

Ann Holbrow Verwiel, M.P.P.

DIRECTOR, EXPOSURE SCIENCES
SENIOR MANAGING SCIENTIST

CONTACT INFORMATION

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PROFESSIONAL PROFILE

Ann Verwiel is Director of ToxStrategies' Exposure Sciences Practice and a Senior Managing Scientist. Ms. Verwiel has more than 20 years of experience in environmental consulting in the areas of human health risk assessment, site assessment, and environmental regulation. Over her career, she has focused on integrating risk assessment into an overall risk management approach to problem definition, investigation, and mitigation. She has successfully applied this approach in negotiations with regulatory agencies and public groups to develop cost-effective investigations, assessments, and mitigation strategies. She has also studied the science behind using cumulative impact assessments to assess health conditions in vulnerable communities. She has published and presented papers on a wide variety of topics, including probabilistic risk assessment (Monte Carlo analysis), environmental fate and transport of contaminants, and environmental auditing.

Ms. Verwiel has managed and conducted numerous human health risk assessments that addressed a wide variety of chemicals in soil, soil vapor, air, and groundwater. Petroleum, aerospace, electronics, mining, and MGP sites are among some of the most common sites for which she has performed these risk assessments. She has evaluated the chemical signatures, transport mechanisms and ultimate fate, and likely current and future human exposures as key first steps in the health risk evaluation. She has worked to develop investigation strategies and assess exposure to indoor and ambient air, which included evaluating air emission sources, modeling, soil vapor measurements, and indoor/ambient air measurements. At sites where volatile organic compounds (VOCs) are present in the subsurface, she has addressed the potential existence of a vapor intrusion exposure pathway using modeling and measurement approaches.

Ms. Verwiel has a detailed understanding of a broad cross section of environmental regulations, which she has applied to regulatory impact analyses, environmental compliance, and training programs. She has evaluated potential impacts of new regulations on operating facilities and new developments, assessed compliance at operating facilities with a wide variety of environmental regulations, and developed training materials to help regulatory agencies establish their requirements clearly and help regulated entities comply. She has conducted air toxics analysis to meet the requirements of California Proposition 65, the AB2588 Toxic "Hot Spots" Act, and the California Environmental Quality Act (CEQA).

Ms. Verwiel also has communicated risk to formal public groups, such as Restoration Advisory Boards, as well as the general public, in open meetings and direct written communications. She has worked with regulatory public participation specialists, public affairs officers, and others to develop written summaries and presentation materials to convey complex technical issues to the public. She has provided litigation support for several projects involving disputes between owners and operators, alleged air emissions exposures, and Proposition 65 litigation.

EDUCATION AND DEGREES EARNED

- 1996 Master of Public Policy (M.P.P.)
Georgetown University, Washington, DC
- 1987 Bachelor of Science (B.S.)
Chemistry
University of California, Irvine

CERTIFICATIONS

- OSHA 40-hour training (updated annually since 1987)
- OSHA Supervisor training

PROFESSIONAL AFFILIATIONS

- American Chemical Society (ACS; member)
- Society of Environmental Toxicology and Chemistry (SETAC; member)
- Society of Risk Analysis (SRA; member)

SELECTED PROJECT EXPERIENCE

Cumulative Impact Assessments and Environmental Justice

Co-author of “Comprehensive Review of Frameworks, Methods, and Metrics for Cumulative Impact Assessment of Vulnerable Communities: A Science Perspective,” which presents the results of a multidisciplinary review of the various components of cumulative impact assessment from a scientific perspective. The overall objective of the study was to clarify the current underlying science and identify research needs to improve the quality and usefulness of cumulative impact assessments for communities with environmental justice concerns.

Prepared an evaluation of screening tools used by federal, state, and local entities to identify vulnerable communities with environmental justice concerns. Evaluated parameters in screening tools to compare source data sets, frequency of parameters, indexes, and other information. The report also provided examples of cumulative impact assessments from the literature to contrast with the approach using screening tools.

Air Toxics Health Risk Assessments

Prepared a modeling and risk assessment protocol and completed an air toxics human health risk assessment for a metals recycling facility in Ohio to support a RCRA Part B permit. As part of their permit conditions, Ohio EPA required that the operator complete a risk assessment. Results of community air monitoring had previously

resulted in evaluation of the facilities' air emission sources. A protocol was developed to achieve concurrence on the plan for emission estimates, modeling, and risk assessment. Going forward, comments on the protocol from Ohio EPA will be incorporated, and then emissions from various handling, storage, and treatment operations will be characterized and used in an air dispersion model (AERMOD) to estimate off-site concentrations in air and potential risk.

Managed a California AB2588 health risk assessment (AB2588 HRA) for a metal forge operation in southern California. This facility was the focus of public interest related to odors being observed in the neighborhood, and air emission sources were discussed in a series of public meetings. A community air monitoring program was also in place in the neighborhood. Mitigation strategies were developed, and as a result of source controls and operating procedure changes, the potential exposures from air emissions were below significance levels.

Managed a California AB2588 health risk assessment (AB2588 HRA) to evaluate emissions from a metal-finishing facility in the South Coast Air Quality Management District (SCAQMD). The SCAQMD also instituted a community air monitoring program to assess off-site impacts from this facility and others in the area that identified localized increases in air concentrations of some metals. An air toxics risk assessment was performed that required generating emission estimates for unique sources, characterizing source operations for a facility that operated 24 hours per day, conducting air dispersion modeling, and completing risk evaluation and comparisons to local monitoring data. All work was performed on an expedited schedule to meet agency enforcement deadlines, and the results were reported during a community meeting.

Developed a risk assessment protocol and emission estimates for an explosives manufacturing facility to support a risk assessment prior to renewal of the RCRA Part B permit application for storage and open burning of explosive wastes. Evaluated various waste materials and combustion by-products to identify emission estimates and toxicity criteria. Used air dispersion modeling to estimate off-site concentrations and estimated potential human health risks for off-site residents, ranchers, and recreators.

Managed evaluation of source material testing for metals (including hexavalent chromium) at various emission sources at a cement manufacturing plant in northern California.

Performed a California AB2588 HRA for a manufacturing facility in northern California, and obtained regulatory approval from the Bay Area Air Quality Management District (BAAQMD), receiving only minimal comments.

Prepared a California AB2588 HRA for a film-processing facility with emissions of PCE and other solvents used in film developing and cleaning processes.

Evaluated chemical emissions from multiple air emission sources at an urban medical center, in support of an Environmental Impact Report (EIR) under CEQA.

Evaluated chemical emissions from multiple emission sources at the University of California – Riverside campus, to support preparation of an EIR for the long-range development plan for the university.

Project manager responsible for evaluating potential worker exposure to vehicle emissions in a proposed subterranean parking garage for a convention center that managed large volumes of material transport requiring diesel-emitting trucks. Findings were used to revise the building design to mitigate potential exposures incurred by workers in the garage.

Led a study to evaluate emissions from neighboring industrial sources and a highway prior to construction of a child-care facility at a food production facility, for the convenience of their employees. Conducted air monitoring to understand concentrations and looked at industrial sources in the vicinity of the food production facility.

Project manager responsible for evaluating potential health effects associated with emissions from an oil drilling operation in a highly urban area of Los Angeles.

Prepared an HHRA for remedial action activities, including dust generation and diesel exhaust, in support of a permit application for a remedial action at a former burn dump and shooting range. Managed development and implementation of an air monitoring plan to document concentrations of particulates and lead during remediation activities for comparison to acceptable levels established in the monitoring plan. Monitoring data were made available to the public electronically, which required rapid assessment of the results and adjustments to remedial activities as necessary.

Vapor Intrusion Risk Assessments

Evaluated PCE in groundwater for potential vapor intrusion to off-site residents. Considered the unique geologic setting of a thick, competent clay layer between groundwater and the surface, which likely serves to mitigate vapor intrusion from groundwater to off-site residences. However, soil gas measurements near a sanitary sewer line detected concentrations of VOCs that complicated the interpretation and required additional evaluation.

Evaluated potential vapor intrusion of petroleum hydrocarbons into a building adjacent to a former gas station planned for use as a daycare center. Soil at the gas station was remediated, but a groundwater plume appeared to extend beneath the building, and because excavation would have affected the integrity of the building, residual petroleum hydrocarbons remained in soil near and potentially under the building. Multiple rounds of indoor air samples were collected to demonstrate that vapor intrusion was not an issue for this building.

Evaluated vapor intrusion of TCE at two industrial buildings adjacent to a shallow soil vapor source. The buildings were monitored over a period of 2 years, and results demonstrated minimal impacts, with indoor air concentrations below health-based screening levels.

Evaluated potential vapor intrusion of TCE and six other VOCs at 100+ homes in the vicinity of a shallow groundwater plume. Developed an indoor air sampling protocol, health-based screening levels, and letters reporting results to residents. We developed presentations for the lead agency and other regulators to define the scope of the evaluation, results, and conclusions. Continued monitoring at fewer than 10 homes after 5 years, when the extent of TCE in groundwater was formally assessed.

Provided third-party review for a vapor intrusion assessment at a future residential development. Worked with landowner to design a development plan that minimizes potential impacts to new homes. Open spaces and parks were used for areas where vapor intrusion may have been an issue. Homes were located at least 100 feet from these areas.

Lead risk assessor for a vapor intrusion HHRA at a former manufacturing facility redeveloped as a business park in southern California. VOCs, primarily trichloroethylene (TCE), were detected in subsurface soil, groundwater, and soil vapor. Developed an indoor air sampling program, calculated site-specific screening levels, and evaluated off-site migration using soil vapor measurements under regulatory oversight.

Lead risk assessor for a vapor intrusion evaluation at an operating hazardous waste treatment facility with chlorinated solvents present in soil and groundwater both on and off site. Evaluated potential human health risks at nearby residences for on-site workers.

Conducted an indoor air evaluation using multiple lines of evidence to evaluate conditions at a surgical hospital prior to a property transaction. Soil gas, sub-slab soil gas, and indoor air samples were collected simultaneously to provide information for decision making within the time frame of the property transaction.

Conducted an indoor air evaluation at a public building to address potential vapor intrusion issues related to a tetrachloroethene (PCE) plume from a former dry cleaning operation at the site.

Lead risk assessor responsible for evaluating potential human health risks associated with free product on the groundwater table approximately 200 feet below ground surface at a former refinery, and for assessing potential impacts to off-site residents.

Lead risk assessor for an HHRA for a former (UST) site where potential indoor air impacts were the key issue following soil remediation because of residual concentrations of petroleum constituents and 1,2-dichloroethane in groundwater at the site and off-site.

California Proposition 65 Evaluations

Evaluated concentrations of chemical ingredients in lubricant products such as gear oils, greases, and other oils and lubricants, that would require a warning label pursuant to California's Safe Drinking Water and Toxic Enforcement Act of 1986 (commonly referred to as Proposition 65). Developed exposure scenarios relevant to each product group, such as chemical-specific dermal absorption factors, potential incidental ingestion, product-specific density, and product-specific exposure frequencies. Using these exposure parameters, estimated potential exposures to the listed chemicals in the product, to assess whether Proposition 65 notifications were required.

Provided support to legal counsel and their client in the evaluation of potential off-site exposure to diesel exhaust from ski resort operations.

Performed a Proposition 65 evaluation for a metal forge operation in southern California; results demonstrated that notification was not required for off-site residents.

Evaluated potential exposures to lead in a dietary supplement and in a skin product, based on daily use suggested by the product label. Recommended additional analysis to assess bioavailability to more accurately assess exposure.

Sixty-day notices were sent by plaintiffs' attorneys to numerous industrial facilities in California based on the simple listing of a Proposition 65 chemical in their emission inventory reported to local air districts and made publicly available. Assisted several clients by conducting simple evaluations of their emissions, which showed that, under conservative assumptions, specific regulatory levels for the Proposition 65-listed chemicals had not been exceeded.

Evaluated requirement to notify off-site persons potentially exposed to emissions from an industrial facility in southern California. Developed specific regulatory levels when such levels had not been published by the state.

Provided technical support in negotiations with the California Attorney General's office on behalf of a manufacturing facility that was issued a 60-day notice based on erroneous interpretations of a public air toxics risk assessment report.

Developed a Proposition 65 emission calculator for diesel exhaust from construction activities for a client that conducts numerous construction projects every year, to assess whether notification may be required,

Evaluated building materials, furniture, and chemical products at a large child-care facility, to identify Proposition 65-listed chemicals and assess whether Proposition 65 notification may be required.

Estimated potential exposure to cadmium and lead in a food product, including evaluating laboratory data and researching typical consumption patterns.

Multi-Media Environmental Human Health Risk Assessments

Managed the risk assessment planning process for the soil operating unit of a former airport, aircraft maintenance facility, and military manufacturing site. Worked with EPA to attain concurrence on a scoping document for the risk assessment that addressed the major questions regarding the approach to the risk assessment. This allowed the risk assessment to proceed quickly and streamlined EPA's review.

Managed a site-wide HHRA for an active chemical manufacturing facility subject to RCRA under EPA oversight. Chemicals at the site included VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, dioxin/furans, and inorganics. Key factors included an upgradient contribution of VOCs from an adjacent Superfund site, shallow groundwater (~5 feet below ground surface), redevelopment of a portion of the former site as a regional park, off-site residences 350 feet from the site boundary, a nearby creek, and a variety of source areas.

Managed human health risk assessment activities at a confidential Superfund mining site. Over the last 10 years, participated in the project management team that developed work plans, performed site characterization activities, evaluated nature and extent of affected areas, developed a baseline human health risk assessment work plan, and completed a draft baseline human health risk assessment. Unique features of this project included:

- Developed a site conceptual model that incorporated unique receptors, including Native American tribal members and foragers
- Evaluated incremental sampling methods for mine-waste piles
- Conducted bioaccessibility testing for key metals
- Prepared a work plan and collected data to develop site-specific plant uptake factors
- Collected site-specific background data sets for multiple media and calculated statistically based benchmarks for comparison to site data
- Predicted a risk and hazard index for seven receptors at up to 16 study areas and seven reference areas
- Presented results in a 6-hour meeting with EPA, other federal agencies, and state and tribal representatives.

Provided technical expertise to Nevada Department of Environmental Protection (NDEP) to review documents related to redevelopment of a former manganese mine. ToxStrategies' responsibility was to review documents related to the assessment of potential human health risk, such as the baseline human health risk assessment work plan, the baseline human health risk assessment, the Remedial Investigation report, and other documents. ToxStrategies provided comments to NDEP, which were forwarded to the responsible party and incorporated into their documents.

Developed cleanup goals for future redevelopment of a former Department of Energy facility that was being decommissioned. ToxStrategies was hired by the developer to assist in evaluating the implications of hundreds of due diligence samples collected in support of the property transaction. Developed site-specific cleanup goals for more than 50 chemicals in soil, soil gas, and/or groundwater and evaluated these data with respect to the cleanup goals. The cleanup goals were also used by the developer to estimate remediation costs and strategies. The project team worked with regulators—including Missouri's Department of Natural Resources and Department of Health and Senior Services—to achieve regulatory concurrence on the cleanup goals and enable the project to move forward.

Managed a human health and ecological risk assessment for an operating lumber mill for impacts of dioxins and other chemicals, both on-site in operational areas and off-site in a slough. Developed a baseline human health risk assessment (HHRA) and cleanup levels for upland soil and performed the scoping ecological and off-site human health risk assessment to evaluate ecological and human health risks associated with chemicals present in the slough, both of which received regulatory approval. Developed a sediment management strategy to document that conditions in the slough remained protective of aquatic organisms.

Developed a risk assessment approach for the investigation of former ponds believed to have been affected by mine drainage from a nearby mine. Developed a risk-based investigation and risk assessment work plan to evaluate the residual material and assess the effort necessary to mitigate the impacts at the site.

Project Manager responsible for evaluating environmental issues associated with an approximately 1100-acre ranch where wastewater from a nearby pulp and paper mill was used to irrigate specific agricultural fields, resulting in dioxin in the soil. Developed presentation materials for a public meeting and supported various parts of the California Environmental Quality Act (CEQA) process related to future use of the site as a gravel mine, including preparing public information sheets on dioxins.

Performed an HHRA in support of a Remedial Action Workplan (RAW) for two parcels that were formerly part of a larger manufactured gas plant where PAHs and benzene were key chemicals of potential concern (COPCs) in soil, groundwater, and/or indoor air. The HHRA was approved by the California Department of Toxic Substances Control (DTSC), and the RAW was implemented.

Performed an HHRA and developed risk-based remediation goals for future residential or commercial/industrial land use at a former manufacturing site with metals in soil and VOCs in soil vapor, which were approved by DTSC.

Managed a multi-disciplinary project to provide consulting services to the operators of a former fuel storage terminal (the terminal) in the Port of Los Angeles. Performed the HHRA, obtained regulatory concurrence, developed remediation goals, negotiated with the regulatory agency, and provided support to the client's negotiations with the landowner.

Used a risk-based approach to evaluate off-site risk resulting from a groundwater plume that had migrated from a bulk petroleum storage facility beneath an adjacent residential neighborhood. Worked with members of the public in a formal Restoration Advisory Board (RAB) to refine the existing HHRA Work Plan, perform the risk assessment, and achieve regulatory concurrence.

Managed a multi-phase investigation of petroleum hydrocarbons in soil at a residential development that was discovered after redevelopment. Worked with the City, developer, and numerous regulatory agencies to prioritize investigation needs, conduct a comprehensive investigation, and perform a screening risk assessment. Work was completed in an expedited time frame, and the development was able to move forward.

Managed preparation of an HHRA Work Plan for a jet-fuel plume at a major U.S. airport that focused on current and potential future receptors. Negotiated acceptance of the work plan with property owner, and completed the risk assessment.

Lead risk assessor for a residential development planned adjacent to a former agricultural chemical manufacturing facility (the site) where groundwater had been affected by agricultural chemicals and VOCs. Completed the risk assessment, which was approved by the regulators, within strict time constraints required to obtain approval of development financing by lending agencies.

Lead risk assessor for site characterization activities and subsequent remediation measures related to VOCs in soil gas, VOCs, and hexavalent and total chromium in soil and groundwater at a former metal-plating facility pursuant to a Cleanup and Abatement Order with the Los Angeles Regional Water Quality Control Board (RWQCB).

Managed the health risk assessment components of the evaluation of waste piles at a former mine site. Performed a background comparison and a risk assessment to evaluate site conditions.

PUBLICATIONS

Perry CS, **Verwiel AH**, Covington TR, Proctor DM. 2024. PBPK modeling demonstrates that exposure time adjustment is unnecessary for setting an acute manganese inhalation exposure guideline. *Regul Toxicol Pharmacol* 153:105698; <https://doi.org/10.1016/j.yrtph.2024.105698>

Perry CS, Blanchette AD, Vivanco SN, **Verwiel AH**, Proctor DM. 2023. Use of physiologically based pharmacokinetic modeling to support development of an acute (24-hour) health-based inhalation guideline for manganese. *Regul Toxicol Pharmacol* 145:105518 [[open access](#)].

Verwiel A, Racz L, Mittal L, Rish W. 2022. CDC's national report on human exposure to environmental chemicals. *SETAC Globe* 23(6), https://globe.setac.org/cdc_report_human_exposure_to_chemicals/.

Suh M, Casteel S, Dunsmore M, Ring C, **Verwiel A**, Proctor DM. 2019. Bioaccessibility and relative oral bioavailability of cobalt and nickel in residential soil and dust affected by metal grinding operations. *Sci Tot Environ* 660:677–689.

Holbrow AM, Keller A, Dagdigian JV, Amantea C. 1994. Identifying potential liabilities associated with business transactions. *J Environ Law* May/June.

Copeland TL, **Holbrow AM**, Connor D, Paustenbach DJ. 1994. Use of Monte Carlo techniques to understand the conservatism in California's approach to assessing air toxic contaminants. *J Air and Waste Manag Assoc* 44(12):1399–1413.

ABSTRACTS AND PRESENTATIONS

Perry CS, Vivanco SN, **Verwiel AH**, Proctor DM. Derivation of manganese 24-hour acute inhalation guideline protective of respiratory and neurological effects. Abstract 4751, Society of Toxicology Annual Meeting, Salt Lake City, UT, March 2024.

Rish W, **Verwiel A**. Quantitative methods for including environmental justice in human health risk assessment: An overview. Society for Environmental Toxicology and Chemistry Virtual Conference. November 2021.

Verwiel A, Proctor D. Risk management for VOCs in indoor air and building evacuation decisions. Poster for International Society of Exposure Science Virtual Annual Meeting, September 2020.

Verwiel A, Proctor D, Suh M. Glyphosate risk assessment to assess Proposition 65 requirements for pesticide applicators and construction workers: Risk communication case study. Poster for Society of Toxicology, Virtual Annual Meeting, 2020. <https://eventpilotadmin.com/web/page.php?page=IntHtml&project=SOT20&id=2097>.

Johnson D, Thompson C, **Verwiel A**, Brorby B. Derivation of California Proposition 65 safe harbor levels for nine chemicals. Poster for Society of Toxicology, Virtual Annual Meeting, 2020. <https://eventpilotadmin.com/web/page.php?page=IntHtml&project=SOT20&id=2633>.

Suh M, **Verwiel A**, Proctor D. Oral and inhalation bioaccessibility of cobalt and nickel in metal alloys: A critical consideration for site-specific human health risk assessments and read across. Poster for Society of Toxicology, Virtual Annual Meeting, 2020, <https://eventpilotadmin.com/web/page.php?page=Session&project=SOT20&id=P3190>.

Ring CL, Suh M, Casteel S, Dunsmore M, **Verwiel A**, Proctor D. Relative oral bioavailability of cobalt and nickel in residential soil and dust affected by metal grinding operations. Presented at Joint Annual Meeting of International Society of Exposure Science and International Society for Environmental Epidemiology (ISES-ISEE 2018), Ottawa, Canada, August 2018.

Verwiel, A.H. Assessment of the Risk of Bias in the Evidence Base for Gestational Exposure to TCE and Development of Congenital Heart Defects. Air & Waste Management Association Meeting, Vapor Intrusion, Remediation, and Site Closure. Phoenix, AZ, December. 2018.

Proctor DM, Suh M, Dunsmore D, **Verwiel A**, Casteel S. Bioaccessibility and relative oral bioavailability of cobalt and nickel from metal alloys in soil and dust. Poster presented at Society of Toxicology Annual Meeting. March 15, 2017. Baltimore, MD.

Holbrow Verwiel A. Development of a long-term monitoring solution for dioxins/furans in sediment. Poster Presentation at Dioxin 2010: 30th International Symposium on Halogen Persistent Organic Pollutants, San Antonio, TX. September 12-17, 2010.

Croteau D, Bernhardt T, **Holbrow A**, Conti E, and Ellery B. Site characterization using a dioxin screening method: Former sawmill, California, United States of America. Proceedings of the Dioxin 2008: 28th International Symposium on Halogenated Persistent Organic Pollutants, Birmingham, England. Aug 17-22, 2008. Also published in Organohalogen Compounds, v. 70. 2008.

Connor K, Kelly C, Cheung R, and **Holbrow A**. Risk-based screening values for vapor intrusion pathway and flux chamber data. Society for Risk Analysis 2005 Annual Meeting, Orlando, FL. December 6, 2005.

Rush HC, **Holbrow A**, Embree J, and Szerdy FS. Empirical and modeled attenuation factors and the contribution of preferential pathways to indoor air quality. Vapor Intrusion Attenuation Workshop, 14th Annual West Coast Conference on Soils Sediment and Water, U.S. EPA, San Diego, CA. 2004.

Holbrow AM, Brorby GP and Zemo DA. Reality check? Soil vapor data applied to an evaluation of chemical migration from groundwater to air. 10th West Coast Conference of the Association for the Environmental Health of Soils, San Diego, CA. March 20–23, 2000.

Holbrow AM, Nazmi N, Smith JS and Brorby GP. Implementing a risk assessment work plan developed by stakeholder consensus. Presented at the Society for Risk Analysis Conference, Atlanta, GA. December 1999.

Spencer AL, **Holbrow AM** and Graf T. The 'free product' dilemma: Is free-product removal required to achieve site closure? International Petroleum Institute Conference, Albuquerque, NM. Oct. 20–23, 1998.

Marquis SA, Copeland TL and **Holbrow AM**. A site-specific health-based approach for determining groundwater cleanup concentrations - Part I: Advective transport modeling. Presented at Hazmacon '93, San Jose, CA. April 1993.

Copeland TL, **Holbrow AM** and Marquis SA. A site-specific health-based approach for determining groundwater cleanup concentrations - Part II: Vapor emission modeling and risk characterization. Presented at Hazmacon '93, San Jose, CA. April 1993.

Holbrow AM, Copeland TL and Sullivan MJ. Data characterization methods for contaminated soil and the effects on exposure estimates calculated using a Monte Carlo simulation. Presented at Society for Risk Analysis, San Diego, CA. December 1992.

McCullough ML, Dagdigian JV and **Holbrow AM**. Developing air compliance plans. Presented at the Eighth Annual EA Environmental Compliance Conference, San Diego, CA. August 1992.

Connor K, **Holbrow AM** and Copeland TL, and Paustenbach D. Use of quantitative uncertainty analysis in air toxics risk assessment. Presented at the 85th Annual Meeting of the Air and Waste Management Association, Kansas City, MO. June 21–26, 1992.

Connor K, **Holbrow AM** and Copeland TL. Monte Carlo analysis applied to multipathway risk assessment of chlorinated dibenzo-p-dioxins and dibenzofurans. Poster presentation at the Society of Toxicology 1992 Annual Meetings, Seattle.

Continuing Education

1989 UC Irvine, Hazardous Waste Certification Program