INTRODUCTION TO ENVIRONMENTAL FORENSICS
SECOND EDITION
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INTRODUCTION TO ENVIRONMENTAL FORENSICS
SECOND EDITION

Edited by
Brian L. Murphy and Robert D. Morrison
Acquisitions Editor: Jennifer Soucy
Signing Editor: Pamela Chester
Assistant Editor: Kelly Weaver
Project Manager: Christie Jozwiak
Marketing Manager: Chris Nolin
Cover Designer: Gene Harris

Elsevier Academic Press
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
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INTRODUCTION TO THE SECOND EDITION

Since the publication of the first edition of *Introduction to Environmental Forensics* in 2002, the science of environmental forensics has matured appreciably. In 2005, *Environmental Forensics: A Contaminant Specific Guide* was published in the forensic series by Elsevier with the intent of providing the user with a means to access the forensic methodologies on a contaminant-specific basis. In contrast, this edition of *Introduction to Environmental Forensics* is designed to provide the reader with a methodological organization of the forensic tools available and as a complementary reference to the *Contaminant Specific Guide*. Additional forensic methods in this second edition include chapters on laser ablation inductively coupled mass spectrometry (LA-ICPMS), manual- and computer-controlled scanning electron microscope (SEM) techniques and x-ray diffraction, pattern recognition methodologies, expanded chapters on sampling techniques and statistical methods, and a presentation of several emerging forensic techniques. In this edition and subsequent editions of *Introduction to Environmental Forensics*, methods of general applicability will be emphasized and the *Contaminant Specific Guide* will provide forensic approaches for specific contaminants. We would be grateful to readers for suggestions for improvement.

“Forensic” is related to “forum” and refers to any public discussion or debate. In the United States “forensic” most often refers to courtroom or litigation proceedings. However, environmental forensics may also provide the fact basis for mediated or negotiated transactions or for any public inquiry related to environmental matters. Questions that environmental forensics seeks to answer are:

- Who caused the contamination?
- When did the contamination occur?
- How did the contamination occur? (For example, was it an accidental spill or a series of routine operating releases?)
- How extensive is the contamination?
- Are the test results valid? Is there evidence of fraud?
- What levels of contamination have people been exposed to?
- Can environmental forensics assist in allocating remediation costs?
The contexts of environmental forensic investigations include liability allocation at hazardous waste sites where multiple parties are involved, site assessments for property transfers, insurance litigation, toxic torts, and cost allocation among multiple parties found liable for releasing contaminants into the environment.

Environmental forensic investigations frequently deal with the historical release of contaminants. Generally there are two sources of information in conducting an investigation, namely:

- The documentary record, including statements by witnesses or other knowledgeable individuals, aerial photographs, insurance maps, and electronic information copied from computer hard drives, and
- Measurement or sampling data.

Once the historical information has been acquired and evaluated, one can then identify which forensic technique is most suited for answering the forensic question(s) of concern and how to appropriately use the selected methodology. For example, chemical or isotope concentration data can be used in different ways to answer forensic questions, including:

- Tracer techniques based on the presence or absence of a particular chemical.
- Ratio techniques where the relative amounts of two or more chemicals are compared.
- Trend techniques where the spatial or temporal variation of a concentration, or a ratio, is of interest.
- Quantity techniques that depend on the integrated concentration over space or time, i.e., the mass of a chemical, to provide forensic information.

A forensic investigation may involve multiple forensic techniques and applications that are evaluated to answer the forensic question of interest. For example, identifying the source of and age dating a hydrocarbon spill may be of interest. The presence or absence of lead, methyl tertiary butyl ether (MTBE), or other additives, for example, may provide this crucial information that provides insight regarding the source or age of the release. The ratio of different hydrocarbon components or octane readings may provide the basis to distinguish different fuels or brands. The spatial variation of a contaminant plume or its growth over time may assist in both source identification and age dating. Finally, the total mass or volume of petroleum hydrocarbons in the environment may be compared to inventory or leak detection records for source identification.
The most successful forensic investigations rely on the approach of selecting the most applicable techniques from numerous methodologies. An investigation relying on the results of a single forensic technique, exclusive of other available tools, is frequently successfully challenged when contrary evidence based on multiple forensic approaches is introduced. When forensic evidence is arrayed as multiple, but independent lines of evidence, a stronger scientific case, less susceptible to scientific challenge, emerges. This book is intended to provide you with your own toolbox of forensic techniques.

**Brian L. Murphy**

**Robert D. Morrison**
**CONTRIBUTORS**

**EDITORS**

**Robert D. Morrison**, Ph.D. is a soil physicist with over 36 years of environmental consulting experience. Dr. Morrison has a B.S. in Geology, an M.S. in Environmental Studies, an M.S. in Environmental Engineering and a Ph.D. in Soil Physics from the University of Wisconsin at Madison. Dr. Morrison published the first book on environmental forensics in 1999, is the editor of the Environmental Forensics Journal and is a co-founder of the International Society of Environmental Forensics (ISEF). Dr. Morrison specializes in the use of environmental forensics for contaminant age dating and source identification.

**Brian L. Murphy**, Ph.D. is a Principal Scientist at Exponent. He is the coeditor of *Environmental Forensics: Contaminant Specific Guide*, also with Robert Morrison. He is the author of more than thirty journal publications and is on the editorial board of the journal *Environmental Forensics*. Dr. Murphy has an Sc.B. from Brown University and MS and Ph.D. degrees from Yale University. All his degrees are in physics. He has spent most of his career as an environmental consultant, including as General Manager for Physical Sciences at what is now ENSR, founding President of Gradient Corporation, and Vice President of Sciences International. He also has had Visiting Instructor positions at Harvard School of Public Health and the University of South Florida. His practice focuses on using environmental forensics to reconstruct
past contaminating events, for a wide variety of contaminants, either for the purpose of remedial cost allocation or in order to determine doses in toxic torts.

CHAPTER AUTHORS

Jean Christophe Balouet holds a Ph.D. in Earth Sciences, and is manager, principal owner of Environment International, Le Perreux-sur-Marne. He also serves Université, Paris VII, France. He has developed dendroecological applications to environmental forensics, as well as adapted spectroscopic methods such as EDXRF or LIBS for the measure of elemental tracers in such proxy-recorders and successfully applied it to 27 different sites. As a research scientist, he has served the Smithsonian Institution, the Paris Museum of Natural History and several major research institutions worldwide. He has served and chaired several new international environmental standards and is the author of about 100 peer-reviewed publications and books. Dr. Balouet has over 25 years of international experience as a consultant/expert scientist serving governmental and intergovernmental authorities, including the United Nations Environment Program and its Technology, Industry and Economy Division. He also serves NGOs and private parties, including major industries in environmental issues, including consultancy, expertise and environmental forensics.

Shelley Bookspan, Ph.D. is currently a consultant in Santa Barbara, California. In 1982, she was among the founders of PHR Environmental Consultants, Inc. She is past president of PHR, which pioneered the application of historical methodology to pollution liability matters. Dr. Bookspan’s doctorate, from the University of California, Santa Barbara, is in history, with emphasis on American history, history of technology, and urban history. She also holds a master’s degree in city planning from the University of Pennsylvania and a master’s degree in history from the University of Arizona. Dr. Bookspan is widely published both in the fields of history and environmental consulting, and she is now working in multimedia presentation and video production.
Richard Brown, M.S. is a microscopist and an Executive Director at MVA Scientific Consultants in Atlanta, Georgia. Since 1989 Rich has applied light and electron microscopy to small particle problems in the Environmental Forensics field to characterize and identify the particles and determine their source(s). Rich received his Master’s degree in Forensic Chemistry and worked as a Criminalist doing crime scene investigation and trace evidence examination at the Orange County Sheriff-Coroner Department in Santa Ana California. Rich has testified in court as an expert witness and is a member of the California Association of Criminalists, the American Academy of Forensic Sciences and is a diplomate of the American Board of Criminalistics.

Judith C. Chow is a Research Professor in the Desert Research Institute’s (DRI’s) Division of Atmospheric Sciences specializing in aerosol measurement, method development, and applications. At DRI, Dr. Chow established an Environmental Analysis Facility that quantifies mass, elemental, ionic, and carbon concentrations on filter samples. She has prepared guidance documents on aerosol measurement for the U.S. EPA, authored the 1995 Air & Waste Management Association’s Critical Review of PM$_{2.5}$ measurement methods, and has completed more than 100 research publications on sampling and analysis methods and interpretation of results. She is a member of the National Academy of Engineering’s U.S. Committee on Energy Futures and Air Pollution in Urban China and the United States and was the 1999 recipient of DRI’s Alessandro Dandini Medal of Science. Dr. Chow received her Sc.D. degree in Environmental Science from the Harvard School of Public Health in 1985.

Julie Corley is a Senior Managing Consultant with LECG, LLC. Prior to joining LECG, Ms. Corley was the Director of Research for PHR Environmental Consultants, Inc., a consulting firm specializing in professional historical research conducted in support of environmental, product liability, and other legal disputes. She
has worked for PRP groups as well as private and public sector clients in support of historical fact-finding endeavors to answer questions about the effects of past operations on current conditions.

**Gregory S. Douglas** received M.S. and Ph.D. degrees in Oceanography from the University of Rhode Island and has over 25 years of experience in the field of environmental chemistry. He has designed, implemented, managed, audited, and defended a wide range of environmental forensic chemistry studies for government and industry concerning complex petroleum and fuel contamination issues in marine and soil/ground water systems. Dr. Douglas has performed extensive research concerning the fate of gasoline NAPL and gasoline additives in groundwater. He has prepared interpretive reports on more than 100 site or incident investigations involving petroleum product source and age dating issues, and has published and presented on the development and application of environmental forensics analytical methods, source identification and allocation within complex contaminated environments.

**James I. Ebert**, Ph.D. is an archaeologist, anthropologist, and forensic scientist. He is Chief Scientist at Ebert & Associates, Inc., an Albuquerque, New Mexico firm specializing in forensic, environmental, and archaeological applications of photogrammetry, photo analysis, remote sensing, and digital mapping and imaging technologies. He is a Certified Photogrammist (American Society of Photogrammetry and Remote Sensing), a fellow of the American Academy of Forensic Sciences, and a member of the New York State Police Medicolegal Investigations Unit. Since 1989 Dr. Ebert has conducted ongoing archaeological and environmental research at Olduvai Gorge in Tanzania with Rutgers University’s Olduvai Landscape Palaeoanthropological Project.
Bruce Egan, Sc.D., CCM is President of Egan Environmental, Inc., a small business that specializes in providing air quality consulting services to both public and private sectors. Prior to forming EEI, he was Senior Vice President and Chief Scientist at the ENSR Corporation and Vice President and Technical Director at Woodward Clyde Consultants. A graduate of Harvard College and University, Dr. Egan’s formal training is in Fluid Mechanics, Thermodynamics, Meteorology, and in Environmental Health Sciences. He has been a Visiting Lecturer at the Harvard School of Public Health. His specialties include air toxics, hazard assessments, air dispersion modeling and permitting in complex terrain settings, and compliance demonstrations for facilities subject to state and federal regulations. Dr. Egan is a Certified Consulting Meteorologist, and an elected Fellow of the American Meteorological Society. He is also a Fellow of the Air and Waste Management Association. He has managed projects for the U.S. EPA and for trade associations on the development of air quality dispersion models that are used for New Source Review permitting and has consulted with a large number of clients in the power production, energy, chemical and paper industry sectors on risk management plans and industrial hazard litigation cases. He has provided expert testimony and depositions in a number of litigated cases. He is an author of over 80 technical papers and has served on many professional organization committees and government sponsored panels on air quality and hazard assessment matters.

Robert Ehrlich, Ph.D. For the past 30 years, Dr. Robert Ehrlich has been a leader in applying image analysis and pattern recognition procedures in the earth and environmental sciences. Dr. Ehrlich has been editor of the journal Mathematical Geology and has published more than 100 papers on the application of numeric techniques including development of new algorithms. He was a Professor at the University of South Carolina, Department of Geological Sciences from 1974 to 1997. His M.S. and Ph.D. degrees are from Louisiana State University. He is presently President of Residuum Energy Incorporated and heads Residuum’s Salt Lake City office.
Stephen Emsbo-Mattingly holds an MS in Environmental Science from the University of Massachusetts and more than 18 years of experience in environmental chemistry and forensics. He specializes in the identification of tar, creosote, petroleum, PAHs, PCB, PCP, solvents, and other compounds of concern in various media. Mr. Emsbo-Mattingly’s recent research and publications focus on the formation and weathering of PAHs and PCBs with an emphasis on the transfer of source signatures between sediment, tissue, and vapor phases. His investigations often involve the simultaneous identification of various other contaminant sources, like non-point releases from storm sewer discharges and wastewater treatment plants. Most of these projects use historical laboratory data, multivariate statistics, and GIS-based spatial analysis.

William E. Full, Ph.D. has spent his career in academia and industry focusing on computer applications and algorithm development in the geosciences. He has B.S. in mathematics from the University of Notre Dame, and M.S. and Ph.D. degrees in Geology from University of Illinois, Chicago and the University of South Carolina, respectively. In 1982 he received the Andre Borisovich Vistelius Research Award for Young Geomathematicians from the International Association of Mathematical Geology. He has published many papers on information entropy and multivariate analysis, and he was the principal developer of the Polytopic Vector Analysis procedure. Dr. Full was on the faculty of the Department of Geology at Wichita State University for 15 years, and is currently a Distinguished Professor at the University of Rome, Italy, and President of WEF consulting in Wichita, Kansas.

Thomas D. Gauthier, Ph.D. is a Senior Science Advisor at ENVIRON International Corp. in Tampa, Florida. He has over 15 years of consulting experience and works on projects involving the transport and fate of chemicals in the environment, historical dose reconstruction, source identification and the statistical analysis of environmental chemistry data. Dr. Gauthier received his BS in chemistry from Merrimack College and Ph.D. in analytical chemistry from the University of New Hampshire. He is a member of the American Chemical Society and is a frequent reviewer for the Journal of Environmental Forensics.
A. Mohamad Ghazi, Ph.D. is an analytical geochemist. His major area of research is in environmental geochemistry with special focus in environmental forensics involving the application of chemical concepts to interpretation, distribution, speciation, impacts and bioavailability of chemicals in the environment and wide range of other media. With more than 20 years of laboratory, field and classroom experience, Dr. Ghazi has made significant contributions in the developing and application of laser ablation ICP-mass spectrometry for in-situ analysis of material. Currently he is a geologist with the DoD Remediation Unit Georgia Environmental Protection Division. Previously he was a research scientist and an associated professor in Geology and the Director of the Laser Ablation Plasma Mass Spectrometry at Georgia State University. Dr. Ghazi is the author and co-author of over 70 peer reviewed articles and book chapters. He has been the principal investigator on 15 successful research proposals to National Science Foundations and other private funding agencies. He is an honorary member of Sigma Xi International Scientific Society. In addition, he is an associate editor for the International Journal of Environmental Forensics and a member of Geological Society of America, American Geophysical Union and American Geochemical Society.

Michael E. Ginevan, Ph.D. a Principal Scientist at Exponent Inc., is an internationally recognized expert in health and environmental statistics, with more than 25 years experience in the application of statistics and computer modeling to problems in public health and the environment, and in the conduct of environmental, epidemiologic, and risk assessment studies. He is the author of “Statistical Tools for Environmental Quality Measurement,” and over 60 other publications in the areas of statistics, computer modeling, environmental studies, and epidemiology. He is a former Deputy Director of the Office of Epidemiology and Health Surveillance at the U.S. Department of Energy, is a founder and past Secretary of the American Statistical Association (ASA) Section on Statistics and the Environment, a recipient of the Section’s Distinguished Achievement Medal, and is a Charter Member of the Society for Risk Analysis. He has served on numerous review and program committees for ASA, the U.S. Department of Energy, The U.S. Nuclear
Regulatory Commission, the National Institute for Occupational Safety and Health, the National Cancer Institute, and the U.S. Environmental Protection Agency.

**A.J. Gravel** is the Managing Director of LECG’s Forensic History and Analysis Group. Mr. Gravel has managed the execution of hundreds of domestic and international environmental, products liability, and other investigations, and litigation support projects. He specializes in matters involving retrospective analysis and environmental cost recovery. His environmental projects have dealt with numerous CERCLA, RCRA, State Voluntary Cleanup Program and toxic tort related issues such as Potentially Responsible Party (PRP) identification; corporate succession and asset searches; land use and business operation histories; past industrial chemical generation, usage, and disposal analysis; cost allocation analysis; insurance investigations and government involvement studies. His work has involved the examination of historical contamination and/or product liability issues for petroleum, chemical, shipbuilding, tire manufacturing, railroad and utility industry clients.

**Mark Hawley**, Ph.D. is a Senior Science Advisor at ENVIRON Corporation in Arlington, Virginia. His technical specialties include hydrology, statistics, modeling, and interpretation of environmental data. Dr. Hawley received a B.S. degree in Geology from Rensselaer Polytechnic Institute and M.S. and Ph.D. degrees in Civil Engineering (Water Resources/Hydrology) from the University of Maryland, and was formerly an Assistant Professor at the University of Virginia. Since joining ENVIRON in 1989 he has managed and participated in a wide variety of projects related to site investigation and remediation, risk assessment, product safety, and management of industrial and hazardous wastes. He has served as an expert witness or provided litigation support in cases involving the fate and transport of potentially hazardous substances including petroleum products, chlorinated solvents, metals, and PCBs.
Emilie Jardé, Ph.D. received her Ph.D. in organic geochemistry from the University of Nancy (France) in 2002. Her Ph.D. dealt with the organic composition of various sewage sludges originating from Lorraine (North-East of France): molecular characterisation and biodegradation effects. She then spent two years as a post-doctoral fellow with Professor G. Gruau at the University of Rennes (France) still working in organic environmental geochemistry and more specifically on the identification of the origin of organic matter in superficial waters from Brittany. After that, she spent a few months at the University of Oklahoma, Norman (USA), as a post-doctoral fellow with Professor R.P. Philp to learn more about the use of stable isotope in monitoring organic pollutants in the environment. In July 2006, she joined the group of G. Gruau at the University of Rennes (France) as a CNRS-researcher. The major theme of her research is the molecular analysis of organic matter from sediments, water, soils, sewage sludge, and animal slurry in environmental studies. To achieve that, she uses the correlation between organic compounds and sources by the identification of specific molecular marker or distribution from typical origins with gas chromatography-mass spectrometry or pyrolysis methods.

Glenn W. Johnson, Ph.D. received his M.S. from the University of Delaware in 1988 and his Ph.D. from the University of South Carolina in 1997. Both graduate research programs involved application of multivariate techniques to geological and environmental chemical data. In the seven years between degrees, he worked as an environmental consultant with Roux Associates, Inc. and McLaren/Hart Environmental Engineering Corp., where much of his work focused on environmental forensics and litigation support. Dr. Johnson is currently a Research Associate Professor at the Energy and Geoscience Institute at the University of Utah. His work at EGI includes research in chemometrics and environmental forensics, as well as teaching within the Department of Civil and Environmental Engineering. Dr. Johnson is a registered professional geologist, and a member of the Society of Environmental Toxicologists and Chemists and the International Society of Environmental Forensics.
Ashok K. Katyal, Ph.D. is Principal Engineer and President of Resources & Systems International, Inc. Ashok received his Ph.D. in Engineering Science from Washington State University. He is recognized as an expert in multiphase flow, surface-groundwater interaction, and watershed management. He is an author of BIOFT3D, BIOSLURP, MARS, MOVER, MOFAT, SVE_3D, and several more software programs currently used in the environmental industry in many countries. Ashok is a consultant to several national and multinational companies.

Kevin J. McCarthy has over 20 years experience in the field of petroleum environmental chemistry. His experience is in the detailed chemical analysis and chromatographic interpretation of petroleum products and wastes and their characterization using advanced instrumental methods and chemometric data analysis techniques (forensic chemical fingerprinting). His expertise includes the molecular-level characterization of petroleum and petroleum products and investigations of the chemical alteration of petroleum due to physical and biological weathering. He has participated in developing specialized methodologies for the analysis and characterization of oil and petroleum products.

James R. Millette, Ph.D. is an Executive Director of MVA Scientific Consultants in Atlanta, Georgia. Since 1972, Dr. Millette’s research focus has been the investigation of environmental particles using microscopy techniques and has published over 60 peer-reviewed articles in the area. Dr. Millette’s previous work included 11 years as a research scientist at the United States Environmental Protection Agency Research Center in Cincinnati, Ohio, and 5 years at McCrone Environmental Services performing and supervising analysis of particulates in various media. Dr. Millette is a full member of the American Academy of Forensic Scientists and has testified in court on several occasions concerning environmental science and particulate analysis.
Gil Oudijk is the owner of Triassic Technology, Inc., a consulting firm located in Hopewell, New Jersey (USA) and founded in 1994. He is a graduate of the Pennsylvania State University and has close to 25 years experience in the hydrogeological field with special emphasis on ground-water pollution problems and forensic techniques such as the age-dating and fingerprinting of contaminant releases. He is presently an Associate Editor for the Journal of Environmental Forensics and a task leader for the American Society of Testing & Material’s (ASTM’s) standards committee on environmental forensics.

Ioana Petrisor, Ph.D. has a PhD in Biology/Environmental Biotechnology from Romanian Academy of Sciences (awarded in 2000) and a Bachelor in Chemistry with a Major in Biochemistry from Bucharest University in Romania, Faculty of Chemistry (awarded in 1992). In December 1999 she has completed an UNESCO training program (3 months) on Plant Molecular Genetics at the University of Queensland, Department of Botany in Brisbane, Australia. She is co-author of 63 scientific papers published in peer-review Journals and Proceedings and of one invention patent. She has more than 12 years of experience (both academic and industry) in the Environmental Engineering/Biotechnology field. She is Managing Editor for the Environmental Forensics Journal and a member of the Editorial board of several other peer-review Journals. She was recently elected as Vice-Chairman of the newly formed ASTM committee on Forensic Environmental Investigations (sub-committee of Environmental Assessment, Risk Management and Corrective Actions main E50 committee). She is a member of ACE, AEHS, ITRC (Vapor Intrusion and UXO teams) and other professional organizations. Her work experience includes managing and conducting innovative research (at lab, field and pilot scales) for U.S. DOE and the European Community on the topics of bioremediation and phytoremediation, environmental characterization and risk assessment. She is now involved in forensics studies aiming to identify the source and age of contamination, and subsequently allocating responsibilities between different potential responsible parties for case studies involving gasoline and other petroleum products releases, PCB contamination, as well as chlorinated solvents and heavy metals.
**R. Paul Philp**, Ph.D. is Professor of Petroleum and Environmental Geochemistry at the University of Oklahoma. He received his Ph.D. from the University of Sydney, Australia in 1972 and a D.Sc. from the same University in 1998 on the basis of his research in geochemistry over the past 20 years. Prior to starting at the University of Oklahoma in 1984 Dr. Philp was a Principal Research Scientist, C.S.I.R.O., Sydney, Australia. His current research interests center around petroleum, environmental and forensic geochemistry with an emphasis on molecular and isotopic characterization of oils, gases, rock extracts and contaminants for the purposes of source determination, characterization of depositional environments, maturity, biodegradation and for correlation purposes. Much of the current research activity in the area of forensic geochemistry involves the use of stable isotopes for the purposes of fingerprinting contaminants in the environment for correlation purposes; source determinations and evaluating whether or not natural attenuation is active. This approach is particularly valuable in the case of refined products or single component contaminants when the more traditional GC and GCMS techniques are of little or reduced use. He has authored or co-authored over 340 articles and books and has lectured extensively on petroleum and environmental geochemistry in SE Asia, South America, Europe and Africa.

**Scott Ramos**, Ph.D. is an analytical chemist with experience in environmental and trace hydrocarbons, natural products and chemometrics. He has a B.S. degree in chemistry from MIT, an M.S. in environmental science from Washington State University, and a Ph.D. in analytical chemistry and chemometrics from the University of Washington. Scott has worked for NOAA’s National Marine Fisheries Service, in Seattle, at FEEMA, the state pollution control agency in Rio de Janeiro, and the federal Amazon Research Institute (INPA) in Manaus, both in Brazil. During the last 22 years, he has been the chief scientist at Infometrix, Inc, in Bothell, WA. Publications include studies on contamination by polycyclic aromatic hydrocarbons, essential oil characterization, and various applications of chemometrics.
Charles Ramsey is the founder and President of EnviroStat, Inc., a company that provides training in sampling and laboratory subsampling for defensible environmental decisions to federal and state agencies as well as private companies. He has a BA in Chemistry from the University of Denver and a MS in Environmental Science from the Colorado School of Mines. Mr. Ramsey has 20 years sampling experience including seven years with the National Enforcement Investigations Center (NEIC) of the USEPA. While with the EPA, Mr. Ramsey provided sampling and statistical expertise on all major environmental regulations. Mr. Ramsey is involved with the development of guidance documents for sampling and statistics.

Scott A. Stout is an organic geochemist with nineteen years of petroleum and coal industry experience. He has extensive knowledge of the chemical compositions of coal-, petroleum-, gasoline-, and other fuel-derived sources of contamination in terrestrial and marine environments. Dr. Stout has written interpretive reports on more than 250 site or incident investigations and has authored or co-authored nearly 100 papers published in scientific journals and books. He has conducted environmental research while employed at Unocal Corporation, Battelle Memorial Institute, and is currently a partner at NewFields Environmental Forensics Practice, Rockland, Massachusetts.

Allen D. Uhler has over 25 years experience in environmental chemistry. He has developed advanced analytical methods for petroleum-, coal-derived and anthropogenic hydrocarbons and other man-made organic compounds in waters, soils, and sediments, vapor and air. He has conducted assessments of the occurrence, sources, and fate of fugitive petroleum at refineries, offshore oil and gas production platforms, bulk petroleum storage facilities, along petroleum pipe-
lines, at varied industrial facilities, and in sedimentary environments. He has studied coal-derived wastes at former manufactured gas plants, wood-treating facilities, and in nearby sedimentary environments. His experience includes expertise in the measurement and environmental chemistry of man-made industrial chemicals including PCB congeners and Aroclors, persistent pesticides, dioxins and furans, metals, and organometallic compounds.

Dallas Wait, Ph.D. is a chemistry expert at Gradient Corporation with over 28 years of experience evaluating the source and fate of chemicals in the environment, characterizing consumer products, designing test method and quality assurance programs, interpreting data, and determining the reliability of chemistry measurements and sampling procedures. Dr. Wait’s consultations often resolve data quality issues, aid in agency negotiations concerning data usability, and provide pivotal chemistry testimony. He serves on the editorial board for two peer-reviewed journals and coauthored the second edition of EPA’s SW 846 Test Method Manual. Dr. Wait is a member of the Scientific Advisory Board for the International Conference on Soils, Sediments and Water and for eight years was the Chairperson for either the Risk, Forensic or Analysis sessions of the conference. He is a member of numerous scientific work groups involved with developing and evaluating test methods and quality assurance programs, such as ASTM and AOAC. Before joining Gradient in 1989, he was Technical Director, Vice President and cofounder of ENSECO’s ERCO Laboratory, a nationally prominent environmental laboratory involved, in part, with oil spill research, agency method development studies, aquatic toxicology GLP testing support, and site investigations. Dr. Wait received his BS and Ph.D. degrees in Chemistry from the University of Rhode Island.

John G. Watson, Ph.D. is a Research Professor in the Desert Research Institute’s (DRI’s) Division of Atmospheric Sciences specializing in the characterization, source apportionment, and control of suspended particles that cause adverse health effects and regional haze. Dr. Watson has developed theoretical and empirical models that, when coupled with appropriate measurements, quantify contributions for pollution from different sources. With his colleagues, he has applied these
methods in urban and regional aerosol studies to solve problems of excessive concentrations, visibility impairment, and deposition. Dr. Watson obtained his Ph.D. degree in Environmental Science from the Oregon Graduate Institute in 1979 and was awarded the Howard Vollum Prize for Distinguished Achievement in Science and Technology in 1989, DRI’s Alessandro Dandini Medal of Science in 1992, and the Air & Waste Management Association’s 2000 Frank A. Chambers Award for major contributions to the science and art of air pollution control.