Exponent®
Engineering & Scientific Consulting

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Professional Profile

Dr. Tarek Saba is a Principal Scientist in Exponent's Environmental & Earth Sciences practice and the Maynard, Massachusetts, Office Director. As a consultant and expert witness, Dr. Saba advises clients in matters involving claims of liability for environmental contamination and associated response costs.

Dr. Saba has 27 years of professional and academic experience in reconstructing events that led to claims of contamination by applying his knowledge of industrial operations and processes, waste handling practices, prevailing laws and regulations over different time frames, chemical forensics, fate and transport analysis, and hydrogeology. Dr. Saba also allocates contamination liability and cleanup costs among responsible parties under different legal frameworks such as CERCLA, RCRA, NRDA, and product liability claims, and in different industrial settings, such as airports, manufacturing facilities, hydraulic fracturing, natural gas storage fields, petroleum refineries, salt domes, manufactured gas plants (MGPs), landfills, coal ash basins, coal mines, salvage yards, pesticide and herbicide manufacturing facilities, military sites, airports, and shipyards, among many others.

Dr. Saba's expertise includes chemical fingerprinting and evaluating the environmental chemistry of different chemical groups such as PFAS, PCBs, dioxins and furans, metals, PAHs, petroleum products (e.g., gasoline, diesel fuels) and petroleum additives (e.g., MTBE), LNAPL, DNAPL, chlorinated solvents (PCE, TCE, and their degradation products and additives such as 1,4-dioxane), tar and creosote, and radioactive compounds (e.g., radium). Before joining Exponent, Dr. Saba worked on developing groundwater remediation technology as a subcontractor for EPA. .

Academic Credentials & Professional Honors

Ph.D., Environmental Engineering, University of Colorado, Boulder, 1999

M.S., Water Resources, Cairo University, 1994

B.S., Civil Engineering, Cairo University, 1992

Publications

Book Chapters

Saba, T. Hydraulic fracturing: Data analysis methods to identify sources of dissolved gas and chemical compounds in drinking water wells. Chapter 14. In: Introduction to Environmental Forensics. Murphy, B.L., and R.D. Morrison (eds), pp. 513–529, 2015. ISBN: 9780124046962.

Shields, W.J., T. Saba, P.D. Boehm, and J. Pietari. Congeners: A forensics analysis. In: Introduction to

Environmental Forensics. Murphy, B.L., and R.D. Morrison (eds), pp. 347–393, 2015. ISBN: 9780124046962. Congeners addressed included dioxins/furans, PAHs, PCBs, and PFAS congeners.

Peer Reviewed and Other Publications

L. Silver and T. Saba. 2022. What EPA designation of PFAS as hazardous means for companies. Law 360. December 9.

Saba, T. 2019. Forensic analysis of breakthrough curves in fractured bedrock to reconstruct a past contaminant release event— a case study, Environmental Forensics. DOI: 10.1080/15275922.2019.1657518.

Boehm, P.D., J. Pietari, L. Cook, and T. Saba. 2018. Improving rigor in polycyclic aromatic hydrocarbon source fingerprinting, Environmental Forensics, 2018; DOI:10.1080/15275922.2018.1474287.

Saba, T., and P.D. Boehm. 2018. Determination of the applicability of CERCLA's petroleum exclusion at contaminated sites – focus on metals. Environmental Forensics; 19(1):27–38.

Saba, T. 2015. Study finds Marcellus NORM exposure risks low. Oil and Gas Journal; June.

Saba, T. 2013. Evaluating claims of groundwater contamination from hydraulic fracturing. Oil and Gas Journal. July. Available at: http://www.ogj.com/content/ogj/en/articles/print/volume-111/issue-7/drilling-production/evaluating-claims-of-groundwater-contamination.html.

Saba, T., and S. Su. 2013. Tracking polychlorinated biphenyls (PCBs) congener patterns in Newark Bay surface sediment using principal component analysis (PCA) and positive matrix factorization (PMF). Journal of Hazardous Materials; 260:634-643.

Saba, T., and P.D. Boehm. 2012. Use of natural gas compositional tracers to investigate gas migration from a gas storage field. Environmental Geosciences June; 19(2):1-12.

Saba, T., and M. Orzechowski. 2011. Lack of data to support a relationship between methane contamination of drinking water wells and hydraulic fracturing: A response to Osborn et al. Proceedings, National Academy of Science of the United States of America. www.pnas.org/cgi/doi/10.1073/pnas.1108435108.

Saba, T., and P.D. Boehm. Congener-based analysis of the weathering of PCB Aroclor 1242 in paper mill sludge. Chemosphere 2011; 82:1321-1328.

Saba, T., and P.D. Boehm. 2011. Quantitative polychlorinated biphenyl (PCB) congener and homologue profile comparisons. Environmental Forensics; 12(2):134-142.

Saba, T., and P.D. Boehm. 2011. CERCLA's petroleum exclusion and the use of chemical forensic methods. ABA Superfund and NRD Litigation Committee Newsletter; 6(2).

Saba, T., F. Mohsen, B. Hilbert, M. Garry, and B. Murphy. 2012. White paper: Methanol use in hydraulic fracturing fluids. Submitted to the Methanol Institute, August 2011 (Version 2 issued January).

Saenton, S., T.H. Illangasekare, K. Soga, and T. Saba. 2002. Effects of source zone heterogeneity on surfactant enhanced NAPL dissolution and resulting remediation end-points. Journal of Contaminant Hydrology; 59(1-2):27-44.

Saba, T., T.H. Illangasekare, and J. Ewing. 2001. Effect of flow dimensionality on mass transfer rate coefficient estimations under enhanced conditions. Journal of Contaminant Hydrology; 51(1-2):63-82.

Saba, T., and T.H. Illangasekare. 2000. Effect of groundwater flow dimensionality on mass transfer from

entrapped nonaqueous phase liquid contaminants. Water Resources Research; 36(4):971-979.

Conference Proceedings and Presentations s

Drollette, B., T. Saba, L. Cook, and G. Getzinger. PFAS Environmental Forensics: Unique Approaches to a Unique Contaminant. Presented at the 36th Annual International Conference on Soils, Sediments, Water and Energy. October 20, 2020.

Saba, T., and L. Cook. Considerations for PFAS Fingerprinting. Presented at:

• The 36th Annual International Conference on Soils, Sediments, Water and Energy. October 20, 2020.

• The Law Seminar International - PFAS litigation in the Pacific Northwest. Virtual interactive zoom broadcast. September 14 - 15, 2020.

Saba, T. Simulation of Contaminant Flow Through Fractured Bedrock to Calculate Oil and Gas Impoundment Leakage Date. Presented at the 35th Annual International Conference on Soils, Sediments, Water, & Energy, October 21-24, 2019, Amherst, MA.

Saba, T., and L. Cook. Application and Interpretation Pitfalls of Principal Component Analysis (PCA) for Assessment of Contaminated Sediment Sites. Presented at the 35th Annual International Conference on Soils, Sediments, Water, & Energy, October 21-24, 2019, Amherst, MA.

Saba, T. Hydraulic fracturing and the use of chemical fingerprinting methods in claims of natural gas migration and groundwater contamination. Presented at:

• Short course, SETAC North America 36th Annual Meeting, Salt Lake City, UT. November 1-5, 2016.

• Association for Environmental Health and Sciences Conference, Amherst, MA. October 2015.

• Chartered Institution of Water and Environmental Management Annual Conference, University of London, England, July 2015.

• United Kingdom Environmental Law Association. Liverpool, England, July 4, 2015.

• British Water Technical Forum, London, England, November 19, 2014.

• Department of Environmental Earth and Atmospheric Sciences Lecture Series, University of Massachusetts, Lowell, March 5, 2014.

• Association of Engineering Geologists, Woburn, MA, November 21, 2013.

• International Network of Environmental Forensics Conference, Penn State University, University Park, PA, June 10-12, 2013.

• American Nuclear Society Northeast Meeting, Canton, MA, June 5, 2013.

• The Hydraulic Fracking Conference, the Seminar Group, Santa Barbara, CA, February 8, 2013.

• Conference on Research Frontiers in the Science of Unconventional Energy Resources, Yale Climate and Energy Institute, New Haven, CT, March 5, 2013.

• Future Energy Conference, Seattle, Washington, November 13-14, 2012.

Saba, T. CERCLA's petroleum exclusion and the use of chemical forensic methods. The 29th Annual International Conference on soils, sediments, water, and energy. University of Massachusetts, Amherst,

MA. October 21-24, 2013.

Saba, T., and F. Mohsen. Hydrofracking: Separating the realities from the myths. The American Bar Association 41st Annual Conference on Environmental Law, Salt Lake City, UT, March 22-24, 2012.

Garry, M., T. Saba, F. Mohsen, and L. Hilbert. Health assessment of methanol used in hydraulic fracturing fluids. The 51st Annual Meeting of the Society of Toxicology, San Francisco, CA, March 11-15, 2012.

Saba, T., and S. Su. Tracking sources of polychlorinated biphenyls (PCBs) to Newark Bay sediments using principal component analysis (PCA) and positive matrix factorization (PMF). SETAC North America 32nd Annual Meeting, Boston, MA, November 13-17, 2011.

Saba, T., and P.D. Boehm. Quantitative PCB congener and homologue profile comparisons. Presented at the 6th International Conference on Remediation of Contaminated Sediments. New Orleans, LA, February 7- 11, 2011.

Menzie, C., M. Kierski, T. Saba, S. Meyer, E. Kovatch, J. Kahler. R. Fox, and J. Kern. Multisite ambient investigation for MGPs on the Chicago River. Presented at the 6th International Conference on Remediation of Contaminated Sediments, New Orleans, LA, February 7-11, 2011.

Saba, T., P.D. Boehm. Congener-based analysis of the weathering of PCBs in paper mill sludge. Presented at the 2010 Dioxin Conference, San Antonio, TX, 2010.

Saba, T., and P.D. Boehm. Historical reconstruction of contamination using environmental forensic methods. Boston Bar Association Seminar, Boston, MA, February 11, 2010.

Boehm, P., J. Brown, T. Saba, and K. O'Reilly. The three-part approach to PAH source identification and apportionment in sediments as applied to petroleum, coal tars, and combustion sources. SETAC North America 30th Annual Meeting, New Orleans, LA, November 19-23, 2009.

Saba, T. Environmental weathering of PCBs in sediments. The 26th Annual International Conference on Soils, Sediments, and Water, University of Massachusetts at Amherst, MA, October 18-21, 2009.

Boehm, P.D., W. Shields, A. Fairbrother, and T. Saba. Determination of the chemical background for sediment — Approaches and conundrums. SMWG meeting in Sarasota Springs, NY. September 29, 2009.

Saba, T., and P.D. Boehm. Using chemical forensics and other lines of evidence to distinguish PAH contributions from different pyrogenic sources to the sediments of the Hylebos Waterway Superfund Site — A CERCLA and MTCA cost recovery case. SMWG Spring Sponsor Forum, Kalamazoo, MI, April 29-30, 2008.

Saba, T., P.D. Boehm, and L. Benton. Identification of natural gas sources using geochemical forensic tools. The 23ed Annual International Conference on Soils, Sediments, and Water, University of Massachusetts at Amherst, October 15-18, 2007.

Butler, E., and T. Saba. Use of PCB congener and homolog analysis in source apportionment at a rail yard Superfund site. The Annual International Conference on Soils, Sediments, and Water, University of Massachusetts at Amherst, October 16-19, 2006.

Biemer, T., M. Brown, E. Butler, and T. Saba. Better litigation through chemistry. Presentation to the Boston Bar Association, October 6, 2005.

Saxe, J.K., T. Saba, and E.J. Wannamaker. Do arsenic-containing products influence arsenic concentrations in subsurface drinking water supplies? Society of Environmental Toxicology and Chemistry 24th Annual Meeting, Austin, TX, November 9-13, 2003.

Sharma, M., T. Saba, and A. Bittner. Optimization of groundwater pump and treat systems using numerical modeling and the Monte Carlo approach. 2003 NGWA Midsouth Focus Conference, Philadelphia, PA, 2003.

Sharma, M., T. Saba, and A. Bittner. Optimization of groundwater pump and treat systems using numerical modeling and the Monte Carlo Approach. Presented at the National Ground Water Association Mid-South Focus Conference, Nashville, TN, September 19, 2003.

Illangasekare, T.H., S. Saenton, T. Saba, and C.S. Wilson. Up-scaling of NAPL dissolution from entrapped sources: Implications on end-points for risk assessment. Proceedings, Contaminated Site Remediation Conference, Melbourne, Australia, December 4-8, 2000.

Illangasekare, T.H., T. Cort, T. Saba, F. Barranco, and D. Dai. Pilot-scale laboratory evaluation of subsurface restoration technologies for a diesel contaminated site. Summit of the Geological Society of America, Reno, NV, 2000.

Illangasekare, T.H., and T. Saba. Upscaling of contaminant transport in heterogeneous aquifers: Dissolution of entrapped separate phase organic chemicals. Proceedings, Engineering Jubilee Congress, Engineering of Peradeniya; (2):127-132, 2000.

Illangasekare, T.H., and T. Saba. Intermediate scale physical model testing to investigate upscaling of dissolution of non-aqueous phase liquids in aquifers. Proceedings, Physical Modeling and Testing Environmental Geotechnics, Network of European Centrifuges for Environmental Geotechnic Research (NECER). Garnier J, Thorel E, and Haze E (eds), pp. 285-292, La Baule, France, May 15-17, 2000.

Saba, T., and T.H. Illangasekare. Surfactant-enhanced dissolution of non-aqueous phase waste chemicals: Effect of flow dimensionality. Conference of Hazardous Waste Research, St. Louis, MO, April 1999.

Saba, T., and T.H. Illangasekare. Effects of aquifer heterogeneity and groundwater flow dimensionality on upscaling of natural and surfactant enhanced dissolution of non-aqueous phase liquid waste chemicals. Conference on Hazardous Water Research, Snowbird, UT, 1998.

Saba, T. and T.H. Illangasekare. Effect of aqueous phase flow dimensionality on surfactant enhanced dissolution from entrapped non-aqueous phase liquid contaminants at the spill-site scale. American Geophysical Union, San Francisco, CA, December 6, 1998.

Illangasekare, T.H., and T. Saba. Upscaling of mass transfer from zones with entrapped nonaqueous phase chemicals. American Geophysical Union, San Francisco, CA, December 6, 1998.

Vestal, E.W., T.H. Illangasekare, A. Ramaswami, A. Bielefeldt, A.M. Riffel, and T. Saba. Modeling of net interphase mass exchange in NAPL-water systems undergoing biodegradation at the spill-site scale. American Geophysical Union, San Francisco, CA, December 6, 1998.

Saba, T., and T.H. Illangasekare. Natural dissolution of organic chemicals entrapped in a two-dimensional groundwater systems. AGU 18th Annual Hydrology Days, Colorado State University, Fort Collins, CO, 1998.

Project Experience

Cost Allocation-Related Projects

Waterway sediment sites, northeastern United States (CERCLA Sites): Developed frameworks to allocate environmental response costs among responsible parties. Allocation frameworks were supported by chemical forensics, historical operational information, and transport pathways from upland sites to the sediment.

Major waterway sediment sites, northwestern United States (CERCLA): for confidential Alternative Dispute Resolution (ADL) processes, provided several expert reports evaluating 1) upland sites (e.g., historical operations at different manufacturing facilities, contaminants associated with those operations, historical and current transport pathways) and 2) fingerprinting analyses of waterways sediment chemistry data to track contaminant sources. The outcome from the analyses included reconstruction of historical upland operations, contaminant releases, and spatial extents of impacts to the sediment by different potential responsible parties (PRPs), and proposals of allocation parameters to be considered by the allocation team.

Paoli Railyard Site (CERCLA): Identified PCB sources and approximate spill timing as part of a soil remedial cost allocation model. Reviewed historical PCB purchase records and waste handling practices and performed fingerprinting analysis using PCB congener data.

Major rivers, Midwestern Unites States (CERCLA): Designed and directed field sampling programs, conducted fingerprinting analysis, and calculated mass of PCBs discharged as part of contamination liability and remedial cost allocation analysis.

Petroleum refinery/terminal, Midwestern United States: Reviewed and provided comments on an allocation model to allocate cleanup costs between successive refinery owners. Age-dated petroleum products in groundwater, and linked contamination to the evolution of refinery operations with time.

Hylebos Waterway (CERCLA): Evaluated PAH sources to the sediments as part of a dredging cost allocation matter. Determined the relative importance of candidate sources (primarily creosoted pilings, aluminum smelter sludge, and urban runoff) through chemical fingerprinting, sediment age dating, and PAH concentration gradients.

Industrial site, Kansas: Developed a model to allocate environmental response cost between successive owners/operators at a site. Historical operations included chemical manufacturing, a warehouse, and pipe fabrication. Main chemicals of concern included chlorinated solvents, acetone, and petroleum components (i.e., naphthalene, and trimethylbenzene).

Former munitions site, Massachusetts (CERCLA): Evaluated fate and transport of metals in soil and groundwater resulting from historical munitions and other industrial disposal activities in support of contamination liability analysis.

Per- and polyfluorinated alkyl substances (PFAS)

For confidential clients at multiple sites: Advised clients on sources and potential liabilities for PFAS contamination in groundwater, soils, and sediments at multiple sites (e.g., former military sites, airports, landfills, sites where previous fires occurred). Analysis of the PFAS data obtained from the sites required detailed understanding of PFAS manufacturing processes (ECF vs. telomerization), PFAS formulations in different products (e.g., AFFF), changes in PFAS formulations with time, and understanding of domestic and international manufacturing sources. Conducted fate and transport analysis including tracking compound transformations associated with PFAS migration in soil, surface water, groundwater, and air. Forensic analysis included evaluation of percent linear versus branched compounds to assist in evaluating PFAS sources, and the effect of transport in different environmental media on PFAS fingerprints. Evaluated background PFAS concentrations and profiles resulting from regional industrial activities.

Oil and Gas: addressed claims of PFAS impacts to residential water wells from hydraulic fracturing operations.

Hydraulic Fracturing, Former Oil and Gas operations, Drilling Mud, Produced Water, Natural Gas Fingerprinting (composition and isotope analysis), NORM, Evaluation of Groundwater Contamination Claims, and Impoundment Emissions of Hazardous Air Pollutants

Natural gas production, Pennsylvania and West Virginia: Evaluated the scientific merit of claims of groundwater and surface water contamination from hydraulic fracturing operations. Sampled groundwater, streams, ponds, and natural gases in shallow and deep soils, and characterized potential contamination sources such as land use, household activities, former coal mining, roads, and dust. Reconstructed natural baseline conditions in the study areas, using natural gas composition and stable isotope analysis to track sources of gases in groundwater. Issued expert reports, scientific publications, articles, book chapters, and provided expert testimony in depositions and court.

For several energy companies, Louisiana: at several sites, evaluated claims of groundwater and wetland impacts from former oil and gas operations and the generation of produced water. Work included design of sampling programs and evaluation of compounds consistent with 29-B parameters, evaluation of background concentrations, and reconstruction of oil and gas operational histories and the use of different compounds.

For a proppant manufacturer, directed laboratory testing to leach chemical components from coated proppants and conducted life-cycle analysis of the leached material.

For an energy company: Developed a conceptual site model (CSM) for storage gas transport and fate in the subsurface following a catastrophic gas release event from a storage field. Combined information from gas isotope analysis to identify the types of subsurface gases, geology, and gas well mechanical integrity analysis. Designed and directed field programs to screen soil and water wells for the presence of gases.

For the Methanol Institute, evaluated the use of methanol in hydraulic fracturing and modeled hypothetical scenarios of methanol impacting groundwater and surface water. Assessed health impacts of methanol and air emissions from gas operations. Issued a white paper detailing the analysis.

Drilling mud accidental releases (West Virginia and Pennsylvania): Characterized the extent of impacts and remedy effectiveness.

Chemical emissions from ponds: Calculated emission rates of methanol from ponds and tanks used to store recycled water (tons per year), as part of a permitting process.

Naturally occurring radioactive material (NORM) in produced water: Characterized NORM concentration levels with time and space at gas pads to define trends and designed a treatment system to reduce NORM-containing solid waste.

Produced water treatment facility: Assessed design, chemical reactions, and failure points along the produced water treatment train.

Natural gas migration from storage fields using gas isotope analysis:

• Gas Storage Fields, Kansas, Louisiana, Wyoming, Michigan, and New York: Designed and implemented forensic field programs to differentiate native gas from storage gas using composition and isotope analysis. Authored reports to State's Conservation Commission, presented findings to FERC, and served as an expert witness.
• Gas Storage Fields, northeastern Pennsylvania: Investigated sources of natural gas bubbling in residential water wells and potential connection to nearby natural gas storage fields. Designed field

sampling programs and used gas composition and isotope analysis to determine the origin of the gas in the water wells.

PCBs: Tracking of Sources, Timing of Releases, and Apportionment of Liability Cases for Upland Soils and Major Sediment Waterways

Major bay, Northeast: Analyzed homologue and congener patterns to identify PCB sources to the sediments. Identified congeners associated with specific sources using EPA numerical models (Positive Matrix Factorization). Conducted principal component analysis (PCA) and analyzed PCB profiles in sediment cores as part of a remedial investigation report for the bay.

Bayou (CERCLA site) connected to a major channel, southern United States: Investigated fate and transport of PCBs in sediment and the effect of dredging on surface water quality.

Major bay, Florida: Investigated PCB sources to the surface sediment by analyzing PCB congener data (profile analysis, spatial and concentration distribution analysis, and PCA).

Midwestern city: Identified historical uses of PCB-containing hydraulic fluids in the die casting industry.

Major waterway, East Coast: Analyzed PCB congener data to determine PCB sources and entry points to a waterway for allocation of contamination and remedy costs between responsible parties.

Major waterway, Washington: Analyzed PCB congener data to determine PCB sources and entry points to a waterway for allocation of contamination and remedy costs between responsible parties.

Landfill site, Georgia: Evaluated feasibility of proposed remedial alternative at a PCB- and VOC-contaminated landfill. Recommended modifications to the proposed design to optimize the remediation process.

Northeast nuclear facility: Characterized the spatial distribution of PCBs and lead in soils; contaminants were present in paints used in the facility and contaminated soils, sediments, and groundwater during decommissioning of the facility. Conducted statistical analysis (e.g., variogram) to calculate the sample spacing needed to characterize the extent of spatial impacts.

Hydrogeology, Fate and Transport Analysis, Groundwater Modeling, and Government Research.

New Hampshire Superfund site: Developed a 3-D numerical groundwater and solute transport model for chlorinated solvents (MODFLOW and MT3D). Designed a numerical code that automated conducting hundreds of groundwater simulations to optimize the design of a pump and treat system (i.e., optimize groundwater well locations, injection, and extraction rates) to minimize the treatment time of a chlorinated solvents groundwater plume.

Coal ash: Reviewed and assessed the ability of groundwater numerical models to simulate fate and transport of metals associated with coal ash.

Coal mine, West Virginia: Analyzed groundwater data to investigate the cause of a coal mine flooding.

Oil and gas impoundment, Pennsylvania: Calculated timing of produced water release by conducting groundwater flow analysis through fractured bedrock.

Chemical manufacturing facility, Argentina: Designed and modeled a hydraulic barrier system to mitigate offsite transport of contaminated groundwater. Conducted contaminant transport modeling and optimization of injection/extraction well locations.

Government Scientific Research

For the Hazardous Substances Research Center, revised USGS groundwater numerical codes MODFLOW and MT3D, capable of simulating the fate and transport of dissolved contaminants in groundwater. Revisions extended MODFLOW/MT3D capabilities to simulate the behavior of NAPLs in the subsurface, including NAPL entrapment in subsurface soils and dissolution in groundwater.

Developed a proprietary model for DNAPL dissolution and transport in groundwater as part of a DOD contract for a decision support system to evaluate effectiveness and cost of DNAPL source zone treatment.

For EPA, investigated novel groundwater remediation technologies on a field scale at the Dover Air Force Base. Supervised and provided technical assistance for research groups to investigate cutting-edge groundwater-remediation technologies (funded by the Strategic Environmental Research and Development Program SERDEP; a joint program between Department of Defense, EPA, and Department of Energy). Managed treatment and disposal of hazardous waste generated from remediation experiments. Collected aqueous and soil samples required for regulatory compliance and performance monitoring. Established and maintained electronic data acquisition systems.

For EPA, served as technical reviewer for BIOCHLOR, a numerical model that simulates biodegradation of chemicals in groundwater.

For NSF, developed groundwater numerical models to predict soil heterogeneity using chemical data (i.e., breakthrough curves) generated from chemical tracers injected into groundwater.

Dioxins/Furans: Fingerprinting and Analysis of Source

Louisiana site: Evaluated dioxin and furan fingerprinting patterns in the sediment of bayous and marsh areas to determine responsible parties. Combined dioxin/furan data with sediment age dating information to determine with a high degree of certainty the likely sources of contamination.

Transformer service facility, Mississippi: Evaluated dioxin and furan fingerprint patterns in dust and soil samples collected from residential areas around a transformer service facility to determine whether the dioxin/furans originated from the facility or from background sources.

Major Bay, eastern United States: Analyzed dioxin and furan data from the bay sediments as part of remedial investigation phases. Analysis included age dating of sediment core samples, contaminant spatial patterns (e.g., dioxins/furans, PCBs, PAHs, heavy metals), correlation between dioxins (e.g., 2,3,7,8-TCDD) and other contaminants, and evaluation of the impact of historical dredging activities on current contaminant spatial profiles. Tracked dioxin contamination in the bay sediment to potential upland site sources by reconstructing historical industrial operations at sites located along the bay boundaries, evaluating dioxin generation from different industrial process and contaminant transport pathways to the bay.

Petroleum Chemistry: PAHs, BTEX, Metals, and Additives (e.g., MTBE)

Southern U.S. refinery: As part of insurance claim, evaluated petroleum products, sources, and timing of releases of petroleum compounds and additives (MTBE) to state-owned groundwater. Reconstructed releases by combining refinery unit operational and closure histories before and after the enactment of the CWA with chemical data collected over 20 years.

CERCLA sediment site (Brooklyn, New York): Conducted chemical fingerprinting analysis on different chemical classes (i.e., PAHs, PCBs, metals) and identified industrial markers in the sediment to track impacts from different facility on the sediment site as part of CERCLA remedy design costs allocation.

Former refinery sites, CERCLA liability (Illinois, Oklahoma): Combined historical waste handling practices, waste handling unit closures, RCRA cleanup actions, and chemical fingerprinting analysis to determine

the sources and timing of contamination, with a focus on the applicability of the "petroleum exclusion" under CERCLA at the sites.

Texas refinery: Conducted chemical fingerprinting to age-date a petroleum plume beneath the refinery site to determine the responsible party among successive owners.

Midwestern steel manufacturing site: Evaluated the connection between sediment PAH contamination and surface water sheens using chemical fingerprinting techniques.

West Virginia salvage yard site: Evaluated the use of benzene/xylene ratio to age-date contamination and allocate cleanup costs between successive owners.

Petroleum spill, Oregon: Conducted laboratory studies to understand the fate of a diesel spill. Tracked diesel spilled in pilot-scale tanks using gamma ray spectroscopy techniques.

Metals: Fate and Transport Analysis, Age Dating, and Source Tracking for Allocation of Liability and Remedial Costs

Former crushed glass disposal site, Pennsylvania: Assessed leach tests conducted on crushed glass and other material to determine the leachability of different metals from the disposed material to the site and assessed the extent of impacts to the site soils, groundwater, and a nearby river.

Arsenical pesticide: Evaluated fate and transport of the different arsenic species in soils and their potential for migration to groundwater and surface waters at Florida sites. Authored reports to the Florida Department of Environmental Protection.

Bayou sediment, Louisiana: Tracked Bayou sediment metal contamination to multiple responsible parties in support of remedial cost allocation. Data evaluation included identification of marker metals and combination of metals used by different industries located along the creek.

Metals in paint: Used statistical methods (variogram analysis) to investigate the sufficiency of a soil-sampling program in characterizing a lead contaminated site.

Former petroleum refinery site, Oklahoma: Investigated the sources of metals in soil and groundwater (petroleum products versus petroleum waste) to determine whether CERCLA’s petroleum exclusion applies to the site.

Hydraulic Fracturing, northeastern United States: Evaluated metals data in residential water wells to determine their sources.

Coal Ash

For utility companies, eastern United States: Evaluated coal ash basin closure options through the state of North Carolina, by addressing several technical aspects such as: analyses of compound (e.g., boron) leaching rates from coal ash to groundwater under different basin closure scenarios (e.g., cap in place, excavation), evaluation of contaminant fate and transport models (USGS numerical codes called MODFLOW and MT3DMS) to predict the spatial extent of ash-related compounds in groundwater inside and outside ash basin regulatory compliance boundaries, and analysis of seep discharge rates under basin decanting scenarios.

For utility company, southern United States: Evaluated groundwater data produced from monitoring wells located around coal ash ponds. Compared recent data to historical regional background groundwater data and designed field sampling programs to evaluate groundwater condition at different hydrogeologic formations.

Manufactured Gas Plants (MGPs): Fate and Transport Analysis and Chemical Fingerprinting (DNAPL, Tar, Distillation Products such as Creosote and Road Tar), Standard of Care, and Site Characterization

Former MGPs in New York, New Hampshire, Maine, Vermont, and Florida: As part of insurance litigation, evaluated standard of care regarding byproducts handling practices and approximate timing of contamination. Researched historical literature regarding status of environmental knowledge at different times, the different MGP equipment and their construction and operation, historical records such as feedstock changes with time, tar records, spills, leaks, Sanborn insurance maps, public service commission reports, and aerial photographs, among other sources of information. Integrated historical information with forensic analysis, fate and transport, and hydrogeology to identify approximate period of historical leaks and spills. Analyzed tar, oil, and NAPL entrapment and migration patterns to identify contamination sources and track the extent of spatial impact to soil, sediment, and groundwater.

New York former MGPs: As part of site characterization efforts required by the New York State Department of Environmental Conservation, designed environmental sampling programs of soil, sediment, and groundwater to identify potential contamination sources. Conducted chemical fingerprinting analysis on different chemical classes (i.e., PAHs, PCBs, metals) as part of site investigations to track sources of contamination at former MGP sites in Brooklyn, New York. Work is part of site characterization efforts.

Former MGP Site, Michigan: Evaluated the source of impacts to site's soil and groundwater. Potential sources included manufactured gas plant, a landfill, and wastewater treatment facility, all occupying the same footprint at different time frames. Presented findings to an arbitration committee.

Olympia, Washington: Integrated hydrogeology, fate and transport, and chemical fingerprinting analysis of available environmental data to evaluate sources of DNAPL/tar/PAH contamination at a site located two city blocks from a former MGP.

Bellingham, Washington: Investigated sources of PAH contamination in soils in an area adjacent to former MGP operations. In addition to the former MGP operations, other potential sources included creosoted pilings, historical wood milling operations, and operations related to railroad activities.

Former MGP, Rhode Island: Conducted analysis to distinguish between PAHs and metals from different sources (historical filling material, former MGP operations, a former rubber manufacturer, and natural background).

Chlorinated Solvents and 1-4 dioxane: Fate and Transport Analysis, Field Sampling Design and Analysis of Isotope Data, and Soil Vapor Intrusion Analysis

Several manufacturing facilities, Midwestern and western United States: Evaluated sources of chlorinated solvents (PCE, TCE, and degradation products and 1-4-dioxane) at or near manufacturing facilities. Utilized different contaminant evaporation models to estimate the approximate start date of PCE release(s) to the soils. Combined information from compound-specific isotope analysis, solvent additive concentrations (1,4-dioxane), and historical information to determine sources and contribution from different sources.

Manufacturing facility, Illinois: Conducted isotope analysis for carbon and chlorine and fate and transport analysis to age-date multiple chlorinated solvent plumes (PCE, TCE, and their degradation products). Used multiple lines of evidence including groundwater travel times, daughter/parent compound ratios, and historical construction of contamination to determine the age of the different plumes. Presented findings to the Illinois Environmental Protection Agency.

Dry cleaning facility, Massachusetts: Reviewed cost recovery documents for municipal water treatment due to alleged contamination from dry cleaning activities. Documented overestimated treatment costs.

Dry cleaning facility, Canada: evaluated carbon isotope data for TCE in groundwater to identify different sources of chlorinated solvents contamination downgradient from the dry cleaner.

Superfund site, New Hampshire: Optimized injection and extraction well locations and flow rates for faster PCE recovery in a pump and treat system, reducing total remediation time by 25%. Modified MODFLOW and MT3D computer modeling to fit Superfund site-specific characteristics and linked the modified versions to a USGS optimization code. Reduced projected plume recovery time by 25%.

Dry cleaning facility, Massachusetts: Allocated contamination shares between responsible parties in a chlorinated solvents plume. Evaluated PCE degradation pathway and performed groundwater modeling and soil vapor intrusion analysis.

Metal electroplating facility, Oklahoma. Conducted analysis, including fate and transport and isotope analysis, to identify sources of chlorinated solvents around the facility. Work included investigating solvent spatial and degradation patterns in groundwater, and assessment of soil vapor intrusion analysis.

Natural Resource Damage Assessment

New Jersey Bayway and Bayonne refineries (NRDA): Under the NJ Spill Act, NJ DEP sued the former owner of the Bayway/Bayonne refineries for natural resource damages to soil, sediment, and groundwater. NJDEP experts used the Habitat Equivalency Analysis (HEA) model to calculate the value of damage to natural resources. Work included analysis of the spatial extent of impact to soil, sediment, and groundwater and the start date of contamination for VOCs, PAHs (SVOCs), metals, NAPLs, and pesticides. Reconstructed operations at refinery areas of concern from the early 1900s and identified whether chemical impacts to the environment were attributed to refinery activities or other sources (e.g., background, offsite sources, or other historical activities unrelated to refinery operations). Divided the refineries into areas that either needed additional analysis to determine whether there is harm to ecological receptors or included impacts unrelated to refinery operations. Calculated extent of groundwater contamination with time in response to remedy actions and whether groundwater use was lost from the early 1900s through future. Coordinated work with ecological experts.