low, but adequate ventilation was shown to virtually eliminate them.

#### **Drinking Water Criteria**

Massachusetts DEP

Reviewed the adverse health effects of methyl ethyl ketone, methyl isobutyl ketone, and acetone. Developed drinking water criteria for these compounds.

#### **Uncertainty in Risk Assessment**

Harvard School of Public Health, Cambridge, Massachusetts

Performed a comparative investigation of how scientific uncertainty and parameter choice affect the carcinogenic potency estimates calculated by governmental agencies for EDB, PCB, PCE, and 2,3,7,8 TCDD. Choice of dose response model had the largest potential impact on potency estimates, but agencies usually chose the same model. As a result, a large source of uncertainty is usually not addressed.

#### **Contaminants in Fish**

Harvard School of Public Health, Cambridge, Massachusetts

Assessed the predicted excess cancers and cancer risks associated with consumption of PCB, 2,3,7,8 TCDD, and 2,3,7,8 TCDF contaminated East Coast striped bass. The largest risks were caused by PCB contamination. Striped bass from New Jersey, New York, and Connecticut posed the highest risks. Compared the increased cancer risk to the decreased risk of coronary heart disease associated with consumption of contaminated fish. The benefits of eating some types of contaminated fish may outweigh the excess cancer risks.

#### **Striped Bass Decline and Fisheries Management**

Harvard School of Public Health, Cambridge, Massachusetts

Analyzed how science, politics, economics, and the natural history of striped bass contributed to the decline of the East Coast striped bass population. A multitude of causes contributed to the decline, but because they were simultaneous, the relative importance of each cause cannot be assessed.

#### **Biology of Buried Seeds**

Harvard University, Cambridge, Massachusetts

Identified sources of mortality, examined how mortality sources and seed longevity changed with depth of burial, and quantified the rate of seed burial in forests. Assessed the relative effects of ant and mammal predation on *Viola fimbriatula* seeds. Investigated the germination requirements of *V. fimbriatula* seeds in vitro and in vivo. Explored the role of biphasic germination through mathematical simulation of seed and plant populations having different demographic parameters.

#### **Mammalian Field Ecology**

Boston University, Boston, Massachusetts

Participated in an investigation of the effect of insect abundance and diversity on the intensity of bat feeding activity. Used capture recapture method to investigate small mammal population size and habitat partitioning by small mammals.

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#### **Selected Publications/Presentations**

Paul D. Anderson, Daniel J. Caldwell, Frank Mastrocco, Robert Hannah, Andrew Johnson, Danielle Pfeiffer, John Sumpter, and Richard Williams. 2010. Characterization of Aquatic Risk in U.S. Surface Waters Associated with Estrogens Derived From Humans. To be submitted to *Environmental Toxicology and Chemistry* in Fall 2010.

Daniel J. Caldwell, Paul D. Anderson, Frank Mastrocco and John P. Sumpter, J.P. 2010. Aquatic predicted no effect concentrations for estradiol, estrone and estriol. To be submitted to *Environmental Toxicology and Chemistry* in Fall 2010.

Daniel Caldwell, Frank Mastrocco, Edward Nowak, James Johnston, Harry Yekel, Danielle Pfeiffer, Marilyn Hoyt, Beth M. DuPlessie, and Paul D. Anderson. 2010. An Assessment of Exposure to Prescribed Estrogens in Drinking Water. *Environmental Health Perspectives*, 118:338-344.

Paul D. Anderson, Kimberly Groff, Marilyn Hoyt, Barbara Pugh, John Samuelian and Kathleen Sellers. 2008. Technical Brief: Trace Organic Compounds and Implications for Wastewater Treatment. Water Environment Research Foundation. 62 pages.

Brian Magee, Paul Anderson, Kevin Haines and Giovanni Longoni. Drinking water remedial goals for two pharmaceuticals in drinking water. Platform presentation. CONSOIL 2008. June 2008. Milan, Italy.

Paul D. Anderson and Daniel J. Caldwell. A first pass at evaluating potential human health risks from estrogens in surface water. Platform presentation. 5th Annual Water Resources Conference., University of Massachusetts, Amherst, MA. April 2008.

Robert Hannah, Vincent J. D'Aco, Paul D. Anderson, Mary E. Buzby, Daniel J. Caldwell, Virginia L. Cunningham, Jon F. Ericson, Andrew C. Johnson, Neil J. Parke, John H. Samuelian, John P. Sumpter. 2009. Evaluation of 17a ethinylestradiol concentrations in surface waters using measured data and modeling estimates. *Environmental Toxicology and Chemistry*, 28: 2725-2732.

Daniel J. Caldwell, Frank Mastrocco, Thomas H. Hutchinson, Reinhard Länge, Dagobert Heijerick, Colin Janssen, Paul D. Anderson, John Sumpter. 2008. Derivation of an Aquatic Predicted No-Effect-Concentration for the Synthetic Hormone, Ethinyl Estradiol. *Environmental Science and Technology*, 42:7046-7064.

Paul D. Anderson, Beth M. DuPlessie, Marilyn Hoyt, Frank Mastrocco, James Johnston, Daniel Caldwell and Edward Nowak. An Assessment of Overall Estrogen Exposure for the General Population and Several Subpopulations in the United States. Platform Presentation. Water Environment Federation Conference on Compounds of Emerging Concern. July 2007. Providence, Rhode Island.

Frank Mastrocco, James Johnston, Edward Nowak, Dan Caldwell, Paul D. Anderson, Beth M. DuPlessie and Marilyn Hoyt. 2007. An Assessment of Overall Estrogen Exposure for the General Population and Several Subpopulations in the United States. Poster. Society of Environmental Toxicology and Chemistry Europe. 17th Annual Meeting, May 20-24, 2007. Porto, Portugal.

Paul D. Anderson, Beth M. DuPlessie and Marilyn Hoyt. 2007. An Assessment of Overall Estrogen Exposure for the General Population and Several Subpopulations in the United States. Poster. Society of Toxicology. 46th Annual Meeting, March 25-29, 2007. Charlotte, North Carolina.

Virginia Cuningham, Beth DuPlessie, Paul Anderson and Vince D'Aco. 2006. Use of the PhATE Model for Regional Environmental Risk Assessment. Poster. Society of Environmental Toxicology and Chemistry 25th Annual Meeting. November 5-9, 2006. Montreal, Canada.

Paul D. Anderson, William R. Alsop, Marilyn P. Hoyt, Marilyn J. Schwartz, Chris C. Stransky, John Rudolph, and Jane Patarcity. 2006. Development of Ambient Water Quality Criteria for m-Benzene Disulfonic Acid, Benzene Monosulfonic Acid and p-Phenol Sulfonic Acid. Poster. Society of Environmental Toxicology and Chemistry 25th Annual Meeting. November 5-9, 2006. Montreal, Canada.

Paul Anderson, Arjun Nair, Jane Patarcity and Ken Cerreto. 2006. Toxicity of Creosote-Derived PAH in Sediment. Society of Environmental Toxicology and Chemistry 25th Annual Meeting. November 5-9, 2006. Montreal, Canada.

Amy E. Nelson, Paul Anderson and Jane Patarcity. 2006. Reducing Uncertainty in Ecological Risk Assessment: Measured Tissue Residues in Fish and Aquatic and Terrestrial Insects and Derivation of Bioaccumulation Factors. Poster. Society of Environmental Toxicology and Chemistry 25th Annual Meeting. November 5-9, 2006. Montreal, Canada.

Amy E. Nelson, Paul Anderson and Jane Patarcity. 2006. Reducing Uncertainty in Ecological Risk Assessment: Measured Tissue Residues in Fish and Aquatic and Terrestrial Insects and Derivation of Bioaccumulation Factors. Platform Presentation. University of Massachusetts Soils Conference. Amherst, Massachusetts.

Frank J. Mastrocco, Paul D. Anderson, David Cragin, Vincent J. D'Aco, Roger D. Meyerhoff, and Nicholas M. Roden. 2006. Human pharmaceuticals in US surface waters: A human health risk assessment. Poster. Joint DIA/HESI/SAPS Conference on Environmental Assessment of Human Medicines. Stockholm, Sweden.

Invited Speaker. Endocrine Disruptors in Wastewater Treatment Plants: Possible Sources, Treatment and Potential Effects. New England Water Environment Association. 2006 Annual Conference.

Paul D. Anderson, Stephen Clough, Beth DuPlessie, Michael Gray, Marilyn Hoyt and Kathleen Sellers. 2005. Endocrine Disrupting Compounds and Implications for Wastewater Treatment: An Overview. Poster. University of Massachusetts Soils Conference. Amherst, Massachusetts.

Paul D. Anderson, Stephen Clough, Beth DuPlessie, Michael Gray, Marilyn Hoyt and Kathleen Sellers. 2005. Technical Brief: Endocrine Disrupting Compounds and Implications for Wastewater Treatment. Water Environment Research Foundation. 36 pages.

Bradley W. Schwab, Eileen P. Hayes, Janice M. Fiori, Frank J. Mastrocco, Nicholas M. Roden, David Cragin, Roger Meyerhoff, Vincent J. D'Aco and Paul D. Anderson. 2005. Human pharmaceuticals in U.S. surface waters: A human health risk assessment. Regulatory Toxicology and Pharmacology, 42:296-312.

P.D. Anderson, V.J. D'Aco, P. Shanahan, S.C. Chapra, M.E. Buzby, V.L. Cunningham, B.M. DuPlessie, E.P. Hayes, F. Mastrocco, N.J. Parke, J.C. Rader, J.H., Samuelian and B.W. Schwab. 2004. Screening Analysis of Human Pharmaceutical Compounds in U.S. Surface Waters. *Environmental Science and Technology*, 38:838-849

C.R. Harman, W.R. Alsop, and P.D. Anderson. 2005. Ecological Risk Assessment Applied to Energy Development. in *Encyclopedia of Energy*. ed. C.J. Cleveland. Elsevier Science, San Diego, CA.

P.D. Anderson, M. Dourson, J. Unrine, J. Sheeshka, E. Murkin and J Stober. 2002. Framework and Case Studies. *Comments on Toxicology, Special Issue Comparative Dietary Risk: Balance the Risks and Benefits of Fish Consumption*, 8:431-502.

P. Anderson, B. Manoogian, S.Matkoski, M.Slenska. 2002. Evaluation of Toxicity in a South Carolina Marsh Sediment Containing PAH and Metals. Poster. Society of Environmental Toxicology and Chemistry 23rd Annual Meeting. November 16-20. Salt Lake City, Utah.

Rothrock, J.A., P.D. Anderson, M. Bollinger, and J. Patarcity. 2002. Use of the Sediment Quality Triad to Evaluate the Effects of PAH in a New England Pond. Poster. Society of Environmental Toxicology and Chemistry 23rd Annual Meeting. November 16-21. Salt Lake City, Utah.

Rothrock, J.A., P.D. Anderson, B. Alsop, A. DiBenedetto, and B. Schwab. 2002. The Hidden Role of Risk Management in the Development of Sediment Quality Guidelines. Interactive Poster Presentation. Society of Environmental Toxicology and Chemistry 23rd Annual Meeting. November 16-21. Salt Lake City, Utah.

Rothrock, J.A., P.D. Anderson, B.W. Schwab, and B.A. Manoogian. A Critique of the Use of Sediment Quality Guidelines in Ecological Risk Assessment. *Environment International* (in press).

Anderson, P.D., A.L. Nightingale, J.A. Rothrock and K. Geoffroy. 2001. Evaluation of the Effect of Dioxins in Kraft Mill Effluent on Maine Bald Eagles. Presentation. Annual meeting of the Society of Environmental Toxicology and Chemistry. Baltimore, MD.

Anderson, P.D., J.A. Rothrock and B.A. Manoogian. 2001. A real-life demonstration of the implications of using only effects-based sediment quality guidelines. Poster. Annual meeting of the Society of Environmental Toxicology and Chemistry. Baltimore, MD.



Anderson, P.D., J.A. Rothrock and W.R. Alsop. 2001. Hidden risk management assumptions in the traditional application of EqP-based sediment criteria. Poster. Annual meeting of the Society of Environmental Toxicology and Chemistry. Baltimore, MD.

Rothrock, J.A., P.D. Anderson and B.A. Manoogian. 2001. A real-life demonstration of the implications of using only effects-based sediment quality guidelines. Proceedings of the International Conference on Remediation of Contaminated Sediments. Venice, Italy. October, 2001.

Prouty, A.L., N.J. Klootwyk, W.R. Alsop, A.L. Nightingale, J.A. Rothrock and P.D. Anderson. 2001. Approach to managing the ESA process as part of a NPDES renewal. Proceedings, TAPPI 2001 Environmental Conference.

Toxicology Excellence for Risk Assessment. 1999. Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption. Member of Research Team and author. August. Cincinnati, Ohio

Anderson, Paul D. 1999. A framework for comparing the risks and benefits of eating contaminated fish. Annual meeting of the Society for Risk Analysis. Atlanta, GA.

Keenan, R.E., P.D. Anderson, W.R. Alsop and J.H. Samuelian. 1999. Risk-based management principles for evaluating sediment management options. Contaminated Sediment Management Technical Papers. Prepared for the Sediment Management Work Group.

Keenan, R.E., P.D. Anderson, W.R. Alsop and J.H. Samuelian. 1999. Risk-based management principles for evaluating sediment management options. Annual meeting of the Society of Environmental Toxicology and Chemistry. Nashville, TN.

Anderson, P.D., A.L. Nightingale, R.E. Keenan, S. Craig, and J. Patarcity. 1998. Biota to Sediment Accumulation Factors for PAH, Metals, and Dioxin in Two East Coast Tidal Marshes. Presented at the Thirteenth Annual Hydrocarbon Contaminated Soils Conference, University of Massachusetts, Amherst, MA. October 21.

Anderson, P.D., K. Sellers, S.P. Farnsworth, and R.K. Cleary. 1998. Strategy for Remediating a Massachusetts River Near a Former MGP Site to Local Conditions, 14th Annual Conference on Contaminated Soils, University of Massachusetts, Amherst, MA. October 19 - 22.

Bartell, S.M., J. LaKind, J.A. Moore and P.D. Anderson. 1998. Bioaccumulation of hydrophobic organic chemicals by aquatic organisms: A workshop summary. International Journal of the Environment and Pollution, 9(1):3-25.

Anderson, P.D., A. Yuhas, S. Craig and J. Duncan. 1997. Combining the Toxicity Quotient Method and Geostatistics to Improve the Characterization of Potential Ecological Risks. Annual meeting of the Society of Environmental Toxicology and Chemistry. San Francisco, CA.

Yuhas, A., P.D. Anderson and S. Craig. 1997. Biota to Sediment Accumulation Factors for Several Metals and Dioxin in a South Carolina Estuarine Marsh. Annual meeting of the Society of Environmental Toxicology and Chemistry. San Francisco, CA.

Anderson, P.D., A. Yuhas and J. Patarcity. 1997. Biota to Sediment Accumulation Factors for PAH in a Tidal Marsh in Delaware. Annual meeting of the Society of Environmental Toxicology and Chemistry. San Francisco, CA.

Magee, B., P. Anderson, and D. Burmaster. 1996. Absorption adjustment factor (AAF) distributions for polycyclic aromatic hydrocarbons (PAHs). Human and Ecological Risk Assessment, 2(4):841-873.

Pavlou, S.P., E.J. Zillioux, P.D. Anderson, P.J. Serie and S.M. Roberts. 1996. Technical and policy challenges in developing and implementing risk-based environmental regulations. Proceedings, Probabilistic Safety Assessment 1996 (PSA '96), Moving Towards Risk-Based Regulation.

Ecological Risk Assessment Screening, a Risk-Based Corrective Action Approach to Ecological Standards. 1996. K. Reinert, P. Brussock, P. Anderson and A. Miller. 1996. Annual meeting of the Society of Environmental Toxicology and Chemistry. Washington, D.C.

Iterating the Baseline Risk Assessment: Risk-Based Remediation Without Derivation of Cleanup Levels. Paul D. Anderson, Brian H. Magee, Amy C. Miller, Bradley W. Schwab and Allison L. Yuhas. 1996. Annual meeting of the Society of Environmental Toxicology and Chemistry. Washington, D.C.

Anderson, P.D. and A.L. Yuhas. 1996. Improving risk management by characterizing reality: A benefit of probabilistic risk assessment. Human and Ecological Risk Assessment, 2:55-58.

Anderson P.D. and J.B. Wiener. 1995. Eating Fish. Chapter in: Risk Versus Risk Tradeoffs in Protecting Health and the Environment, J.D. Graham and J.B. Wiener, eds. pp: 104-123.

Application of Monte Carlo Techniques to Derive Water Quality Criteria for the Protection of Wildlife. Paul D. Anderson and Betsy Ruffle. 1994 Annual SETAC Meeting, Denver, Colorado.

An Evaluation of U.S. EPA's Food Chain Multiplier Methodology Used to Estimate Bioaccumulation Factors for BCFs. Paul D. Anderson, Jay Unwin, Paul Weigand and Bill Alsop. 1994 Annual SETAC Meeting, Denver, Colorado.

An Evaluation of Select Aspects of the Food Chain Multiplier Methodology Used by the Great Lakes Water Quality Initiative to Estimate Bioaccumulation Factors. April 1994. Paul D. Anderson, Betsy Ruffle and Jay Unwin. TAPPI Environmental Conference.

Anderson, P.D., B. Ruffle and J. Unwin. 1994. Application of Monte Carlo analysis to the derivation of water quality criteria for the Great Lakes Water Quality Initiative. Proceedings, TAPPI 1994 Environmental Conference: 221-229.

Burmester, D. and P.D. Anderson. 1994. Principles of good practice for the use of Monte Carlo techniques in human health and ecological risk assessments. Risk Analysis, 14:477-481.

Ruffle, B., D. Burmaster, P.D. Anderson, and H. Gordon. 1994. Lognormal Distributions for Fish Consumption by the General U.S. Population. Risk Analysis, 14:395-404.

Bonfiglio Giordano, M., R. Zale, B. Ruffle, E. Hawkins, and P.D. Anderson. 1994. Review of mathematical models for health risk assessment: V. Chemical concentrations in the food chain. Environmental Software, 9:115-131.

Alsop, W., B. Ruffle, E. Frohberg, and P.D. Anderson. 1993. Development of risk based cleanup standards using monte carlo analysis. Proceedings. Developing Cleanup Standards for Contaminated Soil, Sediment and Groundwater. How Clean is Clean? Water Environment Federation. TT042.

Anderson, P.D., B.W. Schwab and B. Ruffle. 1993. Monte Carlo analysis: A realistic approach to assessing human health risks. Proceedings, Air and Waste Management Association 1993 Annual Meeting. 93-TA-40.03.

Anderson, P.D., B. Ruffle, and B. Gillespie. 1992. A Monte Carlo Analysis of Dioxin Exposures and Risks from Consumption of Fish Caught in the Freshwaters of the United States Affected by Bleached Chemical Pulp Mill Effluents. Proceedings, TAPPI 1992 Environmental Conference. pp. 879-893.

Anderson, P.D. 1992. Human Health Risk Assessment: Revising the EPA Guidelines for Deriving Human Health Criteria for Ambient Water. The methodology is too conservative. Water Quality Standards for the 21st Century. U.S. EPA. Office of Science and Technology. 823 R 92 009. December 1992.

Anderson, P.D. 1992. Monte Carlo Analysis: Finally Realism in Risk Assessment. *Insight*, 5:1 6.

Anderson, P.D. 1992. Controlling with Remediation Costs Risk Assessment. *Insight*, 2:8 10.

Seigneur, C., A. Venkatram, D. Galya, P.D. Anderson, D. Liu, D. Foliart, and R. von Burg. 1992. Review of mathematical models for health risk assessment: I. Overview. *Environmental Software*, 7:3 7.

A Monte Carlo Analysis of Dioxin Risk from Fish Consumption. Paul D. Anderson, and Betsy Ruffle. *Society of Risk Analysis*. 1992 Annual Meeting. December 1992.

A Practical Technique for Calculating Correlation Between Indicator Chemicals at Superfund Sites and Applying it to Monte Carlo Analysis. Lauren Wojciechowski, Betsy Ruffle, and Paul D. Anderson. *Society of Risk Analysis*. 1992 Annual Meeting. December 1992.

Uncertainty Analysis and the EPA Guidelines on Exposure Assessment. *Boston Society of Risk Analysis*. October 1992.

Invited speaker. The NCASI Model. Dioxin and PCBs: National Conference on Approaches to Address Human Health Effects and Aquatic Life Impacts, May 1990.

Invited speaker. A procedure for predicting dioxin concentrations in river water and fish and estimating potential exposures and risks to humans. 75th Annual TAPPI Conference, April 1990.

Invited speaker. Why the war on dioxin costs more lives than dioxin itself. 75th Annual TAPPI Conference, April 1990.

Invited speaker. Air toxics impacts on human health and ecological receptors. Executive Enterprises Conference on the Clean Air Act, February and May 1990.

Invited speaker. A comparison of human and ecological risk assessment methodologies for hazardous waste: A call for research. *Ecological Society of America*, Annual Conference, August 1989.

Abstract. A procedure for estimating TCDD/TCDF concentration in fish. *Dioxin 89*, September 1989.

Invited speaker. Calibrations of a procedure to estimate exposures and risks from TCDD/TCDF concentrations in river water and fish. Presented by J. McKeown. *Dioxin 89*, September 1989.

Invited speaker. Developing a site cleanup plan under the Massachusetts Contingency Plan (MCP). Associated Industries of Massachusetts, March 1988.

Invited speaker. Multi pathway risk assessments for resource recovery facilities: the relative importance of different exposure pathways. Mid Atlantic States Section American Pollution Control Association 33rd Anniversary Technical Conference and Exhibition. November 1987.

Invited speaker. Incineration versus landfilling of municipal solid waste: An approach for comparing the health risks. USEPA, Region I, May 1987.

Invited speaker. Origins of incompatibility among potency estimates for carcinogens. Society for Risk Analysis, April 1987; USEPA Region II Conference on Risk Assessment, March 1987.

Invited speaker. Closing of the striped bass fishery in the North Atlantic States. Conference on Risk Assessment and Contaminated Fish and Shellfish. New England Interstate Water Pollution Control Commission, January 1987.

Invited panelist. Scientific origins of incompatibility among risk assessments. Ninth symposium on statistics and the environment, October 1986.

Invited speaker. How assumptions about metabolism influence the outcome of PCE risk assessments. Northeast States for Coordinated Air Use Management, November 1985.

Invited speaker. Predicted excess cancers and cancer risks associated with consumption of dioxin contaminated fish. Northeast Regional Meeting of the National Council for Air and Stream Improvement, October 1985.

Invited panelist. Doing a risk assessment: How different agencies have developed different risk values for dioxin. Risk Assessment and Risk Management Training Seminar, New England Interstate Water Pollution Control Commission, September 1985.

Invited speaker. Striped bass: Should you eat one? Interdisciplinary Programs in Health Seminar, May 1985.

Invited speaker. Carcinogenic risk associated with consumption of dioxin contaminated striped bass. Fish Monitoring Seminar, New England Interstate Water Pollution Control Commission, July 1985.

Anderson, P.D. 1988. Scientific origins of incompatibility among risk assessments. Statistical Science.

Anderson, P.D., J. Dudley, D. Galya, V. Fry, J. McKeown, and A.B. Shortelle. 1990. A procedure for estimating 2,3,7,8 TCDD/TCDF concentrations in river water and fish and estimating potential impacts to humans. Proceedings of the 75th Annual TAPPI Conference.

Anderson, P.D. 1990. Why the war on dioxin costs more lives than the compound itself. Proceedings of the 75th Annual TAPPI Conference.

McKeown, J., V. Fry, A. Shortelle, J. Dudley, P.D. Anderson, and D. Galya. 1990. An example of using NCASI program river and fish in computing the date of dioxin in receiving waters. Proceedings of the 75th Annual TAPPI Conference.

Anderson, P.D., B. Beck, and E. Calabrese. 1988. The use of toxicology in the regulatory process. In Haye's Methods and Principles of Toxicology. Raven Press.

Anderson, P.D., P. Grogan, and C. Lindsey. 1988. Multi pathway risk assessments for resource recovery facilities: the relative importance of different exposure pathways. Proceedings of the Mass APCA 33rd Anniversary Conference.

Harkov, R. and P.D. Anderson. 1988. Risk assessment: An introduction. ERT Newsletter 2:1.

Anderson, P.D. 1986. Synergy: Positive interaction among chemicals in mixtures. The Journal of Pesticide Reform 6:11 14. (With the HSPH Working Group on Synergy in Complex Mixtures.)

Anderson, P.D. 1984. The sources of mortality of *Viola fimbriatula* seeds in the soil. Abstract. Ecological Society of America meeting, August.

Anderson, P.D. 1983. The dynamics and longevity of *Viola fimbriatula* seeds in the soil. Ph.D. Thesis, Harvard University.

**Education:**

M.S., Civil and Environmental Engineering, Massachusetts Institute of Technology, 1994  
B.S.E., Civil and Environmental Engineering, Duke University, Durham, North Carolina, 1992

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**Professional Experience:**

GeoTrans, Inc., Atlanta, Georgia, (1994-Present), *Principal Engineer*  
Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, (1992-1994),  
*Research Assistant and Teaching Assistant*  
Brown and Caldwell Consultants, Atlanta, Georgia, (1992), *Intern Engineer*

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Sixteen years of experience in environmental engineering and consulting. Project manager for diverse environmental projects ranging from remedial investigation/design to software development. Professional expertise in groundwater hydrology, analysis of contaminant migration, remedial design, numerical simulation of groundwater flow and contaminant transport, optimization methods, and contaminant dispersion theory.

**Project Experience:**

US Superfund Site, Florida (confidential private-sector client) – Project manager for coordination of investigation and remediation activities and liaison with the regulatory agencies. Met monthly with USEPA Region 4 staff on behalf of the Potentially Responsible Party (PRP) for a wood-treating (DNAPL) site in Florida. Facilitating a consensus-building process with the USEPA to select a comprehensive site remedy. The contaminants of concern include PAHs, arsenic, and dioxin. Coordinated the client's site investigation, interim action, and final remedy selection schedules with USEPA schedules for the project. Discussed the major issues at the site and helped reach resolution and approval of client plans. Prepared a Feasibility Study for the site. Designed and oversaw construction of a horizontal-drain groundwater collection system. Conducted a field pilot test for soil solidification/stabilization.

Florida RCRA Site (confidential private-sector client through Babst Calland Clements and Zomnir) – Strategy and legal-support consultant for a former wood-treatment site. Prepared sampling workplans, conducted soil sampling, investigated human/ecological risk, and communicated frequently with the Florida Department of Environmental Protection. The primary contaminants are dioxins, polynuclear aromatic hydrocarbons, and arsenic.

Stine Lumber, Lake Charles, Louisiana (through Taylor Porter and Zurich) – Groundwater contamination expert for litigation. Reviewed site documents and conducted site investigations. Prepared an expert report regarding contamination sources, migration pathways, and costs of remediation. Contaminants include chlorinated solvents and petroleum hydrocarbons. Prepared for trial.

US Superfund Site, Waynesville, NC (USEPA Office of Superfund Remediation and Technology Innovation through Dynamac Corporation) – Conducted a Streamlined Remedial System Evaluation. Identified areas of substantial cost savings and improved protectiveness. In particular, concluded that the groundwater pump-and-treat system at the Site was ineffective and unnecessary. Suggested consideration of hot-spot soil remedies such as chemical oxidation along with monitored natural attenuation (MNA).

State Superfund Site, Tennessee (confidential mining client through Bryan Cave) – Project Manager for a site investigation and remediation project at a former alloys smelter. Led a team of GeoTrans and subcontractor personnel to collect data, improve the understanding of potential environmental impacts, and develop a site closure and restoration plan. Conducted site investigation, human-health and ecological risk assessments, feasibility study, and remedial design. Designed a \$10M site remedy including source capping and stream re-routing. Prepared a probabilistic future-cost financial model and an assessment of health, safety, environmental, legal, and public-relations risks at the site. Identified and evaluated liability transfer and environmental insurance



options. Met with the regulatory agency to present site data and discuss the course forward. The contaminants of concern are hexavalent chromium, lead, arsenic, barium, and manganese. The pH of a creek running through the site is also outside the acceptable range.

US Superfund Site, North Carolina (confidential manufacturing client) – Conducted soil sampling, soil-gas sampling and surface geophysical surveys at a site with TCE and PCB impacts. Conducted and reviewed analyses of impacts.

US Superfund Site, Fort Valley, Georgia (USEPA Region 4) – Conducting aquifer test analysis and groundwater extraction/treatment remediation system review at a former pesticide/chemical manufacturing site.

State Hazardous Substance Site, Macon, GA (confidential client) – Prepared work plan for investigating dioxin impacts at and near a former wood-treatment plant.

Nuclear Power Plant, FL (confidential client) – Evaluated saltwater intrusion issues and the feasibility of potential engineered solutions.

Kennecott Eagle Minerals Company, Marquette, Michigan (through Warner Norcross & Judd) – Groundwater modeling expert for litigation. Provided peer review of groundwater models of mine inflow and water-resource impacts. Constructed and calibrated a new groundwater flow model and used the model to assess potential impacts of mining on groundwater levels and surface-water flows. Used FEFLOW and MODFLOW for modeling analyses. Reviewed and critiqued modeling analyses submitted by mine opponents. Testified at the mine permit contested case hearing.

Mosaic Company, Ft. Meade, Florida (through Holland and Knight) – Consulting expert for groundwater/surface-water modeling. Reviewed wetland hydroperiod modeling for a proposed phosphate mine expansion. Provided ways to strengthen the technical case at the permit hearing.

Nicolet Minerals Company, Crandon, Wisconsin (through Foth and Van Dyke) – Estimated the environmental effects of a proposed underground mine and a mine-tailings repository using 3-D numerical groundwater models and analytical techniques (technical lead).

Chem-Nuclear Solutions, Barnwell, South Carolina – Constructed and calibrated a groundwater flow and tritium-migration model for the Barnwell Low-Level Radioactive Waste Facility (project manager and technical lead).

US Department of Energy, Savannah River, Aiken, South Carolina (through Washington Savannah River Company) – Designed and used groundwater flow and transport models to assess environmental impacts and remediation effectiveness at the U.S. Department of Energy's Savannah River Site. Prepared technical reports and presented analyses at technical meetings. Project manager and/or technical lead for over 20 modeling projects.

US Department of Energy, Office of Civilian Radioactive Waste Management (through Bechtel/SAIC, Inc.) – Reviewed and constructed models of radionuclide transport for the Yucca Mountain Project Total System Performance Assessment. Used the GoldSim™ simulator and component models to evaluate the performance of the engineered barrier system at the proposed repository and to model flow and transport through the saturated and unsaturated zones. Reviewed the simulation of source release from waste packages and the simulation of colloid-facilitated transport. Developed alternative conceptual models and programmed them with GoldSim™. Issued memoranda and reviewed modeling reports.

US Department of Energy, Nevada (through Shaw Environmental) – Evaluated radionuclide transport pathways from underground test sites at the Nevada Test Site (Frenchman Flat Corrective Action Unit) (technical lead). Used the GoldSim™ program and Monte Carlo simulation to analyze the effects of different conceptual models (transport pathways) and understand transport uncertainty. Translated new field data into updated probability density functions for model variables and used the updated distributions to improve predictions of peak concentrations and doses at potential receptor points.

US Army Corps of Engineers, Sacramento District – Developed a numerical model of TCE transport at the Tooele Army Depot along with the U.S. Army Hydrologic Environmental Center (technical lead). Used the model to identify the important source areas, suggest improvements to remedial system operation, and identify important uncertainties. Developed a GIS database to manage model and site data. Presented model results at a meetings with the lead state regulator. Performed automated calibration analyses using PEST. Addressed model uncertainty using Monte Carlo simulation.

US Army Corps of Engineers, Mobile District – Developed a cost-effective approach for prioritizing contamination sites at the Milan Army Ammunition Plant in central Tennessee (technical lead). Developed a plant-wide 2-D numerical model of groundwater flow and several simple analytical transport models to estimate plume arrival time at the plant boundary and the expected amount of dilution. For other projects at the plant, numerically modeled contaminant plume movement and remedial well capture zones at the plant. Suggested practical locations for monitoring wells at the plant.

Northwest Florida Water Management District, Florida – Used MODFLOW and SEAWAT models to assess the feasibility of an inland groundwater supply wellfield in Franklin County (project manager). Assessed potential aquifer drawdown, wetland impacts, and saltwater upconing due to the proposed wellfield.

St. Johns River Water Management District, Florida – Modeled groundwater/surface-water interaction in northwest Seminole County and northwest Volusia County using MODFLOW with the Surface/Vadose (SV) Package and Lake Package (project manager; code developer). The modeling was used to assess the effectiveness of alternative water policies in the regions. Developed estimates of ET demand and irrigation using various data sources and analytical methods. Used radar-derived data to specify spatially-variable, daily precipitation rates. Developed customized pre-processing utilities to calculate net recharge from available data on rainfall, runoff, and irrigation. Calibrated the model to observed groundwater levels, lake levels, and stream flows. Executed long-term predictive scenarios to generate stage-duration and flow-duration curves under alternative management scenarios. Trained the District on the use of the model and application at other sites.

Hillsborough County, Florida (through Holland and Knight LLP) – Reviewed a numerical modeling report on seepage from a proposed reservoir in northwest Florida. Used simple models and analytical calculations to demonstrate that the reservoir model underestimated groundwater seepage and potential land flooding. Also reviewed integrated groundwater/surface-water modeling and uncertainty analysis performed by Tampa Bay Water and the Southwest Florida Water Management District.

Peace River Manasota Regional Water Supply Authority, Florida (through Carey, Whittaker, O'Malley, and Manson, P.A.) – Designed a reservoir storage and release model to predict the effectiveness of a proposed reservoir in southwest Florida for meeting environmental goals (minimum stream flows) and water-supply demand.

Georgia Department of Natural Resources – Conducted uncertainty analyses for models of lake water quality, watershed hydrology, and stream water quality in support of the Georgia Water Plan.

Shell Oil Company, Chevron, ExxonMobil, and the City of Santa Monica, California – Modeling leader for a large groundwater flow and transport modeling project. MTBE in groundwater led to the shutdown of the Charnock municipal supply well field. Used sophisticated modeling to assist with the effort to design a treatment plant that will allow the wellfield to return to operation. Managed and performed several activities including information review, three-dimensional plume depiction and visualization, model calibration, and transport model predictions.

Aberdeen Pesticides Dump Sites PRP Group, North Carolina (through NewFields, Inc.) – Assessed the feasibility of a monitored natural attenuation remedy at the Aberdeen Pesticides Dump Site using numerical models. Demonstrated that the natural-attenuation remedy would be more effective than other alternatives.

Bofors-Nobel PRP Group, Muskegon, Michigan (through NewFields, Inc.) – Performed numerical modeling and particle tracking for evaluation of proposed remedial alternatives at the Bofors-Nobel Superfund Site. Evaluated mechanisms for solute transport.

Various locations and clients – Conducted and managed Environmental Site Assessments in the southeastern United States.

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**Awards:**

Ralph M. Parsons Fellowship Grant, Division of Water Resources and Environmental Engineering, Massachusetts Institute of Technology, 1992-1993  
Aubrey Palmer Award for Academic Achievement in Civil and Environmental Engineering, Duke University, 1992  
Outstanding Senior Award, American Society of Civil Engineering (North Carolina), Duke University, 1992  
Graduated Summa Cum Laude and Phi Beta Kappa, Duke University, 1992  
American Society of Civil Engineers (North Carolina) Scholarship Award, 1991

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**Professional Registrations:**

Professional Engineer, GA, No. 25048

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**Professional Affiliations:**

Member: American Geophysical Union

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**Publications:**

1. Council, G.W. and J.L. Ross, 2010. Predictions of TCE Plume Expansion Using Calibration-Constrained Monte Carlo Analysis. Ground Water Summit and Ground Water Protection Council Spring Meeting, Proceedings. April. Denver, CO.
2. Council, G.W. and Richards, C.J., 2008. A Saltwater Upconing Model to Evaluate Wellfield Feasibility. SWIM: 20<sup>th</sup> Salt Water Intrusion Meeting, Program and Proceedings. June 23-27. Naples, Florida.
3. Andersen, P.F. and G.W. Council, 2008. Making Calibration Targets Consistent with Expectations for Predictions. Proceedings of the MODFLOW and More 2008 Conference. May, 2008.
4. Andersen, P.F. and G.W. Council, 2008. Practical Tools for Calibration of Transient Groundwater Flow Models. Calibration and Reliability in Groundwater Modeling: Credibility of Modeling (Proceedings of ModelCARE 2007 Conference, held in Denmark, September 2007). Edited by J.C. Refsgaard, K. Kovar, E. Haarder, and E. Nygaard. IAHS Publ. 320.
5. Gee, J.R. and G.W. Council, 2007. In Situ Treatment of Dissolved-Phase Chlorinated Solvents. Paper H-50, in: A.R. Gavaskar and C.F. Silver (Symposium Chairs), In Situ and On-Site Bioremediation—2007. Proceedings of the Ninth International In Situ and On-Site Bioremediation Symposium (Baltimore, Maryland; May 7–10, 2007). ISBN 978-1-57477-161-9, published by Battelle Press, Columbus, OH.
6. Council, G.W., 2005. The Surface/Vadose Package for Computing Runoff, Evapotranspiration, and Net Recharge in MODFLOW. Proceedings of the 2005 Georgia Water Resources Conference, April 27. The University of Georgia. Edited by Kathryn J. Hatcher.
7. Council, G.W., P.F. Andersen, and A.L. Stieve, 2003. Groundwater Modeling to Evaluate Remediation Alternatives at the Savannah River Site, proceedings of the 2003 National Ground Water Association Mid-South Focus Conference: Environmental Monitoring & Modeling Issues: Hydrogeologic Model Calibration, Uncertainty and Confirmation, September 18-19. Nashville, Tennessee.
8. Council, G.W., P.F. Andersen and S.V. Donohue, 2001. Crandon Mine Permit Application: A Modeling Odyssey, proceedings of the MODFLOW 2001 and Other Modeling Odysseys conference, September 11-14. Colorado School of Mines. Edited by H.S. Seo, E. Poeter, C. Zheng, and O. Poeter.

9. Council, G.W. 1999. A Lake Package for MODFLOW (LAK2): Documentation and User's Guide.
10. Council, G.W., 1998. A Lake Package for MODFLOW, proceedings of the MODFLOW '98 conference, October 4-8. Colorado School of Mines. Edited by Eileen Poeter, Chunmiao Zheng, and Mary Hill.
11. Council, G.W., 1998. Numerical Simulation of Lake-Groundwater Interaction: Method and Application at a Proposed Mine Site in Crandon, Wisconsin. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
12. Andersen, P.F. and G.W. Council, 1998. Design of a Solute Transport Model for the Tailings Management Area, Crandon Project. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
13. Andersen, P.F., G.W. Council, R.T. Hagemeyer, and S.V. Donohue 1998. Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Crandon Mine. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
14. Donohue, S.V., P.F. Andersen, and G.W. Council, 1998. Project Overview of Groundwater Studies for the Proposed Crandon Mine. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
15. Council, G.W., 1997. Simulating Lake-Groundwater Interaction with MODFLOW, proceedings of the 1997 Georgia Water Resources Conference, March 20-22. The University of Georgia. Edited by Kathryn J. Hatcher.
16. Council, G.W., 1994. Solute Dispersion in Groundwater: The Synergistic Effect of Heterogeneity and Hydraulic Gradient Variability. Master's Thesis, Massachusetts Institute of Technology.

**Education:**

M.S., Hydrogeology, Colorado State University, 1985

B.S., Geology, University of Wisconsin, 1976

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**Professional Experience:**

GeoTrans, Inc., Louisville, Colorado, (1986-Present), *Principal Hydrogeologist*

U.S. Geological Survey, Water Resources Division, Nuclear Hydrology Program, Lakewood, Colorado, (1981-1986),  
*Hydrogeologist*

U.S. Geological Survey, Water Resources Division, Champaign, Illinois, (1977-1980), *Hydrogeologist*

U.S. Geological Survey, Water Resources Division, Madison, Wisconsin, (1976-1977), *Hydrogeologist*

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Mr. Erickson is a Principal Hydrogeologist specializing in nonaqueous phase liquids (NAPLs) remediation and fate/transport analysis. He has over 30 years of experience in groundwater analysis and remediation, including the development of 3-dimensional numerical models to simulate long-term effects of groundwater and soil remedies. Mr. Erickson has extensive experience in the development of innovative and cost-effective remedies for free-phase and dissolved-phase organic contaminants such as creosote constituents, polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol, and organic solvents. Over the past 10 years Mr. Erickson work has concentrated on the use of enhanced in-situ anaerobic and aerobic degradation of organics, and groundwater containment remedies. Mr. Erickson's work at wood-treating sites includes the use of innovated technologies such as in-situ chemical stabilization of residual NAPLs, phytoremediation, enhanced anaerobic degradation, aerobic treatment curtains (ATC), and monitored natural attenuation.

Mr. Erickson has extensive experience in negotiating technically defensible remedies on the behalf of clients and PRP groups. One example of a multi-party PRP final remedy negotiations is an expedited RCRA Brownfields remediation of hydrocarbon and solvent contaminated site on the behalf of 160 PRPs. The remediation approach for the site achieved clean closure for unrestricted future use with no-further action. This was the first of eight RCRA Brownfields pilot programs in the U.S. to achieve closure. Mr. Erickson also has extensive experience in the analysis of fracture rock hydrology, radioactive waste disposal, mining hydrogeology, allocation support for PRP committees, water resource investigations, and litigation support.

**Relevant Project Experience:**

**Southern Wood Piedmont – Technical Expert for characterization and remediation of dioxin, arsenic and PAH-impacted sediments at a former wood-treating site in Baldwin, Florida.** Historical wood-treating operations at a site in Baldwin, Florida resulted in organic and metal impacts to soils. GeoTrans was retained in 2008 to develop a systematic approach to characterize on-site and off-site impacts to soil, and to assist in technical negotiations with Florida Department of Environment Protection (FDEP) on final remedial approach to surface soils.

**Fluor Hanford. – Project Manager for groundwater and vadose zone support at the DOE Hanford Site in Richland, WA.** GeoTrans is tasked with providing technical support to the Fluor Team in the areas of groundwater fate and transport analyses and numerical modeling.

**Montana DEQ – Technical Expert for enhanced groundwater remediation at former wood-treating site in Butte/Silver Bow, Montana.** In 1993 a groundwater collection and treatment system was placed into operation at a former wood-treating plant, Montana Pole and Treating Plant (MPTP), to prevent impacted groundwater from flowing off site and discharging to Silver Bow Creek. Site contaminants include pentachlorophenol, polycyclic aromatic hydrocarbons (PAHs), and dioxins/furans. As part of a Tetra Tech Team, GeoTrans was retained by the Montana Department of Environmental Quality (DEQ) in 2007 to complete an evaluation of the current condition of the groundwater treatment system and to assess the system's capabilities to meet groundwater capture and treatment requirements both now and in the future.

**Beazer East, Inc. – Program Manager for creosote NAPL and groundwater remediation and analysis at a former wood-treating Superfund site in Newport, Delaware.** An Administrative Order for Remedial Design and Remedial Action (RD/RA) was issued by the U.S. EPA for remediation of the 317-acre Site. The Order detailed an



approximately \$50 million remedy for soils, groundwater and NAPLs at the Site. As part of the optimization of the final remedy design, GeoTrans is tasked with developing a 3-dimensional groundwater flow model to evaluate fate and transport of pentachlorophenol, PAH constituents and NAPL. In addition, GeoTrans is tasked with free-phase NAPL characterization and remediation at multiple locations across the Site.

**Beazer East, Inc. – Technical Expert for subsurface Dense Nonaqueous Phase Liquids (DNAPLs) remediation at a former wood-treating facility in Dolomite, Alabama.** Historical wood-treating operations at a former site in Dolomite, Alabama has resulted in DNAPL impacts to a fractured bedrock aquifer. GeoTrans was tasked with developing remedial approaches to groundwater impacted with creosote DNAPLs. GeoTrans worked cooperatively with regulatory agencies and stakeholders in the development of the final remedy for this site.

**Beazer East, Inc. – Program Manager for subsurface Dense Nonaqueous Phase Liquids (DNAPLs) characterization an active wood-treating facility in Gainesville, Florida.** Historical wood-treating operations at an active site in Gainesville, Florida has resulted in DNAPL impacts to groundwater. GeoTrans was tasked with developing remedial approaches to groundwater impacted with creosote DNAPLs as part of the Feasibility Study (FS). As part of the FS process, GeoTrans worked cooperatively with regulatory agencies and stakeholders in the development of the characterization approaches and final remedies for this site.

**Beazer East, Inc. – Program Manager for the installation of 26 quadruple-cased Floridan Aquifer monitoring wells at an active wood-treating facility in Gainesville, Florida.** The quadruple-cased wells are required to mitigate constituent drag down and to isolate the approximately 120 feet of hydraulic-head differential across three overlying clay units. The wells were installed with three isolation casings (24-inch, 16-inch and 10-inch diameter casings) and one 4-inch diameter well casing to depths ranging from 245 to 380 feet. The wells were installed with a combination of cable-tool, dual string reverse rotary, and rotasonic drilling methods. Westbay multi-port sampling systems were installed in all 20 wells for discrete zone pressure monitoring and groundwater sampling. The wells were installed as part of the Site characterization and will be used for long-term monitoring. Primary constituents of concern at the Site are PAHs; however, the distribution of BETX, pentachlorophenol and arsenic are being investigated and characterized as well.

**Approved Oil Services (AOS) Site – Program Manager for a GFPR RCRA Brownfields remediation of a former oil recycling facility impacted with hydrocarbons, solvents, metals and asbestoses in Colorado.** The Approved Oil Services (AOS) site was the first RCRA Brownfields site to achieve clean closure for unrestricted future use in EPA Region 8 and the State of Colorado. The RCRA Brownfields remediation was a cooperative effort between 160 PRPs, the EPA, and the State. The EPA staff that oversaw the remediation received a Bronze metal from EPA Headquarters and the Stakeholder Steering Committee received an EPA External Award for the successful completion of this project.

The site remediation required approximately 2 months to complete; however, determining the remediation approach, defining the regulatory liability status of contributing PRPs, and collection of voluntary funds required approximately 2 years of planning, coordination and negotiations between the PRPs and regulators. Specific project responsibilities include: 1) Establishing a remediation stop lose insurance policy; 2) Negotiations with regulatory agencies on remediation approach and closure; 3) Disposal of over 30,000 gallons of hazardous ASTs and USTs liquids; 4) Excavation and disposal of over 3,100 cyds of impacted soils, 5) Asbestos removal and demolition of process building and equipment; and 6) Negotiating MNA remedy for groundwater with no future groundwater sampling and monitoring requirements.

**Beazer East, Inc. – Program Manager for groundwater fate and transport analysis of an active wood-preserving facility in Gainesville, Florida.** Groundwater beneath the site is impacted with residual-phase creosote NAPLs, dissolved-phase creosote compounds and arsenic. Creosote impacts extend approximately 150 feet from land surface to the Upper Floridan Aquifer. Specific project responsibilities include: 1) Program management and regulatory negotiations on the final groundwater remedies; 2) Development of a 3-dimensional, 11-layer, 25 square mile fate and transport model to evaluate dissolved-phase transport of site constituents; 3) Development and evaluation of groundwater remedies; 4) Development of a Feasibility Study (FS) report; and 5) Assistance in the field investigation of source locations and transport mechanisms.

**Kearny Peninsula Group – Program Manager for groundwater evaluation and Remedial Design (RD) for three adjacent sites in New Jersey that include a historical chemical coke manufacturing/processing site, chemical manufacturing facility and a chromium ore processing facility.** Program responsibilities included fate and transport analysis of free-phase NAPLs, dissolved-phase organics and dissolved-phase chromium in groundwater. Specific project responsibilities include: 1) Development of a 3-dimensional, 9-layer, 25 square mile groundwater flow model to evaluate the optimal location of the barrier-wall groundwater containment and treatment system; 2) Development of a solute transport model to evaluate fate and transport of organics and chromium species adjacent to the Hackensack River; 3) Development of a MNA technical approach for dissolved-phase constituents; 4) Negotiations with regulatory agencies on the final groundwater remedies.

**Beazer East, Inc. – Program Manager for RCRA Facility Remedial Design/Remedial Action (RD/RA) for a wood preserving site in Jacksonville, Florida.** Program responsibilities included development of an alternative groundwater remedy approach to dissolved-phase boron and arsenic impacts. The alternative approach eliminated a groundwater extraction and a constructed wetlands remedy and replaced it with a risk-based approach to boron impacts to groundwater and a soil stabilization approach to arsenic impacted sediments and groundwater.

**Beazer East, Inc. – Program Manager for RCRA Facility Corrective Measures Study (CMS), and Remedial Design/Remedial Action (RD/RA) for a wood preserving site in Montgomery, Alabama.** Program responsibilities included fate and transport analysis of free-phase NAPLs and dissolved-phase organics (PAHs and pentachlorophenol) in groundwater for the development of groundwater remedies for the facility. Specific project responsibilities include: 1) Evaluation of 18-yr of groundwater flow and chemistry data as part of the RCRA Facility Investigation (RFI); 2) Development of a 3-dimensional, 13-layer groundwater flow model to evaluate the optimal location of the slurry-wall groundwater containment system; 3) Negotiations with the Alabama Department of Environmental Management (ADEM) for the final groundwater containment and Monitored Natural Attenuation (MNA) remedy for the site; 4) Regulatory negotiations for the reducing the groundwater monitoring program; and 5) Development of a CMS report and a CMI report for remedy selection and implementation.

**Beazer East, Inc. – Project Manager for RCRA Facility Investigation (RFI), Corrective Measures Study (CMS), and Remedial Design/Remedial Action (RD/RA) for a wood preserving site in Denver, Colorado.** Specific project responsibilities include: 1) Design and installation of remedial systems for in-situ anaerobic and aerobic biological degradation of polyaromatic hydrocarbons (PAHs) and pentachlorophenol in the groundwater system; 2) Analysis and installation of nonaqueous phase liquids (NAPL) recovery systems; 3) Analysis and installation of a sheet-pile wall/treatment gate system; 4) Use of MODFLOWT to evaluate the optimal location of the sheetpile wall/treatment gate system; and 5) Negotiations with the State and EPA for the interim measures and final remedy for the site.

**San Gabriel Valley PRP Steering Committee, Allocation Support, San Gabriel Valley, California – Project Manager of Superfund PRP allocation analysis for the San Gabriel Valley Baldwin Park Operable Unit.** The basin is impacted by VOCs from industrial manufacturing, storage, disposal, and solvent recycling operations from the past 55 years. Allocation analysis includes development of three-dimensional flow (MODFLOW) and particle tracking models (MODPATH) of the groundwater basin, development and implementation of technically defensible allocation approach that allows for a reduction in individual PRP allocation based on site investigations, and development of databases for management and analysis of PRP data.

**Confidential Client, Utah – Project Manager for density-dependent flow analyses and geochemical characterization at a mine tailings facility in support of a permit to expand the tailings impoundment.** The density-dependent flow analysis required the use of both a two-dimensional flow model (SWIFT) and analytical techniques to evaluate the effects of high TDS fluids on the local groundwater flow and solute transport system.

**Union Pacific Resources, Wyoming – Performed a hydrogeologic and geochemical evaluation of a uranium tailing impoundment.** Provided technical support for developing alternatives for dewatering the tailings impoundment and limiting the transport of low pH fluids and metals from the facility.

**Electric Power Research Institute, Palo Alto, California – Project Manager of a nationwide, six-year research study for the collection, analysis, and development of hydrogeologic and geochemical data sets for the validation of coupled groundwater flow and geochemical numerical models.** The research program consisted of: 1) Evaluation of over 300

potential candidate sites for the selection of three sites for detailed hydrogeologic and geochemical data collection; 2) Development of a guidance manual for data requirements and usage in numerical models; 3) Development of innovative field techniques to characterize both saturated and unsaturated groundwater flow and geochemical processes at utility sites; and 4) Hydrogeologic characterization and analysis of electric utility ash and FGD disposal ponds in the southeastern, midwestern, and southwestern areas of the United States.

Department of Energy, Nevada Test Site (NTS) – Performed a review and analysis of two numerical groundwater flow and solute transport codes for simulating radionuclide transport. Specific responsibilities included the development of test data sets and the application of the FEHM and Tracr3D codes to evaluate their performance for simulating groundwater flow and solute transport in fracture bedrock. This work was performed in support for the Environmental Restoration Program at the NTS.

Southern California Edison – Evaluated the potential long-term effectiveness of a single-layer clay liner for reducing pond water infiltration at the Cool Water Generating Plant. A one-dimensional unsaturated flow model was developed, using the U.S. Geological Survey code VS2D, to evaluate the amount of pond water infiltration across the existing clay liner. The relative effectiveness of the existing single-layer clay liner was compared to the effectiveness of a prescriptive multi-layer liner required by the State of California. As a result of this analysis, the State granted SCE a variance for an alternative liner design, resulting in a net savings of over \$10 million.

Department of Energy, Nevada Test Site – Developed a one-dimensional unsaturated flow model to evaluate the depth of pond water and radionuclide infiltration for an evaporation pond. Results of the numerical model analysis were used to evaluate the maximum depth of soil remediation required for the site. This work was performed as part of the remedy and final closure of the site.

Peabody Coal Company – Developed a groundwater tracer test approach to evaluate the source of mining related constituents in spring-water discharge at the Black Mesa Mine. Specific project responsibilities included an analysis of groundwater flow conditions at the site, evaluation of potential tracers suitable for the site, and the development of tracer test procedures and analysis approach.

Colorado Department of Law, Colorado – Analysis of infiltration and leachate generation, evaluating alternative cover designs for a large tailings pile impoundment at a precious metals site. The evaluation of alternative cover designs required the use of an unsaturated/saturated flow model (EFLOW) for simulating seasonal variations in recharge to the tailings impoundment from rainfall and snow melt events in a high-mountain alpine environment.

Peabody Coal Company, Arizona – Development of an analytical open-pit inflow model to predict inflow volumes according to pit advancement and configurations for a coal mine.

Peabody Coal Company, Arizona – Provided technical review of a mine permit application for a large open-pit coal mine.

BFI, Louisiana – Development of a three-dimensional, groundwater flow (MODFLOW), particle tracking (STLINE) and solute transport model (SEFTRAN) for a hazardous waste landfill site in Louisiana to assess the impacts of contaminant transport on a shallow water supply aquifer. Numerical models were successfully used to predict the long-term effectiveness of the existing recovery well system and the locations of additional recovery wells to prevent off-site migration of organic contaminants.

Participating member of the Association of American Railroads (AAR) Environmental Engineering & Operations Working Committee – This committee meets three times a year to discuss and address environmental issues that directly impact the railroad industry. Currently a member of the RBCA subcommittee responsible for tracking the adoption of RBCA standards in state regulatory agencies. In addition, the subcommittee has assumed the task of educating both railroad employees and regulatory agencies on the RBCA process in various states.

Confidential Transportation Client, Wisconsin – Project Manager responsible for performing an analysis of a hypothetical spill of concentrated sulfuric acid in a river in northern Wisconsin as part of a spill response plan for a railroad. Performed both geochemical modeling and surface-water transport modeling of an acid spill in a river system



crossed by a railroad. The unique approach to the problem was both cost-effective and efficient. The analysis was reviewed by the regulatory agencies and was unconditionally approved.

Confidential Transportation Client, Wisconsin – Project Manager responsible for performing fate and transport modeling of an arsenic spill in a wetlands resulting from a railroad derailment that occurred over 50 years ago. Responsible for hydrogeologic and geochemical data to perform a one-dimensional analysis of the arsenic transport. This work is completed and has received regulatory agency approval for closure.

Electric Power Research Institute, Palo Alto, California – Co-authored an EPRI guidance document for electric utilities entitled "Techniques to Develop Data for Hydrogeochemical Models (1989)." Technical responsibilities included coordinating geochemical studies, density-dependent flow analysis, and numerical model development.

Edison Electric Institute, Washington, D.C. – Co-authored an Edison Electric Institute guidance document for electric utilities entitled "Groundwater Monitoring Manual." Technical responsibilities included writing sections of the report dealing with hydrogeologic concepts, groundwater monitoring system design, data management, and analysis.

ARCO, Colorado – Project Manager for investigating the extent of hydrocarbon contamination resulting from leaking UST and for developing remedial alternatives for contaminated groundwater. Responsibilities included developing the monitoring network, meeting and negotiating with regulatory agencies, and developing the closure plan for the site.

Union Pacific Resources, Wyoming – Project Manager for geochemical transport and hydrogeologic analyses. Developed an Alternative Concentration Level (ACL) permit application for a uranium tailings impoundment. Permit application required the use of an Analytical Element Model (TWO-DAN) for analyzing the response of the shallow groundwater aquifer to shutting off the recovery well system currently capturing impacted groundwater down gradient of the impoundment, and the use of a geochemical transport code (BIO1D) for predicting the long-term concentrations of trace metal contaminants at POC and POE locations down gradient of the impoundment.

Calcasieu Waste Disposal Facility, Louisiana – Task Leader for the development of a three-dimensional groundwater flow model, particle tracking, and solute transport model for a hazardous waste landfill to evaluate the potential for offsite contaminant migration. Numerical models were successfully used to predict the long-term effectiveness of the existing recovery well system and the locations of additional recovery wells to prevent offsite migration of organic contaminants. Reviewed and analyzed existing geologic, hydrologic, and chemical data. Modeling and geochemical results successfully defended to the regulatory agencies and Final RCRA Part B permit conditions were met.

Department of Energy, Nevada Test Site – Co-project Leader and Investigator for the characterization of a potential high-level nuclear waste repository.

Confidential Client, Sheffield, Illinois – Assistant Project Leader for the hydrogeologic characterization of a low-level radioactive waste disposal site.

South Florida Water Management District, Palm Beach County, Florida – Development of a three-dimensional groundwater flow model (MODFLOW) to assess the impacts of municipal wellfield pumpage on the shallow aquifer and lakes. The analysis of groundwater pumpage on surface-water lakes required the development of a coupled groundwater flow/lake-stage module for the MODFLOW code. This module was successfully used to simulate historical groundwater/ surface water elevations in the region and to predict the long-term impacts of groundwater withdrawals on lake stages.

CALTRANS, Los Angeles, California – Development and implementation of a site characterization program to evaluate NAPL, pesticides, and metal contamination at an abandoned landfill.

Peabody Coal Company, Arizona - Performed regional aquifer characterization and evaluation for a surface coal mining project.

Department of Energy, Nevada Test Site - Project Manager for the development of a numerical parameter estimation technique for the analysis of single well tracer tests at a potential high-level nuclear waste disposal site at Yucca

Mountain. The numerical technique required the use of the U.S. Geological Survey MOC code coupled to a parameter estimation module for the analysis of tracer-test data.

Department of Energy, Nevada Test Site - Supervised the drilling, sample collection, well construction, and hydrologic testing of deep wells (3,000-4,000 feet) as part of the characterization of the Yucca Mountain site for high-level nuclear waste disposal.

Department of Energy, Nevada Test Site - Conducted an analysis of hydrogeologic tests in fractured rock at the Yucca Mountain site.

Department of Energy, Nevada Test Site - Designed and implemented *in situ* single- and multiple-well tracer tests to assess travel times and retardation mechanisms at the Yucca Mountain site.

Confidential Client, Sheffield, Illinois - Quantified the complex glacial stratigraphy for a low-level radioactive-waste disposal site; assisted in the development of both the conceptual and two-dimensional groundwater flow models; designed and supervised the drilling, sampling, well construction, and hydraulic testing of a 40 well monitoring system; and supervised the construction of a 290-foot tunnel under four waste disposal trenches to characterize unsaturated groundwater flow and radionuclide transport.

Municipalities, Southeast Wisconsin - Constructed water-level and contamination-potential maps for counties in southeastern Wisconsin.

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**Professional Certifications:**

Registered Professional Geologist, #1765, WY

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**Professional Affiliations:**

American Geophysical Union

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**Publications:**

1. Mueller, J., J. Moreno, J. Valkenburg, G. Council, J. Erickson, T. Al, D. Loomer, M. Slenska and M. Brouman. (2009). Field Performance of *In Situ* Biogeochemical NAPL Stabilization. Battelle's Tenth International *In Situ* and On-Site Bioremediation Symposium, May 7-10, 2009 Baltimore, MD.
2. Mercer, J. W., Toth, J. P, Erickson, J. R., Slenska, M., Brouman, M. 2006. DNAPL Source Evaluation at a Portion of the Cabot Carbon/Koppers Superfund Site, First International Conference on DNAPL Characterization and Remediation, September 25-28, 2006. Pittsburgh, PA.
3. Roemer, G., Erickson, J., Tischuk, M., 2006. Bridging the Technical Divide for Groundwater Remedy Selection at a Wood-Treating Facility, MODFLOW and More 2006: Managing Ground Water Systems. May 21-24, 2006, Golden, CO.
4. Mueller J. Lakhwala, F., Mercer, J., Erickson, J., Hill D., Dmitrovic, E., Seech A., Slenska, M., Brouman, 2005. Site-Specific Limitation of Using KMNO<sub>4</sub> for *In Situ* Biochemical Stabilization (ISBS) of Creosote/Penta DNAPL Proceedings, Battelle's Eighth International In-Situ and On-site Bioremediation Symposium. June 6-9, 2005, Baltimore, MD.
5. Erickson J.R., K. L. Baker, M, J. Franko, J. K. Will, S. D. Richtel, 2004. RCRA Brownfields Remediation and Clean Closure of an Oil-Recycling Facility in Denver Colorado, National Groundwater Association Conference, New Orleans, LA, November 15-16, 2004.
6. Erickson J.R., J. Mueller, M.D. Tischuk, M. Bollinger, 2004. Cost-Effective Multi-Component Remedy for Closure of Creosote NAPL Sites, National Groundwater Association Conference, New Orleans, LA, November 15-16, 2004.

7. Erickson J.R., J. Mueller, M.D. Tischuk, M. Brouman, 2004. Field Demonstration of In Situ Biochemical Stabilization of Creosote/Pentachlorophenol NAPLs Using Permanganate, Oxidation Reduction Technology 3 Conference, San Diego, CA, October 25-28, 2004.
8. Erickson J.R., J. Mueller, M.D. Tischuk, M. Bollinger, M. Brouman, 2003. In Situ Biochemical Stabilization of Creosote/Pentachlorophenol NAPLs Using Permanganate, The Seventh International Symposium In Situ and On-Site Bioremediation, Orlando, FL, June 2-5, 2003.
9. Mueller, J., J. Erickson, N. Thomson, C. Lamarche, J. Cook, M. Tischuk, and M. Brouman 2002. *In situ* biogeochemical stabilization versus attempted NAPL removal. Proceedings, Battelle's Third International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA May 20-24, 2002.
10. Mueller, J. J. Erickson, M. Brouman, M. Bollinger, M. Tischuk, and J. Cook. 2001. Integrated Technologies for *In Situ* Source Management at an Operating Wood Treatment Site. In Situ Containment Conference, Orlando FL June 11-14, 2001.
11. Erickson, J.R., M.D. Tischuk, J.A. Cook, J. Mueller, W.R. Mahaffey, 2000. Enhanced Aerobic/Anaerobic Bioremediation for a Wood-Treating Site, The Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, May 22-25, 2000.
12. Berger, M.T, M.A. Bergeon, and J.R. Erickson, 1997. Remedial Action to Limit Direct Contact Exposure in an Arsenic-Impacted Wetland, 12th Annual Conference on Contaminated Soils, October 20-23, University of Massachusetts.
13. Erickson, J.R., 1995. "Use and Misuse of Numerical Groundwater Flow and Solute Transport Models" Presentation to the Association of American Railroads (AAR), Chicago, IL, June 8, 1995.
14. Holcombe, L.J., A. Weinberg, R.J. Coel, A.T. Willden, R.A. Coffan, J.R. Erickson, and J.S. Fruchter, 1995. Co-management of High-Volume Combustion By-Product and Other Utilities Wastes: A Southwestern Site.
15. Holcombe, L.J., J.R. Erickson, J.J. Fruchter, C.M. Thompson, and A. Weinberg, 1994. Model validation data set for utility by-product management sites -- Volume I: Site characterization data, Electric Power Research Institute, Palo Alto, California, in publication.
16. Holcombe, L.J., J.R. Erickson, J.J. Fruchter, C.M. Thompson, and A. Weinberg, 1992. Co-management of coal combustion by-products and low volume wastes: A midwestern site, Electric Power Research Institute, Palo Alto, California, TR-100955.
17. Fruchter, J.J., J.M. Thomas, R.K. Waddell, and J.R. Erickson, 1992. Strategies for field calibration and validation of groundwater models, Electric Power Research Institute, Palo Alto, California, TR-101063.
18. Holcombe, L.J., J.R. Erickson, J.J. Fruchter, C.M. Thompson, and J.A. Rehage, 1991. Co-management of coal combustion by-products and low-volume wastes: A southwestern site, prepared by Radian Corporation, GeoTrans, Inc., and Battelle Pacific Northwest Laboratories, Electric Power Research Institute, Palo Alto, California, EN-7545.
19. Erickson, J.R., 1990. A field investigation of groundwater quality at a waste co-management pond, presented at Edison Electric Institute Groundwater Task Force Symposium on Technology and Policy Development, July 18-19, Washington, D.C.
20. Erickson, J.R., 1990. Site characterization methods for groundwater monitoring and modeling, presented at Electric Power Research Institute Seminar on Waste Disposal and Groundwater Quality Assessment Methods, August 7-8, Atlanta, Georgia.

21. Murarka, I.P., and J.R. Erickson, 1990. Case studies and results for actual waste management/ co-management sites, presented at Electric Power Research Institute Seminar on Waste Disposal and Groundwater Quality Assessment Methods, August 7-8, Atlanta, Georgia.
22. Electric Power Research Institute, 1989. Techniques to develop data for hydrogeochemical models, prepared by Radian Corporation, GeoTrans, Inc., and Battelle Pacific Northwest Laboratories, Electric Power Research Institute, Palo Alto, California, EN-6637.
23. Star, I., J.R. Erickson, and R.K. Waddell, 1989. Groundwater monitoring manual; prepared for and copyrighted by the Edison Electric Institute, Washington, DC.
24. Dacey, C.A., J.R. Erickson, and R.K. Waddell, 1988. A coupled three-dimensional groundwater flow and lake-stage model of northern Palm Beach County, Florida, American Water Resources Association Symposium on Coastal Water Resources, Wilmington, North Carolina.
25. Erickson, J.R., C.A. Dacey, and R.K. Waddell, 1987. A coupled three-dimensional groundwater flow and lake-stage model of northern Palm Beach County, Florida, AGU, San Francisco, California.
26. Erickson, J.R., and R.K. Waddell, 1985. Identification and Characterization of Hydrologic Properties of Fractured Tuff Using Hydraulic and Tracer Tests-Test Well USW H4, Yucca Mountain, Nye County, Nevada, U.S. Geological Survey Water Resources Investigations Report 854066, 30 pp.
27. Erickson, J.R., D.L. Galloway, and K. Karasake, 1985. Interpretations of Falling Head Injection Test Data for Fractured Volcanic Tuffs, Yucca Mountain, Nevada Test Site, GSA, Orlando, Florida.
28. Erickson, J.R., and R.K. Waddell, 1985. Parameter Estimation Techniques for the Analysis of Single Well Tracer Tests, AGU, Baltimore, Maryland.
29. Galloway, D.L., and J.R. Erickson, 1985. Tracer Test for Evaluating Nonpumping Intraborehole Flow in Fractured Media, ANS, San Francisco, California.
30. Waddell, R.K., and J.R. Erickson, 1984. Transport Experiments in Fractured Tuffs at Yucca Mountain, Nevada Test Site, AGU, Cincinnati, Ohio.
31. Foster, J.B., J.R. Erickson, and R.W. Healy, 1983. Hydrogeology of a Low-Level Radioactive Waste Disposal Site Near Sheffield, Illinois, U.S. Geological Survey Water Resources Investigations Report 834125, 83 pp.
32. Erickson, J.R., 1980. Hydrogeology of a Low-Level Radioactive Waste Disposal Site Near Sheffield, Illinois, North-central Section GSA, Bloomington, Indiana.
33. Foster, J.B., and J.R. Erickson, 1979. Preliminary Report on the Hydrogeology of a Low-Level Radioactive Waste Disposal Site Near Sheffield, Illinois, U.S. Geological Survey Open File Report 791545, 87 pp.
34. Sherrill, M.G., and J.R. Erickson, 1979. Water Table Map of Walworth County, Wisconsin, U.S. Geological Survey Water Resources Investigations Report 7942.
35. Sherrill, M.G., J.J. Schiler, and J.R. Erickson, 1979. Water Table Map of Milwaukee County, Wisconsin, U.S. Geological Survey Water Resources Investigations Report 7940.

# PROFESSIONAL RESUME

**DALE R. FOSTER, P.E.**  
**Principal Engineer**

**Education:** B.S., 1984, Chemical Engineering, Grove City College

**Professional Registrations:** Professional Engineer, Pennsylvania, Alabama, New Hampshire

**Experience Summary:**

25 years of environmental engineering experience. Areas of experience include remediation technology development and implementation, waste water and ground water treatment process engineering, conceptual design, feasibility studies, construction oversight, system start-up and operations oversight. Remedial design experience includes design of in situ biological groundwater and soils treatment systems, design of biological in situ treatment techniques for metals contamination, design of air sparging and vapor extraction remediation systems, design of groundwater recovery and treatment systems, design of DNAPL and LNAPL recovery systems, and other related remedial systems. As senior project and principal engineer Mr. Foster has led engineering functions at KEY Environmental for the past 15 years and is responsible for oversight of all process engineering related functions conducted by the corporation. Mr. Foster was directly responsible for the following project tasks.

**Key Projects:** Design and construction management of a groundwater treatment and oil recovery system for a manufactured gas plant site in Maryland. Responsible for conceptual and detailed design including direction of process, mechanical, structural, electrical and control engineering team. Currently overseeing operation of this system.

Engineering evaluation of remedial options for a manufactured gas plant Site on Lake Michigan. Performed engineering evaluations in support of cost allocation between MGP related issues (our client) and other previous land use issues.

Design, installation and operations oversight of a replacement groundwater treatment system, along with upgrades to an existing groundwater extraction system and high vacuum multi-phase extraction system for a chlorinated solvent Site in New Jersey. The treatment system meets all applicable regulatory requirements at significantly reduced cost than a system originally installed by others, which failed to meet air treatment requirements.

Design and installation oversight of a creosote DNAPL recovery system at a coal tar Site in Maryland. System incorporates both vertical and horizontal groundwater recirculation techniques, in-well separation of DNAPL and groundwater, and is integrated into an overall Site remedy including enhanced natural attenuation, low permeability capping and slurry wall containment.

Design, installation and operation of an in situ chemical oxidation pilot project for treatment of chlorinated hydrocarbons at an active manufacturing facility in New Jersey. Project involved controlled injection of potassium permanganate solution through a series of injection wells. Responsibilities included conceptual design, field health and safety supervision, equipment specification, system construction oversight, oversight / assistance with permanganate solution mixing, control of injection system and direction of data gathering effort.

Completed engineering aspects of a natural attenuation groundwater remedy and contingency planning for a former MGP and coal tar chemicals facility in New Jersey. Project is currently in long-term monitored natural attenuation phase. Recently completed technical justification and won regulatory approval to significantly scale-back monitoring frequency based on groundwater velocity assessment and historic data trend analysis.

Process engineering oversight of activated carbon adsorption dynamics for two groundwater treatment / recirculation systems in central Pennsylvania. The process is designed to minimize precipitation of inorganic species in groundwater, eliminating several potential unit processes and allowing recirculation of groundwater into a shallow aquifer with minimal fouling. This project has resulted in a decrease in environmental set-asides for the potentially responsible parties in excess of \$15 million. The Site remedies are in-place, and awaiting trigger of any of several options including demonstration of natural attenuation, demonstration of technical impracticability, and demonstration of acceptable risk to terminate system operation.

Provided engineering oversight of remedial excavations of a below-grade former gas holder base and several below-grade and above-grade former tar facilities. Responsibilities included development of bidding documents for selection of contractors and engineering supervision throughout remediation. An innovative in-place volume fixed unit price approach, supported with investigative data, was used to minimize costs and Clients risks. KEY turn-key contracted the work which was completed at a fraction of the cost estimated by a third party consultant. Overall Site remedy is in-place including natural attenuation demonstration and surface capping integrated into a public ball park.

Provided engineering oversight of remedial excavations of two below-grade former gas holder bases. Responsibilities included development of bidding documents for selection of contractors and engineering supervision throughout remediation. An innovative in-place volume fixed unit price approach, supported with investigative data, was used to minimize costs and Clients risks. KEY turn-key contracted the work which was completed at less than half of the cost bid by a third party consultant. Overall Site remedy is being implemented including natural attenuation demonstration and LNAPL recovery at one location using vertical recirculation well technology. Off-Site source of LNAPL investigated through analytical “finger-printing”, coupled with geophysical investigation successful in focusing remedial efforts on MPG issues versus off-Site sources.

Designed an air sparging and vacuum extraction system for an organic solvent Site in Texas. System is currently in operation and achieving remedial objectives.

Designed potable and fire suppression water distribution systems for development and remedial projects in Pennsylvania and New Jersey.

Completed engineering functions for a remedial investigation / remedial evaluation and a subsequent remedial action plan for an active chemicals facility in South Carolina. The project involved a TCE release in groundwater. Mr. Foster was responsible for directing the collection of biological and physical attenuation data during the investigation, which later supported a non-biological natural attenuation argument for two of three impacted areas. One of the areas was determined to require some form of active remediation, as concentrations of constituents currently exceed state mandated levels at the point of compliance. A supplemental remedial program including a recirculation well *in situ* air stripping technology to supplement natural attenuation was developed for this area as part of remedial evaluation. This technology was determined to be significantly less costly than either pump and treat or conventional air sparging / vapor extraction approaches.

Completed a comprehensive treatability study for a former organic chemicals (primarily dyes and intermediates) facility in central Pennsylvania. The treatability study included evaluations of a number of treatment approaches including three forms of chemical oxidation, biological treatment, carbon adsorption, air stripping, and combinations of each. Natural attenuation was determined to occur, but was not sufficient to meet proposed standards at the point of compliance. *In situ* treatment approaches including recirculation type physical/chemical treatment (air stripping and/or activated carbon) were recommended for pilot scale testing, based on significantly lower costs compared to conventional pump and treat and conventional air sparging / vapor extraction systems.

Completed engineering functions for a Remedial Action Proposal for a former manufactured gas plant coke and by-products site in New Jersey. The recommended remedial actions based on an engineering evaluation included a physical barrier and hydraulic containment for groundwater in DNAPL impacted areas, natural attenuation of constituents in groundwater for the majority of the site groundwater, DNAPL recovery, risk based soil remediation including engineering and institutional controls, and source material removal for ecological protection in an ecologically sensitive area of the site. The program also includes monitoring to assure groundwater does not violate surface water quality standards adjacent to the property, and monitoring of ecological receptors on site. This project has been completed and is now in natural attenuation phase.

Mr. Foster provides continued oversight of operations and design of improvements for an existing DNAPL/groundwater recovery facility at a former manufactured gas plant and coke and coke/by-products plant in New Jersey. This facility, designed by Mr. Foster in past employment, recovers approximately 150,000 pounds of dewatered coal tar derived DNAPL annually which is recycled through a coal tar distillation facility at no charge to the site owners. The system operates under a NJPDES permit for which Mr. Foster completed the application and assisted in negotiating, which allows infiltration of incidentally recovered groundwater following oil/water separation.

Mr. Foster provided engineering for a novel DNAPL recovery system for a coal tar facility in Texas. The design redirects natural groundwater flow to enhance DNAPL recovery. Engineering calculations including DNAPL droplet formation through an artificial orifice representing well screen openings, separation of DNAPL and groundwater based on terminal velocity of droplets, and coalescing separation options were completed to support the design. The design does not result in groundwater pumping or treatment, but rather relies on natural attenuation of groundwater for protection of off-site receptors.

Mr. Foster has been responsible and in charge of process engineering work completed by KEY Environmental, Inc. since February, 1995. Additional projects which Mr. Foster has been responsible for include:

Provided oversight of operations of an existing DNAPL recovery / groundwater treatment facility at a former wood treating site in Maryland.

Completed an engineering evaluation of air sparging biological treatment of groundwater as an enhancement to natural attenuation down gradient of a DNAPL source for a coal tar site in Pennsylvania. This evaluation included fate and transport modeling and a kinetics evaluation.



Completed oversight of a 1,000,000 gallon storage tank removal completed on a former MGP / coal tar site in New Jersey. The tank contained approximately 600,000 gallons of naphthalene and phenanthrene product, requiring a Level B confined space investigation. Through thorough sampling and characterization of the tank contents for both recycling and disposal options, followed by a competitive bidding program involving vendors from several industrial segments, the project costs were reduced by approximately \$200,000 versus bids received prior to the investigation. The investigation and bidding tasks cost a fraction of the money saved.

Proved expert assistance for cost recovery evaluations for a legal client in Pennsylvania. A cost recovery basis was developed which addressed the degree to which PRP related constituents either 1) resulted in the need to complete remedial action and 2) affected the cost of implementing any required remedial action). This approach allowed the PRP group to negotiate costs on the basis of the degree to which each party caused the remediation to be necessary, and the degree to which each party caused the remediation expense to increase due to less toxic but costly to remediate constituents.

**Project Engineer, Chester Environmental, Inc. Moon Twp., PA**

As a project engineer at Chester Environmental, Mr. Foster was responsible for preparing design documents for wastewater, groundwater, and soil treatment systems, oversight of construction and operation of remedial treatment systems, developing and evaluating engineering alternatives for environmental remediation under RCRA, CERCLA and various state regulatory programs, completing Feasibility Studies under CERCLA and Corrective Measures Studies under RCRA, and design and implementation of laboratory treatability studies. The following is an abbreviated list of Mr. Foster's project and related work experience while employed by Chester Environmental, Inc.:

Mr. Foster completed the engineering functions for a successful demonstration of natural attenuation at a facility located in Michigan. Groundwater in a permeable limestone bedrock unit was impacted with milligram per liter concentrations of pentachlorophenol. Testing was completed to quantify the attenuation mechanisms occurring on-site. Biodegradation was documented, and determined to be occurring under phosphorous limiting conditions. Geochemistry equilibrium calculations revealed that the available inorganic phosphorous was limited due to the supersaturation of the groundwater with calcium. Nutrient interaction testing was completed which demonstrated that triethylphosphate could be introduced if needed to increase the bio-availability of phosphorus. Natural attenuation with nutrient addition if required based on compliance and effectiveness monitoring was successfully defended for the facility.

Mr. Foster completed the engineering functions associated with a feasibility study for remediation of a former wood treating facility site in Maryland. The site is on the state superfund priority list and the feasibility study was completed in compliance with CERCLA requirements. The selected site remedy includes a demonstration of natural attenuation for groundwater downgradient of source areas, with *in situ* biological enhancements to natural attenuation to be incorporated as needed, DNAPL recovery from shallow and deep aquifers, hydraulic containment of DNAPL impacted areas, risk based engineering and institutional controls for surface soils, and excavation/replacement and habitat mitigation for impacted sediments.

Mr. Foster designed an *in situ* biological chromium reduction treatment system for an active metals fabrication facility in Maryland. Natural attenuation of chromium through reduction of hexavalent chromium to trivalent chromium was demonstrated to have greatly reduced the plume of dissolved chromium in groundwater, however, the reductive capacity of the groundwater was limiting the conversion of chromium. The *in situ* process was designed to produce milligram per liter levels of dissolved hydrogen sulfide *in-situ* through a biological process. This concentration of hydrogen sulfide is capable of reducing hexavalent chromium to the less mobile and less toxic trivalent form at the natural pH of the site groundwater. Also, Mr. Foster proposed an alternative chemical approach utilizing ferrous ammonium sulfate as a reducing agent in the event that toxicity or odor problems developed with the biological approach, which would be capable of reducing hexavalent chromium at the ambient groundwater pH at a somewhat greater total cost.

Mr. Foster completed planning, conceptual design, review of detailed design, construction inspection, start-up and continuing oversight of operation of a groundwater and coal tar related Dense Non-Aqueous Phase Liquids (DNAPL) recovery and treatment system at a former integrated coke and coal tar byproducts facility in New Jersey. The system has recovered approximately 60,000 gallons of DNAPL to date. Mr. Foster more recently designed, supervised construction and testing of and initiated operation of an expansion to the successful DNAPL recovery system. Mr. Foster now oversees continued operation of this system as principal engineer of KEY.

Mr. Foster performed engineering performance evaluation and optimization studies of a Light, Non-Aqueous Phase Liquid (LNAPL) recovery and treatment system at a former wood treatment site in Wisconsin. The recovery and treatment system includes 5 groundwater recovery wells, two of which employ dedicated LNAPL recovery pumping systems. Recovered groundwater was treated to reduce pentachlorophenol concentration from approximately 30 mg/L to less than 10 ug/L. The treatment system included primary settling followed by a biological fluidized bed reactor and activated

carbon polishing. Mr. Foster's responsibilities included directing operation of the recovery well network, directing operation of the treatment system, optimizing treatment system efficiency through control of recycle rates, air and oxygen deliver rates, nutrient rates, microbiology inspection including visual and scanning electron microscope techniques, modifying the pretreatment system, and lab and field trials of alternative pretreatment scenarios, and assuring discharge limitations were met throughout the performance evaluation and optimization.

Mr. Foster completed planning, design and execution of a program for monitoring the performance of an existing 14 well DNAPL/groundwater recovery system in South Carolina. The program included modifications to piping to install pressure and vacuum measurement points. Initial calculations of well performance, pump performance, and force main condition were performed using well water levels, pump suction vacuums, pump discharge pressures, force main pressures, and pump flow rates. Theoretical force main pressure losses were compared to actual losses, and the apparent effective size of the force main piping calculated. Baseline pump performance, force main pressure, and suction piping losses were established. Regression analysis of actual field pump performance was used to predict average pump output under varying field conditions. This program was transformed into an ongoing monitoring program to track the performance of the system and to reveal defects and/or reduced performance of system components prior to possible major malfunctions.

Mr. Foster conducted an engineering evaluation as part of a Corrective Measures Study under RCRA including an analysis of alternatives for treatment of soils, groundwater, and DNAPLs for an active creosote, pentachlorophenol and copper chromated arsenic wood treatment facility in South Carolina. Alternatives evaluated include:

- In situ and ex situ biological treatment of soils, DNAPL recovery with and without gradient control;
- Groundwater isolation alternatives including hydraulic barriers, slurry walls, and low permeability caps; and,
- Conventional alternatives including incineration for soil and activated sludge followed by activated carbon for groundwater.

Mr. Foster designed, supervised, and interpreted the results of treatability testing for upgrades to an existing pilot groundwater treatment system for a site in Maryland. Mr. Foster assisted in completion of the conceptual design of system improvements including modification of the pretreatment system for iron removal, upgrade of a gravity settling system to operate as a polymer enhanced dissolved air floatation system, addition of a biological treatment step using a fixed film process, and addition of a solids handling system.

Mr. Foster designed a DNAPL and groundwater extraction, conveyance, treatment and storage facility at an active wood treating facility in Kentucky. The design allowed for separate recovery of DNAPL and groundwater, direct piping of DNAPL, groundwater treatment incorporating coalescing separation and oleophilic (quaternary amine modified clay) sorption of free oils, and activated carbon adsorption of dissolved organic constituents.

Mr. Foster designed an air sparing biodegradation system for a former service station in Michigan. This system was installed and recently upgraded (to adjust the sparge well depth necessitated by a change in the site use and resulting alteration of the groundwater elevation), and is operating successfully.

Mr. Foster assisted in the design of an air sparing / vapor extraction for a privately owned vehicle maintenance facility now operating in Pennsylvania.

Mr. Foster assisted in the completion of a vapor extraction field testing program for a municipal maintenance facility in Pennsylvania. A successful vapor extraction system was subsequently designed and installed (by others) at the site utilizing the data developed through the testing program.

**Sanitary Engineer, Pennsylvania Department of Environmental Resources, 1012 Water Street, Meadville, PA**

Mr. Foster performed environmental engineering and project management of United States Environmental Protection Agency (EPA) Construction Grant and Pennsylvania Department of Environmental Resources (DER) State Revolving Loan sewage treatment works projects. Mr. Foster's projects involved the determination of need, planning, design, construction, initiation of operation and performance evaluation of primarily publicly owned sewage treatment facilities.

Determination of need included completion of the biannual national needs survey for the Northwest region of Pennsylvania. The needs survey is a priority ranking system used to determine funding priorities for sewerage and drinking water infrastructure across the United States. The survey ranks needs based on a number of factors including epidemiological data, population density, problem history, projected land use, and regulatory / compliance history. The survey is conducted by EPA using a centralized data-base, with state agencies assisting in data gathering, quality control, and review of the updated needs ranking.

The planning phase included review of facilities planning documents. Facilities planning documents established areas of sewerage service and facility design sizing and loading criteria, presented treatment technology evaluations and general system configuration, established grant/loan eligibility

apportioning, and determined environmental impacts associated with implementation of the plan.

Other functions performed during the planning phase of projects included:

- Review of NPDES discharge permit applications and assisting in permit preparation; and,
- Meeting with public officials and citizens to discuss the legal and environmental requirements for sewerage service in areas of need.

Mr. Foster's design phase responsibilities included review of the following:

- Detailed plans and specifications;
- Professional Engineers calculations and engineering reports; and,
- Part II Water Quality Management permit applications.

Mr. Foster's construction phase responsibilities included the following:

- Pre-Construction review of bids, bid selection process, bidders insurance and bonding documents, and construction contract documents for completeness and compliance with Federal procurement requirements;
- Assisting U.S. Army Corps of Engineers project managers in construction adequacy inspections and in completing periodic Construction Management Evaluations;
- Review and recommendation for approval of eligibility construction contract change orders and engineering oversight contract amendments;
- Assurance that facilities comply with approved plans and specification including change orders; and,
- Assisting in negotiations between contractors and municipalities.

Mr. Foster's initiation of operation and performance evaluation responsibilities included assisting in the facility start-up, tracking initial system performance, assuring the operator was qualified and competent to operate the facility, and reviewing post initiation of operation changes required to improve operation of correct defects.

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**KEITH W. HENN, P.G.**  
**REMEDIATION AND CARBON MANAGEMENT SERVICES MANAGER,**  
**VICE PRESIDENT**  
**PITTSBURGH, PENNSYLVANIA**

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**EDUCATION:** M.S., Hydrogeology, Wright State University, 1996  
B.S., Geology, University of Pittsburgh at Johnstown, 1993

**CERTIFICATIONS/  
REGISTRATIONS:**

Professional Geologist – Pennsylvania (#PG-003767-E, 2000);  
Professional Geologist – South Carolina (#2242, 2000)  
Professional Geologist – Florida (#PG-0002133, 2000)  
Professional Geologist – Illinois (#196-001091, 2003)  
Professional Geologist – Texas (#5451, 2003)  
Professional Geologist – Alabama (#1237, 2009)

**TRAINING:**

OSHA 1910.120 40-Hour HAZWOPER Training; June 1996  
OSHA 1910.120 8-Hour Annual Refresher Training; annual updates  
OSHA 1910.120 8-Hour Supervisory Training; June 1998;annual updates  
Ohio Voluntary Action Program Certified Professional Initial Training 2006

**AWARDS:**

FY2005 Technical Achievement Award, presented by Tetra Tech “In Recognition of Innovative Technical Excellence.” (Annually presented to individual or group from over 10,000 employees).

2006 Young Professional of the Year, presented in recognition of outstanding accomplishments for its members, Society of American Military Engineers (SAME), Pittsburgh Post, Pittsburgh, PA

**EXPERIENCE SUMMARY:**

Henn has more than 17 years of professional experience in technical and project management in hydrogeology, site investigation, remediation, groundwater flow/transport modeling and carbon and energy management.

Investigation and Remediation: Site assessment and remediation experience includes management and treatment of petroleum and chlorinated VOCs, SVOCs, metals, PCBs, explosives/energetics, perchlorate, fuel oxygenates, and emerging contaminants (e.g., 1,4-dioxane). Core competencies within these areas include natural attenuation and geochemistry evaluations, all types of in situ remediation, and state of the art remediation technology evaluation and implementation. Specifically, Mr. Henn has implemented or participated in over 100 *in situ* treatability studies and full scale design and implementations involving bioremediation, chemical reduction, chemical oxidation, and thermal treatment technologies for these contaminants and has achieved regulatory no further action on several of these sites. Specifically, Mr. Henn is recognized as a national expert in the use of nanoscale zero valent iron for *in situ* remediation. Mr. Henn has utilized these skills in supporting Tetra Tech Asset Solutions program including Brownfield redevelopment liability transfer utilizing Guaranteed Fixed Price Remediation (GFPR).

Mr. Henn is the Director of Tetra Tech's Remediation Leadership Group (Tt RLG), an appointed technical expert team that conducts strategic remediation planning, identifies innovative technologies of today and tomorrow, and conducts innovative remediation demonstration projects for Tetra Tech. Mr. Henn is also the Director of the Remediation Strategies Team (Tt RST), a nation-wide network of remediation experts that collaborate and foster tech transfer of remediation technologies across the network of more than 10,000 Tetra Tech employees.

Carbon/Energy Management and Bioenergy: Mr. Henn is the Carbon Management Services (CMS) manager for Tetra Tech and serves as Vice President for Tt Bioenergy LLC. In these roles, Mr. Henn has spearheaded and manages Bioenergy, Carbon Sequestration and Storage, Sustainable Remediation, Energy Management, Climate Change and Green House Gas (GHG) Management business lines. As Vice President for Tt Bioenergy LLC, Mr. Henn is responsible for strategic business development of the bioenergy and waste to energy (WTE) business line. He has worked on numerous WTE Feasibility Studies (FS) evaluations for food waste and agriculture anaerobic digestion (AD) systems across the United States include both "on site" and centralized AD systems ranging from \$1M to \$50M. With over 16 years of experience with anaerobic bioremediation systems, Mr. Henn is familiar with biogeochemistry necessary to generate biogas rich methane from the AD systems.

Overview: Mr. Henn is proficient in technical writing and verbal communication. He has used these skills on behalf of clients as a central participant in technical negotiations, public meetings, and litigation support. Mr. Henn has also given numerous seminar and technical training presentations both at industry conferences, technical meetings, and for Tetra Tech, Inc's nationwide "Brown Bag University" and "Initiatives Webcast Series" tech transfer training sessions.

Mr. Henn is also the Coordinator for the Tetra Tech Tech Transfer (T4) Internal Growth Webcast seminar series. Mr. Henn works under the direction of the Tt Chief Strategist to administer and transfer innovative concepts and/or information regarding Resource Management, Infrastructure, Communications, and Information Technology across Tetra Tech.

#### **PROJECT EXPERIENCE (Remediation):**

**Lead Program Hydrogeologist, Department of the Navy, NAVFAC SE, Naval Facilities Engineering Command, Comprehensive Long-Term Environmental Action Navy (CLEAN) Program; Multiple Facilities; Multiple EPA Regions; \$250 MM (CLEAN III), \$125 MM (CLEAN IV), and \$125 MM (NAVFAC Atlantic CLEAN) July 2000 to present.** Mr. Henn is responsible for maintaining technical standards for all aspects of geology/hydrogeology, site investigation planning and practices (e.g., monitoring well installation, data quality objectives, groundwater modeling, etc), and remediation design and implementation for the program. In this role, Mr. Henn participates in more than 500 contract task orders and ensures that all of the projects follow and comply with the defined intra-company, client, and regulatory technical standards and policies. Mr. Henn develops and coordinates the implementation of technical guidelines related to all geology/hydrogeology and natural attenuation related aspects of the contract. Mr. Henn is responsible for developing, implementing and distributing information on innovative and cost-saving methodologies and strategies. Some of the investigative technologies

implemented include the use of Membrane Interface Probe (MIP), passive diffusion bag (PDB) and HydraSleeve™ groundwater samplers, borehole flowmeters (heat-pulse and colloidal borescope), prepacked micro-wells, multi-channel wells, and development of a mobile laboratory system for explosive residues. Some of the remediation approaches include selection and implementation of conventional bioremediation [(Oxygen and Hydrogen Releasing Compound® (ORC/HRC)], alternative bioremediation approaches {e.g., alternative substrate [chit-in, direct oxygen, hydrogen and propane gas delivery using the in situ Submerged Oxygen Curtain (iSOC™)]}, cometabolism, biosparging, amendment delivery mechanisms (e.g., hydraulic/pneumatic fracturing), abiotic destruction/adsorption of contaminants (e.g., permeable reactive/adsorptive wall technologies and micro/nanoscale iron particle injection), and chemical and thermal destruction technologies (e.g., electrical resistive heating, ERH). Many of these have been demonstrated with significant time and cost savings. Mr. Henn is also leader of the Field Operation Leader (FOL) Discussion Group, a nation-wide network of professionals responsible for the expansion, growth, and coordination of FOLs and field work. Cliff Casey (Technical Support Branch, 2004) stated that a recent ESTCP proposal submittal spearheaded by Mr. Henn "was outstanding (and)...was TtNUS' best effort yet."

**Project Manager/Lead Remediation Specialist; Focused Feasibility Study, Vapor Intrusion Evaluation, and Expanded Site Investigation; Anniston Army Depot (ANAD); U.S. Army; Anniston, Alabama, September 2008 to present.** Spearheaded the proposal, orals presentation and project and technical leadership in performing a Focused Groundwater Feasibility Study (FGFS) at OU1 [Southeast Industrial Area (SIA)] and an Expanded Site Investigation (ESI) at OU-5 [Western Industrial Area (WIA)]. The FGFS includes completion of 8 technical memoranda addressing mass flux assessments and metrics, optimization of an existing pump and treat system, development of remedial treatment trains, and groundwater and natural attenuation modeling for 4 primary source areas where multiple releases have resulted in up to 27 million pounds of CVOCs in the subsurface. A large percentage of the DNAPL containing TCE is in the clay dominated residuum, weathered, and unweathered (karst and fractured carbonate) bedrock. Fate and transport of contaminants in the residuum, rubble/transition zones, karst (e.g., epikarst including pinnacles and depressions, caverns and sinkholes) and the underlying fractured (regional and local thrust faults) bedrock are being evaluated. Techniques used to assess the complex flow network included the use of multiple tracer tests and aquifer pump test results. The FGFS is currently evaluating numerous innovative remedial technologies (bioremediation, chemical oxidation and thermal treatment) where a Technical Impracticability (TI) proposal by a previous contractor was dismissed by ADEM and EPA. Cleanup scenarios include 100 years, 500 years, and 1,000 years cleanup times to achieve regulatory standards. Vapor Intrusion is being evaluated to determine if it is a concern for industrial site conditions. Five sites in OU-5 containing petroleum hydrocarbons (LNAPL), pesticides, and metals are being investigated as part of the ESI.

**Green and Sustainable Remediation (GSR) Specialist; Confidential Client; 2010 to present.** Prepared a Green and Sustainable Remediation assessment for sites in Georgia and Florida. This work included assessment of greenhouse gas emissions (e.g., CO<sub>2</sub>e (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>), energy use (e.g., electrical and fuel use), natural resources impacts, primary pollutants (e.g., NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>10</sub>), economics, water consumption, implementation requirements, energy



production, and material production, waste minimization, and, safety (risk of remedy). Remediation included active remedies (e.g., sodium permanganate (NaMnO<sub>4</sub>), zero-valent iron (ZVI), and pump and treat) and passive remedies (e.g., LTM and MNA).

**Remediation Specialist; Combined Technologies Groundwater Remediation Design, Industrial Client; Texas, 2008 to present.** Prepared remedial goals, investigation, remediation design and bench studies for In Situ Chemical Oxidation (ISCO) in the source area and anaerobic biostimulation/bioaugmentation via recirculation (extraction of impacted groundwater and injection of amendments) from a network of injection and extraction wells. 1,4-dioxane will be treated by an advanced oxidative processes (AOP) and polished by activated carbon.

**Project Manager/Co-Principle Investigator; Application of Nucleic Acid-Based Tools; DoD Environmental Security Technology Certification Program (ESTCP); Project # CU-0518; January 2005 to present.** Mr. Henn co-prepared the proposal, demo plan and implementation of a comprehensive nucleic acid-based (i.e., bio-marker) toolkit which evaluates and assesses dechlorinating bacteria [*Dehalococcoides (Dhc)* and specific target genes such as *tceA*, *bvcA*, and *vcrA*] testing in field applications. This unique demonstration and validation (Dem/Val) project applies the results to support sites where MNA is being evaluated; predict sites where biostimulation will be successful; and identify sites where bioaugmentation is required. This is the first Navy Environmental Broad Agency Announcement (BAA) proposal granted to Tetra Tech NUS, Inc.

**Project Manager; In Situ Remediation; NAS Jacksonville; U.S. Navy, NAVFAC SE CLEAN; Jacksonville, Florida, December 2001 to October 2006.** Prepared the proposal and work plan (including objectives, design, rationale, and approach) for injection of bimetallic nanoscale particles (BNP) to promote in situ abiotic degradation of chlorinated solvents. This field study was one of the first 10 implementations of its kind. BNPs are nanometer (10<sup>-9</sup> m) or bacteria-sized particles of zero valent iron (ZVI or Fe<sup>0</sup>) with a trace noble metal catalyst [palladium (Pd)] and other coatings used to destroy contaminants. This ongoing study includes the supplemental site characterization, bench scale testing (batch and column treatability studies), and field scale implementation. The study is evaluating BNP for remediation of an estimated source of up to 125 pounds of PCE, TCE, DCE, etc. present as DNAPL and dissolved phase. Rapid and complete dehalogenation results are between 65 and 99 percent in the field. The project was funded by the competitive NAVFAC YO817 program designed to demonstrate/validate innovative technologies. Dr. Dan Waddill (Navy RPM, 2003) noted that "Keith brings top notch technical expertise to this project. As always, Keith is great to work with and could not be more responsive to project needs." The client consistently rates this project within the top 4 award fee ratings out of 145+ total projects. This project was selected as a success story for submittal in the FY05 Five-year Restoration Report to Congress.

**Technical Expert - Remediation Specialist; In Situ Remediation; Vint Hill Farms Station; U.S. Army Corp of Engineers; Warrenton, Virginia, August 2006 to November 2006.** Spearheaded the winning proposal, technical approach, and work plan to implement a performance based contract (PBC) including building demolition, hotspot soil/groundwater remediation, removal/ replacement of monitoring wells, performance monitoring of groundwater,

and site restoration. In situ soil mixing with a combination of ZVI and clay was selected to treat chlorinated ethenes, ethanes, and methanes to treat the overburden soil and groundwater.

**Remediation Design & Implementation Specialist; In Situ Anerobic Remediation and Remediation Planning; Industrial Client, Maryland; 2004 to 2007.** Prepared remedial goals, remediation plan, and designed/implemented 3 pilot-scale studies for comparison and selection of remedial technologies for full scale implementation. The pilot scale technologies included (1) nanoscale zero valent iron (ZVI) injection; (2) sodium lactate injection coupled with bioaugmentation; and, (3) emulsified soy-based oil coupled with bioaugmentation. This study is one of the first where aquifer buffering was performed in combination with bioaugmentation. Results of the pilot studies demonstrated up to 92% reductions (from starting concentrations of up to 33 mg/L TCE and 120 mg/L DCE) coupled with an increase of up to 40 times innocuous byproducts (e.g., ethane and ethane). Modifications to the original remedial approach are being evaluated to address 1,4-dioxane (up to 1.2 mg/L) recently discovered in the subsurface. Remedial goals for full scale remediation (up to \$16.7 million) were prepared and presented to the Head of Remediation of this Fortune 100 client.

**Remediation Specialist; Remediation Planning; Industrial Client, California; 2006.** Mr. Henn was involved in the remedial alternatives analysis and bench scale test planning for perchlorate concentrations in groundwater exceeding 900 ug/L. In situ and ex situ remedial methodologies were evaluated with enhanced in situ bioremediation selected as the preferred remedial technology. Bench scale testing was evaluated as part of this evaluation. Remedial options included carbon injection via wells and mulch biowalls.

**Remediation Specialist; Remediation Planning; Industrial Client, Maryland; January 2005 to 2007.** Remedial goals for full scale remediation and associated implementation costs (up to \$14.9 million) were prepared and presented to the client for remediation requiring clean closure for Brownfield redevelopment. The technical approach and costs were verified by two third party reviewers. Results of the remedial investigation data suggesting CVOCs (up to 5 ppm), BTEX (up to 0.5 mg/L), and 1,4-dioxane (up to 0.12 mg/L) are present at the low permeability site. In situ bioremediation, ZVI, chemical oxidation, and ex situ treatment were evaluated and are currently being written in a site Remedial Action Plan.

**Remediation Specialist; In Situ Remediation Bench Study and Remediation Planning; NAS Jacksonville, Florida; May 2005 to 2007.** Led the technical team on development and analysis of a bench scale treatability study for treatment of chlorinated pesticides and volatile organic compounds. Technologies evaluated included (1) nanoscale zero valent iron (ZVI); (2) electron-donor enhanced micro scale zero valent iron (ZVI), (3) sodium lactate, (4) emulsified soy-based oil, and (4) numerous chemical oxidants.

**Technical Expert; EPA Hdq; OSRTI/TIFSD; 2005 to 2009.** Senior expertise provided to the EPA to assist in the development of programmatic DNAPL remediation strategy. Participated in planning discussions with EPA Office of Superfund Remediation and Technology Innovation (OSRTI) and Technology Innovation and Field Services (TIFSD) Division Directors and Branch

Chief and mining information from Cost & Performance Reports to capture an understanding of the work that has been done on DNAPL source cleanup.

**Project Manager, Remediation for Aircraft Components Manufacturer, Cleveland, Ohio 2007.** Mr. Henn was the project manager of a multi-area remediation project for a confidential defense client headquartered in California. Mr. Henn was responsible for developing and implementing project scope, budgets, and schedule and for communicating with the client's and current site owner's legal and project management teams. This project involved multiple soil source areas that have been remediated under Ohio VAP and Ohio BUSTR programs. Groundwater impacted by CVOCs, petroleum hydrocarbons (LNAPL), and metals are currently being contained by a pump and treatment system. This remedial approach is currently being optimized including refinement of the current system as well as evaluation of alternative approaches.

**Project Hydrogeologist; Optimization Study; OU-1 Landfill; NAS Pensacola; U.S. Navy, NAVFAC SE CLEAN; Pensacola, Florida, July 2003 to 2008.** Completed an optimization study shutting down a pump and treat system by re-evaluating the applicability of vague and in appropriate remedial action goals previously established. The study also optimized a MNA program to better quantify contaminant reduction via numerous chemical, physical and biological attenuation mechanisms. Mike Singletary (Navy Technical Support Branch, 2004) noted that "I am very pleased with (the report). You guys did a very thorough review of the existing site data and researched and presented common-sense regulatory and technical alternatives to improve remedy performance."

**Project Hydrogeologist; Optimization Report; MCLB Albany; U.S. Navy, NAFVAC SE CLEAN; Albany, GA, August 2007 to Present.** Spearheading the remedial process optimization (RPO) and long term monitoring (LTM) optimization to satisfy three primary goals: (1) optimize the ongoing groundwater monitoring program, (2) evaluate the ongoing remedial actions, and (3) fulfillment of the requirement of the 3-year ROD Goal review. Approximately 85 wells have been designated to monitor the effectiveness of the remedy and this study is to minimize the number and frequency of the wells to enhanced the likelihood of remediation risk management. Contaminants included CVOCs and BTEX.

**Remediation Specialist; MNA at Numerous DOD and Industrial Sites; July 2000 to Present.** Performed evaluations or peer-reviews of natural attenuation studies at over seventy-five different sites. Sites included contamination including petroleum hydrocarbons (e.g., BTEX, PAHs), fuel oxygenates (MTBE), chlorinated solvents (e.g., PCE, TCE, TCA, etc.), explosives (e.g. TNT, RDX, HMX, etc.), perchlorate, metals, and other contaminants. Many evaluations included analytical models such as Bioscreen and Natural Attenuation Software (NAS) have been utilized successfully. In addition to the collection of conventional MNA and geochemistry analysis, advanced geochemistry (e.g., bio-available iron), advanced microbial (e.g., *Dhc* and target gene detection using RTm qPCR, DGGE, and PLFA) and isotopic (e.g, compound specific isotopic) analyses has been selected and evaluated.

**Remediation Specialist; RAP and Bench Scale Testing, Long Beach Leads Extension (LBLX) area, Alameda Corridor Transportation Authority (ACTA), California; January 2005 to 2008.** Managed and spearheaded the completion of a RAP including the identification selection of remedial technologies for this site that has chlorinated solvents, petroleum hydrocarbons (GRO, DRO, MOR TPH) in aqueous and light and dense non-aqueous phase liquids (LNAPL/DNAPL) and metals (e.g., trivalent and hexavalent chromium). The remedy selected included in situ chemical oxidation and various oxidants (persulfate and percarbonate), the use of surfactants (Veru-Sol) to increase the chemical solubilization and increase oxidant performance and soil oxidant demand. The bench results will be used to conduct a Pilot Study and full-scale groundwater remediation design.

**Remediation Specialist; Optimization of Remedies for RDX and TCE, Ammunition Burning Grounds (ABG), NSWC Crane, IN; 2003 to 2007.** Mr. Henn co-developed a Site Conceptual Model and site-specific corrective measures proposal based on current onsite and offsite users in an fractured and carbonate karst bedrock aquifer containing chlorinated solvents (e.g., TCE) or explosives (e.g. RDX). The proposal established that no soil or groundwater remediation was required and that LUCs combined with long-term monitoring would be protective of current and future users. EPA has agreed in principle to the implementation of this water quality-based approach for the ABG which will result in cost savings of up to \$14M.

**Remediation Specialist; In Situ Anerobic Bioremediation Pilot Study using HRC<sup>®</sup>; Three Locations; Jan. 2002 to 2007.** Prepared the completion reports for 2 pilot-scale injections and provided oversight and direction on a third study using HRC<sup>®</sup>. At NSWC Indian Head, biostimulation successfully degraded TCE by as much as 98 percent, coupled with DCE decreases and ethene and ethane generation. At NAS Key West, FL biostimulation successfully reduced source concentrations by over 50%.

**Remediation Specialist, Air Sparge/Soil Vapor Extraction (AS/SVE) and MNA Remediation; NRL Orlando, U.S. Navy, NAVFAC SE CLEAN; Orlando, FL, May 2002 to 2006.** Co-designed and assisted in the implementation of an air sparging/vapor extraction (AS/VE) system for the removal of chlorinated organic contamination. The design included the placement of the AS/SVE wells as part of an optimization study to foster the complete removal of contaminants for project closeout. Data from the AS/SVE system and monitored natural attenuation (MNA) data were evaluated to determine the influence on downgradient contamination. Use of the AS/SVE in combination with in situ cometabolic biostimulation and bioaugmentation is being evaluated for future implementation.

**Remediation Specialist; Numerous In Situ Aerobic Bioremediation Studies using ORC<sup>®</sup>; and PermeOx<sup>®</sup>, Numerous DOD and industrial Sites; Jan. 2002 to 2006.** Prepared completion reports at 4 NAS Pensacola, FL (ORC<sup>®</sup>) sites, one site at NAS Pensacola (PermeOx<sup>®</sup>), and one site at NAS Key West, FL (ORC<sup>®</sup>) demonstrating that biostimulation using these compounds successfully degraded BTEX, naphthalene, 1- and -2 methylnaphthene.

**Remediation Specialist; In Situ Aerobic Bioremediation Pilot Studies using iSOC<sup>™</sup>; Numerous locations, NAVFAC SE CLEAN; May 2001 to 2007.** Prepared and assisted in the

work plan, design, and completion reports for pilot-scale studies at 3 sites (NAS Cecil Field, FL, NAS Pensacola, FL, and MCRD Parris Island, SC) using iSOC™. These studies demonstrated that biostimulation successfully degraded BTEX, naphthalene, 1- and -2 methylnaphthene. Implementation of iSOC™ at NAS Pensacola resulted in a no-further action.

**Remediation Specialist; In Situ Chemical Oxidation and Anerobic Bioremediation Pilot Study; NAS Dallas, TX; NAVFAC SE CLEAN; September Jan. 2001 to 2007.** Prepared the work plan, design, procurement, oversaw the implementation, and the reporting for a pilot-scale study at ASA-5 coupling hydraulic fracturing with chemical oxidation (Fenton's and Permanganate) followed by planned biostimulation using emulsified vegetable oil. This study demonstrated that delivery of remedial reagents is critical for in situ remediation of CVOCs.

**Remediation Specialist; In Situ Pilot Study Using Zero Valent Iron; NIROP NAS Dallas, TX; NAVFAC SE CLEAN; May 2005 to 2007.** Led a team of professionals on a technology screening and pilot study implementation to treat low level CVOCs (less than 300 ug/L) in a low permeability matrix at Site 21. Based upon a review of technologies, implementation of micro zero valent iron (ZVI) particle injection via fracturing techniques was selected to promote in situ abiotic degradation of the contaminants.

**Remediation Specialist; In Situ Bioremediation of a Former Terminal and Firefighting training area; NAS Pensacola, FL, NAVFAC SE CLEAN.** Provided project direction, data characterization, modeling, design, and data review of aerobic bioremediation project and subsequent optimization of the remedy for LNAPL and BTEX plume that covered over 20 acres.

**Remediation Specialist; In Situ Anerobic Bioremediation Pilot Study using Chit-in; NIROP NAS Dallas, TX; NAVFAC SE CLEAN; May 2003 to October 2005.** Prepared the work plan to stimulate biostimulation of CVOCs using hydraulic fracturing and chit-in in the subsurface. This work was not implemented by the client for reasons unrelated to this project.

**Remediation Specialist/Project Hydrogeologist; In Situ Anerobic Bioremediation Pilot Study using Emulsified Oil; NIROP Fridley, MN; NAVFAC SE CLEAN; Jan. 2002 to October 2006.** Assisted in the planning and data review of a pilot study using emulsified soy-based oil for remediation of CVOCs by another contractor. Data showed that delivery and distribution of the oil was critical in the outcome of the study.

**Remediation Specialist; In Situ Permable Adsorptive Wall using Activated Alumina; NTC Orlando, FL, NAVFAC SE CLEAN; June 2002 to December 2004.** Provided project direction, data characterization, modeling, design, and data review of a permeable reactive wall using activated alumina to prohibit the migration of arsenic into an adjacent lake. This passive remedy was selected in a parcel of property soon to be transferred and developed as a residential community. The wall was installed using a one-pass trencher.

**PROJECT EXPERIENCE (RI/FS):**

**Remediation Specialist; Groundwater Technologies Evaluation, Industrial Client; Texas, 2008 to present.** Conducted evaluation of technologies to treat 1,2-DCA at concentrations well above the solubility limit suggesting its presence as DNAPL at this chemical manufacturing facility along the Gulf of Mississippi. Evaluation along with supplemental data collection and LTM optimization was conducted.

**Remediation Specialist; FS for CVOCs; Pier A West, Port of Long Beach, Long Beach, CA; August 2005 to 2008.** Senior technical direction and support provided to select remediation technologies viable for in situ treatment of chlorinated solvents at three sites. Total chlorinated VOCs in groundwater (e.g., TCE, VC, 1,1,2-TCA, 1,2-DCA) at concentrations up to 618 mg/L suggest the presence of DNAPL at, at least one of these sites. A treatment train of technologies included a combination of in situ bioremediation/bioaugmentation, chemical oxidation, and multiphase extraction.

**Remediation Specialist; FS for Chromium Remediation; Former J&S Chrome Site, California EPA Department of Toxic Substances Control (DTSC); September-October 2005.** Managed and spearheaded the selection of remedial technologies. The maximum concentration of chromium VI in subsurface soil is 200 mg/kg (to 80 feet bgs) and in groundwater is 166,000 µg/L (shallow aquifer). Report was prepared under an accelerated schedule and was prepared on time and under budget. The remedy selected included a permeable reactive barrier (PRB) using zero valent iron (ZVI) to reduce chromium in the groundwater to chromium III, and subsequently precipitate the chromium III, as it passes through the barrier. The barrier would be installed via directional fracturing from a depth of 65 to 102 feet bgs.

**Senior Hydrogeologist; Forensic and Natural Attenuation Analyses; Industrial Client, Florida; January 2005 to October 2005.** Designed a plan to identify off-site contaminant source(s) that may be contributing to on site contamination. A step-wise approach including use of historical records, geochemistry/natural attenuation data, and evaluation of additional characterization data was used. Isotopic analysis to determine contaminant(s) "fingerprint" analysis was proposed.

**Remediation Specialist / Project Hydrogeologist; Corrective Action Plan (CAP); Former Fuel Farm; United States Coast Guard, Support Center Elizabeth City, North Carolina; December 2001 to Nov. 2004.** Spearheaded the proposal/ work plan and performed the field work and report preparation for supplemental field investigation and CAP. Field work included the use of ground penetrating radar (GPR) and resistivity, MIP, and soil and groundwater sampling to investigate a JP-4/JP-5 LNAPL and a dissolved plume greater than 200,000 gallons encompassing a 3 acre site. The CAP evaluated alternative remedial options including multiphase extraction (bioslurping), bioventing, exsitu soil treatment (biopiles, and low temperature thermal desorption), and continuation of a natural attenuation plan. Designed and prepared a work plan to evaluate a mobile bioslurping/bioventing unit for LNAPL extraction.

**Project Hydrogeologist; NIROP Fridley; NAVFAC SE CLEAN; Fridley, Minnesota; 1997 to 2006.** Performed a lead role in investigations, management, and optimization of a LTM and pump and treat operation (cumulative pumping rate of 675 gpm). Investigations determined the extent

of chlorinated solvents (dissolved and potential DNAPLs). Designed and implemented work plans including installing monitoring wells up to 170 feet deep and long term groundwater sampling strategies. Responsibilities also included hydrogeological interpretation of a complex glacial drift and bedrock aquifer system and its interaction with the adjacent Mississippi River, extent and migration of dissolved contaminants (e.g., long-term data evaluation, trend analysis, plume delineation, etc.), long term process optimization (LTO) of a pump and treat containment system (e.g., mass flux calculations, analytical/numerical capture zone analysis), and in-situ remedy selection and evaluation. Received a letter of accommodation from the EPA Region V Tier II Partnering Alliance “acknowledging your accomplishments which through much hard work, sacrifice, and long hours...have culminated in moving environmental restoration forward at NIROP Fridley”. Demonstrated cost avoidance of over \$300,000 with the implementation of the optimization recommendations while achieving better remedial results.

**Senior Technical Specialist/Project Hydrogeologist; RCRA Closure Soil and Groundwater Assessment Plan; Industrial Client, Ohio; 2002 to 2007.** Spearheaded and prepared a RCRA plan that was accepted by the state agency with few comments after they essentially rejected the previous plan from another consultant. The Ohio EPA regulator complemented Mr. Henn and the other TtNUS project team member’s effort by saying “...Quality work on the front end always makes our turn-around-time quicker and relations with the consultants better. Thanks!”

**Project Hydrogeologist/Field Operations Leader; NAWC Indianapolis; Navy, NAVFAC SE CLEAN; Indianapolis, Indiana; 1997 to 2001.** Performed the RI/FS for this base realignment and closure (BRAC) site. Conducted multi-media sampling, hydrogeological evaluation, plume delineation, remediation assessment, report generation, and formal project presentations to the Base Closure Team (BCT) and the Restoration Advisory Board (RAB). Evaluated remedial approaches including chemical oxidation (modified Fenton’s Reagent), and excavation for an Engineering Evaluation/Cost Analysis (EE/CA) and other remedies for a site wide FS.

#### **PROJECT EXPERIENCE (Site Assessment):**

**Project Manager; Basewide Background Soil Investigation, NSWC Crane; Navy, NAVFAC SE CLEAN; Indiana; 1998 to 2001.** Prepared the proposal, WP/QAPP using the U.S. EPA Data Quality Objective process, and final report. Data sets are being used to evaluate potential contamination at 33 SWMUs over the 100 sq. mile facility. Received written commendation from Bill Gates (2001) saying, “The TOM and the technical support staff did a great job...”, and from U.S. EPA (2000) saying that the “Work Plan and QAPP have been very well planned.” Later the EPA (2001) wrote that, “(they) would like to commend the Navy for it’s efforts,” and verbally stating that they would use the report as a “guide” or “model” for conducting background investigations at other sites. This project saved the Navy an estimated \$250,000 by combining repetitive background efforts from many sites into one project.

**Project Manager; Baseline Characterization Study, NOVA Chemicals, Inc.; Belpre Ohio, and Joliet, Illinois; 1999 to 2001.** Prepared the proposal, work plan, and final reports to evaluate the presence of contamination at chemical facilities. Managed schedule, scope, and budget, and formulation of project objectives, sampling design, rationale, and approach including multiple site

specific work plans, master work plan, and quality assurance project plan for six sites (these two sites, 2 other domestic sites, and 2 European sites). BJ Stephan (client) wrote that, "Belpre is very pleased with how the project has been run, excellent job... (it) was the most efficient and best run external job that they have ever had." Upon completion of the project, Brigitte Goudreau (on site client manager) wrote if "I ever need remediation work, you (Keith) will be the first person I call".

**Field Hydrogeologist; Baseline Characterization Study, NOVA Chemicals, Inc.; Ribecourt France; 1999.** Performed tasks including soil/groundwater sampling and installation of monitoring wells. Soil sampling was performed using 'window' and 'ackerman' samplers and cable tool drilling. Coordinated a multi-national subcontractor team.

**Task Hydrogeologist; International Staple Manufacturing Corporation, Butler, PA, PADEP: ACT II; Phase II Site Assessment, 1996 to 1997.** Installation of soil borings/monitoring wells and groundwater sampling at a manufacturing facility under PADEP ACT II regulations.

**Field Geologist; Cooper Power Industries, Inc., Canonsburg, PA; U.S.; PCB Evaluation and Inspection of Remediation System, 1993.** Delineated the extent of a LNAPL (mineral oils and transformer fluids containing PCBs) plume. LNAPL was measured up to six-feet thick. Inspected the installation of a groundwater interceptor trench and GAC adsorption treatment.

#### **PROJECT EXPERIENCE (Groundwater Modeling):**

**Task Hydrogeologist; Beazer East, Inc., Cabot Carbon/Koppers Superfund Site, Gainesville, FL; U.S.; Groundwater Flow Modeling, 1997.** Evaluated the performance of a pump-and-treat system (13 extraction wells) to ensure contaminant (BTEX, chromium, arsenic, and naphthalene) capture using FLOWPATH model simulations.

**Groundwater Modeling Specialist/ Hydrogeologist; Navy, NAVFAC SE CLEAN; NSWC Dahlgren, VA; 1997 to 1998.** Performed field activities at an ordnance burial area, rocket motor pit/ordnance burn structure, and OB/OD area. Field work included installation of borings/ wells in a UXO laden and tidally influenced coastal wetlands. Created a groundwater flow (MODFLOW), particle tracking (MODPATH), and solute fate and transport (MT3D) models to simulate a cap, slurry wall, interceptor trench, and downgradient leach control options for a remedial design.

**Groundwater Modeling Specialist; EWAN Property Site, OU 2; Shamong Township, NJ; Modeling Report for Remedial Design, 1997.** Created and utilized MODFLOW and MODPATH models to optimize the pumping rates of 7 extraction wells for hydraulic control and re-injection of the treated effluent water into surrounding wetlands. Contaminants: BTEX and CVOCs.

**Groundwater Modeling Specialist; Wright-Patterson Air Force Base; Dayton, OH; Groundwater Flow and Contaminant Fate/Transport Modeling, 1995 to 1996.** Conceptualized and designed a groundwater flow (MODFLOW) and solute fate and transport (MT3D) models simulating groundwater and PCE and TCE migration over 4.5 sq. mile area. Indicator geostatistics were used to establish 3D spatial distribution of aquitard and aquifer facies



and hydraulic conductivity in the buried glacial valley aquifer. The model was used to optimize pumping rates of seven wells that best contained and extracted the PCE and TCE.

**Modeling Specialist; Industrial Client; Long Branch, NJ; Modeling for Litigation Support, 1997.** Created and implemented a groundwater flow and contaminant transport model for litigation support. Favorable results supported the client's defense.

**Groundwater Modeling Specialist; Beazer East, Inc.; Beardstown, IL; Pump and Treat Evaluation, 1996 to 1997.** Implemented the use of WinFlow, an analytical flow/contaminant transport model for remedial design. The model was used to determine the optimal pumping strategy of four extraction wells to capture pentachlorophenol (PCP).

**Geographic Information System/Database Specialist: PPG Industries, Inc.; Moorestown, NJ; GIS Information Update.** Maintained GIS/database (GIS/Key software) including well information, analytical results and graphics.

#### **PROJECT EXPERIENCE (Bioenergy):**

**Co-Project Manager – Bioenergy Feasibility Study; Confidential Poultry Farm; Pennsylvania, 2008 to 2009.** Spearheaded the winning proposal, technical presentation/approach, and work plan to complete a Waste to Energy (WTE) feasibility study. This FS describes the conversion of poultry litter to a combined heat and power (CHP) via anaerobic digestion and gasification technologies. The poultry farm has over 1 million chickens on farm. The power generated from this facility is expected to yield 1.5 MW of power.

**Project Manager – Bioenergy Feasibility Studies; Confidential Clients, 2007 to present.** Managed and coordinated more than 10 waste to energy (WTE) feasibility studies which evaluated the conversion of pre-and post food residuals, vegetable waste, municipal solid waste, manure, and other agricultural waste to combined heat and power (CHP) and renewable natural gas to the grid. The technologies evaluated included anaerobic digestion (AD), incineration, pyrolysis, and gasification. The biogas utilization included the cleanup and the (1) direct combustion in a boiler; (2) fuel for a CHP; (3) biogas upgrade to commercial grade methane for "grid" injection into natural gas pipelines; and, (4) biogas upgrade to commercial grade methane and liquefaction into liquefied natural gas (LNG). Transformation of manure from more than 30,000 milking cows, more than 200,000 wean to finish sows, animal processing waste, and food wastes into biogas are currently being evaluated. The capture of biogas from these AD systems [which includes up to 70% methane, a green house gas (GHG), offsets 21 times that of CO<sub>2</sub> which is also a GHG] is being evaluated thereby generating carbon credits and renewable energy credits.

#### **PROJECT EXPERIENCE (Carbon Management):**

**Project Advisor; Assessment of Risk, Legal Issues, and Insurance for Geologic Carbon Sequestration in Pennsylvania, Pennsylvania Department of Natural Resources (PA DCNR),** Development of a detailed Carbon Capture and Storage (CCS) risk assessment for the

entire commonwealth of Pennsylvania. The report included the analyses of target horizons for potential geologic storage of carbon dioxide (CO<sub>2</sub>); the legal considerations associated with subsurface ownership, rights, and liabilities; the identification and evaluation of all known risks associated with a variety of geologic storage methods; and the development of financial and other instruments to mitigate such risks.

**Project Manager; Preliminary “Fatal-Flaw” Risk Assessment for Geologic Carbon Sequestration, Confidential Client, Confidential locations:** Conducted analyses of several proposed CCS projects on behalf of a national insurance agency to determine the risk of the project. The analysis included CO<sub>2</sub> Capture (equipment and process failure), CO<sub>2</sub> transport (pipeline failure), CO<sub>2</sub> injection/sequestration operation (injection well failure, existing deep well or surface leakage, drinking water supplies, cap rock or fault leakage, lateral leakage, seismicity).

**Project Manager; Lead Hydrogeologist – Geothermal Feasibility Study; Pennsylvania Department of Natural Resources (PA DCNR),** Conducted a feasibility for a closed loop geothermal system for a heating, ventilation, and air conditioning (HVAC) system at the Drake Well Museum, Oil Creek State Park, Titusville, PA. Work conducted involved a desktop technical approach in accordance with PA Department of Environmental Protection (PADEP) regulations and recommendations. Secondly, a 400 foot borehole was drilled and the the average thermal conductivity (k) was determined to support HVAC design.

#### **PROJECT EXPERIENCE (Geotechnical):**

**Engineering Geologist; USX, South Taylor Landfill; West Mifflin, PA; Closure of Hazardous and Residual Waste Landfills, 1993 to 1994.** Supervised placement of controlled fill and performed field tests (e.g., nuclear moisture/densimeter tests, vane shear slope stability tests, plasticity indexes, and proctor tests) for the construction and closure of one hazardous and two residual waste cells (containing BOP, fly ash, and other steel by-products).

**Engineering Geologist; Pennsylvania Department of Transportation; Numerous Highway and Bridge Design Projects, 1993 to 1994.** Supervised drilling 250+ geotechnical and environmental test borings and report preparation for numerous highway and bridge construction projects (e.g., Mon-Fayette Highway, Fayette Co., PA; Lackawanna Valley Industrial Highway, Lackawanna Co., PA; and Myersdale Highway Bypass, Somerset Co., PA).

**Engineering Geologist; Constitution Bridge; Clinton County, PA; Geological Engineering and Soils Reconnaissance Report, 1994.** Completed a Geological Engineering and Soils Reconnaissance Report for a 1,200-foot, eight-span, reinforced concrete arch bridge. Received written commendation from the PennDOT District Materials/Geotechnical Engineer for a “thorough and complete report”.

#### **CHRONOLOGICAL WORK HISTORY:**

**Manager, Remediation and Carbon Management Services Group; Tetra Tech NUS, Inc.; Pittsburgh, PA; 2007 to present.**

**Lead Program Hydrogeologist, Navy CLEAN III/IV; Tetra Tech NUS, Inc.; Pittsburgh, PA; July 2000 to 2006.**

**Senior Hydrogeologist; Tetra Tech NUS, Inc.; Pittsburgh, PA; April 1999 to July 2000.**

**Associate Hydrogeologist; Tetra Tech NUS, Inc.; Pittsburgh, PA; May 1997 to April 1999.**

**Assistant Geoscientist; McLaren/Hart Environmental Engineering Corporation; Pittsburgh, PA; July 1996 to April 1997.** Mr. Henn performed investigation and remediation design projects involving groundwater flow and contaminant modeling, soil and groundwater sampling and monitoring, and GIS/database development. Head of the McLaren/Hart Modeling Group, a nation-wide network of modelers, responsible for the growth of the firm's modeling capabilities.

**Head Tutor; Center for Ground Water Management, Wright State Univ., Dayton, Ohio; June 1994 to June 1996.** Instructed students in graduate-level Interactive Remote Instructional System<sup>®</sup> (IRIS<sup>®</sup>) courses titled *Ground Water Flow Modeling* and *Ground Water Hydrology*. Created the IRIS<sup>®</sup> course titled *Soil and Ground Water Contamination*.

**Engineering Geologist; GeoMechanics, Inc.; Elizabeth, Pennsylvania; May 1993 to June 1994.** Mr. Henn was the resident geotechnical advisor for the installation of engineered fill for residual/hazardous landfill construction/closure and subbase for roads, buildings, and other structures. He supervised and performed geotechnical borings and geotechnical tests for Pennsylvania Department of Transportation (DOT) roads, bridges, and private-sector structures including Geological Engineering and Soils Reconnaissance Reports and Geotechnical Foundation Structure Reports.

**Hydrogeology Intern; Pennsylvania Department of Environmental Protection; Elizabeth, Pittsburgh, Pennsylvania; May 1993 to August 1993.** Mr. Henn reviewed and oversaw site investigation and remediation projects.

**PROFESSIONAL AFFILIATIONS:**

National Groundwater Association (NGWA)  
Society of American Military Engineers (SAME)  
Interstate Technology Regulatory Council (ITRC) Bioremediation DNAPL Workgroup  
ITRC Diffusion Sampler Workgroup

**PRESENTATIONS (chronological order):**

Henn, K. W., 2000, "Multiple Techniques to Assess the Influences of a Heterogeneous Porous Medium on a Multiple Well Capture Zone," Proceedings for GSA Annual Meeting and Exposition, Abstracts with Programs, Vol. 32, No. 7.

Kendrick, A. and K. Henn, 2001, "Successes and Limitations of Accelerating In Situ Bioremediation Using ORC in a Fractured Bedrock Aquifer", Proceedings for the Seventh In Situ and On-Site Bioremediation Symposium, Battelle, San Diego California, June 4-7, 2001.

Henn, K. W., T. Johnston, B. Lewis, 2001, "Generation of Facility-Wide Soil Background Values – A Case Study," 17<sup>th</sup> Annual International Conference on Contaminated Soils, Sediments, and Water Abstract Book, University of Massachusetts at Amherst, October 22-25, 2001

Henn, K. W., and K. Kendrick, 2001, "Use of Passive Diffusion Bag (PDB) Samplers – Advantages, Limitations, and Important Considerations," 17<sup>th</sup> Annual Inter. Conference on Contaminated Soils, Sediments, and Water, Univ. of Mass. at Amherst, Oct. 22-25, 2001

Tillman, N., K. Henn, W. Lacourse, M. Maughon, and T. Johnston, 2002, "Development of a Field Analytical Platform for Energetic Residues in Soil and Water," 18<sup>th</sup> Annual Inter. Conf. on Contaminated Soils, Sediments, and Water, Univ. of Mass. at Amherst, Oct. 21-24, 2002.

Arnseth, R, K. Henn, D. Waddill, and W. Zhang, 2002, "Nanoparticle Iron for Source Area Treatment," 18<sup>th</sup> Annual International Conference on Contaminated Soils, Sediments, and Water Abstract Book, Univ. of Massachusetts at Amherst, October 21-24, 2002.

McRee, E., Bryan, K. Henn, and J. Sanders, 2003 "Bioremediation of Trans/Cis-1,2-Dichloroethene, and Benzene Plumes," Seventh In Situ and On-Site Bioremediation Symposium, Battelle, Orlando, FL; June 2-5, 2003.

Henn, K. 2003, Remediation of Chlorinated VOCs with Nanoscale Zero Valent Iron, Navy/Marine IRP Partnering Program, Tier I/Tier II Joint Meeting, December 3-4, 2003 (invited speaker).

Henn, K, G. Walker, M. Perry, and B. Glover, 2004, Direct Oxygen Injection for Aerobic Respiration of Petroleum Hydrocarbons, Fourth Inter. Conf. on Remediation of Chlorinated & Recalcitrant Compounds Sym., Battelle, Monterey, CA; May 24-27, 2004.

Waddill, D., K. Henn, M. Halil, 2004, In Situ Nano Iron Source Remediation: Site Investigation and Project Design, Fourth Inter. Conference on Remediation of Chlorinated & Recalcitrant Compounds Symposium, Battelle, Monterey, CA; May 24-27.

Henn, K. and D. Waddill. 2004, Implementation of a Pilot In Situ Nano Iron Source Remediation Fourth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Symposium, Battelle, Monterey, CA; May 24-27.

Henn, K., Y.Sun and W. Zhang, D.Waddill., 2004, Feasibility of In Situ Nano Scale Iron Remediation – From Lab to Field, Fourth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA; May 24-27.

Henn, K. and D. Waddill. 2005, Biological Degradation Stimulated by a Nanoscale Iron

Injection, Eighth In Situ and On-Site Bioremediation Symposium, Battelle, Baltimore, MD; June 6-9, 2005.

Jordan, T., G. S. Baker, K. Henn, and J. P. Messier, 2005, Using Normalized Residual Polarization (NRP) Analysis of Ground Penetrating Radar Data to Detect Jet Propellant in Soils, AAPG Eastern Section Meeting, Morgantown West Virginia, September 18-20, 2005.

Henn, K. 2005, Implementation of Nanoscale Zero Valent Iron for In Situ Source Remediation – From the Lab to the Field, US EPA Workshop on Nanotechnology for Site Remediation, Washington, DC. October 20 – 21 (invited speaker).

Lebrón, C., E. Petrovskis, F. Löffler, C. Casey, K. Henn, 2005, Application of Nucleic Acid-Based Tools for Monitoring MNA, Biostimulation, and Bioaugmentation at Chlorinated Solvent Sites, [2005 SERDP & ESTCP Partners in Environmental Technology Technical Symposium & Workshop](#), November 29-December 1, 2005.

Henn, K.W., 2006, Bioaugmentation v. Nanoscale Iron Source Treatment – The Tortoise and the Hare, U.S. Air Force 2006 Environmental Training Symposium, Pittsburgh, PA.

Henn, K.W., 2006, Optimization – It's needed throughout the entire project life cycle, U.S. Air Force 2006 Environmental Training Symposium, Pittsburgh, PA.

Henn, K.W., and M. T. Perry, 2006, How can we learn from BRAC '95: Case Studies Documenting Transfer from DoD Owned Properties to Private Sector Ownership and Use, Joint Services Environmental Management (JSEM) Conference and Expo., Denver, CO.

Henn, K.W. R. Adams. K. Grim, S. Reed, 2006, Treatment of Chlorinated Solvents in a Tight Matrix: A Treatment Train Full of Lessons Learned, Fifth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA.

Henn, K.W., J.S. Wright, C. Pike, and M. T. Perry, 2006, Optimization – It's not only needed after the remedy implementation, EPA 2006 Design and Construction Issues at Hazardous Waste Sites Conference, Philadelphia, PA, April 19-20, Presentation and Panel Discussion.

Lebrón, C., E. Petrovskis, F. Löffler, C. Casey, K. Henn, 2006, Interim Guidance Protocol, Application of Nucleic Acid-Based Tools for Monitoring MNA, Biostimulation, and Bioaugmentation at Chlorinated Solvent Sites, DoD Environmental Security Technology Certification Program (ESTCP); Project # CU-0518.

Rome, S., Waddill D., McGinnis P., Roof, G, Davis, H., and K. Henn, 2006, "Rethinking the Conceptual Model and Technical Approach of a Legacy DNAPL Source," 1st International Conference on DNAPL Characterization and Remediation, Pittsburgh, PA September 25-28, 2006.

Henn, K. and K. Ward, 2006, "Overview of Passive Sampler Technologies and their Application at DNAPL Sites," 1st International Conference on DNAPL Characterization and Remediation, Pittsburgh, PA September 25-28, 2006.

Lebrón, C., E. Petrovskis, F. Löffler, K. Henn, C. Casey, 2006, Application of Nucleic Acid-Based Tools for Monitoring MNA, Biostimulation and Bioaugmentation at Chlorinated Solvent Sites, [2006 SERDP & ESTCP Partners in Environmental Technology Technical Symposium & Workshop](#), November 28-30, 2006.

Henn, K.W., 2007, Using Experiences in BRAC '95 to Transfer BRAC '05 Property, U.S. Air Force 2007 Environment Safety and Occupational Health Training Symposium, Reno, NV.

Lebrón, K. Henn, C., E. Petrovskis, K. Ritalahti, 2007, Protocol for Use of Nucleic Acid-Based Tools for Monitoring, [2007 SERDP & ESTCP Partners in Environmental Technology Technical Symposium & Workshop](#), December 4-6, 2007.

Henn, K. G. Walker, W. Hill, 2007, "Injection of Gaseous Oxygen for Aerobic Respiration of Petroleum Hydrocarbons," Ninth In Situ and On-Site Bioremediation Symposium, Battelle, Baltimore, MD; May 7-10, 2007.

Rome S., Henn, K., C. Metz, and A. Robinson, 2007, "Lab Evaluation of Bioremediation and Chemical Treatment of Chlorinated Pesticides," Ninth In Situ and On-Site Bioremediation Symposium, Battelle, Baltimore, MD; May 7-10, 2007.

Petrovskis, E., C. Lebron, F. Loeffler, K. Henn, K. and C. Casey, 2007, "Application of Nucleic Acid-Based Tools, for Monitoring, Chlorinated Solvent Site Bioremediation," Ninth In Situ and On-Site Bioremediation Symposium, Battelle, Baltimore, MD; May 7-10, 2007.

Singleary, M. K. Henn and C. Pike, 2007, "Biosparging in Anaerobic Aquifers: Effects on Groundwater Geochemistry and Options for Optimization," Ninth In Situ and On-Site Bioremediation Symposium, Battelle, Baltimore, MD; May 7-10, 2007.

Henn K, S. Rome, and A. Janoca, 2007, "Optimization of Legacy DNAPL Source Conceptual Model," 2007 Joint Services Environmental Management & Geospatial Information & Services Conference and Exposition, Columbus, Ohio, May 21-24, 2007.

Henn, K.W., 2008, How to Utilize Innovative Planning Strategies to Optimize Site Remediation, U.S. Air Force 2008 Environment Safety and Occupational Health Training Symposium, Reno, NV.

Singleary, M., W. Gates, R. Basinski, K. Henn, H. Hickey, and T. Brent, 2008, Risk-Based Exit Strategy for an RDX/TCE Plume in a Complex Fractured Rock Aquifer, Sixth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA.

Singletary, M., M. Maughon, D. Waddill, K. Henn, C. Pike, 2008, Incorporating State Risk-Base Corrective Action (RBCA) Guidance into Optimization Strategies for Navy Cleanup Projects, Sixth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA.

Lebrón, C., E. Petrovskis, F. Löffler and K. Ritalahti, K. Henn, 2008, Application of Nucleic Acid-Based Tools for Monitoring, Sixth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA.

Waddill, D., M. Singletary, K. Henn, C. Pike, 2008, Optimization of Active Remediation vs. LTM at Navy DNAPL Sites, Sixth Inter. Conference on Remediation of Chlorinated and Recalcitrant Compounds Sym., Battelle, Monterey, CA.

Henn, K.W., Biomass: Passing Gas...Back to the Grid: Creating Energy and Reducing Greenhouse Gases. Carbon Management in Idaho - Awake - Educate and Motivate. Boise State University, Boise, ID August 6-7, 2008, Invited Speaker and Panelist. Sponsored by the Center for Advanced Energy Studies (CAES) <https://secure.inl.gov/carbonmgmt08/default.aspx>

Lebrón, C., E. Petrovskis, F.E. Löffler, K. Ritalahti, and K. Henn. 2008. Application of Nucleic Acid-Based Tools for Monitoring MNA, Biostimulation, and Bioaugmentation at Chlorinated Solvent Sites. SERDP & ESTCP Partners in Environmental Technology Technical Symposium & Workshop, December 2-4, 2008.

Ritalahti, K.M, J. Hatt, K.W. Henn, E. Petrovskis, C.Lebrón, and F.E.Löffler, 2009. Standardization and comparison of sampling and DNA extraction procedures for analysis of biomarkers in groundwater, Remediation Technologies Symposium 2009

E. Petrovskis, R. Daprato, C. Lebrón, F. Löffler, K. Ritalahti, and K. Henn. 2009. Nucleic Acid-Based Tools for Monitoring Bioremediation at Chlorinated Solvent Sites, Environment, Energy, and Sustainability Symposium & Exhibition, May 4-7, 2008, Denver, Colorado.

E. Petrovskis, C, Lebrón, F. Löffler, K. Ritalahti, and K. Henn. 2009. Protocol for Use of Nucleic Acid-Based Tools for Monitoring Bioremediation at Chlorinated Solvent Sites, In Situ and On-Site Bioremediation The Tenth International Symposium Baltimore, May 2009

Maughon, M., C. Hook, and K. Henn, 2010, Green and Sustainable Remediation (GSR) in the Navy's Environmental Restoration Program, South Carolina Tier I/Tier II Joint Meeting, Texas.

Maughon, M., C. Hook, and K. Henn, 2010, Green and Sustainable Remediation (GSR) in the Navy's Environmental Restoration Program, Georgia Tier I/Tier II Joint Conference, Savannah, Georgia (04-28-10).

Maughon, M., C. Hook, and K. Henn, 2010, Sustainable Remediation, Part I – Overview; part II – Back Diffusion Considerations, Mississippi Tier I/Tier II Partnering Meeting, St. Petersburg, Florida (05-28-10).

2000-present, More than 20 Tetra Tech, Inc. Internal brownbags (educational seminars and presentations).

**PUBLICATIONS (chronological order):**

Henn, K. W., 1996, “Evaluation of pumping strategies for capturing aqueous tetrachloroethylene and trichloroethylene at Wright-Patterson Air Force Base, Dayton, Ohio,” master’s thesis, Wright State University, Department of Geological Sciences, Dayton, Ohio.

Jordan, T., G. S. Baker, K. Henn, and J. P. Messier, 2004, Case Study: Using Amplitude Variation with Offset (AVO) and Normalized Residual Polarization (NRP) Analysis of Ground Penetrating Radar Data to Differentiate a NAPL Release from Stratigraphic Changes, Journal of Applied Geophysics, Elsevier, Amsterdam, Vol 56, pp 41-58.

Henn, K. W. and D. W. Waddill, 2006, Utilization of Nanoscale Zero Valent Iron for Source Remediation - A Case Study, Remediation Journal, Volume 16, Issue 2, pages 57-77.

Henn, K., C. Pike, W. Wright, and B. Li, 2008, State of the Art Remediation for Brownfield Sites, Brownfield Briefs, Brownsfield News (Brownfield News), Summer 2008.

Ritalahti, K.M, J. K. Hatt, V. Lugmayr, K. Henn, E A. Petrovskis, D. M. Ogles, G.A. Davis, C. M. Yeager, C. A. Lebrón, and F E. Löffler, Comparing On-Site to Off-Site Biomass Collection for Dehalococoides Biomarker Gene Quantification to Predict In Situ Chlorinated Ethene Detoxification, Engineering Science & Technology, in press.

E. Petrovskis, C, Lebrón, F. Löffler, K. Ritalahti, and K. Henn. 2010. Protocol for Use of Nucleic Acid-Based Tools for Monitoring Bioremediation at Chlorinated Solvent Sites, ESTCP. In progress.

Henn, K., 2000 – More than 10 nationwide U.S. Navy publications [e.g., Remedial Project Manager News, Navy Currents, Encompass, BRAC Talk, and others].

**WORKSHOPS (chronological order):**

US EPA Workshop on Nanotechnology for Site Remediation, Washington, DC. October 20 – 21  
Invited speaker: Henn, K. 2005, Implementation of Nanoscale Zero Valent Iron for In Situ Source Remediation – From the Lab to the Field,

In situ Chemical Oxidation (ISCO) Technology Practices Workshop, Colorado School of Mines, Golden Colorado March 7-8, 2007, Invited Participant and Panelist. Panel II: ISCO feasibility study; oxidant selection and delivery approaches; lab and field tests.



Carbon Management in Idaho - Awake - Educate and Motivate. Boise State University, Boise, ID August 6-7, 2008, Invited Speaker and Panelist. Sponsored by the Center for Advanced Energy Studies (CAES) <https://secure.inl.gov/carbonmgmt08/default.aspx>



## ***IAN P.G. HUTCHISON, Ph.D., P.E.***

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### **EDUCATION**

B.S., Civil Engineering, University of Capetown, South Africa, 1967.

M.S., Hydraulic and Soils Engineering, University of the Witwatersrand, South Africa, 1974.

Ph.D., Hydrology, University of the Witwatersrand, South Africa, 1976.

### **EXPERIENCE**

**2005 – Present: President, Strategic Engineering and Science, Inc.**

#### **Management Consulting and Strategic Planning**

- Development of strategic plans for water supply management and groundwater remediation for TCE and perchlorate in the Bunker Hill Basin.
- Remedial planning and life cycle cost estimating for groundwater in the Rialto-Colton Basin.
- Planning and layout of a new high altitude underground mine in Chile.
- Acquisition due diligence, environmental liability assessment and closure planning for two open pit mines in the Sierra Madres of Mexico.
- Risk-based remediation pricing for large environmental remediation projects throughout the United States.
- Senior Peer Reviewer for major harbor sediment remediation project in the Boston Harbor area.
- Peer review and risk based cost estimating for sediment, soil and groundwater remediation adjacent to an industrial facility in Chesapeake Bay, Maryland.
- Groundwater supply development in Southern California.
- Remediation of a gas processing plant in Wyoming.
- Remediation of a wood treatment site in Delaware.

#### **Project Director for the following projects**

- Permitting and infrastructure and waste management engineering for an international precious metal mine.
- Closure of mines in California and Idaho.
- Development of tailings management plans to meet heightened containment standards in Chile.
- Development of cost-effective multi-component solutions to management of sulfate issues at a mine site in Chile.
- Remediation of upland conditions in the Honolulu Harbor, Hawaii.

#### **Expert witness for the following**

- City of Pomona vs. Industrial Development Agency on the remediation and closure requirements for a landfill. Expert Report and Deposition.



## **1989-2004: Senior Vice President, TRC**

### **Management Consulting and Strategic Planning**

- Development of risk-based life-cycle cost estimating procedures used for lump-sum-insured pricing of site remedies.
- Application of decision tree and risk-based decision methodologies to strategic decision making and in support of liability transfer negotiations at a Superfund sediment site.
- Strategic planning for obtaining remedy approvals and for cost allocation negotiations at impacted sites.
- Business and financial modeling of performance-based contracts in power generation improvement, infrastructure development, and environmental remediation.
- Application and evaluation of a range of cost allocation methodologies for complex VOC-impacted ground water at a large industrial complex.

### **Project Director or Principal-in-Charge for the following mining projects**

- Closure of acid generating waste rock dumps, Beartrack Mine, Idaho.
- Project development plans and financial analyses, and establishment of water control, waste management and closure plans for a new gold mine in Argentina.
- Development of closure plans for the Cactus Gold Heap Leach Mine in Lancaster, California. Closure elements included regrading and backfilling of pond areas.
- Development of closure plans for wastewater ponds and tailing impoundments, tailings impoundment corrective actions, and ground water impact characterization for the Molycorp Mountain Pass rare earth mine, California. Characterization involved demonstration of limited seepage migration from tailings impoundment, and remedial/ closure technologies included a seepage interception well system, innovative cost-effective silty material caps for landfills and tailings ponds, and improvements to the wastewater treatment system (neutralization and settling).
- Development of closure plans for an acidic waste rock disposal pile at the Homestake Mine, California. Closure technologies included short-term leachate collection and return systems and long-term control by encapsulation of the waste rock in clay cells.
- Assessment of closure liability and costs including conceptual designs and cost estimates for acid mine drainage control and treatment systems at mines in Colorado, Idaho and Nevada as part of a corporate acquisition. Closure technologies included physical, chemical and wetlands (biological) treatment, regrading and capping.
- Development of closure plans and designs, and permitting of wastewater transfers at the Royal Mountain King Gold Mine, California. Operation of mine site during closure period. Technologies employed included RO treatment and solar evaporation of wastewater, regrading, soil and composite covers for tailings ponds and earthfill dam construction to contain pit lake levels.
- Planning and conceptual design of wastewater disposal systems for the Sonora Gold Mine, California. Systems permitted included land application on waste rock piles and blending and discharge under the NPDES program.
- Seepage evaluations, design of seepage control systems and a spill control dam at the Cerro Verde Mine in Peru.
- Assessment of closure liability and costs including conceptual designs and cost estimates for acid mine drainage control and treatment systems at mines in Colorado, Idaho and Nevada as part of a



corporate acquisition. Closure technologies included physical, chemical and wetlands (biological) treatment, regrading and capping.

- Briggs Gold Mine heap leach environmental impact report (EIR), California.
- Soledad Canyon gravel mine and site infrastructure design for TMC.
- Permitting of three copper mines and associated processing plants (heap leaching, SX/copper sulfate and EW facilities) in COREMA Region II (Atacama Desert) in Chile.
- Remediation designs and closure plan development for four lead/zinc/copper mines in the Peruvian Andes. Technologies included regrading, capping, underground mine sealing and wetlands treatment systems.
- Characterization and remedial planning for the control of acid drainage from historic mines in the Moche, Llaucano, and Parcoy River Basins in northern Peru.

### **Project Director or Principal-in-Charge for the following remediation projects**

- Site characterization, design, and construction for a 100,000 cy sediment remediation project in the Seattle Harbor under the EPA's Superfund Program. The project, referred to as the Lockheed Martin Shipyard I, was completed on-time and within budget.
- Site characterization and remedial design for the historic Pacific Coast Pipeline Refinery/Superfund site in Fillmore, California involving heavy and light hydrocarbon fuels. Remediation included soil vapor extraction and ground water pump and treat.
- Site characterization and remedial design for the Purity Oil Recycling Facility Superfund site which is impacted by hydrocarbons and volatile organics (VOCs). Remedial technologies included soil vapor extraction; capping and ground water pump and treat.
- Site characterization, risk assessments and remedial planning for the large operating Unocal refinery at Wilmington. Constituents of concern included benzene, hydrocarbons and lead. Remedial technologies included capping, soil excavation and treatment, and in-situ ground water treatment.
- Management and remediation of perchlorate and TCE ground water plumes in Redlands, California for Lockheed Martin Corporation. Program included aquifer modeling, design and implementation of new ground water supply systems, modifications to water supply delivery systems, water treatment for VOCs and development of technologies for perchlorate treatment.
- Site characterization and remedial design, and record of decision (ROD) changes, for the J.H. Baxter Superfund site (Wood Treatment Plant) in northern California. Constituents of concern include dense nonaqueous phase liquids (DNAPLs); i.e., creosote, polychlorinated phenols (PCP), and metals including arsenic, chromium and zinc. Remedial elements included soil excavation, ex-situ biotreatment, onsite disposal in an RCRA-equivalent cell, in-situ biotreatment, slurry wall and limited ground water extraction and treatment.
- Site characterization, remedial design, and ROD changes for the Cabot Carbon/Koppers Superfund site (Wood Treatment Plant) in Gainesville, Florida involving creosote, PCP and metals. Remedial technologies included capping and "passive" slurry wall systems.
- Site characterization and remedial design, and construction oversight for the Feather River Wood Treatment site in Oroville, California which involves creosote, PCP and metals. Remediation included soil excavation and disposal in onsite RCRA-equivalent cells.



**Site characterization and remediation planning at the Vega Alta industrial site in Puerto Rico (VOCs). Remediation included selective ground water pump and treat.**

- Site characterization and remediation planning at the Boricua Wood Treatment site in Puerto Rico (arsenic). Remedial technologies included soil excavation, offsite disposal and capping.
- Site characterization, remedial planning and design, and remediation construction at a mercury mine and processing facility in California.
- Technologies employed included building decontamination and demolition, soil excavation stabilization and offsite disposal, and buried drum location and removal.
- Remedial design for closure of tailings piles at the Shafter Silver Mine in Texas. Closure included regrading and capping.
- Corrective action planning and design for a RCRA wood treatment facility in Montgomery, Alabama (constituents of concern include PAHs, PCP, metals and dioxins). Corrective action technologies include a "passive" slurry wall.
- Site characterization and interim measures implementation and evaluation at the Charleston Superfund site (wood treatment plan) in South Carolina. The technology tested involved NAPL removal well systems.

**Expert witness for the following**

- Mission Valley Terminal Site Cleanup (Cost of cleanup for MTBE, Benzene, TPH, ground water and soil). Expert Report, Deposition, and Arbitration Hearing Testimony, 2003.
- Buena Vista Mine Site (Mercury, sediment erosion, surface and ground water impact). Expert Report, Deposition, 2002.
- Questa Mine Site, New Mexico (metals, TDS, and sulfate, closure cost estimate clean water act issues, closure plan and costs). Expert Report and Deposition, 1997. Testimony at administrative permit hearing May and July 2000.
- Cal Sierra, California (Placer mining - mercury fate and transport). Testimony at permit hearing June 2000.
- Gainesville Superfund Site, Florida (creosote migration and ground water extraction issues). Expert Report and Deposition, 1997.
- Confidential gold mine site in the southwestern United States (mine waste management, surface and ground water). Expert Review, 1996.
- Hattiesburg Wood Treatment Site, Mississippi (soil and ground water - wood treatment chemicals). Expert Review, 1995 to 1996.
- Meyer's Drum Reprocessing Facilities (soil and ground water PCBs, Bunker C, metals and COCs). Expert Report and Deposition, 1996.
- Testimony to the County Supervisors on the Briggs Mine EIR, Inyo County, California (mine waste management). Hearing Testimony, 1995.
- Hope Brook Gold Mine in Newfoundland, Canada (mine waste management, surface water). Expert Report, 1995.
- Iron Mountain Mine site, California (acid drainage, metals). Expert Review, 1994.
- Stringfellow Superfund site, California (surface water - VOCs and metals). Deposition and Trial Testimony, 1987 through 1993.
- Stanford Research Park Industrial Complex in Palo Alto, California (ground and surface VOCs, DNAPLs). Expert Report, 1993.
- John Wayne Airport site, California (ground water - VOCs, DNAPLs). Expert Report, 1990.
- Rancho California Airport site, California (ground water - hydrocarbons). Deposition.



### **Regulatory development activities, including**

- Senior editor and author of a 650-page textbook on mine waste management.
- Preparation of industry "strawman" mine waste regulations for California.
- Senior editor and reviewer of the Arizona BADCT mine waste regulations.
- Presentation of testimony on mine waste management to State Hearing Boards in California.

### **Senior Review Consultant on the following projects**

- Rancho California MTBE ground water characterization and cost allocation support.
- OII municipal/industrial landfill Superfund site in California (cover design, leachate collection and treatment and ground water characterization and remediation).
- Site characterization and remedial planning at the closed Casmalia RCRA hazardous waste landfill site, California. Remediation includes ground water trench collection systems and capping.
- Design of the B-18 hazardous waste disposal cell at Kettleman Hills, California.
- Expansion plans for the McFarland-Delano Municipal Landfill, California.
- Lead-zinc mining district Superfund site RI/FS in Kansas and Missouri (Jasper County and the Baxter Springs-Treece Superfund sites).
- Development of a strategic RCRA compliance plan and designs for FMC's lithium production facility in Bessemer, North Carolina.
- Site characterization and remedial planning including technology impracticability evaluations for Bristol Meyers' Weck Industrial site in North Carolina.
- Site characterization and remedial design for two drum recycling facilities in Oakland and Emeryville, California (VOCs, PCB, heavy hydrocarbons and metals).
- San Fernando Valley Superfund Site (Glendale Operable Unit) 5,000 gpm ground water remediation project.
- Reassessment of proposed remedial ground water pumping at an industrial site in Ontario, California. Alternative proposed utilized natural attenuation to limit ground water extraction and treatment.
- Characterization of waste rock for the Mule Canyon Mine in Nevada.

### **1981-1989: Managing Principal and Division Head, Water Engineering, Steffen Robertson and Kirsten, Denver, Colorado**

- Responsible for the U.S. operations of the company, including several hundred projects involving waste management, water pollution control, land use and air quality permitting, and open pit mining.
- Direct technical management of solid waste disposal, hazardous waste and hydrologic work carried out by the company.
- Project principal in charge of the design and construction of mine tailings and waste rock disposal facilities in Alaska, Washington, California, Colorado, Utah, and Nevada.
- Expert witness on the Stringfellow Superfund Site.
- Technical oversight on investigations carried out on the Boulder Marshall Municipal Waste Landfill Superfund site in Colorado.



- Technical expert review work on ground and surface water and soil pollution problems on mining Superfund sites including California Gulch, Colorado, and Galena, Kansas. Development of a comprehensive approach for the development of ARARs.
- Presentation of specialist technical evidence for ground and surface water contamination problems at mine sites in California and New Mexico.
- Supervision of regional hydrologic and water balance studies for the Rio Grande River basin.
- Embankment dam design and construction in California and Washington (fill dam heights of up to 400 feet).
- Project management of the design of 100-acre waste water disposal ponds in California.
- Testimony on water quality and waste management issues at the State and Regional Water Quality Control Boards in California.

**1976-1981: Hydraulics Department Head/Project Engineer, Acres International, Buffalo, New York**

- Hydrologic and hydraulic engineering aspects of all projects conducted in the United States, and maintaining a staff team to undertake the work.
- Hydroelectric projects in New York, Maine, Vermont, and Alaska, including the Susitna River project in Alaska.
- Industrial process plants and tailings disposal systems in Ohio and Colorado.
- Streamwater quality studies in New York.
- FEMA flood plain mapping studies.
- The hydrologic and hydraulic engineering associated with a wide range of irrigation, navigation, hydroelectric, and industrial projects throughout Canada, the United States, and South America.
- Irrigation schemes in the Dominican Republic and Bolivia.
- Design and construction of three ports on the Amazon River in Peru.
- Design and construction of hydroelectric generating stations in Newfoundland, Ontario, and Alberta, Canada.
- Large-scale river basin water balance studies in Alberta, Canada.
- Regional flood studies for the province of New Brunswick, Canada.

**1970-1976: Research Officer, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, South Africa**

- The development and application of river basin catchments, ground water, lake and estuary computer models for the evaluation of salinity control measures of the St. Lucia Lake system.
- Provided input to the update of national design flood manuals.
- Numerous consulting assignments involving the development of surface water supplies and implementation of flood control measures for projects in South Africa, Botswana, and Lesotho.
- Conducted graduate courses in computer modeling of surface water systems and water resources project economics.
- Conducted a study tour of the United States and Canada to review available technology for the modeling of flow and water quality of surface systems.

**1968-1970: Engineer, Technical Computing Company, Johannesburg, South Africa**

- Development and application of structural analysis computer software for the design of bridge decks and pile groups, and one-dimensional tidal propagation modeling in estuaries.





## REGISTRATIONS

Professional Engineer in California and seven other states.

## PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers  
American Water Resources Association  
International Mine Water Association

## TECHNICAL PUBLICATIONS

Author and presenter of more than 25 publications and seminar presentations on the subjects of waste management, hydrology, and regulatory development.

*A Mathematical Model to Aid Management of Outflow from the Okavango Swamp, Botswana.* Journal of Hydrology, Vol. 19, No. 2, June 1973.

*The Okavango Delta - Ways of Evaluating the Economic and Environmental Impact of Mass Transport of Water.* Presented at the 5th Quinquennial Convention of the South African Institution of Civil Engineering, South Africa, August 1973.

*A Mathematical Sediment Model for a Sea Water Intake Basin.* Presented at the Conference on Marine and Fresh Water Research in Southern Africa, Port Elizabeth, South Africa, July 1976.

*Lake St. Lucia - Mathematical Modeling and Evaluation of Ameliorative Measures.* The Civil Engineer in South Africa, Transactions of the South African Institution of Civil Engineering, South Africa, Vol. 19, No. 4, April 1977.

*Lake St. Lucia - The Computer Points the Way.* African Wildlife, Vol. 31, No. 2, April/May 1977.

*Leach Pad Cover Design Analyses Salmon, Idaho.* Hutchison I., Whitman A., Juliani J., and Hadj-Hamou, T. Accepted for presentation and publication at Tailings and Mine Waste '10, Boulder, Colorado, October 17-20, 2010.

*Mathematical Modeling of Water Level and Salinity Regions in Some Southern African Lake and Estuary Systems.* Presented at the Seventeenth Congress of the International Association for Hydraulic Research (IAHR), Baden-Baden, Federal Republic of Germany, August 1977.

*Regional Flood Frequency Analysis for New Brunswick.* Presented at the Canadian Hydrology Symposium: 77-Floods, in Edmonton, Alberta, Canada, August 1977.

*A Systematic Approach to Flood Risk Mapping.* Presented at the International Symposium on Risk and Reliability in Water Resources, in Waterloo, Ontario, Canada, June 1978.

*Modeling the Water and Salt Balance in a Shallow Lake.* Ecological Modeling, Vol. 4, 1978, pp. 21-235.





*Aspects of Phosphogypsum Waste Disposal.* Presented at the Seventh Annual Madison Waste Conference, Dept. of Engineering and Applied Science, University of Wisconsin-Extension, Madison, Sept. 11-12, 1984.

*Cyanide Control Options - Lessons From Case Histories.* Presented at the Tucson Cyanide Conference, December 1985.

*Legal Allocation of Augmented Water Supply Due to Silvicultural Activity in the Upper Rio Grande River Basin.* Fourth International Hydrology Symposium on "Multivariate Analysis of Hydrologic Process: Stochastic-Deterministic," Colorado State University, Fort Collins, Colorado, July 15-17, 1985.

*Introduction to Evaluation, Design and Operation of Precious Metal Heap Leaching Projects,* Editor and Author of Chapter on "Surface Water Balance," 1988.

*Management for Hazardous Waste Liability at Mining Sites.* Colorado State University Symposium, January 1991.

*Mine Waste Management.* Editors: I.P. Hutchison and R.D. Ellison. Lewis Publishers, Inc. 1992. pp. 652.

*Summitville Mine - Remedial Alternatives Identification and Evaluation.* I.P. Hutchison, Michael L. Leonard, Sr. and David P. Cameron. Summitville Forum 95: A Forum held in Conjunction with Tailings and Mine 1995, Colorado State University, Fort Collins, Colorado, January 1995.

*Water Balance Management Approach to Mine Closure at The Royal Mountain King Mine, Copperopolis, CA.* Adam Whitman, Ian Hutchison, Jim Juliani and Sarah Bortz, Tailings and Mine Waste '09, Banff, Canada, November 11-14

**Education:**

Ph.D., Geology, University of Illinois, 1973  
M.S., Geology, University of Illinois, 1971  
B.S., Geology, Florida State University, 1969  
A.S., Gulf Coast Jr. College, Panama City, Florida, 1967

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**Professional Experience:**

GeoTrans, Inc., Sterling, Virginia, (1997-Present), *Executive Vice President, Principal Hydrogeologist*  
GeoTrans, Inc., Sterling, Virginia, (1979-1996), *President and Principal Hydrogeologist*  
U.S. Geological Survey, Water Resources Division, Reston, Virginia, (1971-1979), *Hydrologist*

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More than 35 years of experience specializing in all phases of geohydrologic transport analysis including groundwater flow, heat and solute transport in porous media for a wide range of applications such as aquifer resource analysis, aquifer thermal storage, geothermal energy development, radioactive waste storage, seawater intrusion, and hazardous waste characterization and remediation, especially dealing with issues associated with dense non-aqueous phase liquids (DNAPLs).

Authority on geohydrologic transport analysis, including groundwater flow, heat and solute transport in porous media for a wide range of applications. Authored over 90 publications on general groundwater subjects, vadose zone evaluation, wetland hydrology, computer modeling, geochemistry, and groundwater contamination and hazardous waste disposal. Frequently provides expert technical review, expert witness testimony, litigation support and regulatory compliance services for clients throughout the United States, and internationally.

Experience in the following U.S. EPA programs: RCRA, CERCLA/SARA, UST, and UIC. Involved in the conduct of both RI/FS and RI/CMS. Management responsibilities include supervision of over 50 professionals and serving as principal investigator on several contracts. Daily project work involves overseeing data collection, data management, and analysis. Projects involve a variety of chemicals including organics, metals, and radionuclides. Processes considered include advection, hydrodynamic dispersion, diffusion, sorption, biodegradation, multiphase flow, dissolution, and volatilization in fractured and porous media. Various tasks include modeling, training, and expert witness testimony.

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**Relevant Project Experience:**

Various projects – Reviewed subsurface data, surface activities and historical chemical usage and regulations to help estimate timing of releases of contaminants to the subsurface. Some of these timing issues were associated with insurance litigation, triggering policies; other timing issues dealt with private-party cost recovery under CERCLA between owner-operators of the same impaired property.

Coastal Refining and Marketing Inc., Corpus Christi, TX - Provided expert witness support concerning potential off-site petroleum migration at the Coastal Refinery in Corpus Christi. Effort involved transport issues and hydrocarbon fingerprinting analyses.

Chevron (predecessor to Gulf Oil), McAllen, TX - Provided expert witness support concerning potential petroleum releases from a former bulk fuel facility. Data analysis included stratigraphic information, petroleum migration and distribution, and fate and transport.

DuPont, Beaumont, TX – Provided expert witness support in a toxic tort case involving deep-well injection. Fate and transport modeling was used to determine the extent of injectate in the subsurface.

Charnock Well Field, Santa Monica, CA – Technical advisor for fate and transport modeling of MTBE and TBA. Work was performed for the settling parties to predict impacts as a result of well field start up. This modeling study utilized both innovative and practical methodologies, including (1) combined three-dimensional plume kriging and particle

backtracking to define initial MTBE and TBA concentrations for reactive transport modeling and (2) developed reasonable assumptions for (a) expected-case, (b) worst-case, and (c) best-case predictive simulations.

Arcadia Well Field, Santa Monica, CA – Litigation expert in case involving MTBE impacts to well field. Data were evaluated from multiple potential sources to determine the impact pathway. Issues involving characterization, remediation and data interpretation were addressed.

USEPA, Ada, Oklahoma - Project Manager for information transfer programs (workshops, demonstrations, seminars); author of guidance documents (*The USEPA Handbook for the Site Characterization of Dense Non-Aqueous Phase Liquids*, and *The Basics of Pump-and-Treat Groundwater Remediation Technology*); functioned as the off-site support team for groundwater issues; contributed to the Remedial Operations and Performance Evaluation Methodology; and provided technical training on groundwater model applications. As part of this effort, a modeling study was performed to evaluate alternative fuel releases (including constituents MTBE, methanol and ethanol) to the subsurface.

U.S. Nuclear Regulatory Commission - Project Manager for benchmarking of computer codes used for the evaluation of high-level radioactive waste disposal repositories for the U.S. Nuclear Regulatory Commission. Directed the review of literature, selection of codes, code benchmarking, and technology transfer on the use and limitations of the computer models. Also assisted in the development of an earth sciences database for storage and retrieval of data reported for the high-level radioactive waste repositories. To create the database, more than 29,000 measurements of 240 parameters were extracted from a broad base of source references. The data are comprised of hydrogeologic, geomechanical, geochemical, and stratigraphic parameters and their accompanying descriptive information.

Department of Defense - Member of an expert panel advising the Air Force on Non-Aqueous Phase Liquid issues, and a co-author of a document entitled *A Review of Groundwater Modeling Needs for the U.S. Army*. This work has involved briefings with the Corps of Engineers in Vicksburg, Albuquerque, and Tulsa. Member of the Technology Selection Board of DOD's Advanced Applied Demonstration Facility (AADF) at Rice University.

Principal Author - *Subsurface Remediation Modeling--A State-of-the-Art Review*, which analyzes the effectiveness of models to assess such remedial actions as: bioremediation, chemical oxidation/reaction, chemical fixation, *in situ* vitrification, pump-and-treat, free phase NAPL recovery, soil vapor extraction, air sparging, soil flushing, thermal desorption, electro-osmosis, and low permeability barriers.

Yucca Mountain, Nevada - Served as part of the U.S. DOE Peer Review Team for Unsaturated Zone Hydrology. Also served as consultant to U.S. DOE on the conduct of RI/FS projects at nuclear test facilities including the Nevada Test Site. Provided formal review of the Engineered Barrier System (EBS) implementation in the Total System Performance Assessment (TSPA).

Columbus Air Force Base, Mississippi - Principal Investigator for TVA MADE and MADE-2 saturated zone groundwater transport studies. Performed site visits to review field activities and make independent observations on technical activities related to the field tracer experiment. Provided independent analysis on field activities and data acquired during the course of the studies.

Dry Cleaner, Pensacola, Florida - On behalf of a client named as a PRP, served as expert witness in hydrogeology, dense non-aqueous phase liquids (DNAPLs), and fate and transport of chemicals in a subsurface environment. Reviewed and discussed site hydrogeology, contaminant transport, and capture zone analysis of municipal supply wells, and discussed other PCE sources in downtown Pensacola. Analyses performed included graphic analysis of three-dimensional aspects of the plume and flow system relative to water supply wells; estimate of impacts on flow system due to pumping of water supply wells; and estimates of plume development with time from a historical perspective.

Dry Cleaner Study, Modesto, California – Worked with others in GeoTrans, Inc. to investigate approximately 110 dry cleaners to evaluate impacts, especially related to the presence of DNAPL tetrachloroethene (PCE). Testified in trial on DNAPL-related issues.

McDermott, Will & Emery on behalf of Mobil Oil Corp. - Served as an expert in hydrogeology and contaminant hydrology to help interpret data associated with MTBE contamination detected in the City of Santa Monica Arcadia Well Field. As part of this effort, water-level data and water quality data were incorporated into a GIS. Aquifer test data were interpreted, and graphical analysis was performed. In addition, as part of team discussions, additional data requirements were determined. The case settled prior to litigation explicitly involving experts.

Hazardous Waste Site, Pittsburgh, Pennsylvania - Principal Investigator for data review and groundwater modeling to evaluate whether a dissolved benzene plume emanating from an abandoned hazardous waste site was undergoing intrinsic remediation. Performed an initial evaluation, recommended collection of additional geochemical data, and implemented three-dimensional groundwater flow modeling to evaluate the effectiveness of a capture scenario. Data collected during this investigation provided additional evidence that intrinsic remediation of benzene was occurring.

Hazardous Waste Site, Jacksonville, Florida - Principal Investigator for site characterization and pilot testing, design, and construction of air sparging/SVE remedial system at a site contaminated with chlorinated solvents. Assisted in construction management and startup of the system, incorporating groundwater pumping and soil vapor extraction of three dual extraction wells and 12 air sparging points within the pumping well cone of depression.

Former Dry Cleaners, Westminster, California - Principal Investigator for evaluation of PCE contamination related to a former dry cleaning operation. Evaluated site hydrogeology, PCE distribution, and transport modes, including dense non-aqueous phase liquid migration, vapor phase migration, and aqueous phase migration. Served as expert consultant to assist with evaluating the timing and nature of releases in an effort to avoid litigation.

Former Dry Cleaner, Warrington, Florida - Principal Investigator for evaluation of PCE impacts that was found in a water supply well and traced to a former dry cleaner. Represented a shopping center owner against the former dry cleaner. Reviewed site hydrogeology and contaminant distribution, along with site history, which included a solvent spill. Data analysis indicated the presence of dense non-aqueous phase liquid PCE. Analyzed contaminant transport, including sewer lines providing a preferred flow path, and vertical migration due to pumping in the area.

Martin Marietta, Paducah Gaseous Diffusion Plant, Kentucky - Assisted in the development of three-dimensional groundwater flow and transport models for the regional hydrologic system underlying the plant to evaluate the nature and extent of contamination, flow and transport of contamination, and analyze the feasibility of remedial alternatives. MODMAN, an GeoTrans-developed optimization module for MODFLOW, was used to evaluate the efficiency of the five plume containment alternatives.

E.I. DuPont de Nemours & Company, Savannah River Site, Aiken, South Carolina - Assisted in technical support and development of a three-dimensional finite-difference flow model for Savannah River Plant. The model was used as a tool to assist the facility in groundwater resources management and to predict the response of the flow system to various plant activities. The numerical code FTWORK was applied over a 500-square mile area with emphasis on the Tuscaloosa (Middendorf) Aquifer. Evaluation was made for a proposed corrective action.

Feed Materials Production Center, Fernald, Ohio - Provided consultation to the State of Ohio in the oversight, evaluation, and review of the RI/FS performed for the FMPC site by DOE and its contractors. Six operable units were identified at the site including waste storage areas, solid waste areas, facilities/suspect areas, K-65 silos, environmental media, and south groundwater plume.

Plessey, through Latham & Watkins, Park Ridge, New Jersey - Provided litigation support. Produced an expert report and was deposed regarding client's contribution to groundwater contamination of drinking water wells in the borough. Evaluated the reasonableness of Park Ridge's past and future remediation costs.

Expert Testimony and Technical Support, Fresno, California - Project Manager for evaluation of pesticide impacts to groundwater supply wells. Managed the development of a geographic information system (GIS) database containing over 10,000 well records and covering approximately 250 square miles. Data included: base map information, historical water-level maps, historical DBCP and EDB (pesticides) concentrations measured in groundwater, aquifer parameter values, geologic data, crop patterns, and documented applications of DBCP and EDB. Also provided

deposition testimony as an expert witness. Case involved graphical analysis and calculations to determine sources of pesticides in dozens of municipal wells.

Union Bleachery RI/FS - Served as principal investigator of RI/FS conducted in South Carolina as part of a private party cost recovery under CERCLA. The site had nine operable units where chromium was the primary contaminant.

Monsanto, Pensacola, Florida - Project Manager for successful support of deep-well injection permit at Florida Plant.

PSL RI/FS, South Carolina - Principal Investigator of RI/FS as part of a private party cost recovery at a Superfund site. The site had 15 operable units where the constituents of concern were metals and VOCs.

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### **Professional Certification:**

Certified Professional Geologist, #273, VA  
Certified Professional Geologist, #275, FL  
Certified Professional Geologist, #309, DL  
American Institute of Professional Geologists (AIPG), #6020  
American Institute of Hydrology-Professional Hydrogeologist, #886

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### **Awards:**

Phi Beta Kappa  
Pi Mu Epsilon  
Sigma Xi  
Summa Cum Laude  
Chevron Senior Scholarship  
NDEA Title IV Fellowship  
Who's Who in Frontier Science and Technology  
ASCE 1985 Wesley W. Horner Award  
NWWA 1987 Distinguished Seminar Series  
26th Henry W. Shaw Lecture in Civil Engineering (North Carolina State University)  
1994 AIH C.V. Theis Award

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### **Teaching/Lecture Experience:**

Lectured to Virginia Department of Environmental Quality on June 22-23, 2010; Short Course on OVERVIEW OF ENVIRONMENTAL REMEDIAL TECHNOLOGIES (with Dr. Mark A. Widdowson).

Guest lecturer at graduate course on hazardous waste remediation through the Virginia Tech University Commonwealth Graduate Engineering Program (Dr. Mark A. Widdowson, professor), October 7, 2008.

Lectured to six divisions within the U.S. Navy on DNAPL Management Challenges as part of the Navy's RITS Spring 2006 program.

Taught workshop on deep-well injection modeling (on behalf of DuPont) in Beijing, China, November 13-14, 2005.

Participated (on behalf of DuPont) in the People's Republic of China UIC Workshop, Beijing, China, August 20-21, 2003.

Lectured to seven divisions within the U.S. Navy on DNAPL Detection and Characterization Techniques as part of the Navy's RITS Spring 2003 program.

Participated in National Research Council Workshop on Conceptual Models of Flow and Transport in Fractured Vadose Zone, March 18-19, 1999.

Participated in Chemical Risk Management Course on A Practical Approach for Implementing Risk-Based Decision for Corrective Action, Santa Fe, New Mexico, April 27-May 1, 1998.

Presentation to The Potomac Geophysical Society on Intrinsic Remediation, May 16, 1996.

Presentation to Environmental Hydrology Colloquium at The University of Cincinnati on Intrinsic Bioremediation, February 23, 1996.

Participated in American Petroleum Institute's Workshop on Comparative Evaluation of Groundwater Biodegradation Models, Fort Worth, Texas, May 8-9, 1995.

Participated in Electric Power Research Institute's (Manufactured Gas Plant) Advisory Committee Meeting on DNAPL Characterization, Removal and Recycling, New Orleans, Louisiana, March 29-30, 1995.

Participated in Chemical Risk Management Course for Environmental Compliance and Reconstruction, Kiawah Island, South Carolina, February 27-March 3, 1995.

Participated in Stevens Institute of Technology's Seminar on Remediation of NAPL Contaminated Sites, Hoboken, New Jersey (March 14-15, 1994) and Boston, Massachusetts (April 5-6, 1994).

Participated in Hanford Groundwater Remediation Seminar giving lecture on "Subsurface Remediation" in Richland, Washington, November 18, 1993 (Sponsor: Mat Johansen, Corps of Engineers, Walla Walla District).

Participated in U.S. Environmental Protection Agency Seminar on Characterizing and Remediating Dense Nonaqueous Phase Liquids at Hazardous Sites, taught at all 10 Environmental Protection Agency regional offices, Spring - Summer, 1993.

Taught short course on "Practical Contaminant Modeling" as part of the 1993 Spring meeting of the American Institute of Hydrology on May 16, 1993 in Washington, D.C.

Participated in workshop to "Identify Barriers to *In Situ* Ground-Water Remediation" sponsored by the U.S. Environmental Protection Agency; served as group spokesperson (June 24-25, 1992).

Participated in Subsurface Restoration Conference sponsored by the U.S. EPA, presenting a talk entitled "Site Characterization: Use of Site Characterization Data to Select Applicable Remediation Technologies" (June 21-24, 1992).

Participated in workshop entitled "Introduction to Ground Water Modeling" at the National Water Well Association meeting in Washington, D.C. (October 21-23, 1991).

Participated in workshop entitled "Dense Nonaqueous Phase Liquids," sponsored by the U.S. EPA, presented a talk on "Monitoring and Modeling DNAPLs (April 16-18, 1991).

Participated in symposium on Radioactive Waste Repository Licensing, sponsored by the Board on Radioactive Waste Management of the National Research Council, September 1990.

Taught "Modeling of Ground Water Flow" as part of the 1990 Spring meeting of the American Institute of Hydrology on March 14, 1990 in Las Vegas, Nevada.

Participated in U.S. EPA Seminar on Site Characterization for Subsurface Remediation, taught at all 10 EPA regional offices, Fall 1989 - Spring 1990.

Participated in RSKERL Ada Technical Assistance Program: Oily Waste Fate, Transport, Site Characterization, Remediation, Denver, Colorado, May 17-18, 1989.



- Taught short course (3-1/2 days) on "Hydrogeology and Groundwater Pollution" at the U.S. Department of Energy, Grand Junction, Colorado Compound, November 28 - December 2, 1988.
- Participated in short course on "Risk Assessment and Management for Hazardous Materials: From Cradle to Grave" at The Center for Risk Management of Engineering Systems of the University of Virginia, October 25-26, 1988.
- Taught seminar in advanced hydrology (including well testing and modeling) at the George Washington University, Spring Semester 1979; Spring Semester 1983; Spring Semester 1985; Spring Semester 1987; as an Associate Professorial Lecturer in Geology.
- Participated in the U.S. Geological Survey training courses in groundwater modeling, advanced groundwater hydrology, and salt water/fresh water relationships.
- Participated in a short course held at the University of Southern California on recent advances in reservoir simulation, July 5-9, 1977.
- Taught groundwater modeling short courses at the Holcomb Research Institute, Butler University, Indianapolis, Indiana, April and June 1980; May and June 1981; August 1982 (with Dr. Jacob Bear); March 1983; March 1984; March 1985; March 1986; March 1987; March 1988; March 1989, April 1989.
- Included in the U.S. Geological Survey Centennial (1979) lecture series made available to Sigma Xi chapters.
- Taught introduction to groundwater modeling short course at EPA Headquarters, Washington, D.C., March 1980, and EPA Region IV, Atlanta, Georgia, November 1981; taught groundwater modeling short course using personal computers at EPA Region IV, Atlanta, Georgia, February 1985. Taught a groundwater modeling short course at Georgia Southwestern College, Americus, Georgia, July 1982.
- Taught groundwater modeling short courses to St. Johns River Water Management District, Palatka, Florida, October 1982 and October 1983; and to South Florida Water Management District, October 1983 and February 1986; and to Southwest Florida Water Management District, October 1984 and July 1986.
- Included in the University of South Florida's seminar on pesticides in groundwater, May 1984.

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**Committees:**

- Senior Technical Advisor, AFCEE, ST012 Phase 1, Thermal Enhanced Extraction (TEE) Pilot Test, Former Williams Air Force Base, Arizona (2006- 2010).
- Member, SERDP Scientific Advisory Board (2006-2012).
- Chair, technical session 'Recent Advances in Characterization and Remediation of DNAPL Source Zones, SERDP/ESTCP Partners in Environmental Technology Technical Symposium & Workshop, Washington, D.C., December 2008.
- Member, SERDP/ESTCP Expert Panel Workshop on Reducing the Uncertainty of DNAPL Source Zone Remediation, Baltimore, MD, March 7-9, 2006 .
- Member, DOW Technical Assistance Team for Volatile Organic Compound Source Area Contaminant Mass Reduction, East Tennessee Technology Park (ETTP), Oak Ridge Reservation, Summer 2004.
- Member, U.S. EPA Expert Panel on DNAPL Remediation (2001-2003) that produced report: The DNAPL Remediation Challenge: Is There a Case for Source Depletion? EPA/600/R-03-143, December 2003.
- Member, SERDP/ESTCP DNAPL Source Zone Technical Review Panel (2002-2006).

- Member, SERDP/ESTCP Expert Panel Workshop on Research and Development Needs for Cleanup of Chlorinated Solvent Sites, Fairfax County, VA, August 6-7, 2001.
- Member, AFCEE Technical Peer Review Team (TPRT) to review groundwater remediation at the Massachusetts Military Reservation (MMR), 1999.
- Co-Chair, AGU COPA Session on Contaminated Groundwater and Litigation: Lessons from the Woburn Case, Boston, Massachusetts, June 2, 1999.
- Member, AGU Committee on Public Affairs (COPA), 1998-2000.
- Member, Hanford Peer Review Panel for Site-Wide Groundwater Model, 1998-1999.
- Member, Board on Army Science and Technology's Committee on Review and Evaluation of the Army Non-Stockpile Chemical Material Disposal Program, 1998-2000.
- Member, Peer Review of SERDP Project on Cleanup Modeling and Simulation, Vicksburg, MS, June 7-9, 1998.
- Consultant, U.S. Environmental Protection Agency's SES Recruitment Committee, 1998.
- Member, Technical Advisory Group (TAG) to support the Interagency DNAPL Consortium, 1998.
- Session Co-Chair, International Containment Technology Conference, St. Petersburg, Florida, February 9-12, 1997.
- Member, U.S. Department of Energy Yucca Mountain Unsaturated Zone Flow Model Expert Elicitation Project Team, 1996-1997.
- Member, U.S. Air Force DNAPL Expert Panel (Air Education & Training Command) for Altus Air Force Base, Altus, Oklahoma, 1996-1997.
- Member, U.S. Department of Energy Rocky Flats Groundwater Panel, 1996.
- Member, U.S. Air Force DNAPL Expert Panel (Air Education & Training Command) for Vance Air Force Base, Enid, Oklahoma and Reese Air Force Base, Lubbock, Texas, 1994.
- Member, Water Science and Technology Board Committee on Non-invasive Characterization of the Shallow Subsurface for Environmental and Engineering Applications, 1995 - 1997.
- Chair, Peer Review Panel, RCRA Corrective Measures, CWM Chemical Services, Inc., Model City, New York Facility, 1996.
- Member, U.S. Air Force DNAPL Expert Panel, Wakulla Springs, FL, Aug 2-3, 1995.
- Session Leader, International Containment Technology Workshop, Baltimore, MD, August 29-31, 1995.
- Member, National Sciences Foundation's Advisory Committee for Earth Sciences, 1992 - 1993.
- Member, National Science Advisory Committee, Desert Research Institute, University and Community College System of Nevada, 1992.
- Member, Water Science and Technology Board Study Group providing *A Review of Ground Water Modeling Needs for the U.S. Army*, 1992.
- Core Consultant, U.S. Environmental Protection Agency Science Advisory Board (SAB) Environmental Engineering Committee (EEC), 1992-1993; Member, 1993 - 1997.



- Co-chairman, Water Science and Technology Board Committee on Ground Water Cleanup Alternatives, 1991-1993.
- Member, Desert Research Institute - University of Nevada Science Advisory Working Group (SAWG), 1991.
- Member of the U.S. Environmental Protection Agency Workshop on Dense Non-aqueous Phase Liquids, April-Sept., 1991.
- International Association of Hydrogeologists, Vice President for Institute Development, 1990-1993.
- Member of the U.S. Environmental Protection Agency Solid Waste Management Units (SWMUs) Stabilization Workgroup, September, 1990.
- Member of the U.S. Department of Energy Peer Review Team for Unsaturated Zone Hydrology (at Yucca Mountain, Nevada), April - September, 1990.
- Member of a mission to the Donana National Park, Spain, Sponsored by the International Union for Conservation of Nature and Natural Resources (IUCN) and ADENA, the Spanish affiliate of the Worldwide Fund for Nature (WWF), November, 1988.
- Member of the site visit committee of the Natural Sciences and Engineering Council of Canada. Site visit was to the University of Waterloo to review proposal on "Field Behavior of Dense Solvents in Groundwater," July 27, 1988. Continued on committee until 1991.
- Member of Water Science and Technology Board Committee on Ground Water Modeling Assessment, 1987-1989.
- Member of the Water Pollution Control Federation's Groundwater Committee, 1987-1989.
- Member of the Laboratory Director's Annual Review Committee, Earth Sciences Division, Lawrence Berkeley Laboratory, University of California, 1987.
- National Research Council's Water Science and Technology Board, 1986 - 1989.
- Secretary of the Hydrology Section of the American Geophysical Union, 1986 - 1988.
- Member of U.S. Environmental Protection Agency Panel on Leak Detection for Underground Storage Tanks, 1987.
- Co-convenor of the American Geophysical Union Chapman Conference on Microbial Process in the Transport, Fate and In-situ Treatment of Subsurface Contaminants, Snowbird, Utah, October 1986.
- Member of the U.S. Department of Energy Radionuclide Migration (RNM) Project Peer Review Committee, 1986.
- Member of the U.S. Environmental Protection Agency Ground-Water Modeling Study Group, February 1986 - May 1986.
- Co-convenor of the American Geophysical Union Symposium on Saturated/Unsaturated Ground-Water Flow Systems: Measurement and Estimation of Parameters. Baltimore, Maryland, May 1985.
- Member of the Ground-Water Research Subcommittee of the Science Advisory Board of the U.S. Environmental Protection Agency, December 1984 - June 1985.
- Co-convenor of the American Geophysical Union Symposium on Miscible and Immiscible Transport in Ground Water, Cincinnati, Ohio, May 1984.
- National Research Council Panel on Groundwater Contamination (1983).

Advisory panel for the Office of Technology Assessment (Congress of the United States) on national groundwater contamination (1983).

International technical advisory committee of the International Ground Water Modeling Center (1983 - 1985).

Co-convenor of the American Geophysical Union Symposium on the Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, Philadelphia, Pennsylvania, May 1982.

Co-convenor of the Gordon Conference on Fluids in Permeable Media: Mathematics of Modeling and Simulating, Andover, New Hampshire, July 1980.

Co-convenor of the American Geophysical Union Symposium on the Unsaturated Zone as a Barrier in Waste Disposal, Washington, D.C., May 1979.

Co-convenor of the Geological Society of America Penrose Conference on Heat Transport Processes in the Earth, Vail, Colorado, November 1978.

Member of the Editorial Board for Journal of Contaminant Hydrology (1985 - 1992).

Member of the Editorial Board for Ground Water (1980 - 1984; 1992 - 1995).

Member of the Editorial Board for Geology (1979 - 1982).

Member of the 1982 - 1985 American Geophysical Union Ground Water Committee.

Member of the 1978 - 1983 American Geophysical Union Committee on Water in the Unsaturated Zone.

Member of the 1977 - 1978 ERDA Geothermal Exploration, Modeling and Reservoir Assessment Committee.

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**Professional Affiliations:**

Society of Petroleum Engineers, Member  
American Geophysical Union, Member  
Geological Society of America, Fellow  
National Ground Water Association, Member  
International Association of Hydrogeologists, Member  
American Institute of Hydrology  
American Chemical Society, Member

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**Publications:***Publications in Water Supply.*

1. Andersen, P.F., R.M. Cohen, and J.W. Mercer, 1984. Numerical modeling as a conceptual tool to assess drawdown in a multiaquifer system, symposium on Practical Applications of Ground Water Models, sponsored by National Water Well Association, Columbus, Ohio.

*Publications in Vadose Zone Evaluation.*

1. Huyakorn, P.S., J.W. Mercer, and D.S. Ward, 1985. Finite-element matrix and mass balance computational schemes for transport in variably-saturated porous media, *Water Resources Research*, 21(3):346-358.
2. Mercer, J.W., P.S.C. Rao, and I.W. Marine, (Eds.), 1983. *Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal*: Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 339 pp.

3. Mercer, J.W., and C.R. Faust, 1976. The application of finite-element techniques to immiscible flow in porous media, presented at the International Conference on Finite Elements in Water Resources, Princeton University.

*Publications in Wetland Hydrology:*

1. Hollis, T., P. Heurteaux, and J.W. Mercer, 1989. The implication of groundwater extractions for the long-term future of the Donana National Park, report of the WWF/IUCN/ADENA Mission to the Donana National Park, May, 60 pp.

*Publications in General Groundwater:*

1. Moore, J.E., A. Zaporozec, and J.W. Mercer, 1995. *Groundwater, A Primer*, American Geological Institute, Alexandria, VA, 53pp.
2. Mercer, J.W., R.R. Rabold, and W.R. Waldrop, 1991. Practical technology resulting from MADE research, *Proceedings of the International Symposium on Ground Water*, American Society of Civil Engineering (July 29-August 2), Nashville, TN, pp. 113-119.
3. Faust, C.R., and J.W. Mercer, 1984. Evaluation of the skin effect in slug tests, *Water Resources Research*, 20(2):504-506.

*Publications in General Modeling:*

1. Mercer, J.W., 1991. Common mistakes in model applications, *Proceedings of the International Symposium on Ground Water*, American Society of Civil Engineering (July 29 - August 2), Nashville, TN, pp. 1-6.
2. Mercer, J.W., 1988. Standards of performance for investigative methods used in assessing groundwater pollution problems with emphases on the use and abuse on numerical models, *Proceedings of the Workshop on Groundwater Quality Protection*, Water Pollution Control Federation Annual Conference Workshop, Dallas, Texas.
3. Konikow, L.F., and J.W. Mercer, 1988. Groundwater flow and transport modeling, *Journal of Hydrology*, 100:379-409.
4. van der Heijde, P.K.M., P.S. Huyakorn, and J.W. Mercer, 1985. Testing and validation of groundwater models, Symposium on Practical Applications of Ground Water Models, pp. 14-31.
5. Mercer, J.W., and C.R. Faust, 1981. *Ground Water Modeling*, National Water Well Association, Columbus, Ohio, 60 pp.
6. Faust, C.R., and J.W. Mercer, 1980. Groundwater modeling: Recent developments: *Ground Water*, 18(6).
7. Mercer, J.W., and C.R. Faust, 1980. Groundwater modeling: Applications: *Ground Water*, 18(5).
8. Faust, C.R., and J.W. Mercer, 1980. Groundwater modeling: Numerical models: *Ground Water*, 18(4).
9. Mercer, J.W., and C.R. Faust, 1980. Groundwater modeling: Mathematical models, *Ground Water*, 18(3):212-227.
10. Mercer, J.W., and C.R. Faust, 1980. Groundwater modeling: An overview, *Ground Water*, 18(2):108-115.
11. Wells, R.B., C.R. Faust, and J.W. Mercer, 1976. A Cross-Section Plotting Program (CSPP) for Gridded (MAP) Data, U.S. Geological Survey, *Open-File Report 76689*.

12. Faust, C.R., and J.W. Mercer, 1976. An analysis of finite-difference and finite-element techniques for geothermal reservoir simulation, *Proceedings of Fourth Society of Petroleum Engineers Symposium on Numerical Simulation of Reservoir Performance*, Los Angeles, California, February 19-20.

*Publications in Geochemistry:*

1. Li, T.M.C., J.W. Mercer, C.R. Faust, and R.J. Greenfield, 1978. Simulation of geothermal reservoirs including changes in porosity and permeability due to silica-water reactions, presented at the Fourth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California.

*Publications in Optimization Techniques:*

1. Maddock, T., III, J.W. Mercer, and C.R. Faust, 1982. Management model for power production from a geothermal field: 1. Hot water reservoir and power plant model, *Water Resources Research*, 18(3):499-512.
2. Maddock, T. III, J.W. Mercer, C.R. Faust, and E.D. Attanasi, 1979. Management model for electrical power production from a hot water geothermal reservoir, Reports on Natural Resources Systems, No. 34, University of Arizona, Tucson, Arizona, 114 pp.

*Publications in Sea Water Intrusion:*

1. Andersen, P.F., H.O. White, Jr., and J.W. Mercer, 1988. Numerical modeling of saltwater intrusion at Hallandale, Florida, *Ground Water*, 26(5):619-630.
2. Huyakorn, P.S., P.F. Andersen, J.W. Mercer, and H.O. White, Jr., 1987. Saltwater intrusion in aquifers: Development and testing of a three-dimensional, finite-element model, *Water Resources Research*, 23(2):293-312.
3. Andersen, P.F., H.O. White, J.W. Mercer, A.D. Truschel and P.S. Huyakorn, 1986. Numerical modeling of ground water flow and saltwater transport in Northern Pinellas County, Florida, *Proceedings of FOCUS Conference on Southeastern Ground Water Issues*, National Water Well Association, Dublin, Ohio, pp. 419-449.
4. Mercer, J.W., B.H. Lester, S.D. Thomas, and R.L. Bartel, 1986. Simulation of saltwater intrusion in Volusia County, Florida, *Water Resources Bulletin*, 22(6):951-965.
5. Huyakorn, P.S., J.W. Mercer, and P.F. Andersen, 1986. Seawater intrusion in coastal aquifers: Theory, finite-element solution, and verification tests, VI International Conference on Finite-Elements in Water Resources, Lisbon, Portugal.
6. Faust, C.R., and J.W. Mercer, 1982. Preliminary analysis of groundwater development and brackish water upconing at Virginia Beach, Virginia, Special Publications: Number 1, Georgia Southwestern College *Studies of the Hydrogeology of the Southeastern United States*: 1981, B.F. Beck (ed.), pp. 30-37, pp. 797-818.
7. Mercer, J.W., S.P. Larson, and C.R. Faust, 1980. Simulation of saltwater interface motion, *Ground Water*, 18(4):374-385.
8. Mercer, J.W., S.P. Larson, and C.R. Faust, 1980. Finite-difference model to simulate the areal flow of salt water and fresh water separated by an interface, U.S. Geological Survey, *Open File Report 80-407*, 88 pp.

*Publications in Groundwater Contamination and Hazardous Waste Disposal:*

1. Mercer, J.W., R.M. Cohen and M.R. Noel, 2010. DNAPL Site Characterization Issues at Chlorinated Solvent Sites in *In Situ Remediation of Chlorinated Solvent Plumes* (H.F. Stroo and C.H. Ward, Eds.), Springer, New York, 786 p.

2. D.K. Burnell, J.W. Mercer and L.S. Sims, 2010. Estimation of Daughter Product Biodegradation Rate Constants In Advective-Dominated Aquifers, Battelle 7<sup>th</sup> International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA (May 24-27).
3. D.K. Burnell, J. W. Mercer, and L. S. Sims, 2008. A Spreadsheet Model to Estimate Biodegradation Rate Constants, Battelle International Symposium of In Situ and Site Bioremediation, Monterey, CA.
4. D.K. Burnell, M. Van Oort, J.W. Mercer T.R. Suriano, and R.D. Bartlett, 2008. Stochastic Model to Estimate Travel Times From the 52<sup>nd</sup> Street Facility, Phoenix, AZ. 2008 AIPG Meeting, Arizona Hydrological Society, and 3<sup>rd</sup> International Professional Geology Conference, Flagstaff, AZ.
5. Cohen, Robert M., James W. Mercer, Michael Slenska and Mitchell Brouman, 2007. "Creosote Wettability Review and Evaluation at a Portion of the Cabot Carbon/Koppers Superfund Site," In: The Proceedings of the 2nd International Conference on DNAPL: Characterization and Remediation, Niagara Falls, NY, September 24-27, 2007.
6. Burnell, D.K., J.W. Mercer and L.S. Sims, 2007. Estimation of Sequential Biodegradation Product Rate Constants, The Ninth International Symposium on In Situ and On-Site Bioremediation (Battelle), Baltimore, MD, May 7-10.
7. Mercer, J.W., J.P. Toth, J.R. Erickson, M. Slenska and M. Brouman, 2006. DNAPL Source Evaluation at a Portion of the Cabot Carbon/Koppers Superfund Site, The First International Conference on DNAPL Characterization and Remediation, Pittsburgh, PA, September 25-28.
8. Kaback, D., S. Warner, B. Looney, J. Mercer, E. Poeter, J. McCray, D. Steeples and D. Tyler, 2006. An Approach to Refining a DNAPL Conceptual Model, The Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Battelle), Monterey, CA, May 22-25.
9. Mercer, J.W., G.C. Frederickson, D. Burnell, S. Dublin, J.E. Donahue and R.M. Ferris, 2006. Successful Remediation of Chlorinated Solvents Using Source Treatment and Natural Attenuation, The Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Battelle), Monterey, CA, May 22-25.
10. Mercer, J.W., C.R. Faust, C. Brown and J.E. Clark, 2005. Analysis of Injectate Location at DuPont Beaumont Works, in Underground Injection Science and Technology, C.-F. Tsang and J.A. Apps (editors), Elsevier, New York, Chapter 7, pp. 51-64.
11. Mueller, J, F. Lakhwala, J. Mercer, J. Erickson, D. Hill, E. Dmitrovic, A. Seech, M. Slenska, and M. Brouman, 2005. Site-Specific Limitation of Using KMnO<sub>4</sub> for In situ Biogeochemical Stabilization (ISBS) of Creosote/Penta DNAPL, The Eighth International In Situ and On-Site Bioremediation Symposium (Battelle), Baltimore, MD, June 6-9.
12. Burnell, D.K., L.S. Sims, R.P. Lowell, and J.W. Mercer, 2003. Multi-species Model Calibration and Predictive Analyses of Trichloroethene, cis-1, 2- Dichloroethene, and Vinyl Chloride Decreases Over a 20-Year Period by Pump-and-Treat and Natural Biodegradation, MODFLOW 2003 Conference, Denver, CO.
13. Mercer, J.W., C.R. Faust, C. Brown, and J.E. Clark, 2001. Analysis of Injectate Location at DuPont Beaumont Works, in Proceeding, 2001 Ground Water Protection Council Annual Forum, Reno, NV (Sept. 22-26), pp 166-179.
14. Adeel, Z., J.W. Mercer and C.R. Faust, 2001. Models for describing multiphase flow and transport of contaminants, in Groundwater Contamination by Organic Pollutants Analysis and Remediation, ASCE Manuals and Reports on Engineering Practice No.100, Reston, VA.
15. Mercer, J.W., M.R. Noel, and N.D. Durant, 1998. Contaminant source identification based on chemical and degradation products distributions, *The Professional Geologist*, (December).

16. Burnell, D.K., J.J. Benegar, J.W. Mercer, and A.L. Grasso, 1998. Application of transport module MODFLOWT for design of pulsed pumping groundwater remediation system at a site in New York, Proceedings MODFLOW '98, E. Poeter, C. Zhang, and M. Hill (editors), Colorado School of Mines, Golden, CO.
17. Mercer, J.W., 1998. Groundwater Transport and Remediation of Chemicals in, *Encyclopedia of Environmental Analysis and Remediation*, R.A. Meyers (editor), John Wiley & Sons, Inc., New York, NY, pp. 1979-2002.
18. Cohen, R.M., J.W. Mercer, R.M. Greenwald, and M.S. Beljin, 1997. Design guidelines for conventional pump-and-treat systems, U.S. EPA Ground Water Issue Paper, EPA/540/S-97-504.
19. Mercer, J.W., R.M. Parker, and C.P. Spalding, 1997. Chapter 9, Use of Site Characterization Data to Select Applicable Remediation Technologies, in *Subsurface Restoration* (C.H. Ward, J.A. Cherry, and M.R. Scaif, eds.), Ann Arbor Press, Inc., Chelsea, MI.
20. Mercer, J.W., Z. Adeel, and C.R. Faust, 1996. A review of NAPL modeling approaches for remediation, Non-Aqueous Phase Liquids (NAPLs) in Subsurface Environments: *Assessment and Remediation, Proceedings*, ASCE National Convention, Washington, D.C., Nov. 12-14, 1996, pp. 46-65.
21. Rabideau, A.J. (With contributions from J.W. Mercer, et al.), 1996. Section 10 Contaminant transport modeling, in *Assessment of Barrier Containment Technologies*, R.R. Rumer and J.K. Mitchell (Eds.), U.S. Department of Energy, U.S. Environmental Protection Agency, and DuPont Co., pp. 247-299.
22. Lester, B.H. and J.W. Mercer, 1995. Comparative Evaluation of Groundwater Biodegradation Models: Summary of the API Workshop, NGWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration, November 29 - December 1, Houston, TX.
23. Srinivasan, P., S. Donahoe, and J.W. Mercer, 1995. Use of Geographic Information Systems (GIS) in Risk-Based Screening, *The Professional Geologist*, October, 11-12 pp.
24. Jordan, D.L., J.W. Mercer, and R.M. Cohen, 1995. Review of mathematical modeling for evaluating soil vapor extraction systems, U.S. Environmental Protection Agency Report EPA/540/R-95/513, Cincinnati, OH.
25. Jordan, D.L., J.W. Mercer, and R.M. Cohen, 1995. Review of mathematical modeling for evaluation of SVE applications, presented at EPA's 21st Annual RREL Research Symposium, April 4-6, Cincinnati, OH.
26. Cohen, R.M., A.H. Vincent, J.W. Mercer, C.R. Faust, and C.P. Spalding, 1994. Methods for monitoring pump-and-treat performance, U.S. Environmental Protection Agency publication EPA/600/R-94/123, Ada, Oklahoma.
27. Mercer, J.W. and R.M. Cohen, 1994. The limitations of pump-and-treat systems in groundwater remediation, *Pollution Prevention in South Carolina*, 11(1): 18-21.
28. Cohen, R.M., J.W. Mercer, and I. Star, 1993. Delineating subsurface DNAPL using direct and indirect methods, Air & Waste Management Association Annual Meeting, Denver, Colorado, June 14-19, 1993.
29. Cohen, R.M., and J.W. Mercer, 1993. *DNAPL Site Evaluation*, C.K. Smoley, Boca Raton, Florida.
30. Mercer, J.W. and R.K. Waddell, 1993. Contaminant transport in groundwater (Chapter 16) in *Handbook of Hydrology*, D.R. Maidment (Ed.), McGraw-Hill, New York.
31. U.S. Environmental Protection Agency, 1992. Dense Nonaqueous Phase Liquids -- A Workshop Summary, Dallas, Texas, April 16-18, 1992, EPA/600/R-92/030 (Contributing author).



32. Mercer, J.W. and R.M. Cohen, 1992. Site characterization for DNAPL control/restoration, *Proceedings of the Water Environment Federation Pre-Conference Seminar on Detection and Restoration of DNAPLs in Groundwater at Hazardous Waste Sites*, New Orleans, LA, September 20.
33. Ward, D.S., J.W. Mercer, and L.L. August, 1992. Analysis of groundwater flow and injection fluid transport in the Floridan Aquifer near Pensacola, Florida, *Ground Water*, 30(3): 403-414.
34. Mercer, J.W., and C.P. Spalding, 1991. Chapter 2 Site Characterization Overview; Chapter 3 Geologic Aspects of Site Remediation; Chapter 4 Characterization of Water Movement in the Saturated Zone; Chapter 5 Characterization of the Vadose Zone; and Chapter 6 Characterization of Water Movement in Saturated Fractured Media, in *Site Characterization for Subsurface Remediation*, U.S. EPA Seminar Publication EPA/625/4-91/026, Cincinnati, Ohio, 259 pp.
35. Mercer, J.W., and D.C. Skipp, 1990. Considerations in the design of pump-and-treat remediation systems, *Superfund '90: Proceedings of the 11th National Conference*, HMCRI, 720-725.
36. Mercer, J.W., and R.M. Cohen, 1990. A review of immiscible fluids in the subsurface: Properties, models, characterization and remediation, *Journal of Contaminant Hydrology*, 6(2):107-163.
37. Mercer, J.W., D.C. Skipp, and D. Giffin, 1990. Basics of pump-and-treat groundwater remediation, U.S. Environmental Protection Agency EPA/600/890/003, Ada, Oklahoma, 31 pp.
38. Mercer, J.W., 1990. Don't gamble on a real estate purchase: An environmental assessment can separate winners from losers, *American Society of Appraisers, Valuation*, 35(1):116-121.
39. Faust, C.R., J.H. Guswa, and J.W. Mercer, 1989. Simulation of three-dimensional flow of immiscible fluids within and below the unsaturated zone, *Water Resources Research*, 25(12):2449-2464.
40. Mercer, J.W., D.A. Giffin, Jr., J.C. Herweijer, and P. Srinivasan, 1989. Groundwater contamination: Processes, characterization, analysis, and remediation, *International Workshop on Appropriate Methodologies or Development and Management of Groundwater Resources in Developing Countries*, Hyderabad, India, Feb 28 - Mar 4, 1989.
41. Bouwer, E., J. Mercer, M. Kavanaugh, and F. DiGiano, 1988. Coping with groundwater contamination, *Journal Water Pollution Control Federation*, 6(8):1414-1428.
42. Srinivasan, P., and J.W. Mercer, 1988. Simulation of biodegradation and sorption processes in groundwater, *Ground Water*, 26(4):475-487.
43. Faust, C.R., R.R. Rabold, and J.W. Mercer, 1988. Modeling remedial actions at S-Area, Niagara Falls, NY, *Proceedings of the Seminar on Impact of Hazardous Waste Facilities on Water Utilities*, American Water Works Association Annual Conference, Orlando, Florida.
44. Mercer, J.W., C.R. Faust, A.D. Truschel, and R.M. Cohen, 1987. Control of Groundwater Contamination: Case Studies, *Proceedings of Detection, Control, and Renovation of Contaminated Ground Water*, American Society of Civil Engineers, Environmental Engineering Division, pp. 121-133.
45. Duffield, G.M., D.R. Buss, D.E. Stephenson, and J.W. Mercer, 1987. A grid refinement approach to flow and transport modeling of a proposed groundwater corrective action at the Savannah River Plant, Aiken, South Carolina, *Proceedings of the Conference on Solving Ground Water Problems with Models*, National Water Well Association, Dublin, Ohio, pp. 1087-1120.
46. Ward, D.S., D.R. Buss, J.W. Mercer, and S.S. Hughes, 1987. Evaluation of a groundwater corrective action of the Chem-Dyne Hazardous Waste site using a telescopic mesh refinement modeling approach, *Water Resources Research*, 23(4):603-617.

47. Ward, D.S., T.D. Wadsworth, D.R. Buss, and J.W. Mercer, 1986. Analysis of potential failure mechanisms pertaining to hazardous waste injection in the Texas Gulf Coast Region, *Journal of the Underground Injection Practices Council*, 1:120-152.
48. Buss, D.R., B.H. Lester, and J.W. Mercer, 1986. A numerical simulation study of deepwell injection, *Current Practices in Environmental Science and Engineering*, 2:93-117.
49. Mercer, J.W., C.R. Faust, R.M. Cohen, P.F. Andersen, and P.S. Huyakorn, 1985. Remedial action assessment for hazardous waste sites via numerical simulation, *Water Management and Research*, 3:377-387.
50. Mercer, J.W., C.R. Faust, R.M. Cohen, P.F. Andersen, and P.S. Huyakorn, 1984. Remedial Action Assessment for Hazardous Waste Sites Via Numerical Simulation, Seventh Annual Madison Waste Conference on Municipal & Industrial Waste, University of Wisconsin, Madison, Wisconsin.
51. Mercer, J.W., C.R. Faust, and L.R. Silka, 1984. Groundwater flow modeling study of the Love Canal area, New York, *Groundwater Contamination*, Bredehoeft, J.D. and T.M. Uesselman (Editors), National Research Council, Studies in Geophysics, pp. 109-119.
52. Cohen, R.M. and J.W. Mercer, 1984. Evaluation of a proposed synthetic cap and concrete cutoff wall at Love Canal using a cross-sectional model, Fourth National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, Columbus, Ohio.
53. Andersen, P.F., C.R. Faust, and J.W. Mercer, 1984. Analysis of conceptual designs for remedial measures at Lipari landfill, New Jersey, *Ground Water*, 22(2):176-190.
54. Mercer, J.W., L.R. Silka, and C.R. Faust, 1983. Modeling groundwater flow at Love Canal, New York, *ASCE Journal of Environmental Engineering*, 109(4):924-942.
55. Silka, L.R. and J.W. Mercer, 1983. Evaluation of remedial actions for groundwater contamination, presented at the 3rd National Conference and Exhibition on Management of Uncontrolled Hazardous Waste Sites, Washington, D.C.
56. Mercer, J.W., L.R. Silka, C.R. Faust, and A.G. Kretschek, 1981. Draft final report on EPA test problems for groundwater model evaluation, GeoTrans Report No. 07200K01, 92 pp.
57. Faust, C.R., L.R. Silka, and J.W. Mercer, 1981. Computer modeling and groundwater protection, Guest Editorial in *Ground Water*, 19(4):362-365.

*Publications in Geothermal Resource Analysis:*

1. Faust, C.R., J.W. Mercer, S.D. Thomas, and W.P. Balleau, 1984. Quantitative analysis of existing conditions and production strategies for the Baca geothermal system, New Mexico: *Water Resources Research*, 20(5):601-618.
2. Faust, C.R., J.W. Mercer, and W.J. Miller, 1980. The DOE code comparison study: Summary of results for problem 1, presented at the Sixth Workshop on Geothermal Reservoir Engineering, Stanford, California, December 17, 1980.
3. Mercer, J.W., and C.R. Faust, 1980. The physics of fluid flow and heat transport in geothermal systems, *Sourcebook on the Production of Electricity from Geothermal Energy*, Joseph Kestin (ed), U.S. Department of Energy DOE/RA/40511, pp. 121-135.
4. Mercer, J.W., and C.R. Faust, 1979. A review of numerical simulation of hydrothermal systems, *Hydrological Sciences Bulletin*, 24(3):335-343.



5. Mercer, J.W., and C.R. Faust, 1979. Geothermal reservoir simulation 3: Application of liquid and vapor dominated hydrothermal modeling techniques to Wairakei, New Zealand, *Water Resources Research*, 15(3):653-671.
6. Mercer, J.W., and C.R. Faust, 1979. Reservoir engineering and evaluation, presented at the Geothermal Resources Council Symposium on Geothermal Energy and Its Direct Uses in the Eastern United States, Roanoke, Virginia.
7. Faust, C.R., and J.W. Mercer, 1979. Geothermal reservoir simulation 2. Numerical solution techniques for liquid and vapor-dominated hydrothermal systems, *Water Resources Research*, 15(1):31-46.
8. Faust, C.R., and J.W. Mercer, 1979. Geothermal reservoir simulation 1. Mathematical models for liquid and vapor-dominated hydrothermal systems, *Water Resources Research*, 15(1):23-30.
9. Huyakorn, P.S., G.F. Pinder, C.R. Faust, and J.W. Mercer, 1978. Finite-element simulation on two-phase flows in porous media, *Computational Techniques for Interface Problems*, ASME, AMD, 30:19-43.
10. Faust, C.R., and J.W. Mercer, 1977. Version I, A finite-difference model of two-dimensional, single and two-phase heat transport in a porous medium, U.S. Geological Survey, *Open File Report 77-234*.
11. Faust, C.R., and J.W. Mercer, 1977. A theoretical analysis of fluid flow and energy transport in hydrothermal systems, U.S. Geological Survey, *Open File Report 77-60*.
12. Mercer, J.W., and G.F. Pinder, 1975. A finite element model of a two-dimensional, single-phase heat transport in a porous medium, U.S. Geological Survey, *Open File Report 75-574*, 115 pp.
13. Mercer, J.W., and C.R. Faust, 1975. Simulation of water and vapor-dominated hydrothermal reservoirs, presented at 50th Annual Fall Meeting of Society of Petroleum Engineers of AIME, Dallas, Texas.
14. Faust, C.R., and J.W. Mercer, 1975. Mathematical modeling of geothermal systems, presented at the Second United Nations Symposium on the Development and Use of Geothermal Resources, San Francisco, California.
15. Mercer, J.W., G.F. Pinder, and I.G. Donaldson, 1975. A Galerkin finite-element analysis of the hydrothermal system at Wairakei, New Zealand, *Journal of Geophysical Research*, 80(17):2608-2621.
16. Mercer, J.W., C.R. Faust, and G.F. Pinder, 1974. Geothermal reservoir simulation, *Proceedings of National Science Foundation Conference on Research for the Development of Geothermal Energy Resources*, Pasadena, California, pp. 256-257.
17. Mercer, J.W., and G.F. Pinder, 1974. Finite-element analysis of hydrothermal systems, Oden, J.T., et al. (ed), *Proceedings of International Symposium on Finite-Element Methods in Flow Problems*, Swansea, Wales, UAH Press, pp. 410-414.
18. Mercer, J.W., and G.F. Pinder, 1973. Galerkin finite-element simulation of a geothermal reservoir, *Geothermics*, 2(3 & 4):81-89.
19. Mercer, J.W., 1973. *Finite element Approach to the Modeling of Hydrothermal Systems*, Ph.D. Thesis, University of Illinois, 106 pp.

*Publications in Aquifer Thermal Energy Storage:*

1. Mercer, J.W., C.R. Faust, W.J. Miller, and F.J. Pearson, Jr., 1982. Review of simulation techniques for aquifer thermal energy storage (ATES), *Advances in Hydroscience*, Academic Press, New York, 13:11-29.

2. Mercer, J.W., C.R. Faust, W.J. Miller III, and F.J. Pearson, Jr., 1981. Summary of simulation techniques for aquifer thermal energy storage (ATES), presented at Mechanical, Magnetic, and Underground Energy Storage 1981 Annual Contractor's Review, Washington, D.C.

*Publications in Radioactive Waste Disposal:*

1. Huyakorn, P.S., B. Lester, and J.W. Mercer, 1983. Finite-element simulation of fluid flow and solute transport in fractured media, presented at ASCE Engineering Mechanics Specialty Conference, Purdue University, May 23-25.
2. Huyakorn, P.S., B. Lester, and J.W. Mercer, 1983. An efficient finite-element technique for modeling transport in fractured porous media: 2. Nuclide decay chain transport: *Water Resources Research*, 19(5):1286-1296.
3. Huyakorn, P.S., B. Lester, and J.W. Mercer, 1983. An efficient finite-element technique for modeling transport in fractured porous media: 1. Single species transport, *Water Resources Research*, 19(3):841-854.
4. Mercer, J.W., S.D. Thomas, and B. Ross, 1982. Parameters and variables appearing in repository siting models, U.S. Nuclear Regulatory Commission, *NUREG/CR3066*, 244 pp.
5. Ross, B., J.W. Mercer, S.D. Thomas, and B.H. Lester, 1982. Benchmark problems for repository siting models, *NUREG/CR3097*, 138 pp.
6. Thomas, S.D., B. Ross, and J.W. Mercer, 1982. A summary of repository siting models, U.S. Nuclear Regulatory Commission *NUREG/CR278*, 237 pp.
7. Intera/GeoTrans, 1980. Groundwater pathways analysis for the Indian Point Site: Prepared for Pickard, Lowe, & Garrick, Inc., 67 pp.

*Books Reviewed:*

1. *Processing and Synthesis of Hydrogeological Data* by A. Gheorghe: Geology (Geological Society of America), 1979.
2. *Geothermal Reservoir Engineering* by M.A. Grant, I.G. Donaldson, and P.F. Bixley: 1983, EOS Transactions, American Geophysical Union, 64(31):486.
3. *Applied Groundwater Modeling*, by M.A. Anderson and W.W. Woessner: *Journal of Contaminant Hydrology*, 10(4), 1992.

**Title / Position**

Director of Groundwater Services

**Years of Experience**

30

**Education**

B.Sc. Physics and Meteorology, University of Reading, U.K., 1977 (with honors)

Stochastic and Geostatistical Analysis in Groundwater Modeling, Butler University, 1985

Water Well Design and Construction, Colorado School of Mines, 1987

Contaminant Hydrogeology Processes, Model, Uncertainty, Risk: A Strategy for Decision Making, Groundwater Short Course by Domenico, Freeze, Schwartz and Smith, 1991

Advanced Spatial Parameter Estimation, Colorado School of Mines, 2001

**Employment History**

Director, Adventus Americas, Inc., Denver, Colorado, 2004 - Present

Practice/technology Leader: Modeling/Fate and Transport, URS, 1999-2004

Associate, Dames &amp; Moore, Denver, Colorado, 1997-1999

Senior Geoscientist, Dames &amp; Moore, Denver, Colorado, 1993-1997

Senior Physicist/Mathematical Modeler, Dames &amp; Moore, Riyadh, Saudi Arabia, 1991-1993

Staff Engineer and Project Physicist/Mathematical Modeler, Dames &amp; Moore, Denver, Colorado, 1979-1991

Assistant Engineer, Dames &amp; Moore, London, England, 1977-1979

Ms. Moreno has more than 30 years of practical experience providing mathematical modeling evaluations to optimize groundwater remedial designs and resource management in over 200 industry and government projects worldwide. Several of these models have been validated by comparison with field data after eight to ten years of operation. Software used on these projects includes codes capable of analyzing NAPL and saturated and unsaturated groundwater flow, solute transport, inverse groundwater analyses, heat-coupled and density-coupled groundwater flow, and saltwater intrusion: MODFLOW, MT3D, RT3D, FEFLOW, TARGET, PHREEQC, FLOWPATH, TRUST, BPRISC, BIOSCREEN, BIOCHLOR, MODPATH, LNAST, OILVOL, HSSM, VLEACH, SESOIL, MOCENSE, DK3D, MODMAN, MODOFC, PEST, Interactive Groundwater, APIDSS, various surface water models (HOTJET, CAPTURE), various air-quality models (fugitive dust, traffic pollution), various heat transport models (TASTE), and FORTRAN 90.

**Areas of Technical Expertise**

- Groundwater Fate and Transport Modeling
- Groundwater Remediation
- Multiphase Flow and Transport
- Water Supply Modeling
- Software Development

**Representative Groundwater Modeling Projects**

- **No further action ROD based on modeling**-radio nuclides, metals-Idaho and Utah
- **Remediation system closure**-MTBE, solvents-Colorado and New York
- **Modeling innovative remedial designs**-barrier walls, passive treatment walls and recirculating treatment walls in combination with air sparging, dual-phase extraction, Fenton's reagent injection, pumping, and wetland treatment-Colorado, Kentucky, Florida, New York, California and Maryland
- **Remedial system design and cleanup times**-wide range of facilities-Colorado, Oregon, Arizona, Utah, Michigan and Japan
- **Fractured rock model**-remediation optimization-New Jersey and Arizona
- **Regional model**-potential impact of water supply pumping-Arizona
- **Regional model**-saltwater intrusion and well permitting-Florida
- **Groundwater-surface water model**-water supply and water rights-Utah
- **Dewatering and geothermal pumping model**-dewatering design-Papua, New Guinea
- **Regional groundwater/pit-lake model**-aquifer protection permit-Arizona

## Registrations

Professional Hydrologist- Groundwater (No. 1082, 1994)

Certified Groundwater Professional (No.452, 1994)

Engineer-in-Training (Colorado, 1986)

## Publications

- Hull, John, P.E., John Collins, Dr. Jim Mueller, Joanna Moreno, PHG. Laboratory Permeability and Removal Efficiency Data to Model and Evaluate Alternative Active Cap Designs, presented at Fifth International Conference on Remediation of Contaminated Sediments, Jacksonville, Florida, February 2-5, 2009.
- Moreno, J. P. Sinton, T. Bellehumeur, D. Bartlett, 2008. Conclusions on the Use of Model Predictions Derived from Model Post-Audits and Re-Evaluations. AIPG National Conference, September 20-24, Flagstaff, Arizona.
- Moreno J., Andrzej Przepiora, Tracy Bellehumeur, Jim Mueller, and Peter Sinton. Experience with Modeling Enhanced Bioremediation Using Observed Half Lives Varying in Time and Space, presented at MODFLOW and More: Ground Water and Public Policy, May 19-21, 2008, Golden, CO USA.
- Moreno, Joanna, Jim Mueller, Tracy Bellehumeur, Fayaz Lakhwala, Josephine Molin, Alan Seech, Eva Dmitrovic, and Andrzej Przepiora. Experience with Enhanced Bioremediation: Observed Half Lives and Their Variation in Time and Space, Proceedings of Battelle's Sixth Remediation of Chlorinated and Recalcitrant Compounds Conference, May 19-22, 2008, Monterey, CA USA.
- Sinton, P., J. Flynn, R. Dixon, D. Banton, L. Smith, and J. Moreno, 2007. Three-Dimensional Groundwater Model of a Gold Mine Near Republic, Washington. AIPG Conference, October 7-9, Michigan.
- Joanna Moreno, Michael Duchene, and John Hull, 2007. Funnel and Gate Design for the Capping of Impacted Sediments, Fourth International Conference on Remediation of Contaminated Sediments Savannah, Georgia USA January 22-25, 2007.
- Mueller, J., J. Moreno, F. Lakhwala, A. Seech, M. Okin, H. Slager, W. Fisher, and C. Sweeney, 2007. Catalyzed Permanganate for NAPL Stalibization and Flux Reduction , EPRI MGP 2007

- **Analytical model**-mine-flooding prediction-Romania
- **Fuel spill model**-vacuum-enhanced remediation-California
- **Regional groundwater model**-solvent plume source allocation-Arizona and Texas
- **Inverse model-capture and containment optimization**-California (2 sites) and Alaska
- **Unsaturated zone model**-metals in flyash-California

## Groundwater Flow and Transport Research and Teaching

- Co-authored book titled *A Practical Guide to Groundwater and Solute Transport Modeling*, New York: John Wiley & Sons, Inc., 1996. Japanese translation, 2003.
- Developed, tested and documented one-, two-, and three-dimensional computer codes for density-dependent groundwater flow and heat transport, reacting or chain-decaying chemical-species transport, and groundwater/lake interactions in variably-saturated, porous media as part of Dames & Moore's research and development program. These codes are tested and used, or reviewed and accepted, by the US Nuclear Regulatory Commission, US Environmental Protection Agency UK National Rivers Authority, many state regulated agencies, and various universities. Maintained, publicly distributed, and supported users of these codes.
- Conducted comparative evaluation of simulation techniques for radionuclide transport, in ground and surface waters, in two research studies for US Department of Energy.
- Taught several three-day seminars on groundwater modeling and installed three-dimensional groundwater models at water resources agencies in Arizona, Florida and Colorado. Provided groundwater modeling training for the Department of Energy, New Jersey, and Chemical Fate and Transport. Classes for US Air Combat Command Environmental Symposium.

## Remediation Services

- Prepared, calibrated, and used a three-dimensional, complex-geology, flow and transport model to analyze solvent attenuation and remediation by means of dual-phase extraction. Used parameter-estimation techniques to estimate uncertain hydraulic conductivities, recharge rates, and source terms based on historical water level and concentration data. The model will be used to focus and reduce future remediation efforts and explain the interplay of chemical fate processes at this site to regulators and the public.
- Prepared and calibrated long-term, transient three-dimensional, multi-aquifer model for a basin in the Western US. Applied model to evaluate historical and current groundwater flow conditions in the area of NAPL and dissolved plumes. Developed non-linear optimization model to optimize future pumping scenarios for containment of onsite plume and capture of offsite plume. Currently working on NAPL transport spreadsheet and multiphase model to evaluate the possibil-



- Joanna Moreno, Michael Duchene, and John Hull, 2007. Funnel and Gate Design for the Capping of Impacted Sediments, Fourth International Conference on Remediation of Contaminated Sediments Savannah, Georgia USA January 22-25, 2007.
  - Alan Seech, Jim Mueller, and Joanna Moreno, 2006. In-Situ Solid-Phase Bioremediation of Low-level Dieldrin-impacted Agricultural Soil. NGWA 2006.
  - Seech, A., D. Raymond, and J. Moreno, 2006. DARAMEND® Bioremediation for the Treatment of PAH Impacted Soils and Sediments, International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites, Reading, UK, 4-6 April 2006.
  - J. Mueller, J. Moreno, and E. Dmitrovic, 2006. *In Situ* Biogeochemical Stabilization of Creosote/Pentachlorophenol NAPLs Using Catalyzed and Buffered Permanganate: Pilot and Full Scale Applications, International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites, Reading, UK, 4-6 April 2006.
  - Alan Seech, Fayaz Lakhwala, Joanna Moreno, Jim Mueller, John Vogan, Michael Duchene, Jack Trevors, 2005. Mechanisms of Contaminant Removal under Very Low Redox Induced by EHC™, Battelle's Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds Special Session on In Situ Chemical Reduction (ISCR), May 22-25, 2006. Monterey, CA USA
  - Diane J. Fung, Liz Elliott, , Fayaz Lakhwala, Joanna Moreno, 2005. Evolution of an MTBE Plume: Discovery, Containment, and Remediation, National Groundwater Association, May 2005.
  - Moreno, J, 2005. Modeling Techniques for Remediation Design and Evaluation. Air Force 2005 Environmental Training Symposium, Louisville, KY, Feb. 6-12, 2005.
  - Cosme, F, P.O. Sinton, S. Muguet, J. Moreno, W.G. Langley, and G Vermeiren, 2004. Enhancement of Remediation Pilot Test Data Using Groundwater Modelling: A Case Study. International Conference on Finite-Element Models, MODFLOW, and More 2004, Carlsbad, Czech Republic, 13-16 September, 2004.
- ity of mobilizing the NAPL plume, and a transport model to compare remedial alternatives and estimate cleanup time.
- Providing technical oversight for refinery modeling in the Los Angeles Basin. Currently reviewing conceptual framework and practical development of multi-layer model for remediation optimization and source allocation.
  - Reviewed in detail, and provided parameter-estimation analyses of alternate model calibrations, a large three-dimensional flow and transport model of a \$2M/year injection/extraction system at the Tooele Army Depot for the US Army Corps of Engineers. The model will be used to evaluate non-operation test results and methods of implementing alternative measures and reducing remediation costs.
  - Evaluated existing model for refinery site adjacent to ocean in the western US. Updated pumping data, evaluated effectiveness of injection barrier, calculated plume travel times for the purpose of justifying monitoring frequency, and demonstrated minimal aquifer water-quality deterioration in support of the proposed injection of reclaim water.
  - Analyzed free-product volume and vacuum-enhanced remediation wellfield design for mobile free-product remediation for a Jet A fuel spill. The free-product volume was analyzed using OILVOL and the remediation design was first calibrated to pilot test data and then expanded to the full design using API's LNASt model. Cleanup effectiveness and duration were estimated using the model.
  - Performed inverse flow modeling analyses in order to optimize well field design to capture large oil spill in Alaska. The optimized well field pumpage was 40 percent less than current pumping rates.
  - Prepared three-dimensional model of MTBE transport and remediation to demonstrate that construction dewatering would not exacerbate existing contamination, at substantial savings to the client. Hypothesized then demonstrated causes for existing plume, thus dividing liability for plume. Predicted then verified in practice, containment pumping requirements. Used model to control daily containment pumping variations. Model calibration to changing water levels and concentrations was sufficiently exact to allow location of residual source to be identified. Used model to optimize remediation of the residual source area.
  - Conducted three-dimensional groundwater modeling studies, resulting in optimizing remedial alternatives and/or establishing regulatory compliance without active remediation, for: solvent migration in alluvium and fractured rock at two sites in Phoenix, Arizona and one site in New Jersey; solvent migration in fractured till in New York; low-level radioactive waste disposal in Illinois; and metal migration for sites in Colorado and Utah.
  - Provided groundwater modeling technical oversight and communications support for three-dimensional metals transport and density-coupled modeling analyses at a CERCLA site adjacent to Great Salt Lake, Utah. The remedial investigation report developed using this work resulted in an EPA decision to monitor natural attenuation at this site.



- Lakhwala, J. Mueller, J. Moreno, J. Molin, D. Hill, K. Bolanos-Shaw, and A Seech, 2004. mGCW In Situ Bioreactor Technology for Accelerated Removal of Perchlorate and Nitrogenous Compounds from Soil and Groundwater. 228<sup>th</sup> ACS National Meeting, Philadelphia PA, August 22-26, 2004.
- Moreno, J. and P. Sinton, 2003. Groundwater Model Flow Calibration – Comparison of a Decision Tree Approach and Automated Parameter Estimation for a Practical Application with Limited Data. Presented at MODFLOW and More 2003: Understanding Through Modeling, Golden, Colorado, Sep. 17-19, 2003.
- Moreno, J, P. Sinton, and R. Vogwill, 2003. Audit of Model Predictions of De-watering Requirements for a Large Open Pit Gold Mine. Invited Paper *in* Proceedings of 2003 Society for Mining, Metallurgy and Exploration, Inc. (SME) Annual Meeting, Cincinnati, Ohio, February 24-26, 2003.
- Moreno, J.L and P.O. Sinton, 2002. Modeling Mine Pit Lakes: Southwest Hydrology, v. 1, no. 3.
- Moreno, J.L, P.O. Sinton, R.D. Bartlett, and A.L. Williamson, 2002. A Method for Simulating Pit Lake Development and Passive Containment Resulting from Complex Geometry Pit Lakes. Presented at the U.S. EPA Hardrock Mining Conference, Denver Colorado, May 7-9, 2002.
- Mueller, J., Ritter, M, J. Moreno, T. Hopper, J. Cook, and S. Craig, 2001. Hydraulically Facilitated Remediation by Natural Attenuation for Groundwater Impacted by Chromium, Arsenic, and Boron. Presented at The Sixth International In Situ and On-Site Bioremediation Symposium, San Diego, Calif., June 4-7.
- Ritter, M, J. Moreno, T. Hopper, J. Cook, S. Craig, and J. Mueller, 2000. Hydraulically Facilitated Remediation by Natural Attenuation for Groundwater Impacted by Chromium, Arsenic, and Boron. Presented at NGWA conference.
- Bartlett, R.D., J.L Moreno, and A.L. Williamson, 1999. Demonstrating Passive Hydraulic Containment for an Open Pit Copper Mine. Paper *in* Proceedings of 1999 Society for Mining, Metallurgy and Exploration, Inc. (SME) Annual Meeting, Denver, Colorado, March 1-3, 1999.

- Functioned as the principal investigator in modeling evaluation of the historical evolution, cleanup times, and remedial system design for chemical spills and leakage at: electronics facility in Colorado; hazardous waste site in Arlington, Oregon; municipal landfill in Phoenix, Arizona; oil refinery near Salt Lake City, Utah; and chemical plant in Michigan.
- Used models to test conceptual remedial designs and to meet optimal design criteria for innovative designs involving barrier walls, passive treatment walls and recirculating treatment walls in combination with air sparging, pumping, and wetland treatment, at sites in Colorado, Kentucky, Florida, and Maryland.
- Provided technical oversight for the development, and application to remedial selection, of a complex 3D model of arsenic migration at a site in Japan. The modeling analyses were used to defend alternatives to current regulatory guidelines on remedial design and performance.
- Performed unsaturated-zone transport analyses for arsenic, selenium and hexavalent chromium beneath a flyash backfill with proximal groundwater users. Conducted literature survey for transport parameters for this analysis. Project permit is currently being pursued.

### Litigation Support

- Provided review of multiphase and groundwater modeling and expert analyses review for class action lawsuit involving 200 gas station sites in South Carolina. Case was settled favorably.
- Reviewed and reported on two-dimensional, regional groundwater and solvent transport model for the purpose of potential source-allocation litigation.
- Performed hydrogeologic evaluations, and fate and transport modeling in support of potential litigation at an airport.
- Provided critical evaluation and analyses of expert witness reports on contaminant origins and source durations, for the purpose of insurance settlements, at two large mine sites in Colorado, a solvent contaminated site in New Jersey, and a landfill in Texas.
- Conducted groundwater modeling analyses to evaluate alternate source allocation hypotheses, confirm 90% remedial design plans, and support litigation related to division of remedial costs, for a substantial solvent plume in Arizona. The first five years of remedial operation data were used in a successful audit of the model predictions.
- Managed and performed three-dimensional modeling analyses of organic contaminant migration and cleanup in support of litigation for a site in Ontario, Canada. This case was settled successfully.

### Groundwater Resources

- Prepared, for the purpose of groundwater pumpage permitting, a three-dimensional saltwater intrusion model of groundwater management in a

- Moreno, J.L., R.D. Bartlett, and P.H. Townsend, 1997. Use of Groundwater Models in Remediation Decisions. Invited Paper *in* Proceedings of ASCE 26th Annual Conference of the Water Resources Planning and Management Division, Houston, Texas, April 6-9, 1997.
  - Spitz, K. and J. Moreno, 1996. A Practical Guide to Groundwater and Solute Transport Modeling. New York: Wiley Interscience.
  - Krieger, G.R., M.J. Logsdon, C.P. Weis, and J. Moreno, 1995. Chapter 5: Basic Principles of Environmental Science *In Accident Prevention Manual for Business & Industry*, Itasca, Illinois: National Safety Council.
  - Moreno, J.L. and P.O. Sinton, 1994. Are Density Effects of Dissolved Contaminants Important? *In* Proceedings 1994 Groundwater Modeling Conference, Colorado State University, Fort Collins, Colorado, August 10-12, 1994.
  - Moreno, J.L., 1993. Calibration of Numerical Models. Paper presented at IAH Quarterly Meeting, Calgary, Canada, June 25, 1993.
  - Moreno, J.L., 1989. Three-Dimensional Simulation of the Migration and Cleanup of Trichloroethylene. *In* Proceedings of Fourth International Conference, Solving Groundwater Problems with Models, Indianapolis, Indiana, February 7-9, 1989.
  - Moreno, J.L. and S.A. Moreno, 1987. A Three-Dimensional Mathematical Model of Contaminant Transport for Microcomputers. *In* Proceedings of Conference on Computer-Aided Methods and Modeling in Geology and Engineering, Geotech 1987, Denver, Colorado, October 3-6, 1987.
  - Moreno, J.L. and R.D. Bartlett, 1987. Groundwater Model Planning - The Limitations of Data. *In* Proceedings, Waste Management Conference, Focus on the West, Fort Collins, Colorado, June 1-3, 1987.
  - Sharma, D., M.I. Asgian, W.R. Highland, and J.L. Moreno, 1983. Analysis of Complex Seepage Problems with the Disposal of Uranium Tailings: Selected Case Studies: Mineral and Energy Resources, v. 26, no. 1, published by Colorado School of Mines.
  - Moreno, J.L. and O.I. Oztunali, 1980. Comparative Evaluation of Radionuclide Transport Models. Paper presented at the Inter-Agency Workshop on Modeling and Low-Level Waste-Management, Denver, Colorado, December 1-4, 1980.
- three-aquifer system in Florida. The resulting model was approved by the local agency and used to assess basin pumping applications.
- Prepared numerical model evaluating the potential impacts of groundwater pumping to supply water for a natural gas power plant in SW Arizona. Work included evaluation of water resources report, compilation of spring, river, pumping, water level, and hydraulic property databases, development of a water budget, analyses of aquifer pumping test data, collection of isotope data, and numerical modeling of the three aquifers in the basin. A regional (450-square mile) numerical model was prepared, calibrated, and verified. A range of feasible model calibrations was identified and used to quantify the uncertainty in the model predictions. Also, the effect of using a fracture and block model versus porous-media assumptions were evaluated for the volcanic aquifer. Predictive runs were then made to estimate impacts of water-supply pumping on the water levels in the three aquifers, flow rates to the river and wetlands, and effectiveness of mitigation measures. Also long-term recovery of water levels in the volcanic aquifer was predicted and used in presentations to the public.
  - Performed modeling evaluation of optimal design alternatives for dewatering and depressurization wells in: an open-pit coal mine in Texas; and open-pit uranium mine in Colorado; an open-pit phosphate mine in Brazil; an open-pit gold mine in Indonesia; a construction tunnel in Arizona; and two large buildings in Saudi Arabia.
  - Developed predictions of dewatering and geothermal pumping requirements for a large open pit gold mine in a volcano on an island in Papua, New Guinea. Groundwater temperature variations of more than 100° C resulted in the need for a three-dimensional, density-coupled model. The first year of dewatering data were used to validate the model predictions.
  - Reviewed groundwater modeling analyses conducted as part of the EIS associated with the Missouri River Control Plan. Provided technical support at meetings with the EPA and USACOE.
  - Managed and performed multilayer modeling analyses of water supply and water rights maintenance for a horizontal-well system at a power plant in Utah. The model was used to demonstrate the likely causes of a drop in pumping rates.
  - Developed methodology for mine-flooding prediction, and incorporated mine-flooding analytical solutions into a generic database for analysis of abandoned, underground uranium mines for the European Union.
  - Conducted modeling investigations of wastewater recycling by means of artificial recharge via gravity drains and percolation ponds in Florida, and an infiltration bed in Wisconsin.

### Regulatory Compliance

- Assisted in groundwater modeling in support of design of one of the largest tailings impoundments in the world. Three-dimensional FEFLOW model was used to predict the influence of the tailings pond on groundwater divides and seeps in the surrounding fractured rock terrain.
- Assisted with development of transient, variably-saturated, 3D FEFLOW

model of underground gold mine in fractured rock aquifer with the goal of predicting regional impacts on surface water flow, groundwater divides, and wetlands. Seasonal and drought conditions were modeled.

- Simulated mine dewatering flow rates and water quality, and pit-lake development using a specifically developed groundwater / surface water model, for an Environmental Impact Statement for a proposed mine in New Mexico. Performed similar calculations as a key part of the successful demonstration used to obtain an Aquifer Protection Permit for an existing mine in Arizona. Developed 2D and 3D groundwater/pit-lake interaction models for a copper mine in Arizona. The model was used to demonstrate the passive hydrosink around the mine, evaluate effect of storms on pit lakes, plan ultimate pit management, and satisfy operating permit requirements.
- Conducted model simulations of migration and remediation of metals and acids, in support of mine expansion or closure, for: lead-zinc mines in Colorado and Idaho; copper mines in Utah and New Mexico; and uranium mill tailings impoundments in Wyoming, New Mexico, and Colorado.
- Obtained variance through the State of Wyoming, by means of groundwater fate and transport analyses, for the subgrade disposal of uranium tailings in the West Gas Hills of Wyoming.

### Risk Assessment

- Performed fate and transport modeling, remediation optimization, liability estimates, predicted transient future concentrations for input to risk assessments, assessed in-situ biodegradation, and supported dispute-resolution negotiations with agencies on offsite monitoring and remediation for a Fortune 50 company. This project involved development of dipping base codes (to stimulate dipping fracture zone), and code for chain decay of chlorinated hydrocarbons (to stimulate toxic daughter products). The model was used to demonstrate that additional offsite wells were unnecessary, thus avoiding costly involvement in regional water-quality issues. This project continued with the development of a finite-element model based on remediation operation data and site characterization data. This model was used to define time-dependent capture zones in fractured bedrock, predict the future extent of offsite plumes, and optimize the remediation approach.
- Used analytical and numerical models to demonstrate the efficacy of natural attenuation, and justify remedial cleanup goals, for onsite and off-site plumes of arsenic (3 sites), selenium (2 sites), TCE, and BTEX (many sites).

### Project Management

- Lead consultant for work on environmental compliance and monitoring associated with the Batu Hijau copper-gold mine in the Republic of Indonesia. This project involved compliance programs associated with the project environmental permit, and implementation of environmental monitoring programs covering hydrology, climatology, air quality, water quality, marine ecosystems, and terrestrial biology.



- Managed an evaluation, in support of site selection, of the impacts of landfills and ash ponds upon groundwater quality at hypothetical power plants in Colorado, Pennsylvania, Florida, Illinois, and Kentucky.
- Functioned as the project manager and principal investigator for three-dimensional model analyses of municipal water-supply development, downgradient of mining operations, for West Jordan, Utah.

### Title / Position

President/ Director of Remedial Solutions and Strategies

### Years of Experience

19

### Education

Ph.D., Soil Microbiology & Biochemistry/Microbial Genetics, Clemson University, 1988

M.Sc., Soil Microbiology & Biochemistry, Southern Illinois University, 1985

B.S., Soil Microbiology & Biochemistry, Southern Illinois University, 1983

### Postdoctoral Studies

U.S. Environmental Protection Agency, Microbial Ecology and Biotechnology Branch; Research Microbiologist, 1988-1990. Defined creosote and PAH biodegradation processes *in situ*; assessed the feasibility of various bioremediation technologies for effective site restoration.

### Technical Highlights

Two Level Three Science and Technology Achievement Awards from U.S. EPA, 1995.

Lead Project Scientist for U.S.DOD Technology Demonstration/Validation Project (multiple year/site SERDP award of \$2.45 million)

Lead Project Scientist for 2 U.S. EPA SITE Demonstration Projects

Acting Team Leader for Biodegradation Research, Microbial Ecology and Biotechnology Branch, U.S. EPA Environmental Research Laboratory at Gulf Breeze, FL (1992).

Coordinate oil spill bioremediation research for U.S. EPA and SBP (1989-1991).

Design and conduct of bench-, pilot-, and full-scale remediation projects; biotreatability studies.

Develop protocols for evaluation of oil spill bioremediation products when applied to land and open waters (U.S. EPA, NETAC).

Dr. Jim Mueller has 19 yrs of research and consulting experience in the environmental biotechnology industry with a focus on conceptualization, development, validation and international commercialization of *in situ* remediation technologies and source management strategies. He holds multiple patents and has authored/peer reviewed more than 250 scientific publications. He has been a technical advisor in the design and application of many (>1,000) remedial solutions/strategies throughout the world.

### Areas of Technical Expertise

- Biodegradation of Polycyclic Aromatic Hydrocarbons (PAHs), Chlorinated Pesticides and Chlorinated Hydrocarbon Compounds (CHCs)
- Bioremediation / Environmental Biotechnology
- *In Situ* Remediation Design and Application
- Remediation by Natural Attenuation
- Environmental Biogeochemistry
- Environmental Forensics
- Soil and Environmental Microbiology
- Phytoremediation

### Technology Development

- In collaboration with individuals and corporations, the following have been developed and commercialized:
- mGCW-R reactive well technology
- Bioremediation of high molecular weight PAHs
- EHC™ *In Situ* Chemical Reduction (ISCR) Technology
- EHC-M™ technology for *in situ* stabilization of heavy metals
- RemOx™ EC Stabilization Reagent for DNAPL treatment
- O-Sox™ delivery system for accelerated bioremediation
- AquaBlok+™ *in situ* sediment technologies
- HolePlug+ pollution prevention technology

### Representative Project Experience: Polycyclic Aromatic Hydrocarbons (Creosote and MGP Sites)

- **Beazer East, Inc., Denver, CO Superfund Site - Active Wood Treatment Facility** Designed and implemented an *in situ* source management at an active wood treating facility where notable volumes of creosote/penta NAPL were present. The remedial effort entailed: i) an impermeable barrier wall to prevent further off-site migration of NAPL and direct groundwater flow (funnel-and-gate), ii) an *in situ* bioreactor for accelerated aerobic biodegradation, iii) enhanced anaerobic biotreatment zones, iv) natural attenuation for dissolved constituents; v) *in situ* biogeochemical stabilization of NAPL residuals, and vi) phytoremediation.
- **Beazer East, Inc., Salisbury, MD Superfund Site - former Wood Treating Facility** Provided biotechnology support for the design, construction and operation of an *in situ* source management system which entailed: i) an impermeable bar-

## Employment History

President/Director of Remedial Solutions and Strategies, ADVENTUS AMERICAS, INC. 2003 – Present.

Senior Consultant, MALCOLM PIRNIE, INC. 2002 - 2003. One-year special assignment to establish Midwest (Chicago) business operations.

Senior Env. Scientist and Coordinator of Advanced Remediation Technologies (ART) Program and Tier One Consultants Group, URS/DAMES & MOORE, 1997 – 2002.

Scientific Advisory Board, Labroides Dimidiatus, Inc. (LDD) – Israel, 1999-present.  
Scientific Advisory Board on proprietary phytoremediation technologies, Phytotech, Inc. 1996 -1999.

Chief Scientist/Advisor and Manager, Technology Applications Division of The EICON Group, Inc. 1993 – 1997. EICON Group consisted of: 1) SBP Technologies, Inc., 2) SBP-NE, 3) Florida Groundwater Services, Inc., 4) Florida Remedial Services, Inc., 5) Westcott & Mapes, Inc., and 6) EICON Surveys, Inc.

Co-founder, Senior Environmental Microbiologist, VerVal Environmental Enterprises, Inc. (VVEE), 1993 – 1995.

Adjunct Research Assistant Professor, University of West Florida - Center for Environmental Diagnostics and Bioremediation, 1993-1995.

Adjunct Assistant Professor of Microbiology, Clemson University, 1992-present.

## International Experience

United States of America, Australia, Belgium, Canada, Denmark, England, Germany, Hungary, Israel, Italy, Jordan, Latvia, Lithuania, Mexico, Netherlands, Norway, Poland, Spain, Taiwan and Venezuela.

## Publications

5 patents issued, 3 pending  
36 peer-reviewed articles  
25 Book Chapters  
172 Symposia Proceedings / Abstracts / Presentations

rier wall around the entire property boundary, ii) a biologically active gate area, iii) phytoremediation, and iv) enhanced NAPL recovery.

- **Beazer East, Inc., Montgomery, AL - Superfund Site Wood Treating Facility** Designed and field-tested an *in situ* NAPL recovery system based on the modified operations of a vertical groundwater circulation well.
- **Beazer East, Inc., Feather River, CA - Superfund Site.** Designed and conducted bioremediation studies for slurry-phase bioreactor (soil washing process streams), solid-phase biotreatment (composting, engineered biocell and land farming) and *in situ* groundwater bioremediation (bioventing, biosparging and groundwater circulation well technologies) employing indigenous and/or specially selected microorganisms.
- **Beazer East, Inc. Houston, TX South Cavalcade Street Superfund Site** RCRA feasibility study support and conceptual designs for bioremediation of coal tar-impacted soils. Provided regulatory personnel with technical consultations on biodegradation processes, soil microbiology. Subsequently designed an *in situ* solid-phase bioremediation strategy for remediation of ca. 3,500 yd<sup>3</sup> of soil and prepared 30%, 90% and 100% Remedial Design Documents and a detailed cost analysis.
- **Beazer East, Inc., Charleston, SC Superfund Site - former Wood Treatment Facility** Designed and implemented an *in situ* bioremediation strategy for remediation of ca. 20 acres of marsh wetland impacted by PAHs (creosote) and heavy metals (lead). Prepared Remedial Design Documents that addressed engineering issues associated with full-scale *in situ* bioremediation operations and bioremediation monitoring using specialized biogeochemical assays (developed with the US NAVY).
- **Beazer East, Inc., Nashua, NH – former Wood Treatment Site** Project Director for international collaborative effort to provide design, modeling, construction and operation of an *in situ* NAPL containment and source management system for a former wood treating facility NH. The strategy integrated technologies for physical source containment and management (funnel-and-gate technology) with enhanced *in situ* product recovery (modified GCW technology) to replace an existing groundwater pump-and-treat system and save approximately \$700,000 annually in reduced O&M costs.
- **Norwegian State Railway/Aquateam, Inc** Collaborated with Aquateam, Inc. (Norway) to conduct bench-, pilot- and full-scale field demonstrations of the effectiveness of bioremediation technologies for soil, sediment and groundwater impacted by organic wood preservatives using solid phase and/or slurry phase bioremediation strategies.
- **Kerr-McGee Corporation** Co-designed and conducted laboratory studies to evaluate the potential of *ex situ*, solid-phase treatment and *in situ* bioremediation as a remedial technology for creosote-impacted soil at the former Moss-American Creosote Site in Sauget Illinois.
- **U.S. EPA's Superfund Innovative Technology (SITE) Program, American Creosote Works Superfund Site** Lead Project Scientist for full-scale field demonstration of physical (hyperfiltration) and biological treatment technologies (sequential bioreactors) for treatment of soil and groundwater impacted by creosote and PCP (including chlorinated dioxins/furans).
- **Bethlehem Steel, New York** Designed a biofeasibility study to validate the potential for using bioremediation to treat soil and groundwater containing PAHs and related compounds.

**Select Peer-Reviewed Publications  
(36 total)**

- Mueller, J.G., P.J. Chapman and P.H. Pritchard. 1989. Creosote-contaminated sites: Their potential for bioremediation. *Environ. Sci. Technol.* 23:1197-1201.
- Mueller, J.G., P.J. Chapman and P.H. Pritchard. 1989. Action of a fluoranthene-utilizing bacterial community on polycyclic aromatic hydrocarbon components of creosote. *Appl. Environ. Microbiol.* 55:3085-3090. 1989 U.S. EPA Scientific and Technological Achievement Award, Level 1.
- Mueller, J.G., P.J. Chapman, B.O. Blattmann and P.H. Pritchard. 1990. Isolation and characterization of a fluoranthene-utilizing strain of *Pseudomonas paucimobilis*. *Appl. Environ. Microbiol.* 56:1079-1086.
- Mueller, J.G., S.E. Lantz, B.O. Blattmann and P.J. Chapman. 1991. Bench-scale evaluation of alternative biological treatment processes for the remediation of pentachlorophenol- and creosote-contaminated materials: solid-phase bioremediation. *Environ. Sci. Technol.* 25:1045-1055.
- Mueller, J.G., D.P. Middaugh, S.E. Lantz and P.J. Chapman. 1991. Biodegradation of creosote and pentachlorophenol in groundwater: chemical and biological assessment. *Appl. Environ. Microbiol.* 57:1277-1285.
- Middaugh, D.P., J.G. Mueller, R.L. Thomas, S.E. Lantz, M.J. Hemmer, G.T. Brooks and P.J. Chapman. 1991. Detoxification of creosote- and PCP-contaminated groundwater by physical extraction: chemical and biological assessment. *Arch. Environ. Contam. Toxicol.* 21:233-244.
- Mueller, J.G., S.M. Resnick, M.E. Shelton, and P.H. Pritchard. 1992. Effect of inoculation on the biodegradation of weathered Prudhoe Bay crude oil. *J. Indust. Microbiol.* 10:95-105.
- Middaugh, D.P., S.M. Resnick, S.E. Lantz, C.S. Heard and J.G. Mueller. 1993. Toxicological assessment of biodegraded pentachlorophenol: Microtox and fish embryos. *Arch. Environ. Contam. Toxicol.* 24:165-172.
- Mueller, J.G., S.E. Lantz, R.J. Colvin, D. Ross, D.P. Middaugh and P.H. Pritchard. 1993. Strategy using bioreactors and specially selected microorganisms for bioremediation of groundwater contaminated with creosote and pentachlorophenol. *Environ. Sci. Technol.* 27:691-698.
- **FirstEnergy and NiSource** Demonstration of *in situ* biogeochemical stabilization (ISBS) technology for *in situ* source management of secondary NAPL issues at MGP and related sites.
- **Confidential Client – Australia** Designed a sequential aerobic/anaerobic *in situ* bioremediation system for managing PAHs and ammonia and cyanide in groundwater.

**Chlorinated Solvents**

- **U.S. EPA's Superfund Innovative Technology (SITE) Program, Sweden-3 Chapman Site, Sweden, NY** Lead Project Scientist to field demonstrate the effectiveness of microbiologically enhanced *in situ* bioremediation technology for the treatment of chlorinated solvents. Employed mGCW technology integrating *in situ* and *ex situ* bioreactors housing a constitutive TCE-degrading bacterium (*Burkholderia cepacia* strain G4).
- **U.S. ARMY CORPS, Nellis Air Force Base, Las Vegas, NV** Designed and implemented an *in situ* remediation system using mGCW technology to manage chlorinated solvents (TCE and catabolites) present in the dissolved phase along an active flight line.
- **Confidential Client, Australia** Designed a sequential aerobic (bioreactor)/anaerobic (zero-valent iron) permeable reactive barrier system for treatment of BTEX, hydrocarbons, phenols and heavy metals (chromium) in groundwater.
- **Emerson Electric Company, The Netherlands** Designed an *in situ* system for the removal of TCE and related compounds using modified groundwater circulation well technology coupled with advanced oxidation (ozone sparing) and NAPL recovery.
- **GTE Operations and Support, Titusville PA** Reviewed proposed remedial activities and conceptualized remedial alternatives for treating soil and groundwater impacted by TCE and related compounds.
- **Northrop Grumman Corporation, Hawthorne CA** Conducted an initial assessment of the applicability of ground water circulation well technology for removing TCE and related compounds from groundwater. Prepared a remedial design and work plan for field-testing.
- **Whirlpool Corporation, Milan Italy** Conducted a critical review of TCE remediation approaches recommended by existing site consultants. A more thorough understanding of remedial technologies and site conditions resulted in selection of an alternative to pump-and-treat (*i.e.*, *in situ* source management coupled with natural attenuation of dissolved phase constituents versus attempted product recovery).
- **Confidential Client, Detroit MI** Designed and constructed a phytoremediation system for a six-acre industrial facility where TCE and related catabolic daughter products were present in the shallow groundwater aquifer.
- **Confidential Client, Kansas** Designed and validated an *in situ* remediation system for carbon tetrachloride in groundwater. Strategy employed *in situ* source management and newly developed PRB technology for enhanced passive remediation.

- Mueller, J.G., J.-E. Lin, S.E. Lantz, and P.H. Pritchard. 1993. Recent Developments in Cleanup Technologies: Implementing Innovative Bioremediation Technologies. Remediation/ Summer Issue 369-381.
- Pritchard, P.H., J.G. Mueller, J.C. Rogers, F.V. Kremer and J.A. Glaser. 1993. Oil spill bioremediation: Experiences, lessons and results from the Exxon Valdez oil spill in Alaska. Biodegradation 3:315-335.
- Middaugh, D.P., S.E. Lantz, C.S. Heard and J.G. Mueller. 1994. Field-scale testing of a two-stage bioreactor for removal of creosote and pentachlorophenol from ground water: chemical and biological assessment. Arch. Environ. Contam. Toxicol. 26:320-328. 1995 U.S. EPA Scientific and Technological Achievement Award, Level III.
- Middaugh, D.P., R. Thomas, C.S. Heard, S.E. Lantz and J.G. Mueller. 1994. Field-scale testing of a hyperfiltration unit for removal of creosote and pentachlorophenol from ground water: chemical and biological assessment. Arch. Environ. Contam. Toxicol. 26:309-319. 1995 U.S. EPA Scientific and Technological Achievement Award, Level III.
- Mueller, J.G., R. Devereux, D.S. Santavy, S.E. Lantz, S. Willis and P.H. Pritchard. 1997. Phylogenetic and physiological comparisons of PAH-degrading microorganisms from geographically diverse soils. Antonie Van Leeuwenhoek. 71:329-343.
- Sharak-Genthner, B.R., S.E. Lantz and J.G. Mueller. 1997. Persistence of polycyclic aromatic hydrocarbon components of creosote under anaerobic enrichment conditions. Arch. Environ. Contam. Toxicol. 32:99-105.
- Borchert, S.M., F.S. Lakhwala and J.G. Mueller. 1997. UVB Technology invigorates microbes at a Superfund Site. Soil & Groundwater Cleanup. February/March Issue: pages 6-10.
- Lantz, S.E., M.T. Montgomery, W.W. Schultz, P.H. Pritchard, B.J. Spargo, and J.G. Mueller. 1997. Constituents of an organic wood preservative that inhibit the fluoranthene-degrading ability of *Sphingomonas paucimobilis* strain EPA505. Environ. Sci. Technol. 31: 3573-3580.

## Petroleum Hydrocarbons and MTBE

- **U.S. EPA's Exxon Valdez Oil Spill Bioremediation Program** Assisted the U.S. EPA with *in situ* bioremediation of beach material following the release of 11 million gallons of Prudhoe Bay crude by providing on-site laboratory and field support to develop and evaluate multiple bioremediation strategies.
- **Prestige Oil Spill – Galician Coast Spain** Working with an international team of scientists, provided remedial design and on-site field support to LDD in the bioremediation of Galician coastlines following the release of 20 million gallons of fuel oil.
- **Strategic Environmental Research and Development Program (SERDP)/US NAVY** Designed and installed mGCW systems down-gradient of a gasoline/MTBE spill site at the NAVY National Test Site in Pt. Hueneme, CA to field demonstrate the ability of enhanced *in situ* bioremediation to contain dissolved phase plume constituents. Conducted field experiments to validate the use of a newly developed biogeochemical monitoring tool (stable C isotopes of respired gasses) for *in situ* bioremediation applications.
- **Strategic Environmental Research and Development Program (SERDP) US NAVY** Designed and installed a Mesocosm test system at the Bioprocessing Engineering Facility at a Proving Ground, in Maryland to model a variety of *in situ* bioremediation technologies including ground water circulation, biosparging and bioventing.
- **BP Oil** Designed and conducted bench- and field-scale biotreatability studies to identify the most appropriate bioremediation strategy for the treatment of hydrocarbon-contaminated soil and/or groundwater at various facilities throughout the United States (e.g., Service City, Alaska; Port Tampa, Florida).
- **Columbia Propane** Designed laboratory studies to determine the applicability of various *in situ* (e.g., oxygen releasing compound) and *ex situ* (e.g., biocell) bioremediation. Critical review of data led to the recommendation and implementation of an *ex situ* treatment approach.
- **General Electric Company, Charlotte NC** Reviewed the results of a pilot-scale dual-phase vacuum extraction (DPVE) study and determined that the technology was not effective in recovering free and immiscible product and treating groundwater at the site. An alternative *in situ* chemical oxidation approach was designed for full-scale implementation.
- **Unocal Corporation, WV** Worked with the University of Iowa to develop a Field Activity Plan describing the design and implementation of a phytoremediation program at Unocal's Cabin Creek location to reverse hydraulic gradient and enhance the biodegradation of petroleum hydrocarbons by planting 23,000 Imperial Carolina hybrid Poplar along the riparian zones of West Cabin Creek and East Cabin Creek.

## Sediments and Wetlands

- **US NAVY** Team Leader and Senior Scientist for multi-year contract to develop biocomposite materials (biomass encapsulation, immobilization, co-encapsulation) to yield innovative bioremediation solutions.
- **US NAVY** Team member for multi-year contract to assess *in situ* bioremediation monitoring technologies; helped validate fate and transport during for sediment treatment.



- Kelley, C.A., R.B. Coffin, and J.G. Mueller. 1998. Stable Isotope Analyses – An Innovative Technique to Monitor Biodegradation of Petroleum Hydrocarbons. *Geotechnical News* September: 20-24.
  - Lakhwala, F., R.J. Desrosiers and J.G. Mueller. 1998. Demonstration of a micro-biologically enhanced vertical groundwater circulation well technology at a Superfund site. *Groundwater Monitoring and Remediation*. Spring: 97-106.
  - Kelley, C.A., R.B. Coffin, and J.G. Mueller. 1998. Stable Isotope Analyses – An innovative technique to monitor biodegradation of petroleum hydrocarbons. *GeoTechnical News*, September, 1998, Pages 20-24.
  - Hammer, B.T., C.A. Kelley, R. B. Coffin, L.A. Cifuentes, J. G. Mueller. 1998. d13C values of polycyclic aromatic hydrocarbons collected from two creosote-contaminated sites. *Chem. Geol.* 152: 43-58.
  - Trust, B.A., D.L. Hesse, R.B. Coffin, J.G. Mueller, and L.A. Cifuentes. 1999. Tracing biodegradation with stable carbon isotope measurements of respired CO<sub>2</sub>. *Bioremediation Journal*.
  - Mueller, J., M. Ohr, B. Wardwell, D. and F. Lakhwala. 1999. mGCW Technology for Remediation of Groundwater Containing Chlorinated Hydrocarbons and Heavy Metals: I – In Situ Hydraulics. *Soil & Groundwater Cleanup* Oct/Nov 1999: pages 8-14.
  - Ho, Y-F., M. Jackson, Y-Yang, J.G. Mueller, and P.H. Pritchard. 2000. Characterization of Fluoranthene- and Pyrene-Degrading bacteria isolated from PAH-Contaminated Soils and Sediments and Comparison of Several *Sphingomonas* Sp.. *J. Ind. Microbiol. Biotechnol.* 24:100-112.
  - Story, S.P., J.D. Kline, S.H. Parker, T-R J. Tzeng, J. Mueller, and E. Kline. 2001. Identification of Intermediate metabolites of fluoranthene and phenanthrene degradation by three classes of TN5 mutants of *S. paucimobilis* EPA505 deficient in PAH utilization. *Gene* 378-393.
  - Boyd, T. J., Montgomery, M. T., Spargo, B. J., Smith, D.C., Coffin, R. B., Kelley, C. A., and J. G. Mueller. 2001. Effects of oxygenation on hydrocarbon biodegradation in a hypoxic environment. *Bioremediation. J.* 5(2):145-157.
  - Montgomery, M. T., Spargo, B. J., Mueller, J. G., Coffin, R. B., Smith, D. C., and T. J. Boyd. 2002. Bacterial production stimulated across the zone of influence of a groundwater circulation well in a BTEX-contaminated aquifer. *Ground Water Monitoring and Remediation*. Summer 2002:144-150.
  - **General Electric Company PCB Bioavailability Project** Studied physical, chemical and microbiological aspects related to biodegradation of polychlorinated biphenyls (PCBs) in soil and sediment.
  - **Dredging International, N.V** Collaborated with Silts, N.V. (Belgium) for bioremediation of marine sediments in Belgium and Holland contaminated by PAHs and tributyltin (TBT).
  - **Sydney Tar Ponds, Nova Scotia** Sole provider team from an international solicitation for biotechnologies to treat dredged sediment containing PAHs, metals and low-levels of PCBs.
  - **Ciba Specialty Chemical Company, McIntosh AL** Reviewed site characterization data and evaluated the fate and transport issues associated with the presence of chlorinated dioxin/furan in a wetland environment. Subsequent proposal for in situ capping using the AquaBlok™ technology.
  - **Beazer East, Inc., Charleston, SC Superfund Site - former Wood Treatment Facility** Designed and implemented an *in situ* bioremediation strategy for remediation of ca. 20 acres of marsh wetland impacted by PAHs (creosote) and heavy metals (lead).
- ### Environmental Forensics
- **Strategic Environmental Research and Development Program (SERDP)/US NAVY** Group Leader and Senior Scientist for a multi-year, multi-disciplined project entitled “*In situ* Bioremediation and Efficacy Monitoring” funded by the Strategic Environmental Research and Development Program (SERDP) to demonstrate the utility of stable isotope analysis to monitor *in situ* bioremediation of fossil fuels and track sources of contamination in the environment.
  - **Hanson North America/Beazer East, Inc** Conceptualized a new Corporate-wide Program Directive for coordinating with uniformity and consistency the use of remediation by natural attenuation through the development of RNA implementation protocol specific to the wood treatment industry.
  - **Confidential Client, U.S. EPA Superfund Site, Tempe, AZ** Reviewed historical physicochemical data to document discrete plumes of chlorinated solvents. Conducted supplemental microbiological analyses to successfully document that *in situ* biodegradation of chlorinated solvents was occurring on site, and that remediation by natural attenuation was an active process. The data were used to reverse the U.S. EPA’s remedial action recommendation to implement pump-and-treat.
  - **AlliedSignal/ERM** Reviewed historical physicochemical data and supplemental forensic analyses to document discrete age and source of plumes of chlorinated solvents. Used site-specific data on natural attenuation and *in situ* biodegradation of chlorinated solvents to document that remediation by natural attenuation was an active process.
  - **Confidential Client, AST Farm Fire, Georgia** Remediation of 86,000 tons of soil and groundwater was required at a tank farm where NaSH, turpentine, Briquest and Antiblaze-80 were released into the environment following a fire. Independent expert opinion on the influence of the fire fighting actions on the distribution and transport of contaminants was used to support a claim against their third party environmental insurance for compensation.

**Select Book Chapters (25 total)**

- Mueller, J.G., C.E. Cerniglia and P.H. Pritchard. 1996. Bioremediation of Environments Contaminated by Polycyclic Aromatic Hydrocarbons. In R. Crawford and D. Crawford (eds), *Bioremediation: Principles and Applications*. Chapter 5, Pages 125-194. Cambridge University Press.
- Spargo, B.J. (ed) "In Situ Bioremediation and Efficacy Monitoring". US NAVY, Naval Research Laboratory, Washington D.C. NRL/PU/6115-96-317. October 1996. 323 pages.
- Pritchard, P.H., J.G. Mueller, J.C. Rogers, F.V. Kremer and J.A. Glaser. 1993. Oil spill bioremediation: Experiences, lessons and results from the Exxon Valdez oil spill in Alaska. In E. Rosenberg (ed.) *Microorganisms to Combat Pollution*. Kluwer Academic Publishers, Boston. Pages 191-230.
- Mueller, J.G., S.E. Lantz, R. Devereux, J.D. Berg and P.H. Pritchard. 1994. Studies on the microbial ecology of PAH biodegradation. In R. Hinchee (ed.) *In Situ and On-Site Bioreclamation*. Lewis Publishers, Boca Raton, FL. Pages 218-230.
- Pritchard, P.H., J.G. Mueller, S.E. Lantz and D.L. Santavy. 1995. The potential importance of biodiversity in environmental biotechnology applications: Bioremediation of PAH-contaminated soils and sediments. In D. Allsop et al (eds), *Microbial Diversity and Ecosystem Function*. Chapter 9 pages 161-182. CAB International Publishers. Invited Paper.
- Kelley, C.A., R.B. Coffin, L.A. Cifuentes, S.E. Lantz and J.G. Mueller. 1995. The use of GC/C/IRMS coupled with GC/MS to monitor biodegradation of petroleum hydrocarbons. In *Battelle's Third International Symposium on In Situ and On-Site Bioreclamation*. April 24-27, 1995. San Diego, CA.
- Pritchard, P.H., J. Jones-Meehan, W. Straube, J.G. Mueller. 1999. Bioremediation of High Molecular Weight PAHS: Application of Techniques in Bioaugmentation and Bioavailability Enhancement. In Fass et al. (Ed), *Novel Approaches for Bioremediation of Organic Pollution*. Kluwer Academic/ Plenum Publishers, New York. Pages 157-170.
- Mueller, J., P.H. Pritchard, M. Tischuk, M. Brouman, P. Swallow, M. Tabe and J. Smith. 1999. Biostabilization Technology for Treating PAH- and PCP-impacted Soil to Environmentally Acceptable Endpoints: Ten-Year Field Assessment. In Fass et al. (Ed), *Novel Approaches for Bioremediation of Organic Pollution*. Kluwer Academic/ Plenum Publishers, New York. Pages 255-272.
- Spargo, B.J. and J.G. Mueller. 2000. Advanced Remediation Technologies and Management Strategies for Sites Impacted by Hydrocarbon Contaminants. "Handbook of Solvents". ChemTec Publishing. Pages 1617-1630.

- **Mid-America Plaza, Illinois** Reviewed site-specific chemistry data to estimate the amount of time required to reduce the concentration of benzene in groundwater from current levels (ca. 22,000 ppb) to Class I (5 ppb; 20 to 25 years) or Class II (25 ppb; 10 to 15 years) standards.
- **Phillips Petroleum, Elmhurst IL** Reviewed historical soil and groundwater chemistry data to determine that a gasoline UST was later used to store pesticides (methoxychlor and xylene) and which leaked after the transfer of tank ownership in 1972.
- **Israeli Military Institute, Tel Aviv, Israel** Critically reviewed site characterization and assessment data and determined that the source of groundwater contamination was poorly defined and that IMI was inaccurately identified as the party responsible for site mitigation and cleanup.
- **L.J. Shapiro & Associates – Chicago, IL** On behalf of a real estate developer, collaborated with LJ Shapiro to survey a local community and analyze receptiveness to a planned development, answering the question of "how close is too close?"

**Heavy Metals and Inorganic Contaminants**

- **Confidential Client, Port Newark, NJ** Conducted biofeasibility assessment and developed a Conceptual Remedial Design for an estimated 40,000 yd<sup>3</sup> of surface soil containing creosote and the inorganic wood preservatives copper, chromium, and arsenic (CCA).
- **Confidential Client, U.S. EPA Superfund Site, Farmingdale, NY** Successfully negotiated with the U.S. EPA to employ innovative *in situ* bioremediation and metal immobilization technologies to manage chlorinated solvents and dissolved heavy metals in groundwater.
- **Beazer East, Inc., Jacksonville, Florida Active Wood Treating Facility** Designed an *in situ* source management and ground water remediation system at an active wood treating facility where concentrations of chromium, arsenic and boron: a) phytoremediation via constructed wetlands for boron attenuation; b) hydraulically facilitated remediation by monitored natural attenuation, and c) induced *in situ* arsenic precipitation via air sparging.
- **Confidential Client, Munitions Facility, Australia** Designed a sequential aerobic/anaerobic permeable reactive barrier system for biotreatment of groundwater containing nitrate and ammonium.
- **Confidential Client, Animal Feed Lot, Oklahoma** Designed a sequential aerobic/anaerobic permeable reactive barrier system for biotreatment of groundwater containing nitrate.
- **US Chrome Facility, WI** Evaluated site-specific environmental chemistry data and determined that remediation by natural attenuation processes were effective in controlling the migration of chromium. A detailed monitoring plan was designed and implemented.
- **St. Johns River Water Management District, Florida** Evaluated site-specific environmental chemistry data and determined that phytoremediation could be used to manage soluble phosphorus entering Lake Apopka from surface waters.
- **Confidential Railroad Client – Central USA** Designed and implemented an *in situ* stabilization process using EHC-M™ to immobilize arsenic and other heavy metals.

### Select Presentations, Abstracts, or Proceedings (172 total)

- King, M., J. Cook, J. Mueller, and J. Barker. 2000. Natural attenuation trends at wood treatment sites. Proceedings Battelle's Second International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 22-25, Monterey, CA.
- Erickson, J., M. Tischuk, J. Cook, J. Mueller and B. Mahaffey. 2000. Enhanced Aerobic/Anaerobic Bioremediation for a Wood-Treating Site. Battelle's Second International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 22-25, Monterey, CA. 2(7):139-144.
- Mueller, J., M. Brouman, J. Cook, M. Slenska and M. Tischuk. 2000. In situ source management strategies at wood treatment sites. Battelle's Second International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 22-25, Monterey, CA.
- Ritter, M., J. Moreno, T. Hopper, J. Cook, S. Craig, and J. Mueller. 2000. Hydraulically facilitated remediation by natural attenuation for groundwater impacted by chromium, arsenic, and boron. NGWA 2000.
- Bouknight, J., M. Montgomery, T. Boyd, M. Slenska, and J. Mueller. 2001. Accelerated In Situ Bioremediation and Phytoremediation of Marsh Sediments. SETAC Nashville, TN.
- Mueller, J., M. Ritter, J. Moreno, T. Hopper, J. Cook, and S. Craig. 2001. Hydraulically facilitated remediation by natural attenuation for groundwater impacted by inorganic wood preservatives. Battelle's In Situ and On-Site Bioremediation Symposium June 4-7, San Diego, CA.
- Mueller, J. J. Erickson, M. Brouman, M. Bollinger, M. Tischuk, and J. Cook. 2001. Integrated Technologies for In Situ Source Management at an Operating Wood Treatment Site. In Situ Containment Conference, Orlando FL June 11-14, 2001.
- Mueller, J., J. Erickson, N. Thomson, C. Lamarche, J. Cook, M. Tischuk, and M. Brouman. 2002. In situ biogeochemical stabilization versus attempted NAPL removal. Proceedings, Battelle's Third International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 20-24, Monterey, CA.
- Bouknight, J., M. Montgomery, T. Boyd, M. Slenska, and J. Mueller. 2001. Accelerated In Situ Bioremediation and Phytoremediation of Marsh Sediments. SETAC Nashville, TN.
- Mueller, J., M. Ritter, J. Moreno, T. Hopper, J. Cook, and S. Craig. 2001. Hydraulically facilitated remediation by natural attenuation for groundwater impacted by inorganic wood preservatives. Battelle's In Situ and On-Site Bioremediation Symposium June 4-7, San Diego, CA.

- **URS Corporation – Southern Florida, USA** Collaborated in the design and implementation of EHC-M™ for *in situ* stabilization of residual arsenic from a former pesticide operation.

### Environmental Due Diligence

- **LASMO-Venezuela Oil Field** Conducted Phase III Remedial Alternative analysis and cost estimate for remediation of >800 oil production pits impacted by crude oil. Coordinated risk-based remediation and management strategy for treating approximately 445,000 m3 of produced water, 129,000 m3 of solid materials, and 69,000 m3 of oil complied with Venezuelan rules and regulations.
- **Brunswick Corporation, Boat Manufacturing Businesses** Conducted Site Assessments (Phase I/II/III) and estimations of environmental liability at 15 locations throughout the United States and Mexico associated with the purchase or transfer of various boat manufacturing business. Remedial actions for petroleum hydrocarbons, chlorinated solvents, acetone, di-alcohol acetone and MTBE were undertaken at several locations.
- **Road Master Corporation / The City of Olney, Illinois** Provided independent project oversight for the remediation of a former manufacturing facility which included the excavation and disposal of 5,000 buried drums, site characterization, risk assessment and remediation of ground water.



- Mueller, J. J. Erickson, M. Brouman, M. Bollinger, M. Tischuk, and J. Cook. 2001. Integrated Technologies for In Situ Source Management at an Operating Wood Treatment Site. In Situ Containment Conference, Orlando FL June 11-14, 2001.
  - Mueller, J., J. Erickson, N. Thomson, C. Larmar, J. Cook, M. Tischuk, and M. Brouman. 2002. In situ biogeochemical stabilization versus attempted NAPL removal. Battelle's Third International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 20-24, Monterey, CA.
  - Montgomery, M.T., T.J. Boyd, J.K. Steele, D.M. Ward, D.C. Smith, B.J. Spargo, R.B. Coffin, J. Pohlman, J.G. Mueller and M. T. Slenska. 2002. Measuring Intrinsic Bacterial Degradation of PAHs in a Salt Marsh. Battelle's Third International Symposium on Remediation of Chlorinated and Recalcitrant Compounds. May 20-24, Monterey, CA.
  - Mueller, J.G. 2002. "Bioremediation Technologies and Management Strategies for Soil and Groundwater: Experiences and Lessons Learned." 32 Annual Meeting Israel Society for Ecology and Environmental Quality Sciences, Tel Aviv, Israel December 17-19, 2002.
  - Mueller, J., M. Tischuk and M. Brouman. 2002. "In situ biogeochemical stabilization for Source Area Management." 32 Annual Meeting Israel Society for Ecology and Environmental Quality Sciences, Tel Aviv, Israel December 17-19, 2002.
  - Mueller, J., M. Tischuk and M. Brouman. 2002. "In situ biogeochemical stabilization for Source Area Management." 32 Annual Meeting Israel Society for Ecology and Environmental Quality Sciences, Tel Aviv, Israel December 17-19, 2002.
  - Montgomery, M.T. D.C. Smith, C.L. Osburn, J.G. Mueller, and T.J. Boyd. 2002. Seasonal succession of the PAH-mineralizing bacteria in creosote-impacted inter-tidal sediments. 12th Annual West Coast Conference on Contaminated Soils, Sediments and Water. San Diego, CA March 18-21 2003.
  - Seech, A. G. Bell and J. Mueller. 2002. Enhanced Solid-phase Bioremediation of PAH-impacted Dredged Marine Sediments from the Tar Ponds Site in Sydney Nova Scotia, Canada. 18th Annual International Conference on Contaminated Soils, Sediments and Water. October 21-24, 2002 Amherst Mass.
  - Montgomery, M.T. T.J. Boyd, C.L. Osburn, J.G. Mueller, and D.C. Smith. 2003. Preferential degradation of PAHs over natural organic matter by bacteria in intertidal sediments. 225th ACS National Meeting, New Orleans, LA, March 23-27, 2000.
  - MacFabe, S., J. Mueller and S. Pitkin. 2003. Forensic Characterization of Co-mingled Groundwater Plumes Using Detailed Profiling Techniques for the Purpose of Liability Separation and Remedial Design. Amer. Academy of Forensic Sciences 55th Annual Meeting, Chicago, IL. Feb 17-22, 2003.
  - Abrahams, J.A., A.A. Kopania, J.G. Mueller and M. D. Tischuk. 2003. DNAPL Management at a Creosote-Impacted Site. In Situ and On-Site Bioremediation Symposium, Orlando FL June 10-14, 2003.
  - Erickson, J.R., J. Mueller, M. Tischuk, M. Bollinger and M. Brouman. 2003. In Situ Biogeochemical Stabilization of Creosote/Pentachlorophenol NAPLs using Permanganate. In Situ and On-Site Bioremediation Symposium, Orlando FL June 10-14, 2003.
  - Mueller, J., S. MacFabe, D. Hill, K. Bolanos-Shaw and A. Seech. 2004. Enhanced Reductive Dechlorination of Organic Solvents in Groundwater Using Controlled Release Carbon with ZVI. AEHS 14th Annual West Coast Conference on Soil, Sediments and Water. San Diego, CA. March 15-18, 2004
  - Gibson, M., A. Seech, D. Hill, and J. Mueller. 2004. Placement of EHC by Hydrofracturing to Treat Chlorinated Solvent Plumes. Battelle's Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey Ca. May 24-27, 2004.
  - Raymond, D. G. Bell, A. Seech, J. Mueller and T. Slater. 2004. Full-Scale Bioremediation of Pesticide-Impacted Soil/Sediment at the THAN Superfund Site, Montgomery, Alabama. Battelle's Fourth International Conference on Chlorinated and Recalcitrant Compounds.
  - Dmitrovic, E., A. Seech, J. Mueller and J. Trevors. 2004. PRB Fill Material for the Reductive Dechlorination of Chlorinated Solvents. Battelle's Fourth International Conference on Chlorinated and Recalcitrant Compounds.
  - Mueller, J., S. MacFabe, A. Seech, D. Hill and K. Bolanos-Shaw. 2004. Reductive Dechlorination of Solvents in Groundwater Using Controlled Release Carbon with ZVI. Battelle's Fourth International Conference on Chlorinated and Recalcitrant Compounds.
  - Raymond, D. A. Seech and J. Mueller. 2004. Full-Scale Bioremediation of PCP-Impacted Soil. Battelle's Fourth International Conference on Chlorinated and Recalcitrant Compounds
  - Subramanian, S. M. Ander, J. Day and J. Mueller. 2004. Bioremediation of PCP using VS-GCW Technology. Battelle's Fourth International Conference on Chlorinated and Recalcitrant Compounds, Monterey Ca. May 24-27, 2004.
  - Mueller, J and A. Seech. 2004. Bioremediation Technologies for Dredged Marine Sediments. USA – Baltic International Symposium on Advances in Marine Environmental Research, Monitoring and Technologies. Klaipeda, Lithuania. June 15-17, 2004
  - Lakhwala, F., J. Mueller, J. Molin, D. Hill, K. Bolanos-Shaw and A. Seech. 2004. mGCW In Situ Bioreactor Technology for Accelerated Removal of Perchlorate and Nitrogenous Compounds from Soil and Groundwater. 228th ACS National Meeting, Philadelphia PA August 22-26, 2004.
  - Dmitrovic, E., A. Seech, K. Bolanos-Shaw, D. Hill, M. Gibson, J. Mueller and J. Trevors. 2005. EHCTM – A Novel Material for In Situ Reductive Dechlorination of Chlorinated Solvents. First International Conference on Environmental Science and Technology. American Academy of Sciences, New Orleans, LA January 25-27, 2005.
  - Hill, D. J. Mueller, F. Lakhwala, J. Vogan and A. Seech. 2005. Installation Methods for Subsurface Placement of EHC (solid) and EHC-L (liquid amendments). AEHS 15th Annual West Coast Conference on Soils, Sediments and Water. San Diego, March 2005.
  - Mueller, J., M. Mueller, H-P Ratzke and A. Seech. 2005. In Situ Chemical Reduction (ISCR) using EHC Substrate for Accelerated Remediation by Natural Attenuation (RNA). 2nd European Conference on Natural Attenuation, Soil and Groundwater Risk Management. May 18-20, 2005 Frankfurt, Germany.
  - Molin, J., J. Mueller, F. Lakhwala, D. Hill, E. Dmitrovic, A. Seech, M. Helbling and J. Cook. 2005. In Situ Bioreactor System for the Craig Farm Superfund Site.
- Mueller, J., F. Lakhwala, J. Mercer, J. Erickson, D. Hill, E. Dmitrovic, A. Seech. M. Slenska and M. Brouman. 2005. Apparent Naphthalene Production During In Situ Biogeochemical Stabilization of Creosote DNAPL.
- Mueller, M., M. Brouman and J. Mueller. 2005. Understanding how NIMBY (How close is too close?) can Impact Site Remediation and Re-Development Efforts.
- Mueller, J., J. Molin, A. Seech, D. Hill, G. Vierkant and J. Day. 2005. EHC Technology for Managing Chlorinated Solvents in Landfill Leachate. Battelle's Eighth International In Situ and On-Site Bioremediation Symposium, June 6-9, 2005 Baltimore, MD.
- Mueller, J., D. Hill, E. Dmitrovic, J. Vogan and A. Seech. 2005. EHC for In Situ Bioremediation of Groundwater Containing Chloroethanes and other Chlorinated Solvents. UMASS 21st Annual International Conference on Soils, Sediments and Water. October 17-21, 2005.

- Mueller, J., J. Molin, A. Seech, K. Bolanos-Shaw and D. Hill and A. Seech. 2006. Effect of EHC™ In Situ Chemical Reduction (ISCR) on Chlorinated Compounds under Laboratory and Field Conditions. AEHS 16th Annual West Coast Conference on Soils, Sediments and Water March 13-16, 2006 San Diego, CA.
- Seech, A., D. Hill, F. Lakhwala, J. Molin, J. Vogan, M. Duchene and J. Mueller. 2006. In Situ Chemical Reduction (ISCR) - Mechanisms for Contaminant Removal under Very Low Redox Conditions. AEHS 16th Annual West Coast Conference on Soils, Sediments and Water March 13-16, 2006 San Diego, CA.
- Seech, A, J. Mueller and J. Moreno. 2006. DARAMEND™ Bioremediation for the Treatment of PAH Impacted Soils and Sediments. International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites. Reading, United Kingdom, 4-6 April 2006.
- Dmitrovic, E., A. Seech, K. Bolanos-Shaw, D. Hill, T. Slater and J. Mueller. 2006. EHC™ Induced Reductive Dechlorination of Chlorinated Solvent Impacted Groundwater.

Dolfing, J. M. van Eekert and J. Mueller. 2006. Thermodynamics of Low Eh Reactions.

Seech, A., D. Hill, F. Lakhwala, J. Molin, J. Moreno, J. Vogan, M. Duchene and J. Mueller. 2006. Mechanisms of Contaminant Removal under Very Low Redox Induced by EHC.

Jerger, D. W. Hughes, A. Seech, J. Mueller, and J. Harlow. 2006. Full-Scale, In-Place Reductive Remediation of Sediment Containing Organic Explosives at the Yorktown Naval Weapons Station. Battelle's Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey Ca. May 22-25, 2006.
- Mueller, J., J. Molin, R. Corzatt and J. Smith. 2006. Integrated Use of EHC™ and KB-1 for Accelerated ISCR.

Mueller, J., J. Molin and D. Hill. 2006. In Situ Chemical Reduction (ISCR) Technology for Dry Cleaning and Related Sites. 2006 Midwestern States Risk Assessment Symposium. August 21-24, Indianapolis, Indiana.
- Dmitrovic, E., F; Lakhwala, J. Mueller, J. Peale and E. Bakkom. 2006. Comparison of Three In Situ Treatment Technologies For The Remediation of Trichloroethylene Impacted Groundwater.

Mueller, J., J. Molin, R. Corzatt and J. Smith. 2006. Combined Use of EHC™ plus KB-1 Dehalococoides Inoculant for Accelerated ISCR – First Full-Scale Field Application in Ohio UMass 22nd International Conference on Soil, Sediments and Water. Amherst, Mass, Oct. '06

- Mueller, J., F. Lakhwala, J. Molin and J. Moreno. 2006. Selection Criteria for Implementing In Situ Chemical Reduction.

Molin, J, Jim Mueller, Fayaz Lakhwala and Richard Brown. 2006. ISCO or ISCR: Site-Specific Factors to Consider when Selecting a Remedial Approach.

Dingens, M., J. Mueller and A. Seech. 2006. Catalyzed Permanganates for In Situ Stabilization of Organic and Inorganic Contaminants. US EPA 2006 Land Revitalization Summit. October 30 - November 1, 2006, Austin, Texas.
- Mueller, J. D. Hill, A. Seech, M. Duchene and Andrzej Przepiora. 2006. EHC-M™ for In Situ Chemical Reduction (ISCR) of Chlorinated Compounds and/or Immobilization of Arsenic and other Heavy Metals. Florida Remediation Conference. November 14-15, 2006, Kissimmee, Florida.
- Harman, T. and J. Mueller. 2006. Design and Selection Criteria for Implementing In Situ Chemical Reduction (ISCR) Technologies Within the State of Florida. Florida Remediation Conference. November 14-15, Kissimmee, 2006, Florida.
- Moreno, J., J. Mueller, M. Duchene and J. Hull. 2007. Funnel and Reactive Gate Designs for In Situ Sediment Treatment. EPRI MGP 2007 Symposium - Advances and Innovation in MGP Site Remediation. January 8-11, 2007 Atlanta Georgia.
- Mueller, J., J. Moreno, F. Lakhwala, A. Seech, M. Okin, H. Slagle, W. Fisher and C. Sweeney. 2007. In Situ Biogeochemical Stabilization and Flux Reduction of MGP Constituents using Catalyzed Permanganate. EPRI MGP 2007 Symposium - Advances and Innovation in MGP Site Remediation. January 8-11, 2007 Atlanta Georgia.
- Mueller, J., and A. Seech. 2007. In Situ and On-Site Bioremediation Technologies for Impacted Sediments. Battelle's Fourth International Conference on Remediation of Contaminated Sediments. January 22-25, Savannah, Georgia, USA.
- Vogan, J., J. Mueller, J. Hull and D. Reible. (2007). Laboratory Testing of AquaBlok+™ for Capping of Contaminated Sediments. Battelle's Fourth International Conference on Remediation of Contaminated Sediments. January 22-25, Savannah, Georgia, USA.
- Montgomery, M., C. Osburn, S. Walker, T. Boyd, J. Mueller, Q. Li, H. Perl, F. Montiel-Rivera and J. Hawari. (2007). 2,4,6-Trinitrotoluene (TNT) Biodegradation in Coastal Waters and Sediments. 17th Annual AEHS West Coast Conference on Soils, Sediments, and Water. March 19-22, 2007, San Diego, California.
- Mueller, J., J. Molin, A. Seech and J. Vogan. (2007). Comparative Analysis of Contaminant Removal Mechanisms under Reduced Environments. 17th Annual AEHS West Coast Conference on Soils, Sediments, and Water. March 19-22, 2007, San Diego, California.
- Peale, J., E. Bakkom, F. Lakhwala, J. Mueller, J. Moline and P. Dennis. (2007). Integrated Use of EHC™ and KB-1 for Source Area Treatment and PRB Application at a TCE-Impacted Site.

Mueller, J. J. Moreno, M. Duchene and J. Hull. (2007). In Situ Sediment Treatment using AquaBlok+ for Horizontal Permeable Reactive Barriers.

Mueller, J., D. Hill, A. Seech, M. Duchene and A. Przepiora. (2007). EHC-M™ for In Situ Chemical Reduction of Chlorinated Compounds and Simultaneous Immobilization of Heavy Metals.

Mueller, J., J. Molin, T. Harman and D. Brown. (2007). Design and Selection Criteria for Implementing In Situ Chemical Reduction (ISCR) Technologies.

Mueller, J. J. Moreno, F. Lakhwala, A. Seech, M. Okin, H. Slagle, W. Fisher and C. Sweeney. (2007). Catalyzed Permanganate for In Situ DNAPL Stabilization and Flux Reduction.

Biteman, S., J. Valkenburg, S. MacFabe, J. Mueller and J. Molin. (2007). Pilot-Scale Reductive Dechlorination of Carbon Tetrachloride in Groundwater.

Hill, D., A. Seech, K. Bolanos-Shaw, E. Dmitrovic and J. Mueller. (2007). Upgradient Reactive Zones of EHC™ for Treatment of Multiple Chlorinated Organic Compounds. Battelle's Ninth International In Situ and On-Site Bioremediation Symposium, May 7-10, 2007, Baltimore, MD.

### Patents (5)

- Mueller, J.G. and P.J. Chapman. 1992. Biological Remediation of Creosote- and Similarly-Contaminated Sites. U.S. Patent Office No. 5,132,224; EC Patent Number EP O 404 466 B1 (December 27, 1990).
- Mueller, J.G. and P.J. Chapman. 1993. Biological Remediation of Creosote- and Similarly-Contaminated Sites Using Pseudomonas paucimobilis strain EPA505. U.S. Patent Office No. 5,242,825.
- Mueller, J.G., S.E. Lantz and P.H. Pritchard. 1997. Bioremediation of Soil or Groundwater Contaminated with Compounds in Creosote by Two-Stage Biodegradation. U.S. Patent Office No. 5,614,410.
- Spargo, B.J. and J.G. Mueller. (filed 1995). Field Kit for Determining Biotreatability of Polycyclic Aromatic Hydrocarbons. Filed February 15, 1995.
- Bernhardt, B., W.L. Langley, E. Klingel, F. Lakhwala, and J.G. Mueller. 1999. Bioremediation well and method for bioremediation treatment of contaminated water. US Patent 5,910,245 (June 8, 1999).
- Mueller, J.G., E. Dmitrovich and A. Seech. (2006). In situ biogeochemical stabilization technology. Pending.
- Mueller, J.G. and J. Hull.. (2006). Reactive capping matrices for sub-aqueous treatment barriers. Pending.
- Hull, J. and J. Mueller (2006). Reactive hole plug and subsurface sealant for pollution prevention. Pending.

## RESUME

### Education

B.S., 1963, The City College of New York  
M.S., 1965, University of North Carolina at Chapel Hill  
Ph.D., 1968, University of North Carolina at Chapel Hill

### Present Titles

President of Geohazards, Inc.  
Professor Emeritus of Geological Sciences, University of Florida  
Specialties: Sedimentary Geology, Limestones, Karst Hydrogeology, Environmental Geology

### Licenses

Registered Professional Geologist, State of Florida, Registration No. 3  
Registered Professional Geologist, State of Georgia, Registration No. 1136

### Academic Experience

Professor Emeritus, Department of Geological Sciences, University of Florida, 2003-present  
Chairman, Department of Geology, University of Florida, 1988-1995  
Professor, Department of Geological Sciences, University of Florida, 1977-2003  
Associate Professor, Department of Geology, University of Florida, 1972-77  
Assistant Professor, Department of Geology, University of Florida, 1967-72  
Director for Research Development, College of Liberal Arts and Sciences, 1982-88  
Associate Dean for Research, Division of Sponsored Research, 1979-82  
Assistant Director, Division of Sponsored Research, 1977-79  
Visiting Professorships: University of Oxford, England, 2001  
Brigham Young University, 1972  
University of North Carolina at Chapel Hill, 1968  
City College of New York, 1965

### Professional Experience

Co-Principal, Geohazards, Inc., Gainesville, FL 1985-present  
Member, Governor's Board of Professional Geologists, 1987-98  
Member, Board of Directors, Oak Ridge Associated Universities, 1987-1996  
Member, Board of Directors, Coastal Caribbean Oils and Minerals, LTD, 2005-2008

## **Pertinent Publications**

Smith, D.L., and Randazzo, A.F., 1975, Detection of Subsurface Solution Cavities in Florida Using Electrical Resistivity Measurements, *Southeastern Geology*, 16, 227-240.

Smith, D.L. and A.F. Randazzo, 1986, Evaluation of Electrical Resistivity Methods in an Investigation of Karstic Features, El Cajon Dam Site, Honduras, *Engineering Geology*, 22, 217-230.

Smith, D.L., and Randazzo, A.F., 1986, Assessment by Electrical Resistivity Methods of Potential Geological Hazards in Karstic Terranes, in *Environmental Problems in Karst Terranes and their Solutions*, Nat'l. Water Well Assn., 487-501.

Smith, D.L., and Randazzo, A.F., 1987, Application of Electrical Resistivity Methods to Identify Leakage zones in Drained Lakes, in Beck, B.F., and Wilson, W.L., editors, *Karst Hydrogeology: Engineering and Environmental Applications*, Balkema Publ., 227-234.

Smith, D.L., and Randazzo, A.F., 1989, Application of Electrical Resistivity Measurements in the Identification of Preferred Zones of Groundwater Transmissivity, in *Proceedings of Third National Outdoor Action Conf.*, National Water Well Assoc., pp. 979-992.

Randazzo, A.F., 1997, The Sedimentary Platform of Florida: Mesozoic to Cenozoic: in *The Geology of Florida*, Randazzo, A.F. and Jones, D.S. (eds.). University of Florida Press. p. 39-56.

Upchurch, S.B. and Randazzo, A.F., 1997, Environmental Geology of Florida: in *The Geology of Florida*, Randazzo, A.F. and Jones, D.S. (eds.). University of Florida Press. p. 217-249.

Randazzo, A.F. and Jones, D.S., (eds.), 1997, *The Geology of Florida*, University of Florida Press. 327 p.

Denizman, C. and Randazzo, A. F., 2000, Post-Miocene Subtropical Karst Evolution, Lower Suwannee River Basin, Florida. *Geological Society of America Bulletin*, v. 112, p. 1804-1813.

Hirsch, J. D. and Randazzo, A. F., 2000, Hydraulic Seepage Within an Astatic Karst Lake, North-Central Florida. *Proceedings of the International Association of Hydrogeologists, XXXth Congress on Groundwater: Past Achievements and Future Challenges*, Cape Town, South Africa. A. A. Balkema publishers, Rotterdam, p. 159-164.

Smith, D.L. and Randazzo, A.F., 2003, Application of Electrical Resistivity Measurements to Evaluation of a Potential Landfill Site in a Karst Terrain, *Environmental Geology*, v. 43, p. 743-751.

Randazzo, A. F. and Smith, D. L., 2003, Subsidence-induced Foundation Failures in Florida's Karst Terrain. Sinkholes and the Engineering and Environmental Impacts of Karst; The Geo-Institute of the American Society of Civil Engineers, Geotechnical Special Publication No. 122, p. 82-94.

### **Pertinent Abstracts**

- Randazzo, A.F., Butler, G., Denizman, C., and Baker, R., 1995, The origin of a high transmissivity zone in the Floridan aquifer system and its relevance to Karst: International Symposium and Field Seminar on Karst Waters and Environmental Impacts, Antalya, Turkey, Program and Abstracts, p. 63-64.
- Hirten, J. J. and Randazzo, A. F., 1998, Geochemical and hydraulic dynamics between the Upper Floridan Aquifer System and the Suwannee River: International Association of Hydrogeologists, XXVIII Congress, Las Vegas, Nevada, p. 35.
- Smith, D. L. and Randazzo, A. F., 1999, Application of electrical resistivity measurements to an evaluation of a potential landfill site: Geological Society of America, Abstracts with Programs, v. 31, n. 3, p. A-68.
- Randazzo, A. F., Smith, D. L., Commins, K., and Dodek, B., 2002, Sinkhole activity in Florida: causes, occurrences, and solutions. Proceedings of the Symposium, Karst Frontiers: Florida and Related Environments. Karst Waters Institute, Special Publication No. 7, p. 49-50.

### **Pertinent Research Grants and Contracts**

- Horsley and Witten, Inc. Subcontract to a U.S. E.P.A. contract WA 1-06, Alternatives For Disposal Of Treated Municipal Wastewater In South Florida. 2000-2001, \$ 8,000.
- St. Johns River Water Management District: Assessment of Lakes and Ground-Water Levels In the St. Johns River Water Management District- Phases I & II: Contract Numbers 97W117 and 98W139, 1996-1998, \$40,000.
- United States Geological Survey: Surface Water/Ground Water Interactions in the Suwannee River Basin, Florida: Cooperative Agreement Number 1434-94-A-1274, 1994-1996, \$26,000.
- United States Geological Survey: Characterization of Carbonate Rock Confining Sequences for Deep Well Injection Disposal Systems: Project Number FL-06, 1993-1995, \$35,710.
- .

### **Selected Professional Society Activities and Honors**

Astor Visiting Lecturer, University of Oxford, England, United Kingdom, 2001  
Teacher of the Year, College of Liberal Arts and Sciences, University of Florida, 2000  
J. William Fulbright Senior Research Scholar, 1995-96, Budapest, Hungary  
General Chairman, Geological Society of America, Annual Meeting, Orlando, Florida, 1985  
President, Sigma Xi, The Scientific Research Society - University of Florida Chapter, 1984-85

### **Biographical References**

Who's Who in the South and Southwest  
American Men and Women of Science  
Who's Who in Science and Technology

### **Memberships**

Geological Society of America - FELLOW  
American Geophysical Union  
American Institute of Professional Geologists



# Resume

## Tom Sale

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Engineering Research Center, Room B-01  
Fort Collins, Colorado 80523  
CSU (970) 491-8413 Home (970) 482-1793  
TSale@Engr.ColoState.Edu

### ***Education***

#### **Colorado State University 1994-1998 - Ph.D. Agricultural Engineering, May 1998 -**

Course work included multiphase-flow, chemical equilibria in soils, contaminant transport in porous media, and upper level math. Working under the guidance of Dr. David McWhorter, Dr. Sale's dissertation focused on quantification of mass transfer from nonaqueous phase liquids (NAPLs) in field settings and the benefits of NAPL source zone remediation. The Solvents in Groundwater Research Consortium (University of Waterloo) and the Boeing Contaminant Hydrology Fund (Colorado State University) funded this research.

#### **University of Arizona 1983-1984 - MS Watershed Hydrology, December 1984 -**

Interdisciplinary course work included groundwater hydrology, unsaturated flow, surface water hydrology, and water quality. Working under the guidance of Dr. John Thames, Dr. Sale's thesis research focused on measuring and modeling seepage losses from reservoirs in southeastern Arizona. The Salt River Project and the US Forest Service provided funding.

**Miami University (Ohio) 1976-1980 - BA Chemistry, May 1980 -** An accelerated chemistry curriculum designed for students planning careers in chemistry. **BA Geology, September 1980 -** Broad geology curriculum with specific emphasis in hydrogeology.

### ***Professional Positions***

**Director of the Center for Contaminant Hydrology in Civil and Environmental Engineering at Colorado State University (2005-Present) -** Dr. Sale has been the primary force behind the development of the Center for Contaminant Hydrology in the Department of Civil and Environmental Engineering at Colorado State University. Currently, the Center conducts approximately \$1,000,000/year in research and supports five graduate students and one undergraduate student. Current funding comes from the University Consortium for Field-Focused Groundwater Contamination Research, DuPont, US DoD - Environmental Securities Testing and Certification Program, Suncor Energy, American Petroleum Institute, ExxonMobil, GE, ARCADIS, and CH2M HILL. In the last 6 years the Center has acquired five complete and two pending patents.

**Colorado State University – Associate Professor (2009-Present) and Research Scientist / Assistant Professor (1999 – 2009)** - Since receiving his PhD Dr. Sale has been conducting groundwater research and teaching at Colorado State University. To date, Dr. Sale has been integral in gaining funding for and executing \$4,000,000 in funded research. Since 2000 Dr. Sale has advised 17 students (5 Ph.D. /12 M.S.) students, served on 6 graduate committees (2 Ph.D./4 M.S), and funded 19 graduate students. Details are provided below.

| PH.D.  | ADVISOR/<br>CO-<br>ADVISOR | COMMITTEE<br>MEMBER | STATUS<br>ONGOING/<br>COMPLETED | FUNDING   | INSTITUTION         |
|--|----------------------------|---------------------|---------------------------------|-----------|---------------------|
| Mitch Olson                                    | x                          |                     | ongoing                         | x         | CSU                 |
| Azadeh Bolhari                                 | x                          |                     | ongoing                         | x         | CSU                 |
| Jens Blotevogel                                | x                          |                     | ongoing                         | x         | CSU                 |
| Matt Petersen                                  | x                          |                     | 2007                            | x         | CSU                 |
| Maria Raynal- Gutierrez                        | x                          |                     | 2007                            | x         | CSU                 |
| Osama S. Al-Gahtani                            |                            | x                   | 2006                            |           | CSU                 |
| David Hubble                                   |                            | x                   | 2003                            |           | Univ. Waterloo      |
| <b>Ph.D. Total</b>                             | <b>5</b>                   | <b>2</b>            | <b>3/4</b>                      | <b>5</b>  |                     |
| <b>M.S.</b>                                    |                            |                     |                                 |           |                     |
| Ahmed Eldeirly                                 | x                          |                     | ongoing                         | x         | CSU                 |
| Nick Mahler                                    | x                          |                     | ongoing                         | x         | CSU                 |
| Gustavo Vianna                                 | x                          |                     | ongoing                         | x         | CSU                 |
| Eric Petersen                                  | x                          |                     | ongoing                         | x         | CSU                 |
| Jong Hyun Lee                                  |                            | x                   | ongoing                         |           | CSU                 |
| Hamad M. Al-Gahtani                            |                            | x                   | 2008                            |           | CSU                 |
| Tim Smith                                      | x                          |                     | 2008                            | x         | CSU                 |
| Lee Ann Doner                                  | x                          |                     | 2008                            | x         | CSU                 |
| Kristin Sample                                 |                            | x                   | 2007                            | x         | CSU                 |
| Gabriel Iltis                                  | x                          |                     | 2007                            | x         | CSU                 |
| Dave Castlebaum                                | x                          |                     | 2007                            | x         | CSU                 |
| Brian Twitchell                                | x                          |                     | 2006                            | x         | CSU                 |
| Mitch Olson                                    | x                          |                     | 2005                            | x         | CSU                 |
| Bart Wilken                                    |                            | x                   | 2004                            |           | Colo. Sch.<br>Mines |
| Ryan Taylor                                    | x                          |                     | 2004                            | x         | CSU                 |
| Matt Petersen                                  | x                          |                     | 2003                            | x         | CSU                 |
| <b>M.S. Total</b>                              | <b>12</b>                  | <b>4</b>            | <b>5/11</b>                     | <b>13</b> |                     |
| <b>Post Doctoral</b>                           |                            |                     |                                 |           |                     |
| Julio Zimbron                                  |                            |                     | 2004-2005                       | x         | CSU                 |
| <b>Total Ph.D., M.S. and<br/>Post Doctoral</b> | <b>17</b>                  | <b>6</b>            | <b>8/15</b>                     | <b>19</b> |                     |

In addition, Dr. Sale has provide technical guidance and funding for 14 undergraduate research assistants, advised five NSF REU students, advised three senior design project teams, and supported visiting researchers from Denmark, Thailand, and India.

**Independent Consulting Hydrologist (1995-Present)** - Dr. Sale has been working as an independent consulting hydrologist since 1995. Dr. Sale is currently reviewing the sustainability of groundwater production from the Denver Basin Aquifer for the City of Castle Rock, Colorado. In addition, Dr. Sale, in conjunction with Drs. Allan Freeze and Jim Mercer provided peer review of remedial measures at DOE's Rocky Flats Facility near Golden, Colorado. Dr. Sale is currently supporting efforts to manage subsurface hydrocarbons at 3 major US refineries. Key issues at these facilities include natural attenuation of petroleum hydrocarbons, technical practicability of LNAPL recovery, and

appropriate endpoints for mobile LNAPL recovery systems. Dr. Sale has provided technical support to a number of field demonstrations of remedial technologies. This includes projects in Melbourne, Australia; Commerce City, Colorado; Marietta, Georgia; and Ogden, Utah.

**CH2M HILL (1985-1995)** - Upon graduation from the University of Arizona Dr. Sale was employed by CH2M HILL in Denver, Colorado. Over 10 years with CH2M HILL Dr. Sale's responsibilities evolved through positions as a project hydrologist, project manager, department manager, and senior technical resource. Throughout Dr. Sale's career with CH2M HILL his primary focus was development of groundwater resources and mitigation of risks posed by subsurface contaminants. Highlights of Dr. Sale's career with CH2M HILL are described below.

- **Project Hydrologist/Project Manager** - As a project hydrologist and project manager Dr. Sale planned, implemented, and reported on a wide variety of hydrogeologic investigations conducted at locations across the western United States. Through this work Dr. Sale became familiar with a wide variety of hydrogeologic settings including the Columbia Lava Plateau, alluvial basins of the Southwest, fluvial systems of the western and central plains, alpine glacial deposits of the Rocky Mountains, Permian Formations of central Oklahoma, and bedrock aquifers of the Denver Basin. In addition, Dr. Sale gained extensive experience in the collection, evaluation, and documentation of hydrogeologic and water quality data.
- **Department Manager** - In 1989 Dr. Sale became the manager of CH2M HILL's Denver Groundwater Resources Department. As a complement to project work Dr. Sale was responsible for hiring, maintaining workload, staff career development, marketing, strategic planning, and overall department profitability. In this role Dr. Sale increased the department staff from 6 to 18 and diversified the department's workload to include site characterization, remedial design, water supply, and modeling projects. Through these efforts and extensive training provided by CH2M HILL, Dr. Sale gained the skills needed to successfully develop and manage diverse groups of people. Dr. Sale's responsibilities as department manager were concluded in 1994 after successfully training his replacement.
- **Technical Resource** - Through the later half of his career with CH2M HILL Dr. Sale's efforts focused on technical support for projects involving groundwater contamination resulting from Nonaqueous Phase Liquids (NAPLs). In this role Dr. Sale assisted with development of new business, technology transfer within CH2M HILL, and mentoring junior staff. In recognition of Dr. Sale's abilities was invited to speak at a large number of workshops, conferences, short courses, and seminars.

After ten years with CH2M HILL Dr. Sale enrolled in the Ph.D. program at Colorado State University under the direction of Dr. David McWhorter. Dr. Sale's goals in this endeavor were to expand his technical/research skills and to position himself for a career in academia.

**Engineering Enterprises Inc. (1981-1982)** - Upon completion of his undergraduate course work, Dr. Sale was employed as hydrogeologist and geochemist by Engineering Enterprises Inc. (EEI), Norman, Oklahoma. During Dr. Sale's two years with EEI his

activities focused on development of larger water supply wells, product recovery in refineries, and soil and groundwater monitoring systems for land treatment systems. Dr. Sale gained extensive experience with aquifer tests, geologic logging, geophysical logging, soils and groundwater sampling, design, operation, and repair of pumping systems, well drilling techniques, well construction techniques, and engineering consulting practices. After two years with EEI Dr. Sale enrolled at the University of Arizona with the goal of expanding his technical background in hydrology and water quality.

**Prior to Undergraduate Graduation (1980)** - From an early age Dr. Sale worked for his father's civil engineering firm. Experience included rodman, instrumentman, and draftsman. Dr. Sale gained broad exposure to fundamental engineering practices.

### ***Research Interests***

**Denver Basin Groundwater Resources (1998-Present)** - Explosive population growth along the Front Range of Colorado has led to the rapid development of the groundwater resources of the Denver Basin. Over the last ten years, working with Hemenway Groundwater Engineering, Dr. Sale has visually logged in excess of 120,000 linear feet of Denver Basin sediments. Coupling this information with geophysical logs and pump test data, Dr. Sale and Mr. Hemenway are accumulating data that will advance the current state of knowledge regarding the sustainability of groundwater production in the Denver Basin. Building on this, Dr. Sale was hired by the City of Castle Rock, Colorado in the fall of 2006 to advise them on the long term sustainability of groundwater production from the Denver Basin Aquifers.

**ZVI-Clay (2002-Present)** - In 2002 DuPont donated patents to Colorado State University (CSU) regarding treatment of spills of chlorinated compounds using reactive media, stabilizing agents, and soil mixing techniques. This technology holds the promise of being more effective and less costly than competing options for management of chlorinated compounds in soil and groundwater. Presently, funds supporting related research and development are approaching \$1,200,000 per year. Formal partnering agreements are in place with CH2M HILL, and ARCADIS. To date eight sites have used the ZVI-Clay remediation technology resulting in royalty payments to Colorado State University in excess of \$250,000.

**Electrically Induced Redox Barriers (1998 - Present)** - A primary focus of Dr. Sale's research is the use of electrically induced redox barriers for in-situ treatment of contaminated groundwater, Sale and Gilbert (2002). This concept involves closely spaced (e.g. 0.01 – 0.01 m) permeable electrodes installed in a trench that intercepts a plume of contaminated groundwater. Application of an electrical potential to the aqueous media results in oxidation at the positive electrode and reduction at the negative electrode. To date treatment efficacy has been demonstrated for chlorinated ethenes, chlorinated ethanes, energetics, and arsenic. Laboratory studies have led to field demonstrations at Canadian Forces Base, Borden, Ontario (November, 2001), F.E. Warren Air Force Base, Wyoming (August 2002), and Pueblo Chemical Depot, Colorado (January 2006). Results from our laboratory studies are described in Gilbert and Sale (2002), Petersen et al., (2006) and Gilbert et al., (2006). Support on the order

of \$1,100,000 has been obtained from the University Consortium for Field-Focused Groundwater Contamination Research, National Science Foundation, Environmental Security Technology Certification (ESTCP), Strategic Environmental Research Development Program (SERDP), and United Technologies Corporation.

**Mass Transfer from Field-Scale NAPL Sources and the Benefits of Partial NAPL Source Zone Remediation (1996-Present)** - For his dissertation, Dr. Sale and Dr. David McWhorter (Colorado State University) worked to resolve the benefits of partial mass removal from subsurface NAPL zones. This involved laboratory studies, analysis of field data, and assistance with the development of a Multiple Analytical Source Superposition Technique (MASST). Through application of MASST it has been shown that very high NAPL mass removal efficiencies are required to achieve significant near term exposure reductions. This research is described in Sale (1998) and Sale and McWhorter (2001). The significance of the results led to comments on results (P.S. Rao and J.W. Jawtiz) and response to comments (Sale and McWhorter) that were published in Water Resource Research Fall 2002. Building on this work Dr. Sale was awarded \$425,000 by the Air Force Center for Environmental Excellence (AFCEE) in October 2002. This funding has been the seed project for developing a decision guide for the US DoD regarding when to invest in NAPL source remediation. The value of this document will be avoidance of high cost remedies with low potential for risk reduction.

Reflecting the relevance of this research, Dr. Sale has been an invited speaker at the following conferences: National Research Council (NRC), San Diego, February (2001); Battelle Conference, San Diego, May (2001); Solvents Focus Meeting, Chicago October (2001); EPA DNAPL Workshop, Dallas, October (2001); SERDP/ESTCP Partners Conference, Washington, D.C. November (2001); AFCEE Remediation Workshop, San Antonio, March (2002); Battelle Conference, Monterey, May (2002); NRC, Washington D.C August (2002), Battelle Conference, Monterey, May (2004), ESTCP/SERDP Baltimore February 2006) and Battelle Conference, Monterey, May (2006). In addition, Dr. Sale was a member of an expert panels funded by the USEPA. A white paper presenting findings was released in 2005 (UESPA600/R-03/143). Dr. Sale was also a member of a NRC panel addressing benefits of subsurface remediation. This was released in 2005. Lastly, Dr. Sale has been funded to provide technical engineering reviews for the Air Force, Navy, NASA, and numerous petroleum companies regarding the efficacy of proposed NAPL remediation projects.

**Recovery of Mobile Product (1981-Present)** - In the early 1980s Dr. Sale worked on the design, construction, and operation of Light Nonaqueous Phase Liquid (free product) recovery systems at petroleum refineries in the U.S. At a facility in Tulsa, peak production of 90,000 gallons of gasoline/day was achieved from an alluvial aquifer. Building on this Dr. Sale has worked at 21 different petroleum refineries in the US and Puerto Rico. In the mid 1980s Dr. Sale developed the concept of Dense Nonaqueous Phase Liquid (DNAPL) recovery using waterflooding and horizontal drains (Sale and Applegate, 1997). In Laramie, Wyoming, this technology achieved a record recovery of 1,800,000 gallons of DNAPL. Variations of this technology have been applied at two US refineries, two wood-treating facility, and a former manufactured gas plant.

Reflecting his experience with managing releases of fuel hydrocarbons, the American Petroleum Institute (API) funded Dr. Sale to work on Pump and Treat: The Petroleum Industry Perspective, Glass et al., (1992); An Evaluation of Field Methods for Intrinsic Bioremediation Measurements, Piontek et al., (1994); Methods for Determining Inputs to

Environmental Petroleum Hydrocarbon Mobility and Recovery Models, Sale (2001); and Frequently Asked Questions About Managing Risk at LNAPL Sites, Sale (2002). API and its sponsors are now using the latter two documents for training. Their value will be to build a common understanding of technical issues and pragmatic constraints.

Building on results from Dr. Sale 's most recent API publications, he has embarked on a new research initiative focused on *in situ* measurement of LNAPL seepage velocities. Following well bore dilution techniques, the disappearance of a tracer in LNAPL (in a well) is being used to estimate formation LNAPL seepage velocity, Sale et al., (2006). Results to date are promising. Given success, the tools developed through this research will play a major role in resolving the potential mobility of subsurface LNAPL, appropriate endpoints for NAPL deletion, and a potential means of long term monitoring.

**Surfactant and Cosolvent Flushing (1986-1998)** - In the early 1980's Dr. Sale was funded by Sun Oil Company to study the potential for surfactant-enhanced recovery of NAPL. From 1986-1989 Dr. Sale was the technical lead of a project team that developed the first field demonstration of Surfactant Flushing (Sale et al., 1988) and the largest (to date) surfactant flood Sale (1996). Building on this Dr. Sale was successful in a proposal for \$250,000 to Rice University (Advanced Applied Technology Demonstration Facility) for development of a Technical Practices Manual for Surfactant and Cosolvent Flushing. Coauthors of the published book (Simpkin et al., 1999) were Dr. Bernard Kueper, Queens University; Dr. Tom Simpkin, CH2M HILL; and Dr. Malcolm Pitts, SURTEK INC. This comprehensive analysis includes: 1) review of surfactant/cosolvent field demonstrations, 2) surfactant/cosolvent enhanced recovery processes, 3) a step-wise approach for implementation of surfactants/cosolvent flushing projects, and 4) screening tools for analysis of the applicability including rigorous consideration of cost.

**Natural Attenuation of Dissolved Hydrocarbons (1993-Present)** - Dr. Sale worked with Phillips Petroleum and CH2M HILL to evaluate natural attenuation of fuel hydrocarbons at a former natural gas plant. Work at this site led to one of the earliest demonstrations of 1) the use of sulfate as an electron acceptor and 2) increases in alkalinity attributable to anaerobic degradation of petroleum hydrocarbons. Results were published in the Society of Petroleum Engineering's Advanced Technologies Series, Health, Safety, and Environmental Issues (Admire, 1996).

***In Situ* Treatment Process Development Program (1987-1990)** - While working for CH2M HILL Dr. Sale was a lead in proposing, and subsequently conducting, a four year \$15 million insitu treatment technology development program. Work was conducted for Union Pacific Railroad at their former tie-treating plant in Laramie, Wyoming. The focus of the effort was to find remedial alternatives to incineration. Activities focused on design, implementation, and evaluation of small and large-scale field demonstrations. Technologies considered included waterflood DNAPL recovery, surfactant enhanced DNAPL recovery, and in-situ bioremediation. Through this pioneering effort a number of significant breakthroughs were achieved including:

- Development of a dual drainline waterflood DNAPL recovery technology. Full-scale application of this technology has resulted in the production of 1.8 million gallons of DNAPL (Sale and Applegate, 1997).

- The first (Sale et al., 1989) and the largest (Sale et al., 1994) field demonstrations of surfactant flushing.
- Identification of the limitations of oxygen cycling for enhanced bioremediation of NAPL zones (Simpkin et al., 1991).
- Documentation of the technical impracticability of restoring DNAPL zones to drinking water standards (Sale and Piontek, 1992).

**Model for Prediction of Seepage Losses from Small Unlined Water Impoundments (1983-1984)** - As a research assistant at the University of Arizona Dr. Sale developed a model that estimates seepage losses from unlined reservoirs in southeastern Arizona. Finite difference techniques were applied to the Green-Ampt equation. Model validation was accomplished through comparison with historical data obtained from the Walnut Gulch Experimental Watershed, Tombstone, Arizona. Results of this effort were documented in Dr. Sale's Master's Thesis (Sale, 1985).

### ***Teaching Experience***

Dr. Sale has taught three undergraduate classes, four graduate classes, and multiple short courses. Courses taught at Colorado State University are reviewed below.

- **CE - 423 Groundwater Engineering** (Spring 2005, 2006, and 2007) – This is an undergraduate level introduction to groundwater hydrology. Topics addressed include the role of groundwater in the hydrologic cycle, morphology of aquifers, groundwater movement, elastic properties, flow equations, hydraulic testing, groundwater as a resource, well design /construction, and groundwater in the basin hydrologic cycle. Examples from Colorado based groundwater projects are highlighted to help students appreciate the utility of the presented material.
- **CE – 658 Subsurface Remediation** (Spring 2004) - This course carries students through the steps of developing engineered solutions for anthropogenic releases of hazardous compounds. Fundamentals of engineering are applied including application of first principles learned in earlier coursework, conducting design calculations, and analysis of project costs. A pre-release draft of Contaminants in the Subsurface: Source Zone Assessment and Remediation, a National Research Council Book on which I was a co-author (NRC 2005) was the course text.
- **CE – 680 - Solutions to Subsurface Releases** (Spring 2003 and 2008) – This follows the above description of CE-658.
- **CE – 531 Groundwater Hydrology** (Fall 2001) – This is a graduate level introduction to groundwater hydrology. This is similar to CE 423 (described above) but with more rigor. Topics addressed included role of groundwater in the hydrologic cycle, morphology of aquifers, groundwater movement, elastic properties, flow equations, hydraulic testing, groundwater as a resource, well design/construction, and groundwater in the basin hydrologic cycle.



### ***Awards - Recognition***

Selected as the academic representative to 2008-2009 Interstate Remediation Council's panel advancing guidance for use of combined remedies for subsurface releases of chlorinated solvents

Member of the 2003-2005 National Research Council Committee addressing Contaminants in the Subsurface – Source Zone Assessment and Remediation

Member of the 2003-2005 USEPA Advisory Panel Addressing The DNAPL Remediation Challenge: Is There a Case for Source Depletion?

Research Faculty Award for Excellence – Colorado State University - 2003

American Geophysical Union - Best Ph.D. Presentation - Seventh Annual Hydrology Days Conference, Fort Collins, Colorado. April 1997.

Colorado Ground Water Association - Harlan Erker Scholarship 1996.

CH2M HILL Office of Innovation - Innovation Award for the Union Pacific Railroad *In Situ* Treatment Process Development Program 1992.

### ***Professional Affiliations***

National Ground Water Association  
Interstate Remediation Council

### ***Professional Registrations***

Professional Geologist Wyoming, No. PG-1954 (Since 1992)

### ***Peer Reviewed Publications***

#### **Journals**

##### ***Published***

Sale, T., J. Zimbron, and D. Dandy, (2008), Effects of reduced contaminant loading on downgradient water quality in an idealized two layer system, *Journal of Contaminant Hydrology*, Vol 102, pp 72-85.

Sale, T., G. Taylor, G. Iltis, and M. Lyverse, (2007), Measurement of LNAPL Flow Using Single-Well Tracer Dilution Techniques, *Ground Water*, Vol. 45, No.5, September-October, pp. 569-578.

Petersen, M.A. , T.C. Sale, and K. F. Reardon,(2007), Electrolytic trichloroethene degradation using mixed metal oxide coated titanium mesh electrodes, *Chemosphere* Volume 67, Issue 8, April 2007, Pages 1573-1581.

- Gilbert, D. and T. Sale. (2005), Sequential Electrolytic Oxidation and Reduction of Aqueous Phase Energetic Compounds. *Environmental Science Technology* 39:9270-9277.
- McWhorter, D. and T. Sale, (2003), Reply to comments by P.S.C. Rao and J.W. Jawitz on "Steady state mass transfer from single-component dense nonaqueous phase liquids in uniform flow fields" by T.C. Sale.
- Sale, T. and D. McWhorter, (2001), Steady-state mass transfer from single-component DNAPLs in uniform flow fields. *Water Resources Research*, 37(2): 393-404.
- Sale, T. and D. Applegate. (1997). Mobile NAPL recovery: Conceptual, field, and mathematical considerations. *Ground Water*. 35(3). pp. 418-426.
- Sale, T. and D. Applegate. (1996). Oil recovery at a former wood-treating facility. *Water Environment Research*. 68(7). pp. 1116-1122.
- Admire, J., J. de Albuquerque, J. Cruze, K. Piontek, and T. Sale, (1996), Case Study: Natural Attenuation of Dissolved Hydrocarbons at a Former Natural Gas Plant. *Society of Petroleum Engineers . Advanced Technologies Series, Health, Safety, and Environmental Issues*. SPE 29755, Pages 619-630.

### ***In Review***

- Castelbaum, D., M. Olson, T. Sale, and C. Shackelford, (2010), Laboratory Apparatus and Procedures for Preparing Test Specimens of Slurry Mixed Soils, *ASTM Geotechnical Testing Journal*, In Review.
- Bolhari, A., T. Sale, and J. Zimbron, (2010), Conceptual Model and Laboratory Studies Addressing Treatment of Contaminants Stored in Low Permeability Zones, *Journal of Contaminant Hydrology*, In Review.
- Smith, T., T. Sale, and M. Lyverse, (2010), Measurement of LNAPL Flux Using Single Well Intermittent Mixing Tracer Dilution Tests, *Journal of Groundwater*, In Review.

### **Books**

#### ***Published***

- National Research Council, (2005), Contaminants in the Subsurface – Source Zone Assessment and Remediation. National Academy Press, Washington, D.C.
- Simpkin T., T. Sale, B. Kueper M. Pitts, and K. Wyatt, (1999), Surfactants and Cosolvents for NAPL Remediation: A Technology Practices Manual, ATDF Editors. Lowe, D.F., K., Oubre, C.L., Ward, C.H., Lewis Publishers.

#### ***In Print***

Sale, T., C. Newell, and Hans Stroo (2009), Chlorinated Solvent Releases The dependence of plumes on source zones, Chapter Section of ESTCP/SERDP Remediation Technology Monograph.

Gilbert, D., T. Sale, and M. Petersen, (2009), Electrolytic Reactive Barriers (e<sup>-</sup>barriers), Chapter Section of ESTCP/SERDP Remediation Technology Monograph.

### **Patents**

#### ***Final***

Sale, T, G.Taylor, and M. Lyverse, (2007), Measurement of Nonaqueous Phase Liquid Flow in Porous Media by Tracer Dilution, United States Patent 2007/0113676A1.

Sale, T. and D. Gilbert, (2004), Redox Water Treatment System. United States Patent 6,709,567 B1.

Sale, T.C. and D.M. Gilbert, (2002), Redox Water Treatment System. United States Patent 6,342,150 B1.

#### ***Pending***

Sale, T., T. Smith, and M. Lyverse, (2009), Measurement of Liquid Flow in Porous Media By Tracer Dilution Without Continuous Mixing, Pending US Patent Application.

### **Peer Reviewed Industry / Federal Agency Publications**

Sale, T., C. Newell, H. Stroo, R. Hinchee, and P. Johnson, (2008), Frequently Asked Questions Regarding Management of Chlorinated Solvent in Soils and Groundwater, Developed for the Environmental Security Testing and Certification Program (ER-0530).

Sale, T. T. Illangasekare, J. Zimbron, D. Rodriguez, B. Wilking, and F. Marinelli, (2007), AFCEE Source Zone Initiative, Project report developed for the Air Force Center for Environmental Excellence.

USEPA, (2003), The DNAPL Remediation Challenge: Is There a Case for Source Depletion? USEPA\600\R-03\143.

Sale, T. (2003), Answers to Frequently Asked Questions About Managing Risk at LNAPL Sites, American Petroleum Institute, Soils and Groundwater Research Bulletin No. 18.

Sale, T., (2001), Methods for Determining Inputs to Environmental Petroleum Hydrocarbon Mobility and Recovery Models, *American Petroleum Institute Publication No. 4711*.

Sale, T., M. Pitts, K. Wyatt, and K. Piontek. (1996). Chemically enhanced in situ recovery. Chapter 11, *In Situ Remediation of DNAPL Compounds in Low Permeability Media Fate/Transport, In Situ Control Technologies, and Risk*

*Reduction; ORNL/TM-13305*. Oak Ridge National Laboratory, Oak Ridge, TN. pp. 11-1-11-17.

Glass J., H. Hopkins, T. Sale, J. de Albuquerque, and others. (1992), Pump and Treat: The Petroleum Industry Perspective. *American Petroleum Institute Publication 4561*. December.

### **Referred Conferences**

Shackelford, C., T. Sale, and M. Liberati, (2005). In-Situ Remediation of Chlorinated Solvents using Zero Valent Iron and Kaolin Mixtures: A Case History. *Geo-Frontiers* ASCE, Reston. VA.

### **Dissertation and Thesis**

Sale, T., (1998), Interphase Mass Transfer from Single Component DNAPLs. *Ph.D. Dissertation, Department of Chemical and Bioresource Engineering*, Colorado State University, Fort Collins, Colorado.

Sale, T., (1985), Model for Prediction of Seepage from Small Unlined Water Impoundments. *MS Thesis, Department of Watershed Management*, University of Arizona, Tucson, Arizona.

### **Conference Presentations**

Sale, T. and C. Newell, (2009), Guide for Selecting Remedies for Subsurface Releases of Chlorinated Solvents (ER-0530), Short Course Presented at 2009 ESTCP/SERDP Partners Meeting Washington, D.C.

Sale, T. , (2009), Roles and Strategies for High Resolution Data Acquisition and Modeling - Overview and Logistics, University Consortium for Field-Focused Groundwater Contamination Research, 2009 Focus Meeting, Brown Palace Hotel, Denver, Colorado, October 20 and 21, 2009.

Sale, T and C. Newell, (2009), Mapping Remedial Methods Using the 14 Compartment Model Annual Meeting of the University Consortium for Field-Focused Groundwater Contamination Research, Guelph, Ontario, May 19-21 University of Guelph, Ontario May 19-20, 2009.

Sale, T (2009), Emerging Concepts in Subsurface Contaminant Transport and Remediation, Presented at 2009 ITRC Fall Meeting, Louisville, Kentucky.

Sale, T., (2009), Effects of Persistent Contaminants Stored in Low Permeability Zones, Presented at RemTEC '09, Atlanta Georgia, March 2, 2009.

Sale, T. (2009), FAQs and Decision Guide for Chlorinated Solvents, 2009 Army Cleanup Workshop, San Antonio, Texas, March 2009.

Sale, T. (2009), Diffusion, 14 Compartments and Sustainability, Sustainable Remediation Forum, Oakland CA, February 24-25, 2009.

Sale, T., C. Newell, H. Stroo, R. Hinchee, and P. Johnson (2008), Decision Guide for Selecting Remedies for Chlorinated Solvent Releases, Invited presentation at Partners in Environmental Technology Technical Symposium & Workshop Washington, D.C. December, 2008.

Sale, T. (2008), **Natural Attenuation - Tools for Quantification and Implications**, **University Consortium for Field-Focused Groundwater Contamination Research, 2008 Focus Meeting, Denver, Colorado, October 2008.**

Sale, T., C. Newell, A. Leeson, and H. Stroo, (2008), Remediation of Chlorinated Solvent, Workshop presented at New England Waste Management Association, Bedford, Massachusetts, April 9, 2008.

Sale, T. (2008), Emerging Concepts in Contaminant Fate and Transport, Invited presentation at National RCRA Corrective Action Conference, New Orleans, Louisiana, June, 2008.

Gilbert, D., T. Sale, and M. Petersen, (2008), Electrolytic Reactive Barriers for Treatment of Energetic Compounds in Groundwater, Battelle – Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, May 2008.

Sale, T. and S. Day, (2008), Overview of *In Situ* Soil Mixing Remediation Technologies, Battelle – Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, May 2008.

T. Sale, C. Newell, and H. Stroo, (2008), Overview of frequently asked questions and decision guide for chlorinated solvents, Presented at University Consortium for Field-Focused Groundwater Contamination Research Hockley Valley Resort, Orangeville, Ontario May, 2008.

Bolhari, A. and T. Sale, (2008), Resolving the Feasibility of Treating Contaminants Stored in Plumes in Sandy Aquifers, Presented at University Consortium for Field-Focused Groundwater Contamination Research Hockley Valley Resort, Orangeville, Ontario May, 2008.

Sale, T., C. Newell, and H. Stroo, (2007), Recent Advances in the Management and Remediation of DNAPL Source Zones, Workshop presented at Partners in Environmental Technology Technical Symposium & Workshop Washington, D.C. December, 2007.

Sale, T. and T. Illangasekare, (2007), AFCEE Source Zone Initiative, Presented at AFCEE Technology Transfer Workshop San Antonio, Texas, March, 2008

Leeson, A., C. Newell, and T. Sale (2007), DoD's Perspective on Recent Advances in the Management of DNAPL Source Zones, National Association of Remedial Project Managers, Baltimore Maryland, May 2007.

Sale, T. L. Doner, and E. Segar, (2006), Storage and Release of Contaminants in Low Flow Zones in Source Zones and Plumes, Presented at the AGU Fall Meeting, San Francisco, December 12, 2006

Gilbert, D., T.Sale, M. Pettersen, and B. Vencalek. (2006). Demonstration/Validation of Electrolytic Reactive Barriers for Treatment of Energetic Compounds in Groundwater at the Pueblo Chemical Depot (ESTCP ER0519). ESTCP/SERDP Partners in Remediation Conference, Washington D.C., November 27-30, 2006.

Sale, T., C. Newell, H. Stroo, R. Hinchee, and P. Johnson. (2006) Guides for Selecting Remedies for Chlorinated Solvents Releases (ER-0530). ESTCP/SERDP Partners in Remediation Conference, Washington D.C., November 27-30, 2006.

Sale, T., M.Olson, T. Simpkin, and C. Bozzini. (2006). In Situ Remediation of Chlorinated Solvents via Admixing Reactive Media and Stabilizing Agents (ZVI-Clay). ESTCP/SERDP Partners in Remediation Conference, Washington D.C., November 27-30, 2006.

Sale, T., L. Doner, and S. Chapman. (2006). Back Diffusion Laboratory Studies and Modeling. RTDF Permeable Reactive Barriers (PRB) Action Team Meeting, Charleston, South Carolina, October 11-12, 2006.

Sale, T., and M.Olson. (2006). Methods and Results from ZVI-Clay Studies. RTDF Permeable Reactive Barriers (PRB) Action Team Meeting, Charleston, South Carolina, October 11-12, 2006.

Sale, T. (2006). Emerging Technical and Policy Issues for Source Zones and Plumes. GE Remedial Council May 4-5, 2006, Jacksonville, Florida.

Sale, T. (2006). Surfactants Status after 18 Years of Field Studies. ESTCP/SERDP DNAPL Workshop, Baltimore, Maryland, March 7, 2006.

Bozzini, C., T. Simpkin, D. Hood, and T. Sale. (2006). DNAPL Remediation at Camp Lejeune Using Soil Mixing with ZVI-Clay. Battelle – Remediation of Chlorinated and Recalcitrant Compounds, April, 2006, Monterey, California.

Olson, M., T. Sale, and T. Simpkin. (2006). Admixing Reactive Media and Stabilizing Agents for Treatment of Source Zones – Laboratory Studies and Predictive Models, Battelle – Remediation of Chlorinated and Recalcitrant Compounds, April, 2006, Monterey, California.

Gilbert D., M. Petersen, and T. Sale. (2006). An Electrolytic Reactive Barrier for Treatment of Energetic Compounds. Battelle – Remediation of Chlorinated and Recalcitrant Compounds, April, 2006, Monterey, California.

Sale, T. (2006). Trichloroethene – How Recalcitrant are Recalcitrant Compounds - A Historical Perspective and Looking Forward. Battelle – Remediation of Chlorinated and Recalcitrant Compounds, April, 2006, Monterey, California.

Sale, T. (2006). ESTCP Guide for Management of Chlorinated Solvents. University Consortium for Field-Focused Groundwater Contamination Research 2006 Annual Progress Meeting, Orangeville, Ontario, May 9-12, 2006.

Sale, T., G. Amato, M. Olson, and J. Grant. (2006). ZVI-Clay - Driving technology use University Consortium for Field-Focused Groundwater Contamination Research 2006 Annual Progress Meeting, Orangeville, Ontario, May 9-12, 2006.

Rutherford, L., T. Sale, and D. Dandy. (2006). Water Quality Benefits of Upgradient Contaminant Flux Reduction. University Consortium for Field-Focused Groundwater Contamination Research 2006 Annual Progress Meeting, Orangeville, Ontario, May 9-12, 2006.

Sale, T. and G. Amato. (2006). Advancing Innovative Remediation Technologies to Broad Commercial Use. American Geophysical Union, Hydrology Days, Colorado State University, March 22, 2006.

Sale, T. and M. Olson. (2006). In Situ Remediation of Chlorinated Solvents via Admixing Reactive Media and Stabilizing Agents. Groundwater Resource Association of California – DNAPL Source Zone Characterization and Remediation, December 7-8, 2005, San Francisco, California.

Sale, T., C. Newell, P. Johnson, R. Hinchee, and Hans Stoo. (2005). ESTCP Protocol for Selecting Remedies for Chlorinated Solvents Releases, ESTCP/SERDP annual Partner Meeting, Washington D.C. November 29-December 1 2005.

Sale, T., M. Olson, and D. Gilbert. (2005). ZVI-Clay for Remediation of Chlorinated Solvent Source Zones ESTCP/SERDP Annual Partner Meeting, Washington D.C. November 29-December 1, 2005.

Gilbert, Dave, Matt Petersen, and Tom Sale. (2005). Demonstration/Validation of Electrolytic Reactive Barriers for Treatment of Energetic Compounds at the Pueblo Chemical Depot. ESTCP/SERDP Annual Partner Meeting, Washington D.C. November 29-December 1, 2005.

Sale, T., J. Zimbron, D. Dandy, and T. Illangasekare (2005). Laboratory, field, and mathematical analysis of the benefits of source depletion. Annual Meeting of the Solvent-in-Groundwater Research Consortium, Orangeville, Ontario, May 24-26, 2005.

Sale, T. (2005) - Contaminants in the Subsurface: Source Zone Assessment and Remediation. Annual Meeting of the Solvent-in-Groundwater Research Consortium, Orangeville, Ontario, May 24-26, 2005.

Sale, T. (2005) Elements of a Well-Designed Protocol for Managing Releases of Chlorinated Solvent, American Geophysical Union Hydrology Days, Colorado State University, March 8-10, 2005.



Sale, T. (2005) Restoration vs. Risk Reduction - Whirlpools, Reality, and Pragmatism – National Groundwater Association, 2005 Theis Conference, Sedona, Arizona (January).

Petersen, M., D. Gilbert, and T. Sale, (2004). Electrically induced redox barriers for groundwater: ESTCP field experiment. Abstract 3A-41 in: A.R. Gavaskar and A.S.C. Chen (Eds.), Remediation of Chlorinated and Recalcitrant Compounds—2004. Proceedings of the Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Monterey, CA; May 2004). Battelle Press, Columbus, OH.

Sale, T., (2004). Elements of a well-designed protocol for managing chlorinated solvent. Abstract 5C-28, in: A.R. Gavaskar and A.S.C. Chen (Eds.), Remediation of Chlorinated and Recalcitrant Compounds—2004. Proceedings of the Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Monterey, CA; May 2004). Battelle, Columbus, OH.

Sale, T. and T. Illangaskare, (2004). Impact of non-NAPL source mass on groundwater quality and source longevity. Abstract 1D-05 in: A.R. Gavaskar and A.S.C. Chen (Eds.), Remediation of Chlorinated and Recalcitrant Compounds—2004. Proceedings of the Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Monterey, CA; May 2004). Battelle, Columbus, OH.

Gilbert, D. and T. Sale, (2004), Sequential electrolytic degradation of energetic compounds in groundwater. Presented at: the Battelle Conference on Sustainable Range Management January, 2004. New Orleans.

Gilbert, D.M., and T. Sale, (2004). Electrolytic degradation of energetic compounds in groundwater. Presented at American Geophysical Union Hydrology Days. April 2004. Fort Collins, CO.

Gilbert, D., T. Sale, and M. Petersen, (2004), e-barriers: Final cost and performance data for Warren AFB and plans for Pueblo Chemical Depot. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. May 2004. Orangeville, Ontario.

Gilbert, D. and T. Sale, (2004). Sequential electrolytic degradation of energetic compounds in groundwater. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. May 2004. Orangeville, Ontario.

Petersen, E. , D. Gilbert, T. Sale, (2004). Investigation into feasibility and efficacy of an in-well electrolytic reactor for degradation of dissolved phase chlorinated solvents. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. May 2004. Orangeville, Ontario.

Gilbert, D.M. and Sale, T.C. (2003). Emergence of electrolytic processes for in situ treatment. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. June 2003. Orangeville, Ontario.

Ballaban, M.N., Sale, T.C., Gilbert, D.M. and Gillham, R.W. (2003). Electrolytic reactors (e-barrier) for the in situ treatment of chlorinated compounds – Borden field experiment. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. June 2003. Orangeville, Ontario.

Petersen, M.A., Gilbert, D.M., Sale, T.C. (2003). Electrically induced redox barrier for the treatment of groundwater – F.E. Warren AFB Field Experiment. Presented at the University Consortium Solvents-in-Groundwater Research Program Annual Meeting. June 2003. Orangeville, Ontario.

D. Gilbert, C. Repta, and T. Sale, (2002), Electrically Induced Redox Barrier (e-barriers) – Borden Field Experiment, Annual Meeting of the Solvents in Groundwater Research Consortium, Toronto, Ontario, Canada, June.

Sale, T., (2002), Pragmatic Expectation for Source Zone Remediation, GE Remedial Council, Baltimore, Maryland, June.

Sale, T., D. Gilbert, and C. Repta, (2002), Electrically Induced Redox Barriers for Treatment of Contaminated Groundwater, Battelle Remediation of Chlorinated Solvents and Recalcitrant Compounds, Monterey, California, May.

Sale, T., D. Gilbert, and C. Repta, (2002), Field Demonstration of an e-barrier at Canadian Forces Base Borden, Ontario, American Geophysical Union, Hydrology Days, Colorado State University, Fort Collins, April.

Sale, T. (2002) A Priori Analysis of the Benefits and Cost of DNAPL Depletion, Air Forces Center for Environmental Restoration, Environmental Restoration Conference, San Antonio, Texas, March.

Sale, T. (2001), A Priori Analysis of the Benefits and Cost of Source Zone Mass Depletion, SERDP/ESTCP Technical Symposium and Workshop, Washington D.C. November.

Sale, T., (2001), A Priori Analysis of the Benefits and Cost of NAPL Depletion, EPA 2001 DNAPL Workshop Dallas, Texas, October.

Sale, T. (2001), A Priori Analysis of the Benefits and Cost of DNAPL Depletion, Solvents-in-Groundwater Focus Meeting, Chicago, October.

Sale, T. (2001). Benefits of Partial NAPL Mass Removal, Battelle Sixth International In Situ and On-Site Bioremediation Symposium, San Diego, California, June.

Sale, T. (2001), Pragmatic Expectations for Source Zones, Air Forces Center for Environmental Restoration, Environmental Restoration Conference, San Antonio, Texas, January.

Sale, T. 2000 Pragmatic Expectations for DNAPL Source Zones, Solvents-in-Groundwater Focus Meeting, Chicago, September.

Sale, T. (2000). Electrically Induced Redox Barriers Biannual Meeting of the Solvents in Groundwater Research Consortium, Portland, Oregon, May.

McWhorter D. B. and T.C. Sale, (1999), Effects of Source Zone Remediation on Groundwater Quality and Source Longevity. Second Theis Conference, National

Ground Water Association, What is Success in Remediation? Jacksonville Florida, November.

Sale, T.C. and D.M. Gilbert, (1999), Electrically Induced Redox Barriers – An Innovative Technology for the In-Situ Treatment of Groundwater presented at Environmental Engineering Symposium, Colorado School of Mines. September 23.

Sale, T.C. and D.M. Gilbert, (1999), Electrically Induced Redox Barriers for In-Situ Treatment of Groundwater, Presented at American Geophysical Union Hydrology Days, Fort Collins Colorado. August 16 – 20.

Sale T.C. and D.B. McWhorter, (1998), Pragmatic Expectation for Restoration of Large DNAPL Source Zones, Biannual Meeting of the Solvents in Groundwater Research Consortium, Portland, Oregon, October.

Sale T.C. and D. B. McWhorter (1998), Mass Transfer from Field-Scale DNAPL Source Zones, First International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Battelle. Monterey, California, May 18-21, 1998.

Sale T., F. Flechas, and D.B. McWhorter (1998), Pragmatic Expectation for Restoration of Large NAPL Source Zone, Proceedings of the National RCRA Refinery Workshop – Forum on Groundwater Remediation, September. Denver, Colorado, Pp. 209-228.

Sale T.C. and D.B. McWhorter, (1997), The Relationship Between Source Zone DNAPL Removal and Risk Reduction. Biannual Meeting of the Solvents in Groundwater Research Consortium, Toronto, Canada, October 1997.

Sale T.C. and B. H. Kueper, (1997), Surfactant and Cosolvent Flushing: Status of Technical Practices, Biannual Meeting of the Solvents in Groundwater Research Consortium, Fort Collins, Colorado. May.

Sale T.C. and D.B. McWhorter, (1997), Inter-Phase Mass Transfer from Sparse Sources in Porous Media, Seventh Annual American Geophysical Union Hydrology Days Conference, Colorado State University, Colorado, April.

Sale T.C., and D.B. McWhorter (1997), Benefits of Partial Mass Removal from Subsurface NAPL Zones. Presented to the April 1997 Meeting of the Colorado Ground Water Association, Denver, Colorado. April 1997.

Sale T.C. and D.B. McWhorter (1996), The Relationship Between Source Zone DNAPL Removal and Exposure Reduction, Biannual Meeting of the Solvents in Groundwater Research Consortium, Kingston, Canada, October.

Sale T.C., (1996), Mobile NAPL Recovery - Technical Practicability, Biannual Meeting of the API Soil and Groundwater Technical Task Force, Fort Collins, Colorado, October.

Sale T.C. and D.B. McWhorter, (1996), Benefits of Source Mass Reduction, Biannual Meeting of the Solvents in Groundwater Research Consortium, Beaverton, Oregon, May 1996.

Piontek K., T. Sale, and T. Maloney (1995), An Evaluation of Field Methods for Intrinsic Bioremediation Measurements. Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water. American Petroleum Institute/National Water Well Association. Houston, Texas. November.

Brandt K., T. Sale, M. Evans, and B. McKee, (1995), Assessing the Practicability of LNAPL Recovery from Low Permeability Soil. Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water. American Petroleum Institute/National Water Well Association. Houston, Texas. Pp. 467-476. November.

Sale T.C. and D. Applegate, (1995), An Examination of Mobile NAPL Recovery - Conceptual, Field, and Mathematical Considerations. 1<sup>st</sup> Annual Theis Conference, National Ground Water Association, Jackson, Wyoming, September.

van Noort P., B. Cipolletti, and T. Sale, (1994), DNAPL Mobility Assessment at a Former Manufactured Gas Plant. Proceeding of the 1994 Focus Conference on Eastern Regional Ground Water Issues. National Ground Water Association. Pp. 567-579. October.

Sale T.C. and D. Applegate, (1994), Oil Recovery at a Former Wood-Treating Facility. Proceedings of Innovative Solutions for Contaminated Site Management Conference, Water Environment Federation.. Miami, Florida. March.

Sale T.C., (1994), Technical Impracticability - A Case History, Forum on Remediation of Groundwater Contamination, National Ground Water Association, Denver, Colorado, February.

Sale T.C., M. Pitts, K. Wyatt, and K. Piontek (1994), Utilization of Chemical Enhanced Oil Recovery Technology to Remove Hazardous Oily Waste from Alluvium. Proceedings of Innovative Solutions for Contaminated Site Management Conference, Water Environment Federation.. Miami, Florida. March.

Sale T.C., (1994), Technical Impracticability - A Case History, Colorado Hazardous Waste Management Society Round Table, Denver, Colorado, July.

Sale T.C. and P. Huntoon, (1993), Analysis and Mitigation of Environmental Risk, Annual Meeting of the Wyoming Engineering Society, Laramie, Wyoming. February 1993.

Brown S. and T. Sale. (1993). Factors to Consider When Deciding Between Groundwater Cleanup and Long-Term Management. Presented at the March 1993 Water Environment Federation Conference.

McWhorter D.B., T.C. Sale, and D. Hansen, (1992), Removal of Oily Phase: Hydraulics Without Chemical or Thermal Enhancements, Third International Conference on Ground Water Quality Research, Dallas, Texas Pp. 44-46. June.

Sale T. C., D. B. McWhorter and K.R. Piontek, (1992), Analysis of DNAPL Migration at the Former Wood Treating Facility. Proceedings of the 1992 Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration, National Ground Water Association, Houston, Texas. Pages. 285-301. November.

Sale T.C. and K. R. Piontek, (1992), A Decade of Remedial Action at a Former Wood Treating Facility. Proceedings of the Detection and Restoration of DNAPL in Groundwater at Hazardous Sites. Water Environmental Federation. New Orleans, Louisiana. Pages. 85-95.

Sale T.C. and K.R. Piontek, (1992), A Decade of Remedial Action at a Former Wood-Treating Facility, Annual Meeting the American Society of Civil Engineers (ASCE), New York, New York, October .

Sale T.C. and J.S. de Albuquerque, (1992), Subsurface Considerations Associated with Groundwater Remediation. American Institute of Chemical Engineers (AIChE) Summer National Meeting, Pittsburgh, Pennsylvania. August 1992.

Sale T.C. and K.R. Piontek, (1991), Application of Enhanced Recovery Techniques for Remediation of High Viscosity DNAPLs, USEPA Dense Nonaqueous Phase Liquids Workshop, USEPA, Dallas, Texas. April.

Simpkin T., K. Piontek, and T. Sale, (1991), Impacts of Oxygen Demand and Hydrogeology on the Efficacy of In Situ Bioremediation. Proceedings of the HAZPAC '91 Conference in Cairns, Australia..

Sale T., M. Pitts, and K. Piontek, (1989), Chemically Enhanced In-Situ Soil Washing. Proceedings of Petroleum Hydrocarbon and Organic Chemicals in Groundwater. National Water Well Association. Worthington, Ohio. Pages. 487-503. November.

Sale, T.C., R. C. Kuhn, K. R. Piontek, and D. Stieb, (1988), Recovery of Wood-Treating Oil from an Alluvial Aquifer Using Dual Drainlines, Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water, National Water Well Association, Worthington, Ohio. Pages. 419-422. November.

Sale T. and K. R. Piontek. (1988) In Situ Removal of Waste Wood-Treatment Oils from Subsurface Materials. Proceedings of the EPA Forum on Remediation of Wood Preserving Sites. San Francisco. October.

Sale T.C., K.R. Piontek, and D. Stieb, (1988), Characterization and Containment of Contamination Present at a Wood Preserving Site. American Institute of Chemical Engineers (AIChE) Summer National Meeting, Denver, August.

Sale T. and S. Rhoades, (1987), Installation of Monitoring Wells Using the Dual Wall Hammer Drilling Technique. Proceedings of the 8th National Superfund Conference. Washington, D.C.: The Hazardous Materials Control Research Institute. Pages 358-361. November.

Ring, G. T. and T. Sale (1987), Evaluation of Well Field Contamination Using Downhole Geophysical Logs and Depth-Specific Sample. Proceedings of the 8th National Superfund Conference. Washington, D.C.: The Hazardous Materials Control Research Institute. Pages 320-325. November.

Sale T.C. and K.R. Piontek, (1987), Ground Water Contamination - A Case Study, American Waterworks Association Seminar on Groundwater Contamination in the Water /Wastewater Industry, Denver, December.