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PROFESSIONAL PROFILE

Mr. Gregory P. Brorby is a board-certified toxicologist with more than 25 years of experience in the fields of human health risk assessment, exposure simulation, dose reconstruction, and toxicology. Mr. Brorby has evaluated potential human health risks according to risk assessment methods prescribed in CERCLA and other guidance issued by state or federal agencies. These evaluations have involved a wide variety of chemicals (asbestos, metals, VOCs, SVOCs, pesticides/PCBs, dioxins and furans, petroleum hydrocarbons, and radionuclides); environmental media (air, soil, groundwater, surface water, plant material); and exposure scenarios (residential, commercial/industrial, recreational). Mr. Brorby focuses on integrating risk assessment into an overall risk management approach to site investigation and remediation. This approach uses site conceptual models to design risk-based sampling and analysis plans based on the current or proposed future site use; the scope of the investigation is thus streamlined to collect only data needed to support a risk-based decision.

Mr. Brorby has directed or participated in studies to estimate exposure to chemicals from use of consumer products (e.g., PVC-coated electrical cables, children's toys, jewelry, and food and beverage containers), particularly with regard to potential exposure via incidental hand-to-mouth contact, to assess compliance with CPSC, FDA, and California Proposition 65 requirements. Mr. Brorby has also directed or participated in studies to reconstruct historical exposures in occupational settings (e.g., vehicle mechanic exposure to asbestos in friction materials).

Mr. Brorby also specializes in conducting independent review of risk assessment–related work performed by others. He played an instrumental role in the dose reconstruction projects at Rocky Flats and the Oak Ridge Reservation, the Environmental Restoration Project at the Los Alamos National Laboratory, the RCRA/ CERCLA process at the Pantex Plant, and cleanup and restoration of former Naval Air Station Treasure Island. In this capacity, he worked closely with advisory panels and steering committees to develop risk assessment strategies and communicate complicated technical information to a non-technical audience.

EDUCATION AND DEGREES EARNED

1984 University of California, Davis, B.S., Zoology

CERTIFICATIONS

Diplomate, American Board of Toxicology (1994; re-certified 2000–2004; 2005–2009; 2010–2014, 2015–2019, 2020–2024)

PROFESSIONAL ASSOCIATIONS

Society for Risk Analysis

Society of Toxicology

International Society of Exposure Science

Genetic and Environmental Toxicology Association of Northern California

PROFESSIONAL EXPERIENCE

Exposure Simulation and Dose Reconstruction

Participated in the development of a new procedure for estimating exposures from the use of chrysotile-containing joint compound. This procedure builds upon a series of studies, including re-creation of a chrysotile-containing, calcium carbonate joint compound manufactured historically; design, construction, and validation of a bench-scale test chamber used to test both the re-created and modern-day joint compound, and assessment of potential artifacts associated with historical preparation of joint compound samples.

Played a key role in an assessment of the state of knowledge through time as to the magnitude of asbestos exposure and relative risk to workers in various occupations making or using asbestos products. This assessment was intended to provide information as to when specific asbestos-related diseases were recognized in worker populations from epidemiology studies, when exposures incurred by these workers were quantified, what information was being provided by regulatory agencies, what information was being collected or developed by various companies, and of that information, what may have been provided to their workers.

Directed an assessment of the state of knowledge through time related to the potential risks associated with exposure to tremolite, including when tremolite was first recognized as a carcinogen, whether there was a debate regarding the relative potency of tremolite compared to other forms of asbestos, and how regulatory agencies treated tremolite in terms of potency compared to other asbestos fibers.

Participated in a comprehensive assessment of exposure to a residual contaminant in a consumer product, including design and conduct of experimental studies with radiolabeled compound to estimate transfer from the product to skin or food. Detailed information on habits and practices associated with routine use of the product was collected via a consumer diary study.

Conducted a detailed exposure assessment in preparation for California Proposition 65 litigation involving lead in consumer products. Designed experimental studies with volunteers to measure the content of lead in cables, the

amount of lead that can be wiped from cables, and the transfer of lead from cables to hands during the typical use of a variety of products, including kitchen and bathroom appliances, electrical wiring, and office products. Also evaluated preliminary data from plaintiff studies, and developed a second protocol to better evaluate potential exposure to lead transferred to the hands and then ingested via hand-to-mouth contact.

Managed a detailed evaluation of Proposition 65 warning requirements pertaining to potential exposure to a listed chemical used in the paper pulping process that may be present at low concentrations in finished paperboard products used for food packaging or other purposes. This evaluation included development of a no-significant-risk level based on published data and state-of-the-art methods for estimating carcinogenic potency. Additionally, developed an exposure model to estimate exposure via ingestion of food that is in direct or indirect contact with the paperboard, and for dermal contact with the paperboard.

Conducted or assisted in CPCS, FDA, and Proposition 65 compliance evaluations for numerous clients, including manufacturers of consumer products (children's toys, jewelry, and food and beverage containers), and chemicals, including lead, cadmium, asbestos, and phthalate esters. Several of these evaluations entailed estimating potential exposures under typical use conditions and deriving no-significant-risk levels or no-observed-effect levels.

Participated in an evaluation of potential exposures and risks posed by historical releases of small amounts of elemental mercury. Initial sampling activities characterized mercury concentrations in the areas affected by the historical releases and in the breathing zones of living areas in the houses. A second, statistically based, sampling program was undertaken to assess the incidence of unreported mercury releases and to characterize potential exposures.

Played a key role in an exposure assessment for a mortality study of petrochemical research workers at a Southern California facility. This assessment entailed detailed examination of a wide variety of possible sources of quantitative and qualitative exposure information, including systematic file reviews, facility closure and feasibility reports, and key informant interviews. The extensive information reviewed indicated that employees were not exposed to elevated levels of ionizing radiation, electromagnetic fields, or any chemical known or suspected to be associated with an increased risk of brain cancer.

Human Health Risk Assessment/Brownfields Redevelopment

Conducted a series of health risk assessments to support remedial decisions at a 400+-acre industrial site in Henderson, Nevada. Primary chemicals of interest were dioxins/furans, hexachlorobenzene, and asbestos. Negotiated a site-specific remediation goal for dioxins/furans based on the results of a site-specific bioaccessibility study that was approximately three-fold higher than the regulatory default value.

Advised a municipal redevelopment agency regarding upcoming transfer of property formerly used as a military base. Significant issues included adequacy of site investigation data collected by others to make risk-based decisions; soil affected by lead, PAHs, PCDDs, and PCBs adjacent to buildings and/or in areas intended for residential housing; and communication of technical information to a diverse and largely nontechnical residential community and Restoration Advisory Board.

Advised a San Francisco Bay Area developer regarding environmental conditions and potential human health risks associated with residual chemicals in soil, soil vapor, and groundwater at a former industrial property in Nevada County, California, that is slated for redevelopment for mixed commercial and residential use. Previous site investigations indicated the presence of petroleum hydrocarbons, VOCs, PAHs, PCBs, dioxins/ furans, and metals (including arsenic, copper, lead, and zinc) in soil, soil vapor, and/or groundwater. Because the property will be developed in phases, human health risk assessment (HHRA) reports were written for portions of the property as sufficient information regarding environmental conditions and redevelopment plans became available. In conjunction with the developer and the local RWQCB and County Environmental Health Department, the results of

the HHRAs will be used to evaluate the need for remediation or implementation of other risk management practices prior to or during site development.

Directed supplemental evaluation of potential health risks associated with a former chemical storage facility. Chemicals of potential concern included TCE and other chlorinated solvents. A previous baseline risk assessment considered future industrial use of the site, but did not include an evaluation of potential health risks associated with emissions from an onsite treatment plant or inhalation of vapors in indoor air. Worked with the oversight agency to develop a limited soil gas sampling plan and an agreed-upon approach for evaluating emissions from the treatment system. Used both the Jury model and the Johnson & Ettinger model to estimate indoor air concentrations. Results of both models indicated that potential risks to future onsite workers were below levels of regulatory concern, allowing for return of the site to productive economic use.

Conducted a series of evaluations of potential health risks to support the sale and redevelopment of a former chemical distribution and packaging facility for industrial chemicals, including caustics, chlorine, and TCE and other chlorinated solvents. Potential redevelopment scenarios included residential, commercial, and recreational use. Previous remedial activities, including soil removal and operation of a soil vapor extraction system, had significantly reduced the concentrations of chlorinated solvents in soil; treatment of the underlying groundwater was ongoing. Regardless of redevelopment scenario, migration of vapors into indoor air was the primary exposure pathway of concern. Used EPA's volatilization factor (VF) model and the Johnson & Ettinger model to estimate indoor air concentrations. Results of both models indicated that potential risks to future site users, including residents, would not be of concern. These evaluations were approved by the oversight agency and used in negotiations with potential buyers.

Evaluated the potential health risks associated with vapor emissions from a former municipal landfill. Soil gas monitoring data indicated the presence of chlorinated solvents, including TCE, and petroleum hydrocarbons in the subsurface. In addition, significant quantities of methane and carbon dioxide were being generated, facilitating vapor migration to the surface. Used EPA's nonmethane organic compounds (NMOC) model to estimate vapor flux from the landfill and EPA's Industrial Source Complex (ISC) model to estimate offsite air concentrations. Preliminary modeling results suggested that potential risks to nearby workers and residents warranted further study. Vapor-flux chamber samples were collected to refine estimates of vapor migration. Revised estimates of offsite air concentrations were orders of magnitude lower than the model estimates, indicating that off-gassing from the landfill did not pose a significant health risk to nearby populations.

Supervised assessment of potential health risks associated with residual dry cleaning chemicals in soil and groundwater at a site slated for redevelopment as senior housing. Designed a limited site investigation to demonstrate that the area of affected soil and groundwater was limited and chemicals in groundwater were not migrating from the site. Tailored a risk assessment to the proposed development plan, which indicated that affected soil and most highly affected groundwater were outside of the proposed building footprint, thereby reducing the potential health risks, as estimated using the Johnson & Ettinger model, to acceptable levels. Oversight agency granted site closure with no further action being required.

Evaluated potential health risks associated with residual petroleum in soil in an existing residential neighborhood built on a site previously used to store and dispense fuel oil. The facility had been closed and sold by the former operator approximately 20 years before it was redeveloped, without their knowledge, for residential use. Initial investigations suggested that more than 100 individual lots over 45 acres were potentially affected. To avoid implying that potential risks could be evaluated on an individual-lot scale, collected soil samples on a grid pattern across the entire affected area. Then calculated acceptable concentrations, to which the measured concentrations were compared; these concentrations were optimized using Monte Carlo techniques. Demonstrated to the satisfaction of both the community and the oversight agency that residual petroleum in soil did not pose an

unacceptable risk to residents or landscape maintenance workers. No further action was required for the affected soil.

Supervised completion of a baseline risk assessment for a former pole-treating site used as a buffer zone for a California Department of Corrections (CDC) facility. Chemicals of potential concern included PCP, other chlorinated phenols, PAHs, and PCDDs and PCDFs. Potential receptors included current trespassers, offsite workers, offsite residents, and future site users under hypothetical residential and commercial land-use scenarios. Used results of the risk assessment to reduce extent of site remediation. Worked with oversight agency to communicate the results of offsite sampling to nearby residents.

Evaluated potential health risks associated with residual petroleum at a former fuel pump station that was later developed into a migrant farm-worker facility. Although preliminary investigations indicated that potential health risks were low, worked closely with the oversight agency to design a comprehensive site investigation to address potential environmental justice concerns. Results indicated that residual petroleum would not pose an unacceptable risk to residents or workers at the site. Worked with a translator to communicate the results to the local community.

Supervised site investigation and risk assessment of 8.5 acres of mine tailings in northeastern Oregon. Chemicals of potential concern included arsenic, lead, and mercury. Developed focused sampling plan to collect additional chemical data for mine tailings, sediment in an adjacent creek, and background soil. Conducted physiologically based extraction tests to estimate site-specific oral bioavailability of arsenic in the tailings. Results indicated that the concentrations of arsenic, lead, and mercury in the tailings piles were not significantly different from background. Estimated human health risks using the bioaccessibility test results, and reasonable exposure assumptions were within generally acceptable levels. Arsenic, lead, and mercury concentrations in the tailings exceeded ecological screening criteria; however, any potential health risks would be similar to background.

Participated in the assessment of the potential health risks associated with a former industrial/commercial site proposed for the San Francisco Giants baseball stadium. Previous investigations identified coal tar, petroleum compounds (e.g., benzene, PAHs), and metals (e.g., copper, lead, and zinc). Designed a focused investigation based on a site conceptual model of potential sources, transport pathways, exposure media, and receptors, given the proposed use of the site as a ball park. Results indicated that residual chemicals in soil and groundwater would not pose a significant risk to human health during or after construction, or to aquatic receptors in the adjacent San Francisco Bay. The oversight agency granted site closure, saving approximately $2,000,000 to $10,000,000 in investigation and remediation costs.

Evaluated potential health risks associated with excavation and offsite disposal of chemically affected soil in support of litigation. Significant issues included chemical volatilization during excavation, diesel truck emissions, and traffic safety during transport. Clearly demonstrated that offsite disposal presented significantly greater risks than in-place management.

Evaluated potential health risks associated with residual chemicals in soil and groundwater at a former agricultural chemical storage and redistribution facility. Previous investigations identified more than 70 pesticides, herbicides, solvents, and nitrogen compounds. Demonstrated that the majority of the estimated risk was associated with hypothetical ingestion of homegrown produce and domestic use of groundwater; estimated risks associated with other, more likely exposure pathways were within generally acceptable levels. Oversight agency concurred that no mitigation was required because of the significant uncertainties in the uptake of chemicals from soil to plants and the fact that groundwater was unlikely to be used for domestic purposes due to naturally occurring concentrations of arsenic.

Participated in re-evaluating cleanup goals established in the Record of Decision (ROD) adopted 10 years ago for a former wood treatment site. Cleanup goals had been established for arsenic, chromium, PCP, and PCDDs and

PCDFs in soil, based on protection of human health and water quality. Re-evaluated cleanup goals within the context of current regulatory policy for these chemicals as well as additional soil and groundwater data collected since the ROD was adopted. EPA agreed that the original cleanup goals were sufficiently consistent with current regulatory policy as to not warrant reopening the ROD.

Radionuclides

Provided third-party review of chemical and radionuclide risk assessments conducted for the Pantex Plant. Several areas of the site have been affected by radionuclides, primarily depleted uranium. Risk assessments were conducted according to EPA's methods. Oversaw development of a highly graphical summary report to communicate complex risk assessment and subsurface fate-and-transport modeling concepts and results to the public.

Provided risk assessment support as part of the Environmental Restoration (ER) Project at the Los Alamos National Laboratory. Supervised all aspects of risk assessment projects being completed for the largest of five field units, including preparation of RCRA Facility Investigation (RFI) reports and development of Voluntary Corrective Action (VCA) or Expedited Cleanup (EC) plans for sites affected by chemicals and/or radionuclides. Contributed to the development of Laboratory-wide risk assessment strategies as a member of the ER Project's Decision Support Council.

Served as task manager of a quantitative screening evaluation to identify important contaminants and exposure pathways for the Oak Ridge Reservation Dose Reconstruction Feasibility Study. Out of more than 50 chemicals and radionuclides, including plutonium, thorium, and uranium isotopes, identified in earlier tasks as potentially being released from the reservation in sufficient quantities to pose a potential health risk, identified three radionuclides and two chemicals as warranting additional study; recommended further study of five additional radionuclides and two additional chemicals due to a lack of information. Presented results to the Oak Ridge Health Agreement Steering Panel.

Served as task manager of the dose assessment for the Rocky Flats Toxicological Review and Dose Reconstruction Project. Working closely with a 12-member Health Advisory Panel and the interested public, estimated chemical and radiation doses that a person residing near the Rocky Flats Plant between 1953 and 1989 could have received as a result of routine plant operations and accidents. Used Monte Carlo simulation and other techniques to combine uncertainties in material usage and release information, environmental monitoring data, and model predictions to quantify the overall uncertainty in the dose estimates.

MANUSCRIPTS

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ABSTRACTS AND PRESENTATIONS

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Brorby G, Ring C, Loko F, Harris MA. Characterization of hexavalent chromium and total chromium in drinking water monitoring data. Poster MP 117. Society of Environmental Toxicology and Chemistry (SETAC) North America 39th Annual Meeting, Sacramento, CA, November 4–8, 2018.

Wikoff DW; Welsh BT, Henderson R, **Brorby G**, Britt J, Myers E, Goldberger J, Lieberman HR, O'Brien C, Doepker C. Application of systematic review in the evaluation of caffeine safety: Potential adverse effects of caffeine consumption in healthy adults, pregnant women, adolescents, and children. Society of Risk Analysis Annual Meeting. Arlington, VA, December 10–14, 2017.

Brorby GP. The ongoing controversy surrounding the effects of short-term exposure to trichloroethene. Presented at the Association for Environmental Health and Sciences Foundation Annual International Conference, San Diego, CA, March 19–22, 2018.

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Kalmes R, **Brorby G**. Lead, lead everywhere—Evaluating potential exposure to heavy metals in consumer products. American Industrial Hygiene Conference and Exposition, Minneapolis, MN, May 31–June 5, 2008.

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