

# Russell E. Keenan, Ph.D.

## Vice President / Principal Toxicologist



### Education and Credentials

Ph.D., Environmental Biology,  
Duke University, Durham,  
North Carolina, 1983

B.S., Biology, Bates College,  
Lewiston, Maine, 1975

### Professional Affiliations

Member of Society of Toxicology

Member, Advisory Board,  
Association for Environmental  
Health and Sciences Foundation

Member of the Society for Risk  
Analysis

### Achievements and Awards

Society of Toxicology, Award for  
the Outstanding Published Paper  
in Risk Assessment in 1997

Society of Toxicology, Award for  
the Outstanding Presented Paper  
in Risk Assessment at the 1996  
Annual Meeting

Technical Association of the  
Pulp and Paper Industry (TAPPI),  
Russell O. Blosser Memorial  
Award for the Best Paper  
Presented at the 1991  
Environmental Conference

Sandoz Corporation, Board of  
Directors Award for Outstanding  
Technical Excellence in  
Environmental Science, 1990

### Professional Profile

Dr. Russell Keenan is a vice president and principal toxicologist at Integral Consulting with 30 years of experience specializing in chemical risk assessment and toxicology. Much of his work focuses on assessing the potential human health and ecological risks of PCBs, dioxins, furans, mercury, copper, and chromium, and on developing time-dependent probabilistic risk assessment methods. Over the past 30 years, he has directed a team of scientists in evaluating the human health and ecological risks associated with chemical exposures at a number of sites involving multiple exposure pathways. Many of the more complex sites are associated with aquatic environments, including the Hudson, Housatonic, Fox, Penobscot, Woonasquatucket, Columbia, Hackensack, and Passaic rivers. Dr. Keenan has conducted more than 200 human health and wildlife risk assessments for regulated sites and has evaluated risks associated with exposure to conventional and radioactive residuals from former mining operations. He represents clients on multi-stakeholder technical and steering committees; provides technical expertise and support in regulatory negotiations; and provides strategic consultation on CERCLA and RCRA risks, liability issues, and remedy selection.

Dr. Keenan has testified as an expert in several U.S. District Court jurisdictions and before U.S. Congressional panels and state and federal agencies during regulatory proceedings on environmental issues. Among other accomplishments, this work has led to the establishment of EPA-approved alternative ambient water quality criteria in nine states. He served as co-investigator of state and regional angler surveys used by EPA as key studies in evaluating exposures through fish ingestion. Dr. Keenan also managed the first private sector Cooperative Research and Development Agreement with EPA in the field of regulatory toxicology and risk assessment, which developed probabilistic models for characterizing the uncertainty in reference dose estimates used in noncancer risk assessment. Subsequently, he served as one of eight independent experts in the congressionally mandated review of EPA's process for handling toxicological uncertainty in its Integrated Risk Information System (IRIS). He has also served on chemical-specific expert review panels for the nonprofit organization Toxicology Excellence for Risk Assessment (TERA). Dr. Keenan has authored more than 90 publications in his field. He is an active member in the Society of



Toxicology, from which he received two best paper awards; serves on the Advisory Board to the Association for Environmental Health and Sciences Foundation; and is a member of the Society for Risk Analysis.

## Expert Services

**School Campus, Monroe, Washington**—On behalf of Monsanto Company, Solutia Inc., and Pharmacia LLC, authored an expert report (August 3, 2020) providing opinions regarding the safety of school buildings, based on a site-specific risk assessment using an exposure model and methods developed by EPA. (*Kerry L. Erickson, et al., v. Monsanto Company, et al.*, Case No. 18-2-11915-4-SEA in the Superior Court in the State of Washington, County of King)

**Spokane River, Washington**—On behalf of Monsanto Company, Solutia Inc., and Pharmacia LLC, authored an expert report (November 15, 2019) based on a site-specific risk assessment, evaluation of fish advisories, and evaluation of the safety of all common, real-world recreational uses of the Spokane River. (*City of Spokane v. Monsanto Company, Solutia Inc., and Pharmacia LLC*, Case No. 2:15-cv-00201-smj in the U.S. District Court, Eastern District of Washington)

**Petroleum Refinery, North Pole, Alaska**—On behalf of Williams Alaska Petroleum (Shook, Hardy & Bacon), authored an expert report (December 12, 2016) and an expert rebuttal report (January 27, 2017) on the appropriate toxicity values for use in site-specific risk assessment of sulfolane, a chemical substance without toxicity values on EPA's IRIS database. Provided expert testimony in deposition (March 24, 2017) and at trial (October 21, 2019). (*State of Alaska and City of North Pole v. Williams Alaska Petroleum Inc., The Williams Companies, Inc., Flint Hills Resources Alaska, LLC, and Flint Hills Resources, LLC.*, Case No. 4FA-14-01544CI, in the Superior Court for the State of Alaska Fourth Judicial District Court, Fairbanks)

**San Diego Bay, California**—On behalf of Monsanto Company, Solutia Inc., and Pharmacia LLC, authored an expert report (May 9, 2019) and provided expert testimony in deposition (June 27, 2019) based on a site-specific risk assessment, evaluation of fish advisories, and evaluation of the safety of residential and all common, real-world recreational uses of San Diego Bay. (*City of San Diego v. Monsanto Company, Solutia Inc., and Pharmacia LLC*, Case No. 15-cv578-WQH-AGS in the U.S. District Court, Southern District of California)

**Penobscot River Human Health Risk, Maine**—On behalf of Mallinckrodt U.S., LLC, authored an expert report (May 9, 2019) and an expert rebuttal report (May 24, 2019), and provided expert testimony in deposition (August 20, 2019) based on evaluation of the August 2018 report titled, Penobscot River Risk Assessment and Preliminary Remediation Goal Development, prepared by Amec Foster Wheeler Environment & Infrastructure, Inc. (*Natural Resources Defense Council et al. v. HoltraChem Manufacturing LLC et al.*, Civil No. 1:00-cv-69-JAW in the U.S. District Court, District of Maine)

**Centredale Manor Superfund Site, Rhode Island**—On behalf of Emhart Industries, Inc. (subsidiary of Stanley, Black and Decker, Inc.), authored a detailed expert report and provided expert testimony in deposition (July 29, 2014) and at trial (October 3 and 4, 2016), concluding that EPA



failed to follow applicable regulations, appropriate guidance, and objective science in conducting the baseline human health and ecological risk assessments for dioxin and PCBs at the site. EPA's human health risk estimates are not site-specific and are unrealistic or implausible, while EPA's ecological risk assessment is incomplete and inadequate. EPA's determination of site cleanup is much more stringent than necessary to assure the protection of human health and the environment and the record of decision (ROD) significantly overstates the need for remedial action and establishes cleanup goals that far exceed those needed to protect human health and ecological resources.

On August 17, 2017, the U.S. District Court ruled in favor of Emhart's challenge to the unilateral administrative order (UAO) to perform the remedial design, remedial action, and operation and maintenance as described in the ROD. The court found that EPA made several decisions that violated CERCLA because they were arbitrary, capricious, or otherwise not in accordance with law. These included classification of groundwater as a potential source of drinking water and portions of the fish consumption human health risk assessment. As a result, Emhart is not required to pay the fines and fees stemming from its non-compliance with the UAO. (*Emhart v. New England Container Company, Inc. et al.*, Case No. 06-218-S and *Emhart v. U.S. Air Force et al.*, Case No. 11-023S, in the U.S. District Court, District of Rhode Island)

***PCBs at an Old Industrial Site, Wisconsin***—On behalf of SPX Corp., TRC Environmental Corp., and Apollo Dismantling Services, LLC, authored an expert report (November 9, 2017) and an affidavit (December 7, 2017) in support of a summary judgment to dismiss the plaintiffs' federal claims under RCRA and TSCA. Opined that the PCBs found in soil on the plaintiffs' property are not the result of a building demolition project. The Court found in favor of the defendants, stating that the plaintiffs failed to show that the defendants violated the relevant standards under RCRA or TSCA (March 30, 2018). (*William Liebhart and Nancy Liebhart v. SPX Corporation, TRC Environmental Corporation, and Apollo Dismantling Services, Inc.* Case No. 16-cv-700, in the U.S. District Court, Western District of Wisconsin)

***Penobscot River and Estuary, Maine***—On behalf of Mallinckrodt U.S., LLC, authored comprehensive expert and surrebuttal expert reports and provided expert testimony in deposition (February 27, 2014) and at trial (June 20, 23 and 24, 2014) before the U.S. District Court, District of Maine, defending against allegations of unacceptable human health risk and significant adverse ecological risk to fish and shellfish populations due to mercury in Maine's lower Penobscot River and estuary. Derived ecologically relevant target tissue and dietary mercury concentrations for fish in the river and estuary. (*Natural Resources Defense Council et al. v. HoltraChem Manufacturing LLC et al.*, Civil No. 1:00-cv-00069-JAW in the U.S. District Court, District of Maine)

***PCBs in Escambia Bay, Florida***—On behalf of Monsanto, provided expert report and deposition to contest allegations of chemical trespass, nuisance, negligence, and property damage related to potential health effects from PCBs in aquatic biota of Escambia Bay, Florida. Scheduled testimony at trial became unnecessary when the case settled. (*John Allen et al. v. Monsanto et al.*, Case No. 2008 CA 001762, Division B, in the Circuit Court in and for Escambia County, Florida)



**Wood Products Facility, Dierks, Arkansas**—On behalf of Weyerhaeuser, provided services to defend against allegations of chemical trespass, nuisance, negligence, and property damage involving dioxin releases from Weyerhaeuser’s operation of an active wood products facility in Dierks, Arkansas. Provided expert report, rebuttal of plaintiffs’ expert reports, hearing demonstratives, trial testimony, and cross-examination. The jury returned a verdict in favor of Weyerhaeuser on all seven counts. No compensatory or punitive damages were assessed against the company. (*Rhonda Brasel, Individually and as Next Best Friend and Guardian of Christopher Albright and Nathan K. Thomas, et al. v. Weyerhaeuser Company, et al.*, Case No. 4:07cv4037 in the U.S. District Court, Western District of Arkansas, Texarkana Division)

**Chlor-alkali Plant, Orrington, Maine**—On behalf of Mallinckrodt, LLC and United States Surgical Corporation, provided expert testimony for an extensive evaluation of four proposed remedial alternatives at the former HoltraChem chlor-alkali plant site in Orrington, Maine, to assess relative effectiveness at protecting human health from risk due to release of residual mercury into the Penobscot River. Provided similar comparative analysis for risks of death, injury, and property damage due to transport of contaminated wastes. Provided expert report, pre-filed direct testimony, pre-filed rebuttal testimony, hearing demonstratives, adjudicatory hearing testimony, and cross-examination before the Maine Board of Environmental Protection and intervenors for the case. (*Appeal of Designation of Uncontrolled Hazardous Substance Site and Order Concerning Chlor-alkali Manufacturing Facility, Orrington, Penobscot Co., Maine, Proceeding under MRSA §1365 Uncontrolled Hazardous Substance Sites Law*)

**Proposed Total Maximum Daily Load for PCBs, San Francisco Bay, California**—Authored an expert report and wrote sections of the comprehensive comments submitted by the California Chamber of Commerce and the General Electric Company concerning the California Regional Water Quality Control Board’s 2007 proposed total maximum daily load for PCBs in San Francisco Bay.

**Penobscot River Human Health Risk, Maine**—Provided expert services on behalf of Mallinckrodt, Inc. in a case concerning risks due to consumption of fish containing methylmercury from the Penobscot River. Provided testimony in two oral depositions and testified in U.S. District Court. (*Maine People’s Alliance & Natural Resources Defense Council, Inc. v. HoltraChem Manufacturing Company, LLC and Mallinckrodt, Inc.*, Docket No. 00-69-B in U.S. District Court)

**Evaluation of Provisional Toxicity Criteria for Perfluorinated Chemicals**—Evaluated the scientific basis for provisional toxicity factors for PFCs and provided recommendations, consultation, and peer review to counsel on behalf of a confidential client. Provided support and evaluation of exposure and toxicity issues and weighed the merits associated with the generation of *de novo* rodent bioassay data.

**Personal Injury Lawsuit, Maine**—On behalf of Kimberly-Clark Corporation, authored an expert report and was expected to testify at trial. The case was settled before trial. (*Anne Meader, et al. v. Kimberly-Clark, et al.*, Docket No. CV-00-0018, Somerset County [Maine] Superior Court)



**PCB Health Risks, Ohio**— Authored an expert report on the evaluation of health risks posed by PCBs. The case was settled in the U.S. District Court. (Case No. C-1-00530 in U.S. District Court, Southern District of Ohio, Western Division)

**Cement Plant, Kentucky**—On behalf of Lafarge North America, Inc., provided expert testimony in deposition and in videotaped testimony used at trial. (*Lafarge North America Inc. v. Natural Resources and Environmental Protection Cabinet, Commonwealth of Kentucky Natural Resources and Environmental Protection*, Cabinet File No.: DAQ-25389-037)

**PCB Risks, Indiana**— Authored an expert report assessing potential risks from PCBs at a former CBS-Westinghouse facility in a personal injury case. This matter settled before trial. (*Craig Taylor et al. v. CBS Corporation* [now Viacom])

**Post-fire Reentry Criteria, Philadelphia, Pennsylvania**—Provided fact and expert testimony in three oral depositions concerning the establishment of risk-based reentry criteria for PCBs, dioxins, and furans following an office building fire at One Meridian Plaza in Philadelphia. Authored an expert report that ascertained safe exposure limits to these compounds and directed a risk assessment that evaluated the hypothetical exposures and associated potential risks under various use scenarios for the building. The case settled before trial. (Kostow & Daar)

**Mercury Release Site, Vermont**—Provided testimony in expert reports and oral deposition concerning the toxicology of mercury and potential human exposures at a RCRA site where mercury had been released to the environment. The case settled before trial. (Hull, Webber, Reis & Canney)

**GE-Pittsfield/Housatonic River Site, Massachusetts**—In public testimony before the Housatonic River Risk Assessment Peer Review Panel, presented analysis demonstrating that the application of dioxin toxic equivalency factors to evaluate potential PCB health risks was unnecessary to fully characterize health risks. Finding this presentation “compelling,” a majority of the panelists recommended that toxic equivalency factors not be used to assess PCB health risks.

**PCB Cancer Risk, Virginia**—On behalf of American Chemistry Council (Polychlorinated Biphenyls Panel), Utility Solid Waste Activities Group, and National Electrical Manufacturers Association, conducted analysis and wrote expert report demonstrating that the proposed application of dioxin toxic equivalency factors to evaluate the risks posed by PCB mixtures overpredicts the cancer potency of PCBs by at least an order of magnitude. Presented findings in public hearing to the EPA Science Advisory Board, Dioxin Reassessment Review, Arlington, Virginia.

In public testimony before the Executive Committee of the EPA Science Advisory Board, presented analysis demonstrating that application of dioxin toxic equivalency factors to evaluate the risks posed by PCB Aroclor 1254 overpredicts its cancer potency by at least 30-fold. As a result, the issue as to whether it was appropriate to use the dioxin toxic equivalency method to evaluate the risks posed by PCB mixtures was one of the key questions that was evaluated by the National Academy of Sciences in its review of EPA’s Dioxin Reassessment.





***Drinking Water Criteria***—Wrote expert report evaluating the procedures used to derive human health criteria for the Great Lakes Water Quality Initiative and presented findings to the EPA Science Advisory Board, Drinking Water Committee, Washington, DC.

***Cancer Slope Factor for PCB Mixtures***—Conducted the cancer dose-response assessment, wrote expert report, and provided expert opinion for a successful petition by the General Electric Company to revise the cancer slope factor for PCB mixtures.

***Federal Rulemaking for Dioxin-Like Compounds***—On behalf of the American Forest and Paper Association, prepared expert testimony for EPA hearing on estimating exposure to dioxin-like compounds and on evaluating methods of environmental transport and resulting exposures. In its subsequent consensus report, the hearing panel adopted many of the criticisms to the proposed rule and appended the comprehensive expert report to the text of its findings.

***Water Quality Criteria***—On behalf of the National Council of the Paper Industry for Air and Stream Improvement, wrote expert report evaluating the procedures used to derive human health and wildlife criteria for the Great Lakes Water Quality Initiative. Presented findings at public hearing held by the EPA Science Advisory Board, Great Lakes Water Quality Subcommittee, Chicago, Illinois.

***Fish Consumption Study, Maine***—Directed a study and provided regulatory testimony and comments concerning consumption of freshwater fish by Maine anglers and a pathway-specific description of bioaccumulation of dioxin-like compounds from multiple sources. (Pierce Atwood)

***NPDES Permit Limits, Mississippi***—Provided expert testimony in adjudicatory hearing before the Mississippi Department of Environmental Quality regarding NPDES permit limits for Leaf River Forest Products, Jackson, Mississippi.

***Land Application of Paper Mill Sludge***—On behalf of the National Council of the Paper Industry for Air and Stream Improvement, testified in public hearing before EPA regarding a proposed rule for the land application of sludge from pulp and paper mills using chlorine and chlorine-derivative bleaching processes. (EPA TSCA Docket No. OPTS-62100; 56 FR 21802)

***Personal Injury Litigation Support***—Directed confidential client's scientific defense of the personal injury claims related to plaintiffs' alleged exposure to dioxins and furans in wastewater effluent.

***James River Old Town Mill, Old Town, Maine***—Provided expert testimony in public hearing before the Old Town Planning Board on a hazard evaluation of metal and dioxin concentrations in the sludge/ash, lime mud, and leachate at the James River Old Town Mill.

***NPDES Waste Discharge Permits, Oregon***—Rebutted testimony in adjudicatory hearing before Oregon's Environmental Quality Commission regarding NPDES Waste Discharge Permits 100715 and 100716.



***NPDES Permit Limits for Dioxin, Arkansas***—On behalf of International Paper Company and Georgia Pacific, provided expert testimony on the carcinogenic dose response of dioxin given in public hearing before the Arkansas Commission of Pollution Control and Ecology regarding NPDES No. AR0001970 Waste Discharge Requirements for International Paper Company and NPDES No. AR0001210 Waste Discharge Requirements for Georgia-Pacific Corporation.

***State Water Quality Standards for Dioxin, Multiple States***—Provided expert testimony in public hearings before the following regulatory agencies concerning the establishment or refinement of a health-based water quality standard for dioxin:

- Alabama Environmental Management Commission
- Florida Environmental Regulation Commission
- Mississippi Department of Environmental Quality
- South Carolina Water Quality Commission
- North Carolina Environmental Management Commission
- Oregon Environmental Quality Commission
- Washington State Department of Ecology.

***Alabama Water Quality Standard for Dioxin***—Provided expert testimony in public hearing before the Alabama Environmental Management Commission concerning the establishment of a health-based water quality standard for dioxin.

***Florida Water Quality Standard for Dioxin***—On behalf of the Florida Pulp and Paper Association, provided expert testimony in public hearing before the State of Florida Environmental Regulation Commission concerning the establishment of a health-based water quality standard for dioxin in Florida.

***Mississippi Water Quality Standard for Dioxin***—Provided expert testimony in public hearings before the Mississippi Department of Environmental Quality (Starkville and Jackson), concerning the establishment of a health-based water quality standard for dioxin in Mississippi.

***South Carolina Water Quality Standard for Dioxin***—On behalf of the South Carolina Pulp and Paper Association, presented expert testimony in public hearing before the South Carolina Water Quality Commission (Georgetown, Greenville, and Columbia) concerning the establishment of a health-based water quality standard for dioxin.

***North Carolina Water Quality Standard for Dioxin***—On behalf of the North Carolina Forest Products Association, provided expert testimony in public hearing before the North Carolina Environmental Management Commission concerning the establishment of a health-based water quality standard for dioxin in North Carolina.



***Oregon Water Quality Standard for Dioxin***— Provided expert testimony in public hearing before the Oregon Environmental Quality Commission concerning the petition for rule amendment to establish a health-based, water quality standard for 2,3,7,8-TCDD.

***Washington Water Quality Standard for Dioxin, Washington***— On behalf of the Northwest Pulp and Paper Association, testified in public hearing before the Washington State Department of Ecology regarding critical factors for establishing an ambient water quality standard for TCDD.

***Georgia Water Quality Regulations***— Presented expert testimony in public hearing before the Georgia Board of Natural Resources on amendments to Georgia water use classifications and water quality standards.

***Maine Water Quality Regulations***— Presented testimony in public hearing before the Maine Legislative Committee on Energy and Natural Resources to clarify the process by which the Board of Environmental Protection regulates the discharge of toxic substances to the state’s surface waters.

***Minnesota Water Quality Standards***— Provided expert testimony in public hearing before the Minnesota Pollution Control Agency on proposed revisions to Minnesota water quality standards.

***West Virginia Water Quality Standards***— Provided expert testimony in public hearing before the West Virginia State Water Resources Board on proposed amendments and revisions to 46 CSR 1 Title 46 Legislative Rule Series 1 requirements governing water quality standards.

***Health Effects of TCDD, Arkansas***— On behalf of International Paper, presented expert testimony at public hearing before the Arkansas Commission of Pollution Control and Ecology for reevaluation of the tumor histopathology of Kociba et al. (1978)<sup>1</sup> using 1990 criteria: implications for the risk assessment of 2,3,7,8-TCDD using the linearized multistage model.

***Emissions from Sludge Drying Operations, Wassau Papers, Wisconsin***— Presented expert testimony in public hearing before the Wisconsin Department of Natural Resources on evaluation of emissions from proposed sludge drying operation.

***Human Exposure to Dioxins, Florida***— On behalf of the Florida Pulp and Paper Association, presented expert testimony in public hearing before the State of Florida Department of Environmental Regulation on acceptable levels of human exposure to dioxin.

***Public Relations Support, Northwest Pulp and Paper Association, Washington***— Participated in a televised Town Hall debate (Channel 2, Portland, Oregon) addressing dioxin risks.

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<sup>1</sup> Kociba, R.J., D.G. Keyes, J.E. Beyer, R.M. Carreon, C.E. Wade, D.A. Dittenber, R.P. Kalnins, L.E. Frauson, C.N. Park, S.D. Barnard, R.A. Hummel, and C.G. Humiston. 1978. Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in rats. *Toxicol. Appl. Pharmacol.* 46(2):279–303.





## Additional Technical Experience

### Regulatory Toxicology, Risk Assessment, Exposure Evaluation, and Regulatory Support

**Remedial Risk Management Strategy Model Development at CERCLA Site, Montana**—Served as principal-in-charge of an interdisciplinary team that developed a unique exposure apportionment model and risk management tool as an integral component in the feasibility study for a large and complex Superfund site. The risk management tool spatially characterizes the results of the EPA baseline risk assessment through the evaluation of multiple landscape attributes across the 10,000 acres of land comprising the site. This spatial characterization identifies areas of higher and lower potential exposures for the purpose of targeting and predicting the risk reduction associated with remedial alternatives. As principal-in-charge, co-chaired and guided the deliberations of a stakeholder work group to achieve consensus among the potentially responsible party (PRP), EPA, and four other federal and state regulatory agencies concerning the framework of the risk management strategy and its application in the remedy evaluation and selection process.

**Dioxin Reassessment and Implications for PCBs**—On behalf of the American Chemistry Council (Polychlorinated Biphenyls Panel), Utility Solid Waste Activities Group, and National Electrical Manufacturers Association, conducted an analysis and authored a paper showing that the proposed application of dioxin toxic equivalency factors to evaluate the risks posed by PCB mixtures overpredicts the cancer potency of PCB Aroclor 1254 by at least 30-fold. Presented these findings in a public hearing to the EPA Science Advisory Board, Dioxin Reassessment Review Committee and again before the Executive Committee of the EPA Science Advisory Board. In collaboration with coworkers, refined the analyses, prepared five papers for submission to peer-reviewed journals, and presented these findings to members of the Federal Interagency Work Group charged by the U.S. Congress with reviewing and evaluating the merits of EPA's draft dioxin reassessment. Along with other scientific critiques of the EPA reassessment, these analyses and presentations served as compelling evidence in support of a congressional mandate for a National Academy of Sciences (NAS) review of the draft dioxin reassessment. *(During the NAS review, Dr. Keenan and Dr. Silkworth of the General Electric Company were invited by NAS to present their research showing that the toxic equivalency approach ignores empirical evidence regarding PCB toxicity and substantially overpredicts risks. Several of their key findings were expressed in the NAS Final Report under the recommendations for revising the dioxin reassessment.)*

**Lower Passaic River Superfund Site, New Jersey**—Serving as principal-in-charge of the Integral scientific team providing strategic consultation and technical support in human health and ecological risk assessment, conceptual site model development, and remedy selection on behalf of certain parties engaged in the Lower Passaic River Study Area (LPRSA), one of the largest Superfund projects of a contaminated river in the U.S. This work includes providing technical support in the development of the human health and ecological risk assessments; guiding the development and assessment of angler survey methods; and reviewing environmental chemistry, toxicity, bioaccumulation, and related test results. Actively participating as a technical lead in LPRSA working groups assigned to explore important risk and liability issues.



***Housatonic River and Floodplain, Massachusetts and Connecticut***—For more than 15 years, has provided risk assessment, toxicology, and regulatory support related to the Housatonic River and its floodplain in Massachusetts and Connecticut. Evaluated potential risks associated with PCBs in groundwater, subsurface soil, and air in industrial areas and evaluated potential exposures to PCBs in surface soil, sediment, and food products associated with the floodplain of the river. Provided extensive peer review comments and participated in numerous regulatory negotiations associated with selecting and supporting approaches for conducting both the human health and ecological risk assessments for the site. These approaches have included identification of potentially exposed receptors, definition of discrete exposure areas, and selection of potential land uses for evaluation. Designed site-specific studies for the purpose of collecting specific information about the locations and types of recreational activities occurring along the Housatonic River and its floodplain and the fish consumption behaviors of recreational anglers who use it. Applied the microexposure event model to characterize potential risks to fish consumers who might use the site. This work has included interactions and comments with the peer reviewers, exploration of alternative risk assessment approaches, and regulatory negotiations with EPA and the partner agencies.

***PCB Risk Assessment for the Hudson River PCB Superfund Site and Development of Alternative Probabilistic Analyses, New York***—Critically evaluated the risk assessment of PCB-containing sediments in the Hudson River. During this evaluation, directed the development of a site-specific risk assessment based on regional fish consumption rates and other exposure factors using a microexposure event Monte Carlo analysis. Achieved consensus with EPA and its contractors that a Monte Carlo approach should be used for the Hudson River risk assessment. Through the use of the model, it was possible to characterize the distribution of PCB dose rates in a hypothetical population of recreational anglers who might potentially consume fish in the absence of fish consumption advisories. By more accurately characterizing the potential risks from PCBs in the river, the microexposure event analysis became an important analysis in the selection of remedial alternatives for this site.

***Fox River PCB Superfund Site, Wisconsin***—On behalf of the Fox River PRPs, provided consultation, third-party review, and analysis of agency and trustee claims on human health, ecological risk, and natural resource damage issues in conjunction with the Fox River PCB investigation and remedial action program. Developed a microexposure event Monte Carlo model for evaluating the potential human health risks associated with ingesting fish from the river and prepared comments for submission to the administrative record. The incorporation of critical site-specific data on exposure and PCB fish trends enhances the precision of the potential cancer and noncancer risk estimates over those predicted by the default human health risk analysis. Analyzed the various remedial alternatives proposed for the Lower Fox River and found that an extensive dredging remedy would not lead to reduced risks compared to an adaptive management approach. Prepared comments for submission to the U.S. Department of the Interior, Fish and Wildlife Service, concerning the *Draft Joint Restoration Plan and Environmental Assessment for the Lower Fox River and Green Bay*.



***Centredale Manor–Woonasquatucket River Restoration Project Superfund Site, North Providence, Rhode Island***—Led a team in providing human health and ecological risk assessment support, environmental fate and transport consultation, sampling design, data quality assurance, and other support services. The site is associated with potential human health risk issues and ecological concerns from the presence of dioxins, furans, and PCBs in all environmental media, but particularly in aquatic environments, associated biota, and neighboring terrestrial environments. Developed and presented a white paper on assessing and managing human health and ecological risks at contaminated sediment sites to EPA’s Contaminated Sediments Technical Advisory Group. Prepared comments to the administrative record on issues related to the fate, transport, and human health and environmental risks associated with the compounds at this complex site. Developed alternative remedial strategies that considered removing the existing dam structures and placing the contaminated sediment in nearshore confined disposal facilities. In support of the “no dam” alternatives, and as part of an EPA consent order, prepared a comparative ecological assessment report that evaluated the current environs and contrasted the structure and function of those environs against others that would exist under the “no dam” alternatives. Investigated the efficacy of the dam-removal options in terms of flood retention, forested wetlands inundation, and riverbed scour potential.

***Comprehensive Statewide Fish Consumption Survey, Maine***—Directed the development and implementation of a statistically valid statewide survey to assess the rate of freshwater fish consumption by anglers and their families. Coauthored a peer-reviewed journal article presenting the survey methodology and results. The results of this survey provided a full distribution of ingestion rates for use in a Monte Carlo exposure assessment. Performed in cooperation with resource economists at the University of Maine and with representatives of the Maine Department of Inland Fisheries and Wildlife, the Maine Angler Survey became the most definitive study of its type to assess the rate of fish ingestion among freshwater anglers in North America. The Maine Angler Survey was selected as a “Key Study” in EPA’s *Exposure Factors Handbook* and is recommended as a basis for the selection of fish consumption rates by freshwater recreational anglers.

***EPA, National Center for Environmental Assessment Peer Review***—Served as one of eight independent experts selected in the congressionally mandated review of EPA’s process for handling toxicological uncertainty in EPA’s IRIS listing of chemicals. Evaluated and commented on EPA’s characterization of data uncertainty and variability for a subset of IRIS assessments. Results of this peer review were submitted to the EPA Science Advisory Board and to the U.S. Congress.

***First EPA Cooperative Research and Development Agreement (CRADA) in Risk Assessment***—Established and served as principal investigator for the first CRADA under the Federal Technology and Transfer Act with EPA in the field of risk assessment. This CRADA was established to provide the framework for a cooperative research project between the private sector and EPA to develop Monte Carlo–based models for characterizing the uncertainty in reference dose estimates used in noncancer risk assessment. By reducing uncertainty in the reference dose, increased confidence can be placed in setting environmental cleanup levels, thus enhancing cost-effective environmental restoration.



***Comprehensive Evaluation of the Environmental Aspects of Mercury***—Led the proactive research and scientific evaluations of the pulp and paper industry in anticipation of proposed regulatory actions aimed at establishing a zero-discharge limit of elemental mercury to the environment. Headed the team that developed and authored a comprehensive study that included a characterization of the relative contribution of 1) the natural and anthropogenic sources of mercury; 2) current levels in air, surface water, soil, sediment, and biota; 3) potential implications of the Great Lakes Water Quality Initiative and other regulatory programs related to the regulation of mercury in the environment; and 4) an evaluation of inputs and outputs of mercury from various industrial processes at each of the mills and facilities of the trade association’s members. As a result of the team identifying how mercury enters and cycles through the environment, and how various changes in certain industrial processes and raw materials can reduce discharges to the environment, voluntary sustainable practices were instituted and the proposed zero-discharge limits were never promulgated.

***Comprehensive Ecological Risk Assessment of PCBs in a Floodplain***—Developed a comprehensive ecological assessment for evaluating the reproductive success of insectivorous songbirds nesting in the vicinity of a floodplain containing PCBs. This analysis was conducted using “top-down” retrospective techniques in which study area populations were compared to reference populations remote to the influence of PCBs.

***Comprehensive Multisite Human Health Risk Assessment of PCBs in a River***—Directed a comprehensive multisite human health and ecological risk assessment of the river and its environs under RCRA and a state Superfund program. Evaluated potential exposures to soil, air, sediment, groundwater, and surface water, including the design and implementation of fish consumption, land use, and recreational use surveys. Evaluated the need to implement emergency response measures by directing the development of a property-by-property risk assessment of floodplain land use.

***Ecological Risk Assessment for the BROS Superfund Site Located in a Coastal Swamp, New Jersey***—Principal-in-charge of an ecological risk assessment of wetland communities, including a red maple swamp impacted by a historical release from an adjoining waste oil lagoon. The risk assessment work plan was prepared in accordance with EPA’s ecological risk assessment guidance for Superfund. Principal chemicals of potential ecological concern included PCBs, PAHs, and certain heavy metals. Portions of the swamp are tidally influenced, while other areas are influenced by local hydrology. A wide variety of assessment and measurement endpoints were used, in light of the large areal extent (400+ acres) of the swamp. Receptors included vegetation, small mammals, aquatic birds and raptors, and large mammals. Results were used to support the RI/FS for the site.

***Site-Specific Human Health and Ecological Risk Assessments of 20 Chromium Sites, New Jersey***—Characterized the potential human health and ecological risks associated with exposure to chromite ore processing residue (COPR), which had been used historically to fill wetlands and low-lying areas in Hudson County, New Jersey. Several of these sites are located in proximity to the Hackensack River, many are currently the location of commercial or industrial enterprises, and a few are residential properties. Prior to conducting the site-specific risk assessments, developed



detailed protocols and methods for submission to the New Jersey Department of Environmental Protection. Prepared technical white papers on the following topics: evaluating potential inhalation exposures to COPR, characterizing the risks of allergic contact dermatitis, evaluating nature and extent of deep groundwater contamination, evaluating compliance with ambient surface water quality criteria for hexavalent chromium, and characterizing potential ecological risks from chromium in a heavily industrialized waterway. These white papers were presented verbally and in written form to agency staff, were the subject of monthly meetings and informal discussions with the agency, and helped achieve settlement or closure of several sites.

***Human Health Risk Evaluations to Support Alternative Remedies for a Former Uranium Mine, New Mexico***—In response to screening-level cleanup options based on an overly prescriptive and precautionary risk assessment, developed a revised risk assessment for radionuclides and non-radionuclides (predominantly metals) based on site-specific and culturally appropriate exposure parameters. These assessments evaluated and compared the residual risks that would likely remain under a number of proposed remedies, with the purpose of demonstrating the health-protectiveness of less costly options. If pertinent to a given remedy, the risk assessments evaluated and compared the relative risks associated with the transportation and disposal of waste materials offsite. Presented a number of these risk-based approaches in meetings on the nature and conduct of the engineering evaluation and cost assessment with EPA and representatives of the Native American nation.

***Human and Ecological Risk Evaluations, Former Uranium Mine, Grand Canyon, Arizona***—Guided the development of human health and ecological risk assessments designed to target a goal of implementing a cost-effective remedy for a former copper and uranium mine on the rim of the Grand Canyon. Both radionuclides and non-radionuclides (predominantly metals) were included in these assessments. Human health risks from radionuclides were evaluated using the RESRAD model, whereas non-radionuclide health risks, as well as ecological risks, were evaluated in accordance with conventional EPA guidance. Located within a national park, this particular project had the added dimension of multiagency oversight and review, including that of the National Park Service, EPA, and state agencies.

***Site-Specific Risk Assessment of 1,4-Dioxane and Derivation of Risk-Based Concentrations to Support Site Closure, Western U.S.***—Conducted a site-specific human health risk assessment and derived risk-based concentrations for 1,4-dioxane to support closure of a groundwater pump-and-treat remediation system at a site in the western U.S., which had already reduced the levels of trichloroethylene and other volatile organic compounds below their respective regulatory criteria. The risk assessment was submitted to EPA and to the state environmental agency as part of an optimization plan for shutting down the remediation system.

***Health-Based Remediation Plan***—Selected a health-based remedial option and negotiated a remediation plan with an EPA regional office for a hazardous waste site. The plan was based on a risk assessment of groundwater and industrial soils contaminated with PCBs, dioxins, furans, and chlorobenzenes from leaking electrical transformers. The results of the risk assessment were used as the basis for establishing cleanup criteria at the facility.





***Remedial Investigation Endangerment Assessment of PCB-Contaminated Site, Pennsylvania***—Managed a remedial investigation endangerment assessment of a PCB-contaminated railyard and drainage basin. This assessment was prepared on behalf of the PRPs under a consent decree with EPA Region 3 and the Pennsylvania Department of Natural Resources.

***Development of Alternative Ambient Water Quality Standards for Dioxin, Various States***—Developed the basis for establishing alternative ambient water quality standards for dioxin in eight states, receiving state and EPA approval. Submitted and presented these analyses before various state and federal regulatory agencies for the purpose of negotiating scientifically defensible effluent limits. Testified as an expert witness in regulatory hearings and adjudicatory proceedings in 10 states.

***Dioxin and Furan Risk Assessments for Numerous Pulp and Paper Companies***—Represented numerous pulp and paper companies in addressing the risks associated with dioxins and furans. Presented testimony on the hazards posed by dioxins to a congressional subcommittee and before the U.S. Congress Office of Technology Assessment. Conducted the most comprehensive risk assessment to date of the hazards posed by trace levels of dioxins and furans in paper products. U.S. and Canadian federal agencies used these assessments as the basis for concluding that health risks were *de minimis* and that these products did not require further regulation.

***Risk Assessment of Dioxins and Furans in Wastewater Treatment Plant Sludge***—Directed the most comprehensive set of published risk assessments on the hazards posed to humans and wildlife by dioxins and furans in wastewater treatment plant sludge applied to farmland, forestland, and abandoned strip mine sites. Testified as an expert witness in regulatory proceedings at the state and federal level. Assessments have resulted in establishment of the first state dioxin standard for agricultural soils and agency approval of permit applications for land application of sludge and residuals in a number of states.

***Evaluation of EPA's Cancer Slope Factor for Dioxin***—Evaluated the scientific basis for EPA's cancer slope factor for dioxin by critically examining the rodent bioassay data. Proposed and obtained funding for an independent re-review of the rat liver pathology data through the formation of a pathology working group (PWG) of expert pathologists. Based on the group's results, derived a scientifically defensible cancer slope factor through the use of EPA's own model, resulting in a value 16 times less restrictive, and published this analysis in the peer-reviewed literature.

***Risk Assessment Work Plan and Final Report for Stringfellow Superfund Site, Riverside, California***—Prepared a work plan and final report for the supplemental human health risk assessment for the Stringfellow Superfund Site in Riverside, California, and negotiated its acceptance with EPA Region 9. This EPA-approved risk assessment included the use of a microexposure Monte Carlo analysis for evaluating potential risk to a changing population based on site demographics. It became the first EPA-approved work plan in Region 9 for a PRP-generated risk assessment after the agency's moratorium was lifted and the first risk assessment to gain EPA Region 9 approval for the use of a Monte Carlo exposure analysis.



***Regulatory Review of Proposed Rule Related to Chlorophenols***—Analyzed and evaluated the key toxicological and exposure assumptions that formed the basis for an EPA-proposed rule (58 FR 79:25706) under which residuals from the use of certain chlorophenolic formulations in the wood-surface-protection industry would have been classified as hazardous waste under RCRA. As a result, EPA withdrew the proposed rule and decided not to list these chlorophenols as hazardous waste.

***Development of Health-Based, Risk-Driven Remediation Assessments***—Conducted and guided the development of health-based, risk-driven remediation assessments for RCRA facility investigations and as part of the RI/FS process at CERCLA sites. Obtained a monitored natural attenuation remedy in the ROD at the Packaging Corporation of America Superfund Site in Michigan.

***Evaluation of Proposed Ecological Criteria/Water Quality/Soil Contaminants***—Critically evaluated proposed ecological criteria for the Great Lakes, for the State of New Jersey, for water quality in nine states, and for soil contaminants nationwide. Presented critiques of ecological criteria before state and federal agencies and testified on the issues during federal TSCA rulemaking hearings.

***Critique of Scientific Basis for Proposed Federal Standards***—Critiqued and reviewed the scientific basis for proposed federal standards for dioxins and furans in wastewater treatment plant sludges. Provided expert opinion regarding the validity of ecotoxicological and human exposure parameters used by EPA’s contractor, negotiated more reasonable values with regulatory agencies, and testified in federal rulemaking proceedings. As a result, EPA withdrew the proposed national rule for landspread sludge.

***Consumer Product Risk Assessment for a Paper Company Manufacturing Consumer Products from Excess Paper Fiber***—Conducted a quantitative risk assessment to ensure that trace PCBs and dioxins/furans did not pose a health risk to consumers using Consumer Products Safety Commission, Food and Drug Administration, and Occupational Safety and Health Administration exposure protocols.

***Development of Sampling Programs to Support Risk Assessments***—Guided the development of a statistically valid sampling program for sediment and biota to support a comprehensive risk assessment at a series of hazardous waste sites under state and federal jurisdiction. Directed the development of residential, recreational, occupational, and commercial exposure scenarios to characterize potential exposures in soil, air, water, and biota. Developed health-based cleanup goals as part of the remediation strategy.

***Design of a Statistically Based Fish Sampling Plan***—Designed a statistically based fish sampling plan through simulation modeling and predictive methods to ensure an optimal experimental design. Reduced sampling and analytical costs of the proposed plan while maximizing the power of the analysis. Completed this study by conducting the most comprehensive risk assessment to date of dioxin in fish, based on actual measurements of this contaminant in the fish that people are likely to consume.



***Risk Assessment for a Terrestrial Wildlife Species***—Wrote and published one of the first risk assessments for a terrestrial wildlife species based on scientifically refined exposure parameters and toxicokinetic modeling.

***Reinterpretation of Dioxin Bioaccumulation Factors***—Analyzed and evaluated reported bioaccumulation factors for dioxin and published a peer-reviewed paper that reinterpreted the wide variation in reported values on a common basis.

***Advisor to Industry Association***—Served as the toxicologist member of the Scientific Advisory Board to the Cement Kiln Recycling Coalition, the independent blue ribbon panel chosen to evaluate the public health and environmental implications of using waste-derived fuels for producing Portland cement.

***Numerous Multipathway Exposure and Risk Assessments***—Managed multiple-pathway exposure and risk assessments of emissions from resource recovery facilities; releases from leaking underground petroleum storage tanks; and environmental emissions, effluents, and soil contaminants from chemical manufacturing plants. Evaluated the risks to humans and wildlife from exposure to herbicides used for power line right-of-way maintenance.

***Critique of Proposed Ambient Air Level Standards***—Critiqued and reviewed the scientific basis of proposed state ambient air level standards for carcinogenic and noncarcinogenic air pollutants. Testified before the state air toxics board regarding this review and the development of ambient air guidelines.

***Right-to-Know and Hazard Communication***—Implemented right-to-know and hazard communication compliance programs for employers in four northeastern states, including 20 acute-care and rehabilitation hospitals. Conducted hazard communication training for more than 3,000 employees. Also planned, coordinated, and managed regional and international symposia on environmental health-related topics.

***Comprehensive Literature Review and Report, Augusta, Maine***—Conducted a literature review and authored a comprehensive report on the protection of red spruce from spruce budworm defoliation via chemical and biological methods for Forest Service, Maine Department of Conservation, Augusta, Maine.

## **Additional Experience**

***Pesticide Conference Organization***—Planned, coordinated, publicized, and managed the North American Conference on Pesticide Spray Drift and Chemical Trespass, an international symposium on the legal, environmental, human health, and technological aspects of off-target pesticide drift for Board of Pesticides Control, Maine Department of Agriculture, Food and Rural Resources, Augusta, Maine. Edited and coordinated publication of the conference proceedings. Abstracted and authored a document that summarized the conference for legislative and regulatory use.



***Biomass Harvesting Research and Reporting***—Researched, conducted personal interviews, and authored a publication for laypersons about the ecological effects of biomass harvesting in the Maine forest for Maine Audubon Society, Falmouth, Maine.

***Program Development for Maine Audubon Society***—Developed and managed the environmental resource program at the Maine Audubon Society, including planning, grant procurement, budgeting, and implementation. Analyzed and researched environmental issues. Developed policy positions with trustees and staff; presented Maine Audubon Society’s policies through appointments to statewide advisory boards, working groups, and special committees, and through a program of public education utilizing television, radio, and printed media.

***Documentary Television Series on PBS***—Wrote, produced, and conducted on-camera interviews for *The Forest: Maine’s Legacy and Future*, a three-part documentary television series on Maine’s forest resource with the Maine Public Broadcasting Network; funded in part by the Maine Forest Service, USDA Forest Service, Seven Islands Land Company, Maine Audubon Society, International Paper, Great Northern Nekoosa, and the Sachem Trust.

***Gypsy Moth Conference Planning***—Planned, organized, and moderated the R.K. Mellon Conference on Chemical Control and Long-term Management of Gypsy Moth, under contract with Yale University; funded in part by the Maine Forest Service, USDA Forest Service, and the Richard K. Mellon Fund.

***Public Service Announcements***—Wrote three public service announcements, *Bugged by Gypsy Moths*, broadcast in 1982 by WCSH-TV, Portland, Maine.

***Wood Energy Publications***—Wrote and edited wood energy publications under contract with the U.S. Department of Energy, with partial funding from the Maine Forest Service and the Maine Audubon Society.

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Keenan, R.E., and A. Frankel. 2016. Overview of probabilistic risk assessment and decision analysis tools for evaluating environmental issues. (Abstract). Proceedings of the 32nd Annual International Conference on Soils, Sediment, Water and Energy.

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Keenan, R.E., and J.H. Samuelian. 2005. Is TEQ enrichment of PCBs in fish tissue a common phenomenon? *Organohalogen Compounds* (2378):1763-1765. Proceedings Dioxin 2005 – the 25th International Symposium on Halogenated Environmental Organic Pollutants and Persistent Organic Pollutants, Toronto, Ontario. August 21–26.





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Jennings, D.T., B. Withrow, and R.E. Keenan. 1983. Forest biology research. Miscellaneous Report 281. In: Forest Resources Research Advisory Committee 1982 Annual Report. A.R. Leighton (ed). University of Maine Life Science and Agriculture Experiment Station.

Keenan, R.E. 1983. The biology of *Phellinus spiculosus* on hickory of the southeastern United States. Ph.D. Dissertation. Duke University, NC.

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Bessey, E., R.E. Keenan, and R. Wrye. 1982. Formula research. In: Miscellaneous Report 362. Forest Resources Research Advisory Committee 1981 Annual Report. A.R. Leighton (ed). University of Maine Life Science and Agriculture Experiment Station.

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## **Selected Presentations**

Keenan, R.E., and D. Williston. 2018. Plenary Session 4 – Fish consumption rates and data collection. Invited plenary presentation at the Sediment Management Work Group/U.S. Army Corps of Engineers *Workshop on Fish Exposure Processes at Contaminated Sediment Sites*, Vicksburg, MS. May 31.

Keenan, R.E. 2013. Fish consumption rates: the critical factor in assessing human exposure to contaminated sediments. Platform presentation at the Twenty-ninth Annual International Conference on Soils, Sediment, Water and Energy, Amherst, MA. October 22.

Keenan, R.E., and E.S. Ebert. 2012. Overview of human health water quality criteria (HHWQC). Invited presentation at the western regional meeting of the National Council for Air and Stream Improvement, Vancouver, WA. October 1.

Ebert, E.S., and R.E. Keenan. 2012. Fish consumption studies and how the data are used. Invited presentation at the western regional meeting of the National Council for Air and Stream Improvement, Vancouver, WA. October 1.



Keenan, R.E., and E.S. Ebert. 2012. Understanding risk levels used to develop human health water quality criteria. Invited presentation at the western regional meeting of the National Council of Air and Stream Improvement, Vancouver, WA. October 1.

Keenan, R.E., P.O. Gwinn, J.D. Schell, E.A. Carlson, and J.B. Silkworth. 2009. Application of nonlinear dose-response methods based on mode of action for polychlorinated biphenyls. Platform presentation at Society of Toxicology (SOT) Annual Meeting, Baltimore, MD. March 17.

Keenan, R.E., P.O. Gwinn, J.D. Schell, E.A. Carlson, and J.B. Silkworth. 2008. Application of nonlinear dose-response methods based on mode of action for PCBs. Platform presentation at Society for Risk Analysis (SRA) Annual Meeting, Boston, MA. December 10.

Keenan, R.E., P.O. Gwinn, J.D. Schell, E.A. Carlson, and J.B. Silkworth. 2008. Application of nonlinear dose-response methods based on mode of action shows reduced cancer risks from PCBs. Platform presentation at Dioxin 2008 – the 28th International Symposium on Halogenated Environmental Organic Pollutants and Persistent Organic Pollutants, Birmingham, UK. August 19.

Keenan, R.E., and E.S. Ebert. 2007. The selection of fish consumption rates as a risk management decision. Poster presentation at EPA 2007 National Forum on Contaminants in Fish, Portland, ME. July 23.

Keenan, R.E., and J.H. Samuelian. 2005. Is TEQ enrichment of PCBs in fish tissue a common phenomenon? Platform presentation at Dioxin 2005 – the 25th International Symposium on Halogenated Environmental Organic Pollutants and Persistent Organic Pollutants, Toronto, Ontario. August 25.

Keenan, R.E., and J.H. Samuelian. 2005. Is TEQ enrichment of PCBs in fish tissue a common phenomenon? – Implications for risk assessment. Poster presentation at EPA 2005 National Forum on Contaminants in Fish, Baltimore, MD. September 19.

Keenan, R.E., J.M. Hamblen, J.B. Silkworth, M.N. Gray, P.O. Gwinn, and S.B. Hamilton. 2004. An empirical evaluation of the cancer potency of dioxin toxic equivalents (TEQs) in four PCB mixtures. Platform presentation at Society of Toxicology (SOT), Baltimore, MD. March 21–35.

Hamblen, J.M., R.E. Keenan, J.B. Silkworth, M.N. Gray, P.O. Gwinn, E.S. Ebert, and S.B. Hamilton. 2003. An empirical evaluation of the potency of dioxin toxic equivalents (TEQs) in PCB mixtures. Poster presentation at 13th Annual Conference of the International Society of Exposure Analysis (ISEA), Stresa, Italy. September 22–26.

Keenan, R.E., J.M. Hamblen, J.B. Silkworth, M.N. Gray, P.O. Gwinn, and S.B. Hamilton. 2003. An empirical evaluation of the potency of dioxin toxic equivalents (TEQs) in several PCB mixtures. Poster presentation at Dioxin 2003 – the 23rd International Symposium on Halogenated Environmental and Persistent Organic Pollutants, Boston, MA. August 24–29.





Swartout, J.C., P.S. Price, S. Baird, H. Carlson-Lynch, M.L. Dourson, R.E. Keenan, C.A. Gillis, C.W. Schmidt, and K. Thompson. 1999. Probabilistic uncertainty in reference doses. Second Annual Workshop on Practical Issues in the Use of Probabilistic Risk Assessment, University of Florida, Sarasota, FL. March 2.

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.

Price, P.S., and R.E. Keenan. 1998. Advances in non-carcinogenic risk assessment. Toxicology Round Table of the American Crop Protection Association. Seattle, WA. February 28.

Price, P.S., and R.E. Keenan. 1998. Characterizing the RfD/MRL/ADI in a quantitative framework of uncertainty and variability. Annual Meeting of the Society for Risk Analysis. December 7.

Price, P.S., and R.E. Keenan. 1998. Microexposure event modeling an approach to modeling time-varying exposures. New England Chapter – Society for Risk Analysis, Boston, MA. March 11.

Price, P.S., R.E. Keenan, and B.W. Schwab. 1998. Defining the interindividual (intraspecies) uncertainty factor. Third Annual Workshop on Evaluation of Default Safety Factors in Health Risk Assessment. November 11.

Price, P.S., R.E. Keenan, J.A. Rothrock, C.F. Chaisson, D.K. Waylett, M.E. Hawley, C.B. Sandusky, R. Sert, E. DeGraff, W.R. Muir, and J.S. Young. 1998. A case study and presentation of relevant issues on aggregate exposure. ILSI Aggregate Exposure Workshop Program, Washington, DC. February 9–10.

Price, P.S., R.E. Keenan, and S.J. Pauwels. 1998. Using an integrated microexposure event and toxicokinetic model to evaluate the impact of dioxin intakes from the consumption of Maine freshwater fish on angler body burdens. 25th Annual Aquatic Toxicity Workshop, Quebec, Canada. October 21.

Rothrock, J.A., P.S. Price, R.E. Keenan, E.S. Ebert, C.F. Chaisson, W.R. Muir. 1998. The application of microexposure event modeling to the evaluation of water related exposures. Annual Meeting of the Society for Risk Analysis. December 7.

Iannuzzi, T.J., R.E. Keenan, and R.P. Cepko. 1997. Habitat stressors and potential PCB risks to wildlife receptors in Clear Creek, Bloomington, Indiana. SETAC, San Francisco, CA. November 19.

Keenan, R.E., J.A. Rothrock, and P.S. Price. 1997. Should Maine's rivers have fish advisories for dioxin? Society for Risk Analysis/International Society of Exposure Assessment Conference, Washington, DC. December 10.



Keenan, R.E., J.A. Rothrock, and P.S. Price. 1997. Using an integrated microexposure event and toxicokinetic model to evaluate the need for dioxin fish advisories? Society for Risk Analysis Annual Meeting and Exposition, Washington, DC. December 7–10.

Keenan, R.E., and P.S. Price. 1997. FQPA aggregate exposure and common mode of action assessments: new approaches. American Bar Association Section of Natural Resources, Energy, and Environmental Law. Environmental Quality Committee, Washington, DC. September 9.

Keenan, R.E., J.H. Samuelian, T.J. Iannuzzi, S.P. Truchon, and R.P. Cepko. 1997. Calculation of hypothetical PCB risks to wildlife receptors in the Clear Creek Watershed, Bloomington, Indiana. Dioxin 97, Indianapolis, IN. August 24–29.

Keenan, R.E. 1997. Dioxins in the environment: an overview. BFI Organics Dioxin Workshop, Portland, ME. June 6.

Keenan, R.E., and P.S. Price. 1997. Characterizing the uncertainty in the reference dose (RfD). New England Chapter of the Society for Risk Analysis, Cambridge, MA. February 26.

Keenan, R.E., J.A. Stickney, B. Mayes, C.A. Gillis, P.S. Price, and S.B. Hamilton. 1997. Implications of a recent feeding study on the cancer slope factor for PCB mixtures. Platform Presented at the 36th Annual Meeting of the Society of Toxicology (SOT), Cincinnati, OH. March 9–13.

Price, P.S., R.E. Keenan, H. Carlson-Lynch, and C. Gillis. 1997. Defining the interindividual uncertainty factor (UHF): implications for non-cancer dose response modeling. Society for Risk Analysis/International Society of Exposure Assessment Conference, Washington, DC. December 8.

Ebert, E.S., P.S. Price, and R.E. Keenan. 1996. Estimating exposures to dioxin-like compounds for subsistence anglers in North America. Dioxin 96, Amsterdam, The Netherlands. August 12–16.

Keenan, R.E., E.S. Ebert, and P.S. Price. 1996. Estimating exposures of subsistence anglers. Society for Risk Analysis/International Society of Exposure Assessment Conference (SRA), New Orleans, LA. December 8-12.

Keenan, R.E., N.W. Harrington, P.S. Price, and R.O. Richter. 1996. A comparison of potential risks using default point estimates, Monte Carlo modeling, and microexposure event analysis for evaluating impacted groundwater near the Stringfellow Superfund site. Superfund XVII Conference Proceedings, Washington, DC. October 15-17.

Keenan, R.E., P.S. Price, J. McCrodden, and E.S. Ebert. 1996. Using a microexposure event analyses to model potential exposures to PCBs through ingestion of fish from the Upper Hudson River. Platform Presentation at Dioxin 96 – the 16th International Symposium on Chlorinated Dioxins and Related Compounds, Amsterdam, The Netherlands. August 12–16.

Keenan, R.E., and K.L. Rhyne. 1996. Risk assessment in environmental law. King & Spalding Continuing Education Seminar, Georgia Bar Association, Atlanta, GA. February 23–24.



Maritato, M.C., D.W. Crawford, R.E. Keenan, and S.P. Truchon. 1996. Integrating advanced ecological risk assessment techniques with product life cycle impact assessments. Presented at 17th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Washington, DC. November 17–21.

Price, P.S., and R.E. Keenan. 1996. Characterization of the interindividual (UFH) factor: alternative models and approaches. National Health and Environmental Effects Research Laboratory. September 24–27.

Price, P.S., and R.E. Keenan. 1996. An approach for extrapolating dose rate information from animals to humans. Society for Risk Analysis/International Society of Exposure Assessment Conference (SRA). December 8–12.

Keenan, R.E. 1995. Cooperative Research and Development Agreement (CRADA) to estimate noncancer risks from exposure to toxic substances. Presented at EPA Region 1 Seminar on Federal Technology Transfer and Assistance Opportunities, Bath, ME. April 20.

Keenan, R.E. 1995. What is risk? Presented at What You Need To Know About Risk Assessment and Why, Capitol Hill Club, Washington, DC. March 1.

Keenan, R.E., M.H. Henning, J.A. Ducey, and E.S. Ebert. 1995. A field evaluation of the reproductive success of insectivorous passerines inhabiting a flood plain in the presence of PCBs. Presented at the Hydrocarbon Contaminated Soils Conference, New Orleans, LA. January 12.

Keenan, R.E., M.H. Henning, E.S. Ebert, and E.R. Algeo. 1995. Assessment of effects of PCB-contaminated sediments and floodplain soils on reproduction and community structure of insectivorous song birds. Platform presentation at Dioxin '95—15th International Symposium on Chlorinated Dioxins and Related Compounds, Edmonton, Alberta. August 23.

Keenan, R.E., P.S. Price, E.S. Ebert, S.H. Su, and J.R. Harrington. 1995. Uncertainty and variation in indirect exposure assessments: an analysis of exposure to TCDD from a beef consumption pathway. Platform presentation at Dioxin '95—15th International Symposium on Chlorinated Dioxins and Related Compounds, Edmonton, Alberta. August 21.

Keenan, R.E., P.S. Price, C.L. Curry, J.I. McCrodden, and J.G. Haggard. 1995. Using a microexposure Monte Carlo analysis to model potential exposures to PCBs through ingestion of fish from the upper Hudson River. Platform presentation at the Society for Risk Analysis Annual Meeting, Honolulu, HI. December 5.

Keenan, R.E. 1994. Monte Carlo modeling of temporal and spatial variations in exposure. Presented during the Workshop on the Application of Monte Carlo Techniques to Exposure Assessment at the Annual Meeting of the Society for Risk Analysis, Baltimore, MD. December 4.



Keenan, R.E., and P.S. Price. 1994. Development of a Monte Carlo model of uncertainty and variability in reference doses. Poster presentation describing a Cooperative Research and Development Agreement (CRADA) project between McLaren/Hart and the U.S. Environmental Protection Agency. Presented at the Annual Meeting of the Society of Toxicology, Dallas, TX. March 14.

Keenan, R.E., M. Dourson, P.S. Price, J. Swartout, and S.H. Su. 1994. EPA and McLaren/Hart-ChemRisk joint project to develop a stochastic approach for assessing non-carcinogenic risk – A status report. Presented at the Annual Meeting of the Society for Risk Analysis, Baltimore, MD. December 7.

Keenan, R.E., P.S. Price, M.H. Henning, P.E. Goodrum, M.N. Gray, and R.A. Sherer. 1994. Using a microexposure Monte Carlo risk assessment for dioxin in Maine fish to evaluate the need for fish advisories. International Society for Environmental Epidemiology/ International Society for Exposure Assessment Joint Conference, Research Triangle Park, NC. September 18-21.

Keenan, R.E., M.H. Henning, P.E. Goodrum, M.S. Gray, R.A. Sherer, and P.S. Price. 1993. Using a microexposure Monte Carlo risk assessment for dioxin in Maine (USA) fish to evaluate the need for fish advisories. Platform presentation at Dioxin '93—the Thirteenth International Symposium on Chlorinated Dioxins and Related Compounds, Vienna, Austria. September 21.

Keenan, R.E., P.S. Price, E.S. Ebert, P.E. Goodrum, M.N. Gray, and R.A. Sherer. 1993. A Monte Carlo risk assessment for dioxin in Maine fish: using a microexposure approach to evaluate the need for fish advisories. 1993 TAPPI Environmental Conference, Boston, MA. March 31.

Keenan, R.E. 1992. Ecological risk assessment in the 1990s. Presented at the First National Conference on Risk Assessment and Community Relations. General Electric Corporate Environmental Programs, Arlington, VA. September 15.

Keenan, R.E. 1992. Estimating exposures to dioxin-like compounds concerning methods of environmental transport and resulting exposures. Presentation at the EPA Peer Review Workshop, Vienna, VA. September 10.

Keenan, R.E. 1992. Concerning an evaluation of the procedures used to derive human health criteria for the Great Lakes Water Quality Initiative. Presentation to the EPA Science Advisory Board, Drinking Water Committee, Washington, DC. April 14.

Keenan, R.E. 1992. Concerning a preliminary evaluation of the procedures used to derive human health and wildlife criteria for the Great Lake Water Quality Initiative. Presentation to the EPA Science Advisory Board, Great Lakes Water Quality Subcommittee, Chicago, IL. February 19.

Keenan, R.E., E.R. Algeo, and J.W. Knight. 1992. Applying ecological risk assessment strategies to address environmental problems. Presented at the Seventh Annual Hydrocarbon Contaminated Soils Conference, University of Massachusetts, Amherst, MA. September 22.



- Keenan, R.E., E.R. Algeo, E.S. Ebert, and D.J. Paustenbach. 1992. Taking a risk assessment approach to RCRA corrective action. Presented at the RCRA Corrective Action Workshop, Water Environment Federation, New Orleans, LA. September 20.
- Keenan, R.E., E.S. Ebert, J.W. Knight, and N.W. Harrington. 1992. Consumption of freshwater fish by Maine anglers. Contributed paper to 1992 TAPPI Environmental Conference, Richmond, VA. April 15.
- Keenan, R.E., E.S. Ebert, J.W. Knight, N.W. Harrington, and N.L. Bonnevie. 1992. Consumption of freshwater fish by Maine anglers. Presented at the Exposure Session during the Thirteenth Annual Meeting, Society of Environmental Toxicology and Chemistry, Cincinnati, OH. November 11.
- Sherman, W., and R.E. Keenan. 1992. A pathway-specific description of bioaccumulation from multiple sources: a working hypothesis. Presented at Bioavailability of Dioxin, PCBs, and Metals in Aquatic Ecosystems, 1992 Rifkin Conference, Washington, DC. May 14–15.
- Keenan, R.E. 1991. Expert testimony in adjudicatory hearing before the Mississippi Department of Environmental Quality, NPDES Permit Limits for Leaf River Forest Products, Jackson, MS. December 17.
- Keenan, R.E. 1991. Presentation to the EPA Peer Review Panel of Risk Assessments for Land Application of Pulp and Paper Mill Sludge, Greenbelt, MD. October 2.
- Keenan, R.E. 1991. Ecological risk assessment in the 1990's. Contributed paper to Environmental Remediation from Cradle to Grave: An Engineering Primer for Lawyers and Risk Managers. Armstrong and Teasdale Attorneys at Law, St. Louis, MO. January 25.
- Keenan, R.E., E.S. Ebert, D. Gunster, J.W. Knight, E.R. Algeo, M.N. Gray, and N.W. Harrington. 1991. Critical risk assessment factors for establishing a water quality standard for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. Platform presentation at Dioxin '91 – the Eleventh International Symposium on Chlorinated Dioxins and Related Compounds, Research Triangle Park, NC. September 26.
- Keenan, R.E., R.J. Wenning, E.S. Ebert, J.W. Knight, and C.A. Whitaker. 1991. Critical factors for establishing ambient water quality standards for TCDD. Contributed paper to 1991 TAPPI Environmental Conference, San Antonio, TX. April 10.
- Keenan, R.E., E.S. Ebert, E.R. Algeo, M.M. Sauer, J.W. Knight, and R.E. Kross. 1991. A critical evaluation of the EPA risk assessment for pulp and paper mill sludge. Contributed paper to 1991 TAPPI Environmental Conference, San Antonio, TX. April 10.
- Keenan, R.E. 1990. A re-evaluation of the tumor histopathology of Kociba et al. (1978) using 1990 criteria: implications for the risk assessment of 2,3,7,8-TCDD using the linearized multistage model. Keynote paper at Dioxin '90 – the Tenth International Symposium on Chlorinated Dioxins and Related Compounds, Bayreuth, West Germany. September 12.





- Keenan, R.E. 1990. Dioxin risk assessment for the Columbia River. Contributed paper to Dioxin '90—Tenth International Symposium on Chlorinated Dioxins and Related Compounds, Bayreuth, West Germany. September 13.
- Keenan, R.E. 1990. Setting rational health-based water quality standards for dioxin. Risk assessment for the Columbia River. Contributed paper to 1990 TAPPI Environmental Conference, Seattle, WA. April 11.
- Keenan, R.E. 1990. A reevaluation of dioxin cancer potency using the linearized multistage model. Contributed paper to 1990 TAPPI Environmental Conference, Seattle, WA. April 11.
- Keenan, R.E. 1990. Examination of potential risks from exposure to dioxin in soils amended with sludge or ash. Presentation at a workshop sponsored by the Maine Department of Environmental Protection and Maine Department of Human Services, Augusta, ME. January 17.
- Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in Texas. Presentation before the Texas Water Quality Commission, Austin, TX. July 12.
- Keenan, R.E., B.L. Finley, and A.H. Parsons. 1990. Criteria for achieving a no-action alternative: a case study. Contributed paper to Haztech International '90, Pittsburgh, PA. October 3.
- Keenan, R.E., S.A. Martin, and W.J. Gillespie. 1990. A critical evaluation of the EPA human health and wildlife risk assessment for pulp and paper mill sludge. Presentation to EPA Office of Toxic Substances, Office of Solid Waste and Environmental Assessment, and Office of Water Programs, Washington, DC. December 12.
- Keenan, R.E., N.D. Wilson, and J.W. Knight. 1990. Looking to the 1990's: using risk assessment to design cost-effective solutions to environmental problems. Contributed paper to Haztech International '90, Pittsburgh, PA. October 3.
- Keenan, R.E., E.S. Ebert, E.R. Algeo, and M.M. Sauer. 1990. A critical evaluation of the EPA risk assessment for pulp and paper mill sludge. Invited lecture to: Northeast Regional Meeting of the National Council of the Paper Industry for Air and Stream Improvement, Boston, MA. October 25.
- Keenan, R.E. 1989. Risk assessment for the Columbia River. Presentation to the Department of Ecology, State of Washington, Department of Environmental Quality - State of Oregon and Environmental Protection Agency Region 10, Portland, OR. December 18.
- Keenan, R.E. 1989. Sensitivity analysis for dioxin risk assessment and implications for determining acceptable levels of daily exposure. Presented to the Maine Science Advisory Panel of the Maine Department of Human Services, Augusta, ME. November 17.
- Keenan, R.E. 1989. Uncertainties and conservatism in dioxin risk assessment. Contributed paper to 1989 TAPPI Environmental Conference, Orlando, FL. April 19.



Keenan, R.E. 1989. Critical factors for consideration in setting rational health-based water quality criteria for dioxin. Oregon Department of Environmental Quality, Portland, OR. October 27.

Keenan, R.E. 1989. Sources of uncertainty in the carcinogenic dose-response assessment of dioxin. Bureau of Health, Maine Department of Human Services, Augusta, ME. October 12.

Keenan, R.E. 1989. Testimony before the North Carolina Air Toxics Committee regarding the development of ambient air level standards for carcinogenic pollutants, Winston-Salem, NC. January 12.

Keenan, R.E., J.W. Knight, E.R. Rand, and M.M. Sauer. 1989. Assessing potential risks to wildlife and sportsmen from exposure to dioxin in pulp and paper mill sludge spread on managed woodlands. Contributed paper to Dioxin '89—the Ninth International Symposium on Chlorinated Dioxins and Related Compounds, Toronto, Ontario. September 21.

Keenan, R.E. 1988. The impacts upon human health of trace concentrations of dioxin in pulp and paper mill export vectors. Presentation to community leaders and the press, Escanaba, MI. June 30.

Keenan, R.E. 1988. Risk-driven remediation as an approach for determining cleanup of contaminated land. Presentation at 1988 Groundwater Technology Southcentral Regional Seminar, Baton Rouge, LA. January 20.

Keenan, R.E., M.M. Sauer, and F.H. Lawrence. 1988. Assessment of potential health risks from dermal exposure to dioxin in paper products. Contributed paper to Dioxin '88—the Eighth International Symposium on Chlorinated Dioxins and Related Compounds, Umea, Sweden. August 23.

Keenan, R.E. 1987. Examination of potential risks from exposure to dioxin in paper mill sludge used to reclaim abandoned Appalachian coal mines. Contributed paper to Dioxin '87—the Seventh International Symposium on Chlorinated Dioxins and Related Compounds, Las Vegas, NV. October 8.

Keenan, R.E. 1987. Risk assessment methodology to place levels of dioxin in perspective. Presentation to the Pennsylvania Department of Environmental Resources, Harrisburg, PA. July 9.

Keenan, R.E. 1984. Hazard communication training programs. Massachusetts Right-to-Know Law Seminar, Boston, MA. December 17.

## **Invited Presentations/Panels**

### **Invited Presentations**

Keenan, R.E., and D. Williston. 2018. Plenary Session 4 – Fish consumption rates and data collection. Invited plenary speaker at the Sediment Management Work Group/U.S. Army Corps of Engineers *Workshop on Fish Exposure Processes at Contaminated Sediment Sites*, Vicksburg, MS. May 31.



Keenan, R.E., and A. Frankel. 2016. Overview of probabilistic risk assessment and decision analysis tools for evaluating environmental issues. Invited presentation at the 32nd Annual International Conference on Soils, Sediment, Water and Energy, Amherst, MA. October 18.

Keenan, R.E., and E.S. Ebert. 2012. Overview of human health water quality criteria (HHWQC). Invited presentation at the western regional meeting of the National Council for Air and Stream Improvement, Vancouver, WA. October 1.

Keenan, R.E., and E.S. Ebert. 2012. Understanding risk levels used to develop human health water quality criteria. Invited presentation at the western regional meeting of the National Council of Air and Stream Improvement, Vancouver, WA. October 1.

Ebert, E.S., and R.E. Keenan. 2012. Fish consumption studies and how the data are used. Invited presentation at the western regional meeting of the National Council for Air and Stream Improvement, Vancouver, WA. October 1.

Keenan, R.E., E.R. Algeo, and P.D. Anderson. 2007. Characterizing and interpreting fish consumption rates for developing human health water quality criteria. Invited speaker to the 2007 West Coast Conference of the National Council for Air and Stream Improvement, Portland, OR. September 26.

Keenan, R.E. 2007. Quantifying interspecies variability in response to direct-acting compounds. Invited speaker to the 2007 EPA Toxicology and Risk Assessment Conference, Cincinnati, OH. April 24.

Keenan, R.E., and J.B. Silkworth. 2005. The TEQ approach ignores empirical evidence regarding PCB toxicity and substantially over-predicts risks. Invited speaker to the National Academy of Science, Third Meeting of the Committee on EPA's Exposure and Human Health Reassessment of TCDD and Related Compounds, Washington, DC. March 21.

Keenan, R.E., E.S. Ebert, and M.H. Henning. 2004. Principle or Practice? That is the question: perspectives of practitioners in private practice. Invited platform presentation at Society for Risk Analysis (SRA) Annual Meeting, Palm Springs, CA. December 6.

Keenan, R.E., and J.J. Loureiro. 2004. Selecting site-specific sediment management approaches to reduce human health and ecological risks. Invited speaker to the Centredale Manor Superfund Site Contaminated Sediments Technical Advisory Group of EPA, Providence, RI. July 15.

Keenan, R.E., P.O. Gwinn, and M.C. Maritato. 2003. The potential impact of hormesis on risk assessment. Invited Platform Presentation at Non-linear Dose-Response Relationships in Biology, Toxicology and Medicine—An International Conference. University of Massachusetts, Amherst, MA. May 28.

Keenan, R.E. 2002. Mercury – An overview about its effects on us and the environment. Dinner lecture to Greater Portland Dental Society Meeting, Portland, ME. September 19.



Keenan, R.E. 2000. Applying dioxin TEQs for PCBs. Presentation of comments on behalf of the Polychlorinated Biphenyls Panel of the American Chemistry Council, the Utility Solid Waste Activities Group, and the National Electrical Manufacturers Association to the EPA Science Advisory Board, Dioxin Reassessment Review, Arlington, VA. November 1.

Keenan, R.E., and P.S. Price. 1999. Tricks of the trade: principles of good practice in probabilistic risk assessment. Invited speaker at Second Annual Workshop on Practical Issues in the Use of Probabilistic Risk Assessment, University of Florida, Sarasota, FL. March 1.

Keenan, R.E., J.D. Avantaggio, and P.S. Price. 1997. Should Maine's rivers have fish advisories for dioxin? Using an integrated microexposure event and toxicokinetic model to evaluate this question. Invited keynote presentation at SETAC North Atlantic Chapter Annual Conference, Portland, ME. June 13–14.

Keenan, R.E. 1993. Exposure assessment: then and now and quantum leaps in the future. Invited presentation at Conference on the Risk Assessment Paradigm after Ten Years: Policy and Practice Then, Now, and in the Future. Sponsored by EPA, Naval Medical Research Institute, U.S. Army Biomedical Research, and Armstrong Laboratory, Dayton, OH. April 5.

Keenan, R.E., E.R. Algeo, E.S. Ebert, and D.J. Paustenbach. 1993. Taking a risk assessment approach to RCRA corrective action. Invited presentation at The Development of Soil, Sediment, and Groundwater Cleanup Standards for Contaminated Sites -- How Clean is Clean? Water Environment Federation, U.S. Environmental Protection Agency, and Agency for Toxic Substances and Disease Registry, Washington, DC. January 12.

Keenan, R.E. 1991. Applying the strategy of risk assessment to address environmental problems. Keynote address to 1991 Annual Meeting of the First Tier Association of Railroad Environmental Attorneys, Jacksonville, FL. March 25.

Keenan, R.E. 1991. Applying the strategy of risk assessment to address environmental problems. Guest lecture to the Graduate Program in Toxicology and Public Health, University of Massachusetts, Amherst, MA. April 1.

Keenan, R.E. 1991. Issues in dioxin risk assessment. Presentation given at Seminar on Nuisance and Toxic Tort Litigation in the Paper Industry, Simpson Thacher & Bartlett, New York, NY. February 6.

Keenan, R.E. 1991. Reevaluating the cancer potency of dioxin for regulatory purposes. Presentation to the Minnesota Pollution Control Agency and the Minnesota Department of Health, St. Paul, MN. January 10.

Keenan, R.E., and D.J. Paustenbach. 1991. The use and misuse of risk assessment to address environmental problems. Dinner lecture to 1991 Mobil Oil Corporation Environmental Awareness Conference, Fairfax, VA. June 4.



Keenan, R.E., and D.J. Paustenbach. 1991. The application and use of health risk assessment to address environmental problems. Invited paper to the Forum on Emerging Process Technologies, Sandoz Corporation, Glasgow, Scotland. November 18.

Keenan, R.E., A.H. Parsons, E.S. Ebert, and J.W. Knight. 1991. Critical factors for establishing an ambient water quality standard for TCDD in the State of Washington. Presented before the Department of Ecology for the State of Washington and the Environmental Managers and Legal Counsel for the Member Mills of the Northwest Pulp and Paper Association, Seattle, WA. May 21.

Keenan, R.E. 1990. Critical factors for establishing ambient water quality standards for TCDD. Invited lecture to Dioxin in Maine's Rivers: A Symposium. Bowdoin College, Brunswick, ME. December 1.

Keenan, R.E., N.D. Wilson, and J.W. Knight. 1990. Looking to the 1990's: using risk assessment to design cost-effective solutions to environmental problems. Invited lecture to 1990 TAPPI New England Annual Meeting, Harwichport, MA. June 15.

Keenan, R.E. 1990. Risk assessment for the Columbia River. Presentation to Department of Ecology - State of Washington and Department of Environmental Protection. State of Oregon. Prepared by Oregon EPA and the Northwest Pulp and Paper Association. April 16-20.

Keenan, R.E. 1990. Dioxin--What are the risks? Town Hall TV Debate, Channel 2, Portland, OR. March 4.

Keenan, R.E., W.R. Brown, and A.H. Parsons. 1990. An update of the scientific information critical to the establishment of state water quality standards. Presentation to U.S. Environmental Protection Agency, Region VI, Dallas, TX. October 26.

Keenan, R.E., R.J. Wenning, and A.H. Parsons. 1990. A reevaluation of the cancer potency of 2,3,7,8-TCDD and determination of health-protective exposure levels. Invited lecture to Northeast Regional Meeting of the National Council of the Paper Industry for Air and Stream Improvement, Boston, MA. October 25.

Keenan, R.E., J. Graham, A. Finkel, A. Smith, and R. Frakes. 1990. Invited Panelist, Workshop on Considerations in Risk Level Decision Making. Maine Department of Environmental Protection, Augusta, ME. September 20.

Keenan, R.E. 1989. Potential hazards posed by run-off containing TCDD-contaminated soil. Invited lecture to Dioxin in Dirt--Does 1 ppb Make Sense? Resources for the Future, Washington, DC. November 20.

Keenan, R.E. 1989. Examination of potential risks from exposure to dioxin in sludge used to reclaim abandoned strip mines. Invited lecture to professional development course, The Risk Assessment of Environmental and Human Health Hazards, 28th Annual Meeting of the Society of Toxicology, Atlanta, GA. February 27.





Keenan, R.E. 1989. Examining environmental and human health impacts. Invited lecture to Cornell University Seminar: What Happens When the Landfill Fills Up? Cornell University, Albany, NY. March 9.

Keenan, R.E. 1988. How clean is clean? The use of risk-driven remediation as an approach to solving our hazardous waste problems. Invited paper to the seminar series On-site Corrective Action Solutions for RCRA/CERCLA Sites, Houston, St. Louis and San Diego.

Keenan, R.E. 1986. Relevant issues in setting sludge utilization regulations. Invited lecture to 1986 NCASI Northeast Regional Meeting, Boston, MA. October 30.

Keenan, R.E. 1985. Comparative hazard and benefits assessment via ranking scales and computer graphics. Invited lecture to National Risk/Benefits Assessment Policy Work Symposium, Ottawa, Ontario. March 7.

### **Professional Meetings Organized and Chaired**

Special Session titled “PFAS Risk Assessment: Challenges and Perspectives.” 36th Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2020.

Special Session titled “New Challenges in Evaluating and Communicating Health Risks.” 34th Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2018.

Special Session titled “Biomonitoring – Strategies and Uses for Risk Assessment and Stakeholder Communication.” 33rd Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2017.

Special Session titled “Use of Decision Analysis and Probabilistic Tools to Manage Environmental Risk.” 32nd Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2016.

Special Session titled “Perfluorinated Compounds of Emerging Concern—Challenges, Perspectives, and Risk Considerations.” 31st Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2015.

Special Session titled “Quantifying Human Exposures to Contaminants of Emerging Concern in Soils and Sediments.” 30th Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2014.

Special Session titled “Quantifying Human Exposures to Environmental Contaminants in Soils and Sediments.” 29th Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2013.



Special Session titled “Assessing and Managing Human Health Risks in the U.S.—Striking a Balance between Costs, Benefits, Efficacy, and Unintended Consequences.” 28th Annual International Conference on Soils, Sediments, Water and Energy of the Association for Environmental Health and Sciences Foundation. 2012.

Poster/Discussion Session on the Development and Applications of Probabilistic Reference Doses. 36th Annual Meeting of the Society of Toxicology. 1997.

Ecotoxicology Session. 15th International Symposium on Chlorinated Dioxins and Related Compounds (Dioxin '95). 1995.

Workshop on Application of Monte Carlo Techniques to Exposure Assessment. Society for Risk Analysis Annual Meeting. 1994.

Risk Assessment Discussion Session. 10th International Symposium on Chlorinated Dioxins and Related Compounds (Dioxin '90). 1990.

Risk Assessment Sessions (2). Haztech International '90. 1990.

Pulp and Paper Symposium. Ninth International Symposium on Chlorinated Dioxins and Related Compounds (Dioxin '89). 1989.

Regulatory Session. Fourth Annual Conference on Petroleum Contaminated Soils. 1989.

Conference Organizer and Chairman. Understanding Toxicology and Chemical Risk Assessment—A National Symposium for Risk Managers and Corporate Counsel, University of Massachusetts Division of Public Health. 1984.

Conference Organizer and Chairman. North American Conference on Pesticide Spray Drift and Chemical Trespass, Maine Board of Pesticides Control. 1984.

Conference Organizer and Chairman. R.K. Mellon/Yale University on Chemical Control and Long-Term Management of Gypsy Moth. 1983.

## **Testimony**

Keenan, R.E. 2019. A toxicological evaluation for establishing a reference dose (RfD) for use in site-specific risk assessment of sulfolane, a chemical substance without toxicity values on EPA's IRIS database. Expert testimony at trial in the Superior Court for the State of Alaska Fourth Judicial District Court, Fairbanks, Case No. 4FA-14-01544CI (*State of Alaska and City of North Pole v. Williams Alaska Petroleum Inc., The Williams Companies, Inc., Flint Hills Resources Alaska, LLC, and Flint Hills Resources, LLC*).



Keenan, R.E. 2016. An affirmative characterization of the Centredale Manor Restoration Project Superfund Site human health and ecological risk assessments. Expert testimony at trial in U.S. District Court, District of Rhode Island, Civil No. 11-023 (*Emhart Industries, Inc., et al. v. United States Department of the Air Force et al.*). October 3, 4.

Keenan, R.E. 2014. A characterization of potential risks to human health and an evaluation of ecological effects to aquatic biota due to mercury in the lower Penobscot River and Estuary. Expert testimony at trial in U.S. District Court, District of Maine, Civil No. 1:00-cv-00069-JAW (*Natural Resources Defense Council et al. v. HoltraChem Manufacturing LLC et al.*). Bangor, ME. June 20, 23, 24.

Keenan, R.E. 2010. An assessment of attic dust samples collected in Dierks, Arkansas, using chemical forensic multivariate statistical methods. Expert testimony at trial before jury in U.S. District Court, Western District of Arkansas, Texarkana Division, Case No. 4:07cv4037 (*Rhonda Brasel, Individually and as Next Best Friend and Guardian of Christopher Albright and Nathan K. Thomas, et al. v. Weyerhaeuser Company, et al.*). Texarkana, AR. September 27.

Keenan, R.E. 2010. Human health implications related to corrective action alternatives at the former HoltraChem facility. Expert Testimony in Adjudicatory Hearing before the Maine Board of Environmental Protection on Appeal of Designation of Uncontrolled Hazardous Substance Site and Order Concerning Chlor-alkali Manufacturing Facility. Augusta, ME. February 2.

Keenan, R.E. 2002. An evaluation of potential human health risks to anglers and their families from ingesting fish containing methyl mercury from the Penobscot River. Expert testimony at trial in U.S. District Court, District of Maine, Docket No. 00-69-B (*Maine People's Alliance & Natural Resources Defense Council, Inc. v. HoltraChem Manufacturing Company, LLC and Mallinckrodt, Inc.*). Portland, ME. March.

Keenan, R.E. 2001. Dioxin TEQs overstate the carcinogenic potency of PCBs. Public hearing testimony to the Executive Committee of the EPA Science Advisory Board, Washington, DC. May 15.

Keenan, R.E. 1991. Testimony in public hearing before EPA TSCA Docket No. OPTS-62100: Proposed Rule for the Land Application of Sludge from Pulp and Paper Mills Using Chlorine and Chlorine Derivative Bleaching Processes (56 FR 21802), Washington, DC. October 29.

Keenan, R.E. 1991. Rebuttal testimony in adjudicatory hearing before the Environmental Quality Commission of the State of Oregon regarding NPDES Waste Discharge Permits 100715 and 100716. September 4.

Keenan, R.E. 1991. A hazard evaluation of the metal and dioxin concentrations in the sludge/ash, lime mud and leachate at the James River Old Town Mill. Testimony in public hearing before the Old Town Planning Board, Old Town, ME. April 2.



Keenan, R.E. 1991. Establishing a health-based water quality standard for dioxin in West Virginia. Testimony in public hearing before the West Virginia State Water Resources Board on Proposed Amendments and Revisions to State Water Resources Board, 46 CSR 1 Title 46 Legislative Rule Series 1 Requirements Governing Water Quality Standards. Charleston, WV. June 20.

Keenan, R.E. 1991. Expert testimony in public hearing concerning the petition for rule amendment to establish a health-based, water quality standard for 2,3,7,8,-TCDD. Environmental Quality Commission, Portland, OR. June 13.

Keenan, R.E. 1991. Establishing a health-based water quality standard for dioxin in Alabama. Testimony in public hearing before the Alabama Environmental Management Commission, Montgomery, AL. January 17.

Keenan, R.E. 1991. Establishing a health-based water quality standard for dioxin in Mississippi. Testimony in public hearing before the Mississippi Department of Environmental Quality, Starkville, MS. January 29.

Keenan, R.E. 1991. Establishing a health-based water quality standard for dioxin in Mississippi. Testimony in public hearing before the Mississippi Department of Environmental Quality, Jackson, MS. January 30.

Keenan, R.E. 1991. A toxicologic update concerning the carcinogenic dose response of dioxin. Testimony in public hearing before the Arkansas Commission of Pollution Control and Ecology regarding NPDES No. AR0001970 Waste Discharge Requirements for International Paper Company and NPDES No. AR0001210 Waste Discharge Requirements for Georgia-Pacific Corporation, Little Rock, AR. January 3.

Keenan, R.E. 1991. Establishing a health-based water quality standard for dioxin in Florida. Testimony in public hearing before the State of Florida Environmental Regulation Commission, Orlando, FL. June 5.

Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in South Carolina. Testimony in public hearing before the South Carolina Water Quality Commission, Columbia, SC. August 1.

Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in North Carolina. Testimony in public hearing before the North Carolina Environmental Management Commission - Water Quality Committee, Raleigh, NC. July 11.

Keenan, R.E. 1990. Determination of acceptable levels of human exposure to dioxin. Testimony in public hearing before the Florida Department of Environmental Regulation, Tallahassee, FL. May 1.



Keenan, R.E. 1990. Amendments to Georgia water use classifications and water quality standards. Testimony in public hearing before the Georgia Board of Natural Resources, Atlanta, GA. March 13.

Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in Arkansas. Testimony in public hearing before the Arkansas Commission of Pollution Control and Ecology, Little Rock, AR. August 27.

Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in South Carolina. Testimony in public hearing before the South Carolina Water Quality Commission, Georgetown, SC. August 2.

Keenan, R.E., E.R. Rand, M.S. Sauer, J.W. Knight, and J.M. Michaud. 1990. Examination of potential risks from exposure to dioxin in soils amended with sludge or ash. Testimony in public hearing before the New Hampshire Department of Environmental Services and the Towns of Milan and Berlin, Milan, NH. June 19.

Keenan, R.E. 1990. Evaluation of emissions from proposed sludge drying operation. Testimony in public hearing before the Wisconsin Department of Natural Resources, Texas, WI. May 23.

Keenan, R.E. 1990. L.D. 2394. - An act to clarify the process by which the Board of Environmental Protection regulates the discharge of toxic substances to the state's surface waters. Testimony in public hearing before the Maine Legislative Committee on Energy and Natural Resources, Augusta, ME. March 9.

Keenan, R.E. 1990. Proposed revisions to Minnesota Water Quality Standards. Testimony in public hearing before the Minnesota Pollution Control Agency, St. Paul, MN. March 2.

Keenan, R.E. 1990. Establishing a health-based water quality standard for dioxin in South Carolina. Testimony in public hearing before the South Carolina Water Quality Commission, Greenville, SC. July 31.

Keenan, R.E. 1989. Health and environmental risks associated with recycling sludge and residuals. Testimony in public hearing before the Maine Land Use Regulation Commission regarding Proposed Changes to Chapter 10 Land Use Districts and Standards, Bangor, ME. April 20.

Keenan, R.E. 1989. Testimony presented at public hearing before the California Regional Water Quality Control Board regarding NPDES No. CA0004065 Waste Discharge Requirements for Simpson Paper Company, Shasta Mill, Redding, CA.

Keenan, R.E. 1989. Testimony presented at public hearing before the Maine Legislative Joint Committee on Energy and Natural Resources regarding LD1162 -- An Act Regarding Sludge Spreading, Augusta, ME. April 24.





Cavaney, R., R. Estridge, and R.E. Keenan. 1988. Testimony on behalf of the American Paper Institute before the Subcommittee on Health and the Environment of the Committee on Energy and Commerce, U.S. House of Representatives, Washington, DC. December 8.

Keenan, R.E. 1988. Assessment of potential risks to consumers and to pulp and paper mill workers from dermal exposure to dioxin in bleached pulp, paper and pulp-based products. Testimony on behalf of the American Paper Institute before the U.S. Congress Office of Technology Assessment, Washington, DC. November 15.

Keenan, R.E., and B.W. Found. 1988. Assessment of potential risks to humans and to wildlife from herbicide applications on powerline rights-of-way. Testimony in public hearing before the Towns of Dixfield (November 7) and Pownal (February 24), ME.

Keenan, R.E. 1987. Assessment of potential health risks from dermal exposure to dioxin in paper products. Testimony presented on behalf of the American Paper Institute to the U.S. Environmental Protection Agency, the Food and Drug Administration, and the Consumer Products Safety Council, Washington, DC. October 15.

Keenan, R.E. 1987. Potential impacts on human health and wildlife species from forestland application of paper mill sludge. Testimony in public hearing before the Town of Standish regarding S.D. Warren application to apply sludge and residuals under Chapter 567, Steep Falls, ME. September 12.

Keenan, R.E. 1986. Potential impacts on wildlife from dioxin-containing sludges. Testimony in public hearing before Maine Board of Environmental Protection regarding Proposed Amendment to Chapter 567 Dioxin Standards, Rules for Land Application of Sludge and Residuals, Augusta, ME. April 16.

Lawrence, F.H., and R.E. Keenan. 1986. Assessment of human health risks and potential impacts on terrestrial wildlife from exposure to dioxin in BYPRO paper mill sludge used to reclaim abandoned strip mine sites. Testimony in public hearing before the Ohio Environmental Protection Agency, Logan, OH. September 25.

