Review of Kinder Morgan Pipeline Expansion Project Application

Human Health Impact Assessment

Expert Report

Completed for:

Karen G. Wristen
Executive Director, Living Oceans Society
204-343 Railway St., Vancouver BC, V6A 1A4
Ph: 604-696-5044 ext. 104, Fax: 604-696-5045
kwristen@livingoceans.org, Skype: karenwristen

Completed by:

Stuart Batterman, Ph.D.
Environmental Health Sciences
University of Michigan
Ann Arbor, MI 48109-2029, USA
Ph: 734 763 2417
Stuartb@umich.edu, Skype: stuart.batterman

Signature: ________________________________

May 24, 2015
1 Summary

My analysis focused on public health concerns regarding Kinder Morgan's (KM) Trans Mountain Expansion Project (TMEP) with an emphasis on the human health risk and impact assessment performed by KM and its consultants. I examined KM’s analysis of the human health impacts that are likely to arise from (1) fugitive emissions from normal operations of the pipeline, terminal and tankers; (2) a pipeline rupture or release occurring along the pipeline route through the Fraser Valley and Metro Vancouver; (3) a rupture, release or spill occurring at the terminal; and (4) a release or spill occurring on the tanker route within Burrard Inlet and Juan de Fuca/Haro Straits. My examination included materials prepared for the TMEP as well as KM’s responses to relevant Information Requests.

For both routine emissions and accidental releases, the human health risk and impact assessments completed for the TMEP do not provide the information needed to assess human health risks. Due to the many significant omissions and use of flawed methods and analyses, the assessments completed do not provide accurate predictions of the potential health effects that might result from fugitive emissions, ruptures, releases and spills at the terminals, along the pipeline, or on waterways; rather, the completed assessments underestimate the potential risks. The human health risk and impact assessments completed for the TMEP do make it clear, however, that both routine operations as well as accidental spills and releases have the potential to cause significant chemical exposure and harm public health.
2 Introduction

2.1 Scope of Work

I have been retained by Living Oceans Society to review the application of Kinder Morgan for its Trans Mountain Expansion Project (TMEP) with respect to the human health impact assessment, in particular, assessments of the human health impacts likely to arise from (1) fugitive emissions from normal operations of the pipeline, terminal and tankers; (2) a pipeline rupture or release occurring along the pipeline route through the Fraser Valley and Metro Vancouver; (3) a rupture, release or spill occurring at the terminal; and (4) a release or spill occurring on the tanker route within Burrard Inlet and Juan de Fuca/Haro Straits.

2.2 Statement of Qualifications

My analyses and opinions in this report are based on my years of experience as an environmental health scientist and engineer studying air pollutants, pollutant exposures, health impacts and health risks. My research interests and expertise includes exposure science, risk assessment and epidemiology in community, occupational and environmental settings, especially dealing with air pollutants. My laboratory specializes in trace measurements in biological and environmental samples and conducts a wide range of laboratory and field studies, as well as modeling and statistical analyses. I lead the Exposure Assessment Core of the NIEHS P30 Center at the University of Michigan (UM), and I am center director of the NIOSH T42 UM Center for Occupational Health and Safety Engineering. I lead and participate in other research examining exposures in homes, schools, workplaces, communities and other settings, and I examine linkages between exposures and diseases. I serve or have served on various state and federal panels, including Michigan’s Air Toxics Committee, and have provided expert reports and testimony in the USA, Canada, and South Africa. I have supervised or co-directed over 70 research projects, several education and training programs, mentored over 35 pre-doctoral and postdoctoral students, and published over 165 peer-reviewed journal articles and 300 abstracts, reports and proceedings. I teach environmental impact assessment and hazardous substances management at the graduate levels at UM and have provided instruction and seminars on these and other topics in the US and internationally for over 30 years.

In addition to my experience and education, I considered the available data and other information in conducting my analysis and forming my opinions, and have cited key references in footnotes in this report. A copy of my current curriculum vitae is attached as Appendix 1 that summarizes my education, training and experience, and which provides a list of my publications.

2.3 Documents Reviewed

Documents reviewed for this review include, but are not limited to, the following:

- B005 – Trans Mountain ULC – Trans Mountain Expansion Project - Volume 5B: Environmental And Socio-Economic Assessment For The Trans Mountain Pipeline ULC Trans Mountain Expansion Project. Files: A3S1R5 to A3S1T0. Folder: A56004.

1 Most TMEP documents were obtained from the NEB site.
• **B019**: Trans Mountain Pipeline ULC – Trans Mountain Expansion Project – Volume 8B. TR 8B-7: Ecological Risk Assessment of Marine Transportation Spills. Files: A3S4K7 to A3S4R0 Folder: A56022.


• **C214**: Trans Mountain Pipeline ULC Trans Mountain Expansion Project NEB Hearing Order OH-001-2014 Responses to Information Request from Living Oceans Society.
2.4 Provisions

My opinions in this expert report are based on my education, professional experience, information and data available in the scientific literature, as well as information and data about this application. I continue to review available information, and I reserve the right to modify or supplement this report and the opinions contained herein on the basis of any subsequently obtained material information.

2.5 Selected Acronyms

The report uses the following acronyms.

- AEGL: Acute Exposure Guideline Levels
- AAAQO: Alberta Ambient Air Quality Objectives
- CLWB: Cold Lake Winter Blend (oil)
- COPC: chemicals of potential concern
- CWC: credible worse case
- ERA: ecological risk assessment
- ERPGs: Emergency Response Planning Guidelines
- HHRA: human health risk assessment
- HSDA: Health Service Delivery Area
- KM: Kinder Morgan
- MTBE: methyl tert butyl ether
- MPOI: maximum point of impingement
- NO₂: nitrogen dioxide
- NOₓ: oxides of nitrogen
- O₃: ozone
- PM₂.₅: particulate matter below 2.5 microns in diameter
- RSA: Regional Study Area
- RMLBV: remote main line block valve
- TMEP: (Kinder Morgan) Trans Mountain Expansion Project
- TMPL: Trans Mountain Pipe Lines (refers also to associated facilities)
- US EPA: U.S. Environmental Protection Agency
- VOC: volatile organic compound

3 Assessment of Human Health Impacts

3.1 Fugitive emissions from normal operations of the pipeline, terminal and tankers

3.1.1 The assessment of human health effects associated with short- and long-term chemical exposures at the Westridge Marine Terminal and other terminals under routine operating conditions completed in the refined human health risk assessment (HHRA)² followed a conventional HHRA paradigm that involves the following steps: problem formulation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. The TMEP assessment focused on air emissions.

3.1.2 The evaluation of inhalation risks performed for terminal emissions compares “cases” that are misleading and not comparable, with the effect of significantly underestimating Kinder Morgan’s impacts.

The "base case" uses existing conditions in the Air Quality Regional Study Area (RSA), including the current chemical emissions from the existing Westridge Marine Terminal and the existing marine vessel traffic in the Air Quality RSA. Importantly, the base case includes current emissions from the existing tank

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terminals and other sources at the KM Westridge Marine Terminal that are under the control of the applicant, although they are not considered part of the TMEP. For this reason, concentrations attributable to KM-associated operations should be clearly identified.

The "application case" is defined using "existing conditions" in the Air Quality RSA, plus the emissions associated with the Westridge Marine Terminal expansion and the Project-related increase in marine vessel traffic within the Air Quality RSA. However, unlike the base case, the application case also includes the anticipated changes in future marine fuel regulations and the more stringent NOx emission requirements.

The approaches used to define the base and application cases are not comparable and thus the difference between these cases does not show the incremental impact of the proposed TMEP. Instead, this comparison has the effect of significantly lowering the reported impacts due to KM and TMEP operations since the application case uses the assumed fuel regulations and more stringent NOx emission requirements that are assumed to come into effect, rather than the higher current emission rates that define the base case.

The appropriate comparison would use the same marine fuel regulations and the same NOx emission requirements in both cases. This would show the incremental impact of the TMEP.

In addition, the HHRA states neither the quantitative reduction in emissions nor the timeframe for the emission reductions that are assumed to result from new regulations and new NOx controls. Nor does the assessment explicitly differentiate between the emissions and impacts of current operations and those that would come from the TMEP.

In summary, the result of the analyses provided by KM significantly underestimates the true impact of the TMEP's operations on air quality in the Westridge Marine Terminal area and environs.

3.1.3 There is no plan for environmental monitoring or health surveillance to verify the assumptions, predictions, and conclusions in the HHRA. The application should consider monitoring key environmental parameters, beyond the usual compliance-oriented monitoring, to ensure that the assessment is protective of health and the environment. For example, KM should consider establishing air quality monitors for PM2.5, NOx, SO2 and other pollutants at hotspot locations.

3.1.4 The refined HHRA found that the predicted short-term inhalation exposures of the respiratory irritants mixture exceeded the exposure limit by 40% at the maximum point of impingement (MPOI). The HHRA then indicates this exceedance is largely due to nitrogen dioxide (NOx) followed by sulphur dioxide (SO2), two gases that are primarily emitted from the existing tugs, and to a lesser extent, the main engines of the existing tankers. However, even with the limitations imposed by the way the cases are compared (as noted in 3.1.2 above), KM and TMEP project emissions constitute a significant fraction of the risk, approximately half of the risk (or exceedance). Thus, it is important that emissions from KM and TMEP operations be decreased to lower exposures and inhalation risks.

3.1.5 Tug and tanker emissions, implicated in the exceedance of air quality limits discussed in 3.1.4 above, will occur all along the tanker route, and thus will produce plumes that potentially affect long sections of coastline. The assessment focuses only on a single location, the MPOI, and does not indicate the magnitude of concentrations along the coastline, at other potentially affected areas, and at sensitive

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3 Intrinsic, Human Health Risk Assessment of Westridge Marine Terminal. Technical report for the Trans Mountain Pipeline ULC Trans Mountain Expansion Project, Section 3.2.2: Exposure Assessment, SREP-NEB-TERA-00003, June 2014 (A3Y1F4) at PDF page 30

4 Intrinsic, Human Health risk assessment of Westridge Marine Terminal. Technical report for the Trans Mountain Pipeline ULC Trans Mountain Expansion Project, Section 3.2.2.1: Inhalation Assessment, SREP-NEB-TERA-00003, June 2014 (A3Y1F4) at PDF page 31

5 Human Health Risk Assessment of Marine Westridge Terminal, Figure 5.1: Acute Inhalation Risk Quotients for the Respiratory Irritants Mixture, SREP-TERA-00003, June 2014 (A3Y1F4) at PDF page 94
receptors that are expected with both current and future tanker and tug traffic and other emissions associated with KM and TMEP. Instead, the analysis should indicate the maximum hourly concentrations along the coastline and other areas, using maps and other means to identify the region and population potentially affected, including vulnerable populations.

3.1.6 Figure 5.1 (A3Y1F4, page 93) shows that urban dwellers also approach and possibly exceed the exposure limit for the acute respiratory irritants mixture, and TMEP project-associated emissions are responsible for about half of the exposure. Again, as stated in 3.1.5, it is important to reduce emissions from KM and TMEP operations to lower exposures and inhalation risks.

3.1.7 The assessment indicates that the respiratory irritant mixture will exceed the exposure limit 0.9% of the time or 74 hours per year in the base case, and 79 hours per year under the application case. These are frequent and regular occurrences, i.e., it represents 79 times per year that the exposure limit is exceeded.

3.1.8 Assuming the new regulations come into play (i.e. what is assumed in the application case), Figure 5.1 (A3Y1F4, page 93) indicates that there would no exceedances of the exposure limit for the acute respiratory irritants mixture without the TMEP. As noted in 3.1.7 above, with the TMEP, there will be 79 hours per year when this exposure limit will be exceeded in the application case. In effect, this analysis demonstrates that TMEP-associated emissions will lead to regular degradation of air quality that would not otherwise occur if TMEP was not approved.

3.1.9 The assessment indicates that 1-hour NO\textsubscript{2} concentration of 210 \(\mu g/m^3\) exceeds the Metro Vancouver Ambient Air Quality Objective (AAQQO) of 200 \(\mu g/m^3\) and the US EPA National Ambient Air Quality Standard (NAAQS) of 188 \(\mu g/m^3\) (ACY1F4, page 60). The analysis demonstrates a serious degradation of ambient air quality with respect to NO\textsubscript{2} due to TMEP-associated emissions.

3.1.10 The air quality modeling in Volume 5 Section 5.3.1.4\textsuperscript{7} for the combined Burnaby and Westridge Marine Terminals show exceedances of the PM\textsubscript{2.5} Metro Vancouver Objectives (MVO, 25 \(\mu g/m^3\)), and the 1-hr NO\textsubscript{2} Alberta Ambient Air Quality Objectives (AAAQQO, 200 \(\mu g/m^3\)). Predicted PM\textsubscript{2.5} concentrations are nearly twice the MVO. Both pollutants are associated with a range of serious cardiovascular and respiratory impacts including asthma and other chronic diseases, as well as death. PM\textsubscript{2.5} is one of the most important pollutants in terms of the mortality and morbidity associated with even low concentrations, including concentrations below the MVO.

3.1.11 Had the national Ambient Air Quality Objectives for benzene been applied (curiously, this was omitted although other national standards were inserted into Table 5.21)\textsuperscript{8}, the 1-hr benzene concentration (30 \(\mu g/m^3\)) would also be exceeded. Benzene can cause several types of cancer. The analysis demonstrates that TMEP-associated emissions degrade air quality with respect to PM\textsubscript{2.5}, NO\textsubscript{2}, and benzene, and causes exceedances of air quality standards for these three pollutants.

3.1.12 There are numerous other limitations and omissions regarding the methods and interpretations of the HHRA.

3.1.12.1 Background concentrations used in the HHRA are not necessarily conservative. This applies to both short-term estimates, derived as the 98th percentile of one-hour, 8-hour or 24-hour ambient air concentrations at local monitoring sites, as well as the annual average background air, derived as the median of hourly concentrations at ambient monitoring sites. Other concerns regarding background determinations include the representativeness of local background concentrations and the adequacy of monitoring network, including the presence of only a single volatile organic compound (VOC) monitoring site and data collected not more recently than 2009.

\textsuperscript{6} Human Health Risk Assessment of Westridge Terminal, Table 5.5: Frequency of Respiratory Irritants Mixture Exceedances at the Maximum Point of Impingement, SREP-TERA-000003, June 2014 (A3Y1F4) at PDF page 60

\textsuperscript{7} RDWI Consulting Engineers & Scientists, RWDI#1202006 December, 2013 (A3S1U1) at PDF page 125

\textsuperscript{8} RDWI Consulting Engineers & Scientists, RWDI#1202006 December, 2013 (A3S1U1) at PDF page 127
3.1.12.2 The report discusses multiple reasons why NO$_2$ and SO$_2$ concentrations and exposures are not expected to cause health effects, but it does not discuss the many reasons why estimated results may not be conservative. These include: the multiple occurrences above the exposure limit at a particular location; multiple consecutive hours above the exposure limit; the ability of dispersion modeling to represent dispersion conditions above water; the variation and uncertainty in meteorology and emission rates; the representativeness of local background concentrations (Section 3.1.10.1); the temporal and spatial variability of emissions; and the role of NO$_2$ and SO$_2$ pollutants in forming secondary aerosols, which represent a portion of PM$_{2.5}$. This means emissions of NO$_2$ and SO$_2$, in addition to increasing ambient levels of these pollutants, will also add to PM$_{2.5}$, which is already a problem, as discussed in 3.1.10.

3.1.12.3 The report does not provide any assessment of respiratory health of individuals living near the terminal, including the number and locations of individuals who have chronic disease that increases their sensitivity to air pollutants. This information is needed to estimate health impacts from NO$_2$, SO$_2$, and particulate matter.

3.1.12.4 The report and table$^9$ describing health effects associated with short-term NO$_2$ exposure continues to cite mostly older information. It excludes one of the most definitive assessments: U.S. EPA, Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/071, 2008, that provides an in-depth discussion of the consistency of the epidemiologic studies between short-term NO$_2$ exposures and respiratory symptoms and hospitalization or emergency room visits in areas where concentrations range from 3 to 70 ppb for 24 hour averages. This range is highly relevant to the TMEP application given the higher emissions it would cause.

3.1.13 TMEP’s screening-level HHRA examining fugitive air emissions associated with the working and standing losses at the Edmonton, Sumas and Burnaby terminals focused on expected air emissions, and then concluded that adverse health effects from these emissions were not expected, thus no further analysis was conducted for these terminals. Most of these emissions were VOCs from storage tanks for light crude (e.g., 14.7 tons/year at the Burnaby Terminal, total VOC emissions of 27 tons/year at this terminal).$^{10}$ This assessment had several important omissions.

3.1.13.1 The screening-level HHRA at the Edmonton, Sumas and Burnaby terminals did not consider potential health impacts that may result from discharges from stormwater collection and storage systems at the terminals, including spills at the terminals. General information regarding some precautions was provided in the application, but this was not linked to possible human health impacts.$^{11}$ TMEP’s relevant Information Request response$^{12}$ only states that “Trans Mountain anticipates that there will be no measurable hydrocarbons in the storm water flows leading to the oil/water separators.” The assessment does not describe systems for detecting and monitoring oil or other contaminants that may be present in the storm water prior to discharge, nor does it describe the performance requirements of these systems. The assessment does not describe the protocols to be followed by operations personnel during storm events. There is no description of the performance of controls and the potential issues with compliance of discharge rules. This is an omitted exposure pathway that warrants evaluation.

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$^9$ Human Health Risk Assessment of Westridge Terminal, Table 5.6: Potential Acute Health Effects Associated with short-term NO$_2$ Exposure, SREP-TERA-00003, June 2014 (A3Y1F4) at PDF page 60


$^{11}$ B002- Trans Mountain Pipeline ULC – Trans Mountain Expansion Project Volume 4A Part 1: Project Design and Execution – Engineering, Sections 3.4.2.2.1, 3.4.3.2.1 and 3.4.4.2.1, December 2013 (A3SOY8) at PDF, pages 90, 99 and 117.

$^{12}$ Responses to Information Request from Living Oceans Society, IR No. 1, 1.28: Air Quality and Human Health: Storm Water (A3Y2T4) at PDF, Page 47
3.1.13.2 The screening-level HHRA at the Edmonton, Sumas and Burnaby terminals did not consider potential health impacts that may result from wastewater discharges. This is an omitted exposure pathway that warrants evaluation.

3.1.14 Conclusions of peer review - Fugitive emissions from normal operations of the pipeline, terminal and tankers

3.1.14.1 The assessment does not provide the information needed to adequately assess the human health risks presented by the project.

3.1.14.2 The approach used to compare “base” and “application” cases is flawed and does not allow for a fair evaluation of the impacts in the terminal area and environs. The approach used in the TMEP assessment significantly underestimates the impact of KM and TMEP operations on air quality.

3.1.14.3 The scope of analyses considered in the HHRA is narrow and some of the methods are flawed. The assessment does not account for all exposure pathways. The summaries and descriptions in the assessment omit important information and include misleading or incorrect statements, regarding, for example, the impact of the facility in causing exceedances of exposure limits for PM$_{2.5}$, benzene and the respiratory irritants mixture. The HHRA and air quality modeling results are not necessarily conservative.

3.1.14.4 The analyses presented indicate that emissions associated with the TMEP will degrade ambient air quality and result in concentrations of SO$_2$, NO$_2$, PM$_{2.5}$ and the respiratory irritant mixture that exceed exposure limits and/or standards and that have the potential to cause adverse health effects. TMEP-associated emissions are responsible for a substantial fraction of the exceedances of several pollutants over exposure limits and standards, and thus these emissions should be mitigated to improve air quality and reduce human health risks.
3.2 Pipeline Rupture or Release Occurring along the Pipeline Route through the Fraser Valley and Metro Vancouver

3.2.1 The assessment of potential human health effects associated with possible oil spill scenarios along the pipeline examined two similar hypothetical scenarios assumed to occur in the metropolitan area. For each scenario, the assessment follows an approach adapted from conventional human health risk assessments (HHRA) procedures that consists of five steps: problem formulation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. The design of the TMEP assessment is stated to identify potential health consequences associated that could occur under the two scenarios. Unlike most HHRAs, however, the KM assessment uses a hazard approach that does not define the likelihood of scenarios that might lead to exposure, the exposures themselves, and the affected populations. The assessment does not utilize the likelihood or probabilities of any scenarios, either “worst-case” or otherwise, that would increase the realism of results.

3.2.2 The selection of the scenarios is a key concern. The selected scenarios were defined as a breach of the pipeline caused by third-party damage during the summer season that resulted in a credible worst case assumed to be 1,558 m³ of oil or 1,012 m³ for smaller spills. These spill volumes were determined as the 95th percentile and average spill volumes, respectively, estimated for on-land locations along the pipeline segment within Metro Vancouver (i.e., from RK 1137.5 to RK 1181.7). The TMEP scenarios further assumed that the spill would be released over a 1-hr period on level terrain and the liquid would form a uniform pool of 10 cm depth, giving a 70 m pool radius for the larger spill and 57 m for the smaller. Further assumptions included a single wind speed (3 m/s), temperature (21 C), and neutral atmospheric stability. The PHAST and AERSCREEN models were used to predict airborne concentrations of VOCs (e.g., benzene). The TMEP assessment does not represent a conservative credible worst-case scenario of pipeline ruptures for many reasons elaborated below; moreover, the analyses uses highly simplified and flawed approaches that are inconsistent with the approaches taken elsewhere in the HHRA, and they underestimate concentrations, affected areas, and health risks.

3.2.2.1 The spill volume used in the scenarios is not conservative and does not represent the maximum credible release. Spill volume was estimated by considering the expected response time for initiation and completion of valve closure upon detecting a leak and the distance between valve locations. The estimated spill volume includes both the volume of oil that would be released under pressure before the valves close, as well as the drain-down volume for the pipeline between valve locations. The rationale for the selection of 95th percentile and average statistics is not specified. The difference between the 95th percentile and maximum spill volume, and other large spill volume estimates in the metropolitan area, is very large. For example, TMEP’s analyses show a maximum outflow volume within Metro Vancouver of approximately 3100 m³, and there are numerous locations where the estimated outflow volumes exceed 2500 m³. These are all credible spill volumes that were not analyzed in the TMEP assessment.

\[ \text{Spill volume used in the scenarios is not conservative and does not represent the maximum credible release.} \]

\[ \text{Spill volume was estimated by considering the expected response time for initiation and completion of valve closure upon detecting a leak and the distance between valve locations.} \]

\[ \text{The rationale for the selection of 95th percentile and average statistics is not specified.} \]

\[ \text{The difference between the 95th percentile and maximum spill volume, and other large spill volume estimates in the metropolitan area, is very large.} \]

\[ \text{For example, TMEP’s analyses show a maximum outflow volume within Metro Vancouver of approximately 3100 m³, and there are numerous locations where the estimated outflow volumes exceed 2500 m³. These are all credible spill volumes that were not analyzed in the TMEP assessment.} \]


A volume of 3100 m³ would be a better estimate of the maximum credible spill volume, however, even this volume assumes efficient spill detection and rapid valve shut-off procedures. Spill volume could be larger in the event these systems did not perform optimally.

3.2.2.2 The analyses apply only to the new construction proposed for Line 2. The analyses excluded the existing Line 1 and all other existing pipelines and loops, both active and deactivated, including portions that will be upgraded to increase capacity possibly the materials to be transported, and/or modified in terms of flow rates. The older line may be more likely to fail.

3.2.2.3 The assessment focuses on the direct air inhalation as the exposure pathway. Direct physical contact with the spilled oil was considered possible during the early stages of the modeled incident, but it was then omitted from the analysis. The assessment states that the "time that the oil might remain in contact with the skin would be expected to be limited since as part of the emergency response measures, people would be advised to remove any oiled clothing and/or wash any exposed skin with soap and water" and that "these measures would limit the opportunity for the chemical components of the oil to penetrate the skin." Even brief periods of contact can lead to exposure, and dermal uptake is not linear with exposure time. Moreover, many individuals in the general public will rescue materials, pets and wildlife in the event of an oil spill with only limited regard to precautions, remedial measures, and other actions.

3.2.2.4 The report also indicates "in some cases, exposure of people might reasonably be expected to be self-limiting owing to the irritant properties of a number of the hydrocarbon components of the spilled oil as well as the odours that might be noticed" (A3X6U1, page 27). This statement and approach that uses or depends on such behaviors contradicts good management and planning practices that would understand the nature of the population and sensitive receptors (see, for example, 3.1.5), the ability and willingness of all members of the public to evacuate (including the elderly, infirm, etc.), and the behaviors actually undertaken in the event of a release (see 3.2.2.3).

3.2.2.5 The meteorological conditions used in the HHRA were neutral stability and a wind speed of 3 m/s. These do not follow US EPA guidance for the Risk Management Program, contrary to statements in the report. In particular, the US EPA guidance for meteorological conditions for the worst-case scenario are atmospheric stability class F (stable atmosphere) and a wind speed of 1.5 meters per second. The guidance permits higher wind speeds if the minimum wind speed at the site has always been higher than 1.5 m/s, or other stability conditions if atmospheric stability has always been less stable than class F. Neither of these cases applies. As a result, the parameters selected for TMEP do not represent worst-case conditions. They do not represent, for example, releases occurring at night when stable conditions are likely and the resulting concentrations would be much higher. Also, at night, detection, mitigation and emergency response activities (like notification, evacuation) would be much more difficult.

The use of appropriate worst-case meteorological parameters would very substantially increase concentrations (e.g., by a factor of 10), and would result in much larger hazard zones (where concentrations exceed exposure limits) than results shown in the TMEP assessment for ruptures in the metropolitan area. This is important for both community impacts and its implications for emergency response, including the ability to shelter in place or evacuate large numbers of people that could be in the hazard zone.

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3.2.6 In addition to not following US EPA guidance, the atmospheric modeling approach used for the TMEP spill analysis is inconsistent with analyses performed elsewhere in the HHRA (e.g., marine spill, terminal spill, etc.) where a considerably more detailed simulation approach was used (e.g., multiple years of actual meteorology were modeled). In contrast, the spill analysis approach was to simply select a single hypothetical and presumably “representative” hour of meteorology and use a screening level model. The assessment does not represent a credible worst-case assessment given the selection of model inputs.

3.2.7 Emissions would continue far longer than one hour and so longer exposure periods should be considered. For example, considering benzene releases and the larger spill, the stated emission rate of 138 g/s would result in 497 kg of benzene emitted in one hour (the first hour). This represents only about 16.5% of the benzene present in the larger spill (based on a spill volume of 1,558 m³; 0.85% benzene mole fraction; 0.28% mass fraction; and density of 0.926). The remaining 83.5% of the benzene would continue to be emitted in subsequent hours (although some might be lost to seepage and sorption in soils). This shows the likelihood of concentrations and exposure lasting considerably longer than one hour. The assessment should consider multi-hour exposure periods and use the appropriate exposure limits.

3.2.8 The assumption of a 10 cm depth for the entire spill area is not necessarily conservative, particularly if the spill occurs on sloping land, impervious surfaces, and other surfaces that increases the wetted area from which volatilization can occur. Volatilization from a larger surface area can result in much higher concentrations than the assumed scenario.

3.2.9 The assumption of flat terrain is highly simplified. It does not account for topography, cold air drainage, and other factors that can greatly increase concentrations. Much of the terrain in along the pipeline path has a significant grade.

3.2.10 Spills of other products with potentially more volatile and toxic fractions are not considered, and the assessment omits consideration of Line 1. Both lines have the potential to spill materials, and portions of existing lines will be utilized due to the construction and operation of Line 2 and thus should be considered.

The TM assessment considers spill and ecological consequences of only Cold Lake Winter Blend (CLWB) on only Line 2. It does not consider other materials potentially transported by Line 2, e.g., potentially light and synthetic crude, refined products and MTBE.

The application does not consider any spills on Line 1, which may include crude, synthetic and refined materials. Spills of such materials are of significant environmental and health concern. The application should consider all types of materials that may be transported over the lifetime of Lines 1 and 2. This is particularly important since recent spills at TMPL facilities have included diesel fuel, jet fuel, MTBE, waste oil, and other materials.

3.2.3 For the scenarios considered, estimated one-hour concentrations exceed the health-based limits for four groups of compounds (i.e., aliphatic C1-C4, aliphatic C5-C8, benzene, and toluene) at distances up to 1,050 m from the pool (spill) edge, and estimated concentrations exceeded the 1-hr limits for three mixtures (i.e. eye irritants, respiratory irritants, and neurotoxicants) for distances up to 750 m. Maximum concentrations in the scenarios greatly exceeded exposure limits, e.g., the benzene concentration was 100 times the limit. Xylene may also have exceeded limits, however, this chemical seems to have been omitted in Table 5-4; it approaches the exposure limit in Table 5-5.


3.2.4 The assessment does not consider many site-specific factors that can affect the results of the HHRA, including the location and size of the populations potentially affected, sensitive and vulnerable individuals, populations that are difficult to evacuate (e.g., schools, prisons, hospitals, elder care facilities, etc.), evacuation routes, and the resources available for management and mitigation.

3.2.5 Conclusions of peer review - Pipeline rupture or release occurring along the pipeline route through the Fraser Valley and Metro Vancouver

3.2.5.1 The assessment does not provide the information needed to assess the human health risks presented by a pipeline rupture in the metropolitan area.

3.2.5.2 The combined effects of omissions, flawed methods and inconsistencies in the HHRA and other TMPEP assessments make it impossible to predict the potential health effects that might result from ruptures, releases and spills along the pipeline or at the terminals.

3.2.5.3 The two scenarios evaluated in the HHRA for pipeline ruptures represent a subset of possible failures, environmental conditions, and other factors that affect human health, and do not represent the magnitude of health impacts that might reasonably occur and endanger public health from a credible worst-case event.

3.2.5.4 The analysis does not represent a maximum credible spill scenario, and the selected parameters and simplified modeling analyses underestimate the potential for adverse health effects. The analysis should have used the maximum credible spill volume and models that represent worst-case or near worst-case dispersion conditions, which would have resulted in much higher concentrations, larger threat zones that encompass larger populations, and higher health risks. The analysis does not represent best practices for planning or assessment. These are serious limitations of the TMPEP assessment.

3.2.5.5 Even considering the limitations of the two scenarios evaluated, the TMPEP analysis shows that ruptures in the metropolitan area would pose inhalation risks to nearby populations, as well as the potential for significant dermal exposure.

3.3 Rupture, Release or Spill Occurring at the Westridge, Edmonton, Sumas and Burnaby Terminals

3.3.1 The TMPEP report assessing potential human health effects associated with possible oil spill scenarios at the Terminals again follows an approach adapted from conventional human health risk assessments (HHRAs) procedures that consists five steps: problem formulation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. The assessment is designed to identify potential health consequences associated that could occur under the different scenarios. Unlike most HHRAs, however, the analysis again uses a hazard approach that does not define the exposure or the likelihood of scenarios that might lead to exposure.

The first step in the approach is the problem formulation, which lays out the scope and boundaries, including project components to be examined, identification of exposure scenarios, identification of the chemicals of potential concern (COPC), identification and characterization of the human “receptors" that might be exposed, and identification of exposure routes and pathways. Two scenarios at the terminal are considered (summarized in Table E1): a spill of 160 m³ of Winter Cold Lake Blend (CLB) during tanker loading at berth in which 20% of the oil escapes containment; and a smaller 10 m³ spill of CLB, in which all of the oil is assumed to be completely contained within the containment boom. Both result in vapor emissions. The larger spill volume is stated to represent a credible worst case (CWC).

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3.3.2 There are many deficiencies in the problem formulation. Release scenarios that are neither conservative nor comprehensive. The analysis of spills utilize scenarios that focus on Cold Lake Winter Blend (CLWB), modest spill volumes, high containment efficiencies, conditions that produce maximum airborne concentrations over water, and factors affecting population susceptibility and vulnerability are not considered. Only a very general discussion of these factors is provided, and no details relating to the application case are given. These scenarios do not represent worst-case credible conditions for emissions, concentrations and human health risks.

3.3.2.1 The definition of the scenarios is critical as the potential human health risk depends on the scenario definition, including the spill size, location, timing, season, meteorology, mitigation responses, etc.

3.3.2.2 The two scenarios do not represent the maximum credible release. Other possible and potentially worse scenarios include larger spills into the open water, ruptures and containment failures, terrestrial spills, and spills of materials other than Cold Lake Winter Blend (CLWB) that might be handled by TMEP. The scenarios also do not represent potentially more frequent but less severe releases.

3.3.2.3 The seasonal variability of the materials transported (including CLWB) was not evaluated, although volatility and emission rates from spills will vary seasonally, as does outdoor activity of people and other factors that affect exposure. The variability of the volatile components in CLWB, and particularly the risk drivers of the volatile component (e.g., benzene) are not documented, although this can span a large range.

3.3.2.4 The report did not investigate scenarios involving spills of other materials that may have a higher volatility and toxicity than CLWB and may present a greater human health risk, including other products that might be handled by TMEP, e.g., higher volatility or more toxic material.

3.3.2.5 Terrestrial spills were not investigated. Such releases can contaminate soil, groundwater, surface water, and air and involve multiple exposure pathways, e.g., direct contact, inhalation, and ingestion.

3.3.2.6 The assessment states that human receptors include members of the general public found near the Westridge Terminal, specifically: i) people on the water in fishing boats, kayaks, and other pleasure craft; ii) people on shore; iii) people living in adjacent communities; and, iv) first responders. However, contrary to standard emergency planning practice, the report and emergency management plan does not identify or characterize critical receptors near the Edmonton, Sumas and Burnaby terminals (e.g., within a 2 to 5 km radius). Critical receptors can include homes, schools, health care, elderly and convalescing facilities, recreational facilities, and other locations where people may be exposed, exhibit enhanced vulnerability to exposure, and have reduced ability to be evacuated in a safe and timely fashion in the event of a release or spill. Customary and good practice would be to develop threat maps showing potentially affected areas for a maximum credible release and the locations of critical receptors and emergency resources.

3.3.2.7 As noted in 3.3.2.6, identifying critical receptors/individuals is important since such individuals can have difficulty responding to emergency measures. In contrast, the assessment states that "...exposure of people might reasonably be expected to be self-limiting owing to the irritant properties of a number of the hydrocarbon components of the spilled oil as well as the odours that might be noticed. Both of these properties would provide warning of the presence of the chemicals such that individuals could take action to remove and/or distance themselves from the source, thereby limiting the amount and duration of any exposure." This approach that uses or considers such behaviors to minimize harm contradicts good management and planning practices.

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24 [B279-4 - Attachment 2.2 Westridge Marine Terminal Emergency Response Plan (ERP), July 2014 (A4D3F1)]

25 [Responses to Information Request from Living Oceans Society IR No. 1, Section 1.57: Air quality and Human Health: Oil Spill Scenarios at PDF, page 102.]

Page 14
3.3.3 The second step in the assessment of potential human health effects associated with possible oil spill scenarios at the terminals is exposure assessment. Here, predictive air dispersion modeling is used to estimate chemical concentrations for the two exposure scenarios. The report is stated to focus on areas where exposure to COPC might be expected to be greatest and/or where particularly sensitive receptors may be located. The assessment has many limitations in its assessment of potential exposures and human health risks.

3.3.3.1 The presentation of the dispersion modeling analysis reports on a single one-hour period that produced the highest hourly airborne concentration. For this period, northerly winds produced the highest concentration over water. The report should show the highest hourly concentration at each receptor that may result for any hour of the year (or multiyear period modeled), not just a single hour. The lack of this information, which is a standard part of hazard analyses, is an important deficiency in understanding the potential for adverse health effects.

3.3.3.2 The report does not provide a quantitative assessment of potential exposures to terrestrial populations and critical receptors.

3.3.3.3 The report notes that exposures may exceed short-term exposure limits for multiple hours, but uses only a one-hour assessment. Exposure limits for longer periods, e.g., three, eight and 24 hours, should be considered.

3.3.3.4 In open waters, oil films can be much thinner and volatilization rates much more rapid than those derived from the Gainford Study experiments used to estimate release rates. If oil escaped the boom or if the spill occurred in open waters, this would have the effect of significantly increasing concentrations and footprints where exposure limits are exceeded.

3.3.4 The third step in the assessment of potential human health effects associated with possible oil spill scenarios at the terminals is the toxicity assessment. Here, the assessment developed "Exposure Limits" for COPCs, designed to be protective of public health, by reviewing a number of guidelines, objectives and standards. The Exposure Limits were adjusted to one-hour levels. In addition, the assessment referred to benchmarks such as the Acute Exposure Guideline Levels (AEGs) and the Emergency Response Planning Guidelines (ERPgs), and considered exposure to several sets of chemical mixtures.

3.3.4.1 As noted earlier, the assessment is premised on one-hour exposures. However, spills and releases can result in multi-hour exposure periods, specifically up to 13 hours for benzene

3.3.5 The fourth step in the assessment of potential human health effects associated with possible oil spill scenarios at the terminals is risk characterization. Risk characterization is limited to a comparison of potential exposures to exposure limits. The larger spill scenario at the Westridge Marine Terminal produced concentrations that exceeded the acute (1 hr) Exposure Limits for a number of toxic constituents (i.e. aliphatic C1-C4, aliphatic C5-C8, and aromatic C9-C16 groups, benzene, toluene, and xylenes). The maximum concentrations significantly exceeded the exposure limits, e.g., by seven times for the aliphatic C5-C8 group, and by 20 times for benzene. Moderately dangerous adverse impacts are expected to individuals exposed to these levels.

3.3.5.1 As noted above, the report fails to provide information regarding potential exposures or health effects at critical terrestrial receptors. This is an important deficiency.

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27 Intrinsik, Human health risk assessment of facility and marine spill scenarios, Section 5.1.1.3: Duration of Exceedances, SREP-NEB-TERA-00006, June 2014 (A3Y1E9) at PDF, page 45
3.3.6 The final step in the assessment of potential human health effects associated with possible oil spill scenarios at the terminals is uncertainty analysis. This step is noted to be important in that it increases awareness and understanding of the possible health-related consequences of the spills.

3.3.6.1 The uncertainty assessment is qualitative in nature, and cursory. It argues that the assessment incorporates a high degree of conservatism due to the assumptions made to accommodate uncertainties. There is no attempt at a quantitative assessment of uncertainty.

3.3.6.2 As noted above, there is no evaluation of or inadequate emphasis on the many factors that might affect and potentially increase human health risks. The most prominent gaps in the uncertainty analysis include factors that might alter the release/spill size and its location, the fraction of toxic constituents in released materials, emission/volatilization rates from releases, the possibility of multi-hour exposures, and the vulnerability of critical receptors.

3.3.7 Conclusions of peer review - rupture, release or spill occurring at the Westridge, Edmonton, Sumas and Burnaby Terminals

3.3.7.1 The assessment does not provide the information needed to assess the human health risks presented by the project.

3.3.7.2 The combined effects of omissions and flawed methods in the HHRA and other TMEP documents make it impossible to predict the potential health effects that might result from ruptures, releases and spills at the terminals. The assessment excludes critical information that should be considered in evaluating the magnitude of health risks, including mapping of the highest concentrations and the identification of critical receptors.

3.3.7.3 The two scenarios evaluated in the HHRA for terminal spills represent a subset of possible failures and do not represent the magnitude of spills or releases that might reasonably occur and endanger public health.

3.3.7.4 Even considering the limitations of the two scenarios evaluated, spills at the terminal pose potential inhalation risks to nearby populations.

3.4 Release or Spill Occurring on the Tanker Route within Burrard Inlet and Juan de Fuca/Haro Straits

3.4.1 As in the other sections, a modified HHRA was carried out that focused on direct inhalation risks for two scenarios for spills resulting from a grounding of a laden tanker on Arachne Reef. Two spill volumes were considered: 16,500 and 8,250 m$^3$ of CLWB.\textsuperscript{28} As before, the assessment used a hazard approach with no estimates of the probability of releases, spills, exposures or health risks. The scenario selection is critical. The selected scenarios do not necessarily represent conservative and worst-case credible scenarios with regards to human health impacts.

3.4.2 The acute inhalation exposure limits were significantly exceeded for both spill volumes at both marine and terrestrial locations. The area where limits were exceeded was large and included marine and terrestrial locations with the possibility of affecting appreciable numbers of people. The affected persons were stated to include members of the general public, including people on the water in fishing boats, tour boats, sailboats, motorboats, and other pleasure craft; people living on or frequenting nearby, island communities; and first responders. Exceedences occurred immediately after the spill and then 20-30 hours later. Because exposures can vary significantly, a result of different concentrations within the plume; its movement by wind; and because of the variation in an individual’s location, movement and susceptibility, it is difficult without additional information to estimate the nature of health outcomes. However, for the scenarios predicted it is likely that moderately dangerous acute exposures could occur with a range of respiratory, cardiovascular, neurological and psychological outcomes.

\textsuperscript{28} Intrinsik, Human health risk assessment of facility and marine spill scenarios, SREP-NEB-TERA-00006, June 2014, (A3Y1E9)
3.4.2.1 Concentrations exceeded exposure limits for the aliphatic C1-C4 VOC group (by a factor of 1.3 over the exposure limit), the aliphatic C5-C8 group (by a factor of 9), the aromatic C9-C16 group (by a factor of 42), benzene (by a factor of 30), toluene (by a factor of 2), and xylenes (by a factor of 4).

3.4.2.2 Multiple hours of exposure above exposure limits are reported, e.g., Figure 5.33 shows 23 hours when benzene concentrations exceed exposure limits. Most exceedances occur within 30 hours of the spill, however, exposure limits were exceeded long after the spill for some compounds (e.g., aromatic C9-C16 resulted in exceedances 50 hours following the spill).²⁹

3.4.2.3 The spills affected very large areas, e.g., Figure 5.27 shows a region where benzene exceeded the exposure limit was over 20 km in length.³⁰

3.4.2.4 Comparisons to Acute Exposure Guideline Levels (AEGls) and other exposure limits should be used to account for the duration of the exposure. For example, AEGls (proposed) for benzene exist for one-, four- and eight-hour periods (EGL-1 values for these three averaging times are 52, 18 and 9 ppm, respectively).³¹ Since exposure can be prolonged, suitable averaging periods should be calculated to allow comparison with these levels.

3.4.2.5 A number of chemicals and mixtures do not have AEGls³² or Emergency Response Planning Guidelines (ERPGs) for comparison.

3.4.3 The problem formulation, as noted earlier, identifies the scope and boundaries, including project components to be examined; exposure scenarios; chemicals of potential concern (COPC); human “receptors” that might be exposed; and exposure routes and pathways. There are many deficiencies in the problem formulation here. As noted earlier, the assessment focuses on direct air inhalation as the exposure pathway. Direct physical contact is likely during various stages of the incident. Even brief periods of contact can lead to exposure, and dermal uptake is not linear with exposure time. Moreover, many individuals in the general public will rescue materials, pets and wildlife in the event of an oil spill with only limited regard to issued precautions and other actions. Furthermore, a large spill can affect a large region, and the assessment relies on institutional controls, e.g., closure of commercial and recreational fisheries, beach closures, forced evacuation of people offshore and/or on-shore, which will not be completely effective.

3.4.3.1 In open waters, oil films can be much thinner and volatilization rates much more rapid than represented in the Gainford Study experiments used to estimate release rates.³³ This would have the effect of significantly increasing concentrations and footprints where exposure limits are exceeded. The representativeness and limitations of the laboratory tests used to estimate source parameters should be discussed. This should detail the conditions that may decrease their representativeness, particularly those conditions where the tests can underestimate emissions or affect other fate and transport parameters with the effect of increasing risks and/or the difficulty and cost of remediation.

3.4.3.2 The assessment omits the ingestion exposure pathways, with the assumption that the issuance of fish, shellfish or other seafood consumption advisories will be fully effective. The analyzed scenario was in large part selected due to the length of shoreline oiled, which would likely increase the potential for dermal and ingestion exposure, pathways omitted in the analysis.

²⁹ Intrinsik, Human health risk assessment of facility and marine spill scenarios, Section 5.2.1.1.3: Duration of Exceedances, SREP-NEB-TERA-00006, June 2014 (A3Y1E9) at PDF, page 50
³¹ Acute Exposure Guideline Levels (AEGls) Program. U.S. Environmental Protection Agency, Washington DC, USA.
³² Emergency Response Planning Guidelines, American Industrial Hygiene Association, Falls Church, VA, USA.
The assessment claims that the number of individuals exposed might be self-limited due to the irritant properties and odors of spill releases. Of course, individuals are already exposed at this point; moreover, some individuals may be unable to take appropriate and timely actions to remove and/or distance themselves. Moreover, many individuals in the general public will rescue materials, pets and wildlife in the event of an oil spill with only limited regard to precautions and other actions.

Many other scenarios could result in different and potentially more adverse outcomes. For example, a tanker grounding or other event resulting in a large spill could occur in numerous places, any seasons, under different meteorological conditions, under different water temperature and wave action, etc. This could easily alter key conclusions from the modeled scenario that states that most exceedances will occur predominantly over water.\textsuperscript{34} Such results depend entirely on the scenario, including the prevailing meteorological conditions. In addition, spill volumes could be larger and could include other materials that would have higher volatility and toxicity resulting in greater human health risks. While the assessment notes that a large number of simulations were used in the “stochastic” analysis, only one simulation is selected for analysis. It would have been more representative, conservative and informative to evaluate results of the top 10 or so simulations, and to produce threat maps and other outputs showing areas that may experience health risks.

Direct inhalation exposure to combustion products from spill-related fires or explosions should be considered as a scenario.

As highlighted earlier, no information is provided regarding potentially susceptible and vulnerable populations living, working or recreating near the shoreline. Many fishers, for example, would be expected to be older individuals who might be susceptible to adverse impacts.

Conclusions of peer review - Release or spill occurring on the tanker route within Burrard Inlet and Juan de Fuca/Haro Straits

The assessment does not provide the information needed to assess the human health risks presented by a release occurring on the tanker route within the Burrard Inlet and Juan de Fuca/Haro Straits.

The combined effects of omissions and flawed methods in the HHRA and other TMEP documents make it impossible to predict the potential health effects that might result from a major tanker release.

The two scenarios evaluated in the HHRA for tanker releases represent a very small subset of possible failures, environmental conditions, and other factors that might affect human health. The scenarios analyzed do not represent the magnitude of human health risks that might reasonably occur from a maximum credible worst-case spill.

Even considering the limitations of the two scenarios evaluated, releases modeled pose inhalation risks to nearby populations, as well as the potential for significant dermal and ingestion exposures.

\textsuperscript{34} Intrinsik, Human health risk assessment of facility and marine spill scenarios, Section 6.1: General Observations, SREP-NEB-TERA-00006, June 2014 (A3Y1E9) at PDF, page 56
STUART A. BATTERMAN  
Curriculum Vitae

ADDRESS ........................................................................................................................................... 21

EDUCATION .......................................................................................................................................... 21

RESEARCH AND PROFESSIONAL EXPERIENCE ......................................................................... 21

DISTINCTIONS ....................................................................................................................................... 22

STATEMENT OF EXPERIENCE ........................................................................................................... 22

RESEARCH SUMMARY ........................................................................................................................... 22

PUBLICATIONS ....................................................................................................................................... 23

Peer-Reviewed Journal Articles .............................................................................................................. 23

Peer-Reviewed Book Chapters and Proceedings ..................................................................................... 33

Publications Pending .............................................................................................................................. 34

Submitted Manuscripts ........................................................................................................................... 34

In Preparation ........................................................................................................................................ 34

Non-Peer-Reviewed Book Chapters ...................................................................................................... 35

Papers and Abstracts .............................................................................................................................. 35

Papers Delivered at Professional Meetings .............................................................................................. 35

Papers Accepted/Submitted for Delivery at Professional Meetings ......................................................... 47

Organizational Reports or Manuals of a Research and/or Scholarly Nature .......................................... 48

Other Publications .................................................................................................................................. 52

Non-peer-reviewed articles ..................................................................................................................... 52

Other ..................................................................................................................................................... 54

Invited Lectures and Presentations .......................................................................................................... 55

TEACHING ............................................................................................................................................... 59

Full-Time Graduate Level Courses ......................................................................................................... 59

Full-Time Undergraduate Level Courses ................................................................................................. 60

Continuing Education Courses ............................................................................................................... 60

Educational Advising .............................................................................................................................. 61

Doctoral Dissertation Research Committees ............................................................................................ 61

Master’s Thesis Research Committees .................................................................................................... 64

Undergraduate Advising – Undergraduate Research Opportunities Program and Others ..................... 67

Post-Doctoral Advising - (15) .................................................................................................................. 67

Sabbatical and Visitor Advising/Support (8) ............................................................................................ 68

Other ..................................................................................................................................................... 68

Summary of Academic Advising ............................................................................................................. 68

SERVICE .................................................................................................................................................. 68

Professional Memberships and Offices .................................................................................................... 68

Journal, Book and Abstract Reviews ....................................................................................................... 69

Book and Report Reviews for Other Institutions .................................................................................... 69

Grant and Proposal Reviews .................................................................................................................. 69
University Service.................................................................................................71
Texas A&M University..........................................................................................71
University of Michigan..........................................................................................71
School of Public Health, University of Michigan..................................................73
Department of Environmental Health Sciences, University of Michigan..............73

Community Service .............................................................................................74
International Service ...........................................................................................74
State .......................................................................................................................76

Press Interviews/Articles (partial list)......................................................................78
Local Assistance and Advising (selected)...............................................................80

CONSULTING (selected)......................................................................................80

RESEARCH AND TRAINING FUNDING HISTORY ...........................................82
Awarded Research Grants and Contracts: External................................................82
Awarded Training Grants and Scholarships: External..........................................84
Awarded Grants and Contracts: Internal (all direct costs): ..................................86
STUART A. BATTERMAN

4 ADDRESS
6075A SPH-2, Environmental Health Sciences
1420 Washington Heights, Ann Arbor, MI 48109-2029
Tel: (734) 763-2417. Facsimile: (734) 936-7283
Email: STUARTB@umich.edu Web: www.sph.umich.edu/~stuartb

5 EDUCATION
1986 Ph.D., Water Resources and Environmental Engineering, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.
1981 M.S., Technology and Policy Program, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.
1979 B.S., Water and Air Pollution Program, Department of Environmental Science, Rutgers University, New Brunswick, New Jersey.

6 RESEARCH AND PROFESSIONAL EXPERIENCE
2014 Visiting Professor, Department of Energy, Politecnico di Torino, Torino, Italy. (sabbatical).
...2011- Leader, Exposure Assessment Core, The University of Michigan NIEHS P30 Core Center: Lifestage Exposures and Adult Disease.
2010- Director, Center for Occupational Health and Safety Engineering, University of Michigan, Ann Arbor, MI.
2007-10 Director, Pilot Project Research Program, NIOSH Education and Research Center, University of Michigan, Ann Arbor, MI.
2006- Professor of Mechanical Engineering, Faculty of Science and Technology, Universidade de Coimbra, Coimbra, Portugal (sabbatical 2006-7).
2006- Professor of Civil and Environmental Engineering, College of Engineering, University of Michigan, Ann Arbor, MI.
2002- Professor of Environmental Health Sciences. School of Public Health, University of Michigan, Ann Arbor, MI.
2002 Acting Head, Environmental Health Program. School of Public Health, University of Michigan, Ann Arbor, MI.
2000-2005 Associate Chair. Department of Environmental Health Sciences, School of Public Health, University of Michigan, Ann Arbor, MI.
1996-7 Visiting Professor. Technical Research Center of Finland, Espoo, Finland; Technical University of Helsinki (Mechanical Engineering), Espoo, Finland; and University of Kuopio (Environmental Sciences), Kuopio, Finland (sabbatical).
1995-2002 Associate Professor of Environmental Health Sciences with Tenure. Department of Environmental and Industrial Health, School of Public Health, University of Michigan, Ann Arbor, MI.
1989-1995 Assistant Professor of Environmental and Industrial Health. Department of Environmental and Industrial Health, School of Public Health, University of Michigan, Ann Arbor, MI.
1993-present Director, Hazardous Substances Academic Training Program. NIOSH Education and Research Center (formerly Educational Resource Center), University of Michigan, Ann Arbor, MI.
1989-92 Adjunct Assistant Professor of Environmental and Water Resources Engineering. Department of Civil Engineering, Texas A&M University, College Station, TX.
Assistant Professor. Environmental and Water Resources Engineering Division, Department of Civil Engineering, Texas A&M University, College Station, TX.


Graduate Research Assistant. Energy Laboratory, Massachusetts Institute of Technology, Cambridge, MA.

Intern. Massachusetts Port Authority, Boston, MA.

Graduate Research Assistant. Center for Policy Alternatives, Massachusetts Institute of Technology, Cambridge, MA.

Teaching Assistant. Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA.

1975-9 Dean's List and High Honors, Rutgers University, New Brunswick, NJ.

1981 Technology and Policy Fellowship, Massachusetts Institute of Technology.


Outstanding Contribution to Justice and Environmental Safety Award, Flint Genesee United for Action.

Excellence in Community Service Award, Ecology Center, Ann Arbor, MI.

Associate Editor, ASCE Journal of Environmental Engineering


Chair, Resolutions Committee, 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa, Feb. 23-27, 2003.

Professor, Faculty of Science and Technology, Universidade de Coimbra

Delegate, Universities Council on Water Resources

Faculty Associate, Program in the Environment, University of Michigan

Editor, Journal of Environment and Public Health

Honorary Professor, Department of Occupational and Environmental Health, Medical School, University of KwaZulu-Natal, Durban, South Africa

Faculty Associate, Center for Global Health, University of Michigan.

Fulbright Award for Portugal, J. William Fulbright Foreign Scholarship Board.

Honorary Professor, Department of Occupational and Environmental Health, School of Nursing & Public Health, University of KwaZulu-Natal, Durban, South Africa

I have been engaged with occupational and environmental research, teaching and service for over 25 years at several of the leading academic and research institutions. I have authored or co-authored over 300 papers, book chapters, proceedings and technical reports, and have obtained over 80 external research and training grants. I have served or currently serve as peer-reviewer for many scientific journals, governmental agencies, and other organizations. I have taught and continue to teach occupational and environmental health subjects in graduate courses at the premier educational institutions in Michigan, Texas, Finland, Portugal and South Africa, and have been the primary supervisor for over 20 Ph.D. and 60 Masters students. I have served and continue to serve as technical advisor, committee member or chair for various organizations dealing with these topics at local, county, regional, national at international levels, and I have provided outreach and expert testimony in the US and elsewhere.

My current research addresses a wide range of topics in occupational, indoor and environmental settings that include: exposure assessment (especially for volatile organic compounds (VOCs) and traffic-related air pollutants); emerging contaminants in occupational and environmental settings (e.g., brominated flame retardants); biological monitoring;
air quality monitoring; indoor air quality (e.g., assessment and management); air pollution control engineering (e.g., vapor and particle air filtration); environmental and human health risk assessment, and environmental epidemiology. Other research experience and interests include: characterization of VOCs in air, soils and fuels, environmental impact assessment, health impact assessment, risk assessment, environmental statistics, uncertainty analysis; VOC measurement techniques (including Fourier transform infrared spectroscopy, adsorbent collection/thermal desorption); disinfection by-products in drinking water; hazardous waste/medical waste management; environmental justice; sustainable systems; urban scale air pollutant modeling; environmental impacts of energy production; life cycle analysis. This research has been supported by government, industry and nonprofit organizations including the US National Institutes of Health, the National Science Foundation, the US Environmental Protection Agency, the American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE), and the World Health Organization, among others. Further details are provided under research support.


10 PUBLICATIONS

10.1 Peer-Reviewed Journal Articles

* For these papers, Dr. Batterman was the senior author, and a graduate student or post-doctoral research fellow is listed as first author. + denotes relevant to local situation in Detroit.


Note: Amongst over 220 entries, this manuscript was accepted as one of five articles into the premier issue of a new journal designed to be the highest quality peer-reviewed journal of its type.


34. S. Battersman, A. Franzblau, “Time Resolved Absorption and Permeation Rates of Methanol in Human Volunteers” International Archives of Environmental and Occupational Health, 70, 5, 341-351, 1997. PMID: 9352338


The preceding paper received the most “hits” during the month of publication in the on-line version of the Journal of Environmental Monitoring.


43. S. Battersman, A-T Huang, L. Zhang, S. Wang, “Reduction of Ingestion Exposure to Trihalomethanes Due to Volatilization,” Environmental Science and Technology, 34, 4418-4424, 2000. DOI: 10.1021/es991304s


The preceding paper was in the top 10 downloaded articles from this journal in 2005.


The preceding paper was featured as “high impact” article with journal cover photo by S. Batterman


This paper won the best paper of the year (2009) from the South African Thoracic Society (10,000 Rand prize).


   This paper received an award from the "New Frontiers of Engineering Foundation" (Portugal) in the category "Faculty of Engineering Award" (20 September 2012)


Page 29


134. *Zhichao Sun, Yebin Tao, Shi Li, Kelly K. Ferguson, John D. Meeker, Sung Kyun Park, S. Batterman, Bhramar Mukherjee, "Statistical strategies for constructing health risk models with multiple pollutants and their interactions: possible choices and comparisons." *Environmental Health*, 12(1), 85, 2013. PMID: 24099017 PMCID: PMC3857674. [http://www.ehjournal.net/content/12/1/85](http://www.ehjournal.net/content/12/1/85)


143. Breen, Michael; Long, Thomas; Schultz, Bradley; Crooks, James; Breen, Miyuki; Langstaff, John; Isaacs, Kristin; Tan, Yu-Mei; Williams, Ronald; Cao, Ye; Geller, Andrew; Devlin, Robert; Batterman, Stuart; Buckley, Timothy. "GPS-based Microenvironment Tracker (MicroTrac) Model to Estimate Time-Location of Individuals for Air Pollution Exposure Assessments: Model Evaluation in Central North Carolina", *Environmental Science & Technology*, accepted, Dec. 2013.


147. Lei Huang, Sergei M. Chernyak and Stuart A. Batterman, “PAHs, Nitro-PAHs, Hopanes and Steranes in Lake Trout from the Lake Michigan,” Environmental Toxicology & Chemistry, accepted Jan., 2014. DOI:10.1002/etc.2620.


### 10.2 Peer-Reviewed Book Chapters and Proceedings


10.3 Publications Pending

10.3.1 Submitted Manuscripts


28. Chad Milano, Lei Huang, **Stuart Batterman**, Trends in PM$_{2.5}$ emissions, concentrations and apportionments in Detroit and Chicago and the growing share of traffic-related air pollutants, submitted to *Atmospheric Environment*, April 2015.


10.3.2 In Preparation

30. Chunrong Jia, Stuart Batterman, Sergei Chernyak, “Active and Passive Sampling of 1, 3-Butadiene and Other VOCs using Thermal Desorption Tubes”


32. SM. Jeebhay, R. Baatjie, E. Cairncross, S. Batterman, “A followup investigation from massive community exposure to sulfur dioxide.”
33. C.A. Bradlee, S. Batterman, “Assessing the non-cancerous toxicity of solvent mixtures using an interaction-adjusted PBTK model.”
35. RN Naidoo, TG Robins, S Batterman, G Mentz, C Jack, Nasirumbi. "Ambient pollution and variability in respiratory outcomes among school children in Durban, South Africa"

10.4 Peer-Reviewed Book Chapters

10.5 Papers and Abstracts
10.5.1 Papers Delivered at Professional Meetings
5. P. Patel*, S. Batterman, “Movement of VOCs Through the Vadose Zone,” poster presented at the Texas Water Pollution Control Association Annual Meeting, Austin TX, June 7-9, 1983.


22. S. Batterman, "Role of Universities in Solving Environmental Problems," presented at the International Conference on The Egyptian Universities Research and Its Role in Solving Developmental and Environmental Problems, Al-Azhar University, Cairo, Egypt, July 17-20, 1995.


51. S. Batterman, “Integration of MS and MPH Curricula in Environmental Health, Industrial Hygiene, Occupational Medicine, and Toxicology at the University of Michigan: A Risk-Based Approach,” presented at the Environmental and Occupational Health Conference on Sustaining the Environmental Health Workforce, August 1-3, 2001, Seattle, WA.


75. Van DerMerwe, **S. Batterman**, Y Gounden, “PM Collocation Study Conducted At Wentworth, South Durban in 2004” presented at National Association for Clean Air Conference, October 7-8, 2004, Johannesburg, South Africa.


The preceding presentation received the Best New Researcher Poster Award.


137. MF Miller, SM Chernyak, SE Domino, SA Batterman, R Loch-Caruso, “Concentrations and speciation of polybrominated diphenyl ethers (PBDEs) in human amniotic fluid,” presented at Dioxin 2009, 29th


The preceding poster won a Student Achievement Award.


145. A Konoplev, S Batterman, S Chernyak, A Kochetkov, E. Pasynkova, D Samsono, “PBDEs in ambient air of Russian cities and their gradient in direction from Moscow to the Arctic,” to be presented at the International Polar Year Oslo Science Conference, June 8-12, 2010, Oslo, Norway.


Page 43

153. Liuliu Du, **Stuart Batterman**, Edith Parker, Christopher Godwin, Jo-Yu Chin, Ashley O'Toole, Thomas Robins, Wilma Brakefield-Caldwell, Zachary Rowe, Toby Lewis, "Free-Standing Air Filters in Bedrooms of Inner City Children With Asthma. Do They Make A Difference?", Paper presented at Indoor Air 2011, June 5-10, 2011, Austin, TX.


171. **Stuart A. Batterman**, "Workshop on approaches to improve assessment of exposure to traffic-related pollutants," poster presented the Health Effects Institute, Chicago, IL, April 18, 2012.

172. Ana Mendes, Lívia Aguiar, Diana Mendes, Susana Silva, Cristiana Pereira, Mónica Botelho, Paula Neves, Stuart Batterman, João Paulo Teixeira. "GERIA Project – Indoor Air and Quality of Life in Elderly Care Centres" paper presented at Healthy Buildings 8, Brisbane, Australia, 8 - 12 July 2012.


179. Michael Breen, Janet Burke, **Stuart Batterman**, Alan Vette, Gary Norris, Christopher Godwin, Matthew Landis, CAAA, Carry Croghan, Thomas Long, Miyuki Breen, Bradley Schultz. "Air Pollution Exposure Model for Individuals (EMI) in Asthma Health Study: Predicting Air Exchange Rates for Residents in Detroit, Michigan", Presented at the Annual Meeting of the Society of Toxicology, San Antonio, TX, March 10-14, 2013.


182. V. Isakov, Michelle Snyder, David Heist, Steven Perry, Janet Burke, Sarav Arunachalamy, Stuart Batterman, Rajiv Ganguly, and CAAA. "Development Of Model-Based Air Pollution Exposure Metrics For Use In Epidemiologic Studies." Submitted to the 33rd NATO/SPS International Technical Meeting (ITM) on Air Pollution Modeling and Its Applications, August 26-30, 2013 Miami, FL.


198. S. Batterman, Chernyak S. “Performance and Integrity of Blood Spot Measurements of BFRs, PCBs and Halogenated Pesticides,” Presented at the 14th Annual Workshop on Brominated & Other Flame Retardants (BFR), Indianapolis, IN June 22-24 2014.


10.5.2 Papers Accepted/Submitted for Delivery at Professional Meetings


10.6 Organizational Reports or Manuals of a Research and/or Scholarly Nature

1. S. Batterman, "Logan Energy Audit Package," Report to the Planning Department, Massachusetts Port Authority, Boston, MA 1980.

2. S. Batterman, "Energy Use Reporting System Update at the Massachusetts Port Authority," Report to the Planning Department, Massachusetts Port Authority, Boston, MA, Jan. 10, 1981.


74. Naidoo, R; Gqaleni, N.; Batterman, S; Robins. “Multipoint Plan: Project 4: Health Study and Health Risk Assessment. South Durban Health Study.” Centre of Occupational and Environmental Health, University of KwaZulu Natal, Durban, South Africa; Department of Environmental Health Sciences, University of Michigan, Ann Arbor, MI, USA; July, 2006.


10.7 Other Publications

10.7.1 Non-peer-reviewed articles


47.

10.7.2 Other


10.8 Invited Lectures and Presentations
1. S. Batterman, "Uncertainty of Targeted Acid Rain Control Strategies," Technical Research Center of Finland, Helsinki, Finland, Jan. 8, 1990
8. S. Batterman, "Pollution Sources in HVAC Systems: Phase 2. Identification and Quantification of Sources," Presentation to the National Institute for Occupational Safety and Health, University of Michigan, Ann Arbor MI, June 24, 1993.


53. **S. Batterman**, “Air pollution and environmental justice,” 2 hr lecture presented to HBHE class Environmental Education (G. Gee), University of Michigan, March 13, 2002.


59. S. Charles, **S. Batterman**, “Quantification of 2,5-dimethylfuran in Environmental Tobacco Smoke (Quantifying and Reducing Exposures to Environmental Tobacco Smoke),” presented to the 2006 University of Michigan Tobacco Research Network Workshop, School of Public Health, University of Michigan, Ann Arbor, May 9, 2006.

60. **S. Batterman**, “Assessment of Traffic Related Air Pollutants,” Faculty of Science and Technology, University of Coimbra, Coimbra, Portugal, Nov. 29, 2006.


63. **S. Batterman**, “Case studies in exposure and risk assessment: Applications from A (Ais for ADME and Africa) to Z (Z is for z-score and "xenobiotic")”. Presented in course EHS 688: Topics in Environmental Health, School of Public Health, University of Michigan. Oct. 8, 2008.

64. **S. Batterman**, “Public health and air quality in urban environments”. Presented in course Civil Engineering 990 “Sustainable urban environments”. Nov. 11, 2008.

65. **S. Batterman**, “Highways and health.” Presented to the University Chapter of the American Society of Civil Engineers, Ann Arbor, Nov. 21, 2008.


69. **S. Batterman**, “Climate Change and Public Health: The issues, research possibilities and the need for developing postgraduate training initiatives,” Environmental and Occupational Health, University of Kwa-Zulu Natal, Durban, South Africa, April 30, 2010.


75. **S. Batterman** with Maria Gunnoe and Jeremy Richardson, "Impacts of coal, and health effects of power plant emissions," panel Discussion, Rackham Graduate School, University of Michigan, Oct. 25, 2012.

76. **S. Batterman**, "Health Impacts from Air Pollution," presented at the SW District Community-Environmental Meeting, Detroit Hispanic Development Center, Detroit, MI, Jan. 31, 2013.


80. **S. Batterman**, with Linda Birnbaum, others, Air Pollution Community Forum, First Congregational Church of Detroit, Detroit, MI, June 18, 2013.


88. **S. Batterman**, Vehicle Emissions, Exposures, and Health. Division of Epidemiology, Human Genetics and Environmental Science, Health Science enter, The University of Texas, Houston, TX, Feb. 27, 2015.


91. **S. Batterman**, Wells to Wheels: Emissions, pollutant exposure and health, School of Environment, Tsinghua University, Beijing, China, April 28, 2015.


### 11 TEACHING

#### 11.1 Full-Time Graduate Level Courses

Development and delivery of following courses:

1. **CVEN-607 - Engineering Aspects of Air Pollution.** Introductory course addressing air quality fundamentals, including air quality regulations; source emissions; abatement technologies; dispersion and receptor modeling; source apportionment and management; monitoring instrumentation; and contemporary air pollution issues. (Texas A&M University)

2. **CVEN-681 - Graduate Seminar in Environmental Engineering.** Student seminars on various research topics. (Texas A&M University)
3. EHS-572 - **Environmental Impact Assessment.** Comprehensive framework for evaluating and predicting environmental impacts of manmade projects including evaluative and predictive methods addressing air, water and soil quality; transport and fate of contaminants; selection, application, integration and evaluation of computer models; and risk assessment. Also cross-listed in the School of Natural Resources. (University of Michigan)

4. EHS-599 - **Hazardous Wastes: Regulation, Remediation and Worker Protection.** Focus on hazardous waste site assessment and cleanup, including surface water, groundwater and air investigations; remediation practices; ultimate disposal of wastes; facility siting; monitoring methods; worker and community protection. This course is also cross-listed in the College of Engineering. (University of Michigan)

5. EHS-670 - **Studies in Advanced Water Resource Science and Engineering.** In-depth case studies of ongoing proposals and permit applications to site or remediate hazardous waste facilities (incinerators, landfills, etc.) including evaluation of technical issues; facility siting; risk assessment; policy; risk management; regulatory aspects; and communication and public relations. In 1993, this course was also cross-listed in the School of Literature, Sciences and Arts. (University of Michigan)

6. EHS-680 - **Environmental Management of Hazardous Substances.** Overview of selected topics in environmental management, including risk assessment, life cycle analysis, environmental justice, and risk-based decision making. (University of Michigan)

7. **Characterization of Indoor and Outdoor Pollutants and Exposure Assessment.** Graduate course in air pollution, focusing on exposure assessment to indoor and outdoor air pollutants. (University of Kuopio, Department of Environmental Sciences, Oct. 28 - Nov. 1, 1996, 18 lecture-hours)

8. **Indoor Air Pollutants and their Behavior.** Post-graduate course addressing indoor air pollutants, including assessment, monitoring and modeling. (Technical University of Helsinki, Department of Mechanical Engineering, Dec. 9 - 13, 1996, 20 lecture-hours)

9. EHS-869 - **Doctoral Student Seminar** (formerly **Industrial Hygiene Student Seminar**.) Research and literature related to industrial hygiene, environmental health sciences, and environmental management.


11. Participation in other courses in the Environmental Health Department at the University of Michigan includes:

   - **EIH-503 - Principles of Environmental Health.** Occasional lectures.
   - **EIH-531 - Environmental Chemistry.** Occasional lectures and laboratory demonstrations.
   - **EHS-585 – Introductory Environmental Health Sciences.** Occasional lectures.
   - **EHS-507 – Principles of Exposure Assessment.** Occasional lectures (2002-)
   - **EHS-601 – Foundations in Environmental Health Sciences.** Regular lectures (2011-)

   (Participation in courses in other departments, seminars and conferences is shown in Other Invited Lectures and Presentations and Service.)


### 11.2 Full-Time Undergraduate Level Courses

Development and delivery of following courses in the Civil and Environmental Engineering curriculum at Texas A&M University:

13. **CVEN-302 - Computer Applications in Engineering.** Numerical methods applied to engineering problems, including errors; roots of equations; systems of equations; curve fitting; regression; interpolation; integration; ordinary differential equations; and partial differential equations.

14. **CVEN-383 - Engineering Systems Analysis I.** Introductory probabilistic considerations in civil engineering systems design, including models and modeling practices; systems engineering language and communication; probability concepts; inferential statistics; civil engineering systems; and decision-making models.

15. **CVEN-384 - Engineering Systems Analysis II.** Applications of systems analysis techniques to engineering design, operation and maintenance issues, including modeling; numerical methods; optimization; engineering economics; and project planning and evaluation.

### 11.3 Continuing Education Courses


18. **Exposure, Hazard, and Risk Assessment.** Advanced continuing education course for engineers and practitioners, including use of ALOHA and RMP*COMP computer models, 35 lecture hours. Peninsula Technikon, Cape Town, South Africa; also University of Natal, Durban, South Africa, July 19-23, 1999.


11.4 **Educational Advising**

11.4.1 Doctoral Dissertation Research Committees

**Chair**


4. David Bowman - "Analysis of contaminant loss pathways from Great Lakes confined disposal facilities"

5. Andrea Jensen - "Application of environmental performance standards for siting and capacity assessment of hazardous waste facilities"

6. Alok Mittal - "Models of bioventing processes for remediation of VOCs in unsaturated soils" (Civil Engineering).


8. Erin Drury – “Environmental risk assessment and communication” (tentative)

9. Chu-Yun Huang -- “Gas phase filtration for indoor air quality” (tentative)


12. Christopher Bradlee, “PBPK Modeling of Chemical Mixtures”


16. Kai Zhang, “Exposures and Health Risks Due to Traffic Congestion,” Ph.D., Environmental Health Sciences, May, 2010. Assistant Professor, University of Texas School of Public Health, Houston, TX
19. Lei Huang, EHS, Polycyclic Aromatic Hydrocarbons (PAHs), Nitro-PAHs and Petroleum Biomarkers in Lake Michigan (2010-14).
20. Liuliu Du, Efficiency and use of stand-alone filters in residential environments, School of Environmental Science and Engineering, Donghua University, Shanghai, China. EHS (2009 - 2012)
24. Chad Milano, "High resolution dispersion modeling and exposure estimation," UM, 2014-
25. Sheena Martinez, "Development of exposure and health metrics to guide environmental policy," UM, 2014-

Co-Chair - as primary advisor

Member
1. Diana Tsimis - "A kinetic model for the biostrip process," Ph.D., Civil Engineering, 1989
5. Steven Michael - "The development of the quadrupole ion trap storage/reflectron time-of-flight mass spectrometer," Ph.D., Chemistry, March 1994
20. Mamopeli Matooane, “Assessment of Risk to Air Pollution in the South Durban Basin,” University of Natal, Durban, South Africa, Feb. 2004-
21. Dennis Crespo Matos, Adsorption properties of carbon nanotubes, Mechanical Eng. 2004-
22. Qiongyan (Judy) Zong, “A portable gas chromatograph employing novel approaches to sample capture, separation, and detection for trace-level determinations of complex environmental vapor mixture components, Ph.D., Environmental Health Sciences, May, 2008.
25. Ana Sofia Mendes, Indoor Environment and Health Related Quality of Life in Elderly Assisted Living Residences, Environmental Health Department, National Health Institute, Porto, Portugal (2010-)
27. Nkosana Jafita, "Allergens and indoor environment in low and middle incomes homes in Durban, South Africa, Dept of Environmental and Environmental Health, University of KwaZulu Natal, Durban, South Africa (2007-)

**Doctoral Pre-Candidate Qualifying and Research Committees (in addition to above) - (29)**
1. Lenly Weathers - Civil Engineering, 1987
2. Malali Ravindra - Civil Engineering, 1987
4. Andrew Ernest - Civil Engineering, 1987
5. Gwy Am Shin - Environmental Health Sciences, 1992
8. Jeffrey Haskins - Environmental Health Sciences, 1994
12. Janice Lee - Environmental Health Sciences, 1999
13. Wei-Chang Su – Environmental Health Sciences, 1999
14. Erin Drury – Environmental Health Sciences, 1999
15. Laura Brixley - Environmental Health Sciences, 2000
16. Maria Rosario -Environmental Health Sciences, 2000
17. Simin Abrishami - Environmental Health Sciences, 2000; 2001
18. Jamie Meliker - Environmental Health Sciences, 2001
19. Tarino Charleson - Environmental Health Sciences, 2000; 2001
20. Yoo, Sang-Joon - Environmental Health Sciences, 2001
21. Sheryl Kennedy – Environmental Health Sciences, 2002
22. Yi-Chen (Jane) Wu – Environmental Health Sciences, 2003
23. Ronke Soyombo – Environmental Health Sciences, 2003
25. Melissa Slotnick – Environmental Health Sciences, 2003
26. Mary Johnson – Environmental Health Sciences, 2003
27. Zorimar Rivera – Environmental Health Sciences, 2004
28. Luis Omar Rivera-Gonzalez – Environmental Health Sciences, 2004
29. David Choi – Environmental Health Sciences, 2005

11.4.2 Master's Thesis Research Committees

Chair

1. Pinakin Patel - "Modeling the movement of VOCs in the vadose zone" M.S., Civil Engineering, Feb. 1989
2. Dow J. Zabolio - "Decentralized water demand management," MS, Civil Engineering, May 1989
5. Xiao-Fang Yang - "Gaseous and particulate contamination in space" MS, Mechanical Engineering, December 1989 (Co-chair)
6. Nancy Bartoletta - "Fungal volatiles of potential relevance to indoor air quality, MS, Environmental Health Sciences, May 1991
9. Ganda Glinsorn - "Determination of FTIR detection limits for volatile organic compounds, MS, Environmental Health Sciences, April 1992
10. Matthew Pickus - "Dose delivered from a tritium contamination in a laboratory environment,” MS, Environmental Health Sciences, April 1997.
11. Mary Lou Davis - "Surgical suite medical waste audit: a case study at the University of Michigan Medical Center"
12. Norton Fogel - "Comparison of remediation approaches for TCE in unsaturated soils: a field study"
13. Paige Davis - "Adequacy of environmental reporting: a case study and the Fortune 50, MS, Environmental Health Sciences, June, 1994
17. Igor Osak - “Characteristics of existing and potential filter media for high volume air samplers,” MS, Environmental Health Science,” May, 1996
28. Chad Bailey, “Environmental justice studies”
31. Gregory Lower, “Receptor modeling of VOCs in Detroit (tentative)
33. Emily Barnet, “Air quality and exposures at an off-set printing facility”
34. Cindy Harms, “Air quality and worker symptoms and perceptions at an off-set printing facility”
35. Erika Kostocs, “Revisiting the threshold quantity criteria in the US EPA risk management program”
36. Joy Kistnasamy, “Health effects of learners and teachers at the Settlers School in South Durban associated with ambient air pollution” Department of Environmental Health, Technikon Natal, Durban, South Africa.
37. Nitasha Baijnath, “Short Term Exposure Measures For Acute Respiratory Health Effects Among Learners and Teachers at Settlers Primary School in South Durban,” Department of Environmental Health, Technikon Natal, Durban, South Africa.
41. Dang Nguyen (Environmental Health Sciences)
42. Shalonda Lynise Hunter (Urban Planning)
43. Yang-won Suh, “THMs in pools”
44. Yungdae Yu, “Evaporative emissions from vehicle fuel cap assemblies”
45. Tim Kennedy (Environmental Health Sciences)
46. Beth Hedgemen
47. Michael Rosenow (Environmental Health Sciences, OJOC, Nov. 2003 -)
50. Angela Fuller, MS
51. Qin Wei Chow, MPH
52. Kevin Bolon (SNRE), 2007
53. Keita Fujihira (SNRE), 2007
56. Hudda Elasaad, "A gradient study of PAH deposition near roads, MS, September, 2011.
57. Savitha Sangameswaran, "Sources and factors influencing airborne particulate matter in Detroit, MI" (expected October 2011).
58. Dongyan Sun, TBD, expected May 2012.

Member - (11)
1. Evan Cook - "Diffusion of contaminants through landfill liners,” MS, Civil Engineering, 1989
4. Jaebum Choi - "Development of soil/air flux measurement instrumentation" M.E., Mechanical Engineering, 1992
6. Mark Huang, “Surface acoustic wave sensor applications” (tentative)
7. John Raflowski, “Evaluation of agricultural uses of foundry sand” (tentative)
8. Michael Lane, “Risk assessment at a gasification site” (tentative)

Master’s Students Research Projects (non-thesis) - (10)
1. Mary Dawn Azizian - "Emergency response planning and air quality modeling" MPH, Environmental Health Sciences, May 1992
3. Chia-Chin Cheng - "Hazard analysis for the transport of hazardous waste transportation in the University of Michigan, MPH, Environmental Health Sciences, April 1993
6. Richard Martin - To be determined.
8. Megan McMaster, TBD
10. Josh Bennet, MPH 2005

Additional Graduate Students Supervised (since 1989, 15)
1. Haza Rashid Hammad - 1989-90
2. Kimberly Osborn - 1989-90
3. Elizabeth Esseks - 1992
5. Michael Dojka - 1993
6. Anthony Barnard - 1993-
7. Jim Hensley - 1994-
10. Roxanne Present - 1995-6
11. Stephanie Franke - 1996-7

11.4.3 Undergraduate Advising – Undergraduate Research Opportunities Program and Others
2. Ugo Okwumabua – 2002
3. Scott Roberts – 2005
4. Mariesha Lala -- 2012
5. Jennifer Liu -- 2012-3
6. Eva Greenthal -- 2013

11.4.4 Post-Doctoral Advising - (15)
1. Dr. Ling Yu He - Analysis of VOCs in ambient air, 1988
2. Dr. Dr. George Moridis - Analysis of moisture and heterogeneities in soils, 1988-9
3. Dr. Quilin Chang - Analysis of VOCs in soils, 1991
4. Dr. Nicola Pirrone - Indoor air quality and ambient particulate deposition, 1991-3, Director, Institute of Atmospheric Pollution Research, Rome, Italy.
5. Dr. Hong-Kui Xiao - Analysis of VOCs in biological specimens, 1993-6
6. Dr. Guo-Zheng Zhang - VOC analysis related to indoor air quality and wood products, 1993-6
7. Dr. Minghao Zhao - Fast GC and microbial VOC analysis - 1997
8. Dr. Shuqin Wang - FTIR and indoor air - 1997 - 2001
11. Dr. Christopher Godwin – IAQ analyses – 2003
12. Dr. Jae Hwan Lee – VOC analyses – 2004-2005
13. Dr. Sergei Chernyak – VOC and other organic analysis – 2004 –
14. Dr. Simone Charles – 2005 – 2007, Associate Professor, College of Health and Human Sciences, University of Southern Georgia, Stateboro, GA
15. Dr. Chunrong Jia, 2008 – 2009, Assistant Professor, University of Memphis, Memphis, TN
17. Dr. Rajiv Ganguly, 2012-13, Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh, India
18. Dr. Feng-Chiao Su, 2013-15
19. Dr. Liuliu Du, 2012-13
20. Dr. Sarah Le, 2014
21. Dr. Owais Gillani, 2014

11.4.5 Sabbatical and Visitor Advising/Support (8)
1. Dr. Eugene Cairncross, Peninsula Technikon, Bellville, South Africa (4/1/00 – 9/30/00)
2. Prof. Bohua Sun, Peninsula Technikon, Bellville, South Africa (7/30/00 – 8/3/00)
3. Prof. Pentti Kalliokoski, University of Kuopio, Kuopio, Finland (8/1/00 – 7/30/01)
4. Prof. Milan Carsky, University of Durban-Westville, South Africa (7/1/01 – 8/20/01)
5. Dr. Olga Mayan, National Institute for Environmental and Occupational Health (3/16-23/03)
6. Prof. Fausto Freire, University of Coimbra (2/28/08 – 8/15/08)
7. Mr. Peter Mochung Mochungong, Institute for Public Health, University of Southern Denmark (12/27/09-6/25/10)
8. Dr. Liuliu Du, Associate Researcher, School of Environmental Science and Engineering, Donghua University, Shanghai, China. (9/09 –)
9. Dr. Raghavan Sampathraju, Indian National Institute for Occupational Health, Delhi, India, 1/1/12-6/30/12.

11.4.6 Other
Minority International Research Training Program
1. Joy Ervan – 2002 – placement in Chile

11.5 Summary of Academic Advising

<table>
<thead>
<tr>
<th>Committee chairs/cochairs/members</th>
<th>PhD Committee Chairs</th>
<th>PhD Com. Memberships</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theses/Projects</td>
<td>20 (includes 1 co-chair)</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td></td>
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</tbody>
</table>

Total number of advisees (since 1986, graduate only (requires updating)/)

| PhD/DrPH Research Committee      | 42 |
| Qualifying Exam Committee (excluding above) | 29 |
| MS/MPH Research Committee        | 64 |
| Other MS/PhD                     | 26 |
| Post-doctoral fellows            | 16 |
| Sabbatical and visitors          | 3  |
| Total students/postdocs advised  | 180 |

12 SERVICE

12.1 Professional Memberships and Offices
1. Member, Air and Waste Management Association (1982-)
2. Member, American Society of Testing & Materials, Committee D-22 on Sampling & Analysis of Atmospheres (1986-99)
3. Member, American Geophysical Union (1987-93)
4. Member, Association of Environmental Engineering Professors (1987-95)
5. Member, American Association for Aerosol Research (1989-91)
6. Advisory Board Member, Association of Professionals Involved with Non-Utility Power Generation (1990-96)
7. Associate Member, American Society of Heating, Ventilating and Refrigeration Engineers (1992-5)
9. Member, National Environmental Health Association (2000 -)
10. Associate Editor, *ASCE Journal Environmental Engineering* (air pollution topics) (2002-5)
11. Member, International Society for Environmental Epidemiology (2002 -)
13. Member, (External) Scientific Advisory Board of the Energy for Sustainability (EfS) Initiative, University of Coimbra, Portugal (2013 -)

### 12.2 Journal, Book and Abstract Reviews
2. *Air and Waste Management Association* (formerly Air Pollution Control Association) (1988-)
5. *Environmental Science and Technology* (1992-)
12. *Environmental Practice*, the National Journal of the Association of Environmental Professionals (1999-)
14. *Indoor Air* (2000-)
18. Others...

### 12.3 Book and Report Reviews for Other Institutions
1. US EPA (various reports and conference paper reviews (1998-)
2. National Research Council, Transportation Research Board (conferences and journals, 1997-)

### 12.4 Grant and Proposal Reviews
5. Great Lakes Research Protection Fund (March, 1995)
6. National Science Foundation NATO Advanced Study Institute Program (Sept. 1995).
8. US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Center for Environmental Research and Quality Assurance, Graduate Education Fellowship programs (Feb. 1996).
10. Center for Indoor Air Quality (June, 1996; June 1997; June 1998).
14. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Graduate Environmental Study Fellowships (March, 1999).
15. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Graduate Environmental Study Fellowships (January, February, 2000).
16. Panel Member, Office of Life Sciences and Microgravity Sciences, NASA Extramural Grants Program (March, 2000).
17. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Futures Research in Socio-Economics (Sept. 2000).
18. Research Management Group, Linthicum Heights, MD (December, 2000).
27. Subchair, Advanced Research in Environmental Health Special Emphasis Panel (ARCH-SEP), National Institute of Environmental Health Sciences (March, 2005).
30. Panel Member, Graham Environmental Sustainability Institute; Water, Environmental and Health, Pilot Research Program (Feb. 2008).
33. Panel Member, Strategic Environmental Restoration Defense Program, US Department of Defense (Vapor Intrusion), April, 2008.
34. Panel Member, Research Excellence Centers, National Research Foundation, United Arab Emirates (Oct. 2008).
35. Reviewer, Cooperative Grants Program (CGP) of the U.S. Civilian Research and Development Foundation (CRDF), April, 2009.
40. Member, Neurological, Aging and Musculoskeletal Epidemiology Study Section [NAME], National Institutes of Health, Washington, DC. April - June, 2013.
41. Reviewer, Development research grants, Academy of Finland, Helsinki, Finland, July - Aug., 2013.
42. Reviewer, Collaborative Research Fund (CRF), Earmarked Research Grant (ERG), Hong Kong, Feb., 2014.
45. Reviewer, Environmental Health Sciences Center for Urban Responses to Environmental Stressors (CURES), Wayne State University, Detroit, MI. Feb., 2015.
46. Member, Neurological, Aging and Musculoskeletal Epidemiology Study Section [NAME], National Institutes of Health, Washington, DC. April - June, 2015.

12.5 University Service

12.5.1 Texas A&M University
1. Member, Graduate Studies Committee, Department of Civil Engineering (1986-1989).
3. Member, Computer Committee, Department of Civil Engineering (1987).
4. Student Advisor (for Division), Environmental and Water Resources Engineering Division, Department of Civil Engineering (1987-8).
8. Reviewer, University Library Learning Resources Center, for recommendation of statistical software packages (1988).
9. Member, Program Promotions Subcommittee, Graduate Studies Committee, Department of Civil Engineering (1988).
10. Member, Academic Standards Subcommittee, Graduate Studies Committee, Department of Civil Engineering (1988-9).
11. Representative, Graduate Council, Department of Chemistry Dissertation Committee (1989).

12.5.2 University of Michigan
7. Member, Environmental Protection Subcommittee, Vice President Womack's Financial Affairs Committee (1992-5).
8. Member, Education and Research Center (formerly Educational Resource Center) (1993-).
9. Advisor, Occupational Safety and Environmental Health and Plant Departments on indoor air quality and building ventilation (1993-)
13. Faculty Adviser, School of Natural Resources and Environment, Greening the Maize and Blue Course (1995-).
17. Member, Waste Disposal Alternatives Task Force, OSEH and the Medical Center (Feb. – Aug. 1999).
18. Member, Individually Developed Overseas Internship Award Review Committee, International Institute (March - April, 1999; Feb. 2000).
19. Member, Executive Committee, Certificate Program in Industrial Ecology, Rackham School of Graduate Studies (March, 1999-).
20. Member, Environmental Justice Program Development Committee (Nov. 1999).
21. Member, Add-hoc Transportation and Planning Committee (June 2000 – April 2001).
23. Reviewer, Office of Vice President for Research, Faculty Grants and Awards Program (Jan. 2001; May 2005; May 2006)
25. Panelist, A Strategic Integrated Assessment for Revitalizing the Role of the University of Michigan in Great Lakes Research (March 2005).
26. Panelist, Careers in Environmental Health, WISE (Women in Science and Engineering) and UIR (UROP in Residence), March 2005.
27. Panelist, Environmental Sustainability Forum (interviews and focus groups), June, August 2005.
28. Member, Search Committee, Graham Environmental Sustainability Institute, Jan – May, 2006.
30. Reviewer, Environmental Sustainability Multidisciplinary Research Team Grant Proposals, Graham Environmental Sustainability Institute, Mar. 2008.
31. Member, Energy Conservation Committee (Joint between Utilities; Plant Operations; Architecture, Engineering and Construction; Faculty), July 2008 – present.
32. Delegate, Universities Council on Water Resources (2008 -)
33. Faculty Associate, Program in the Environment (University-wide crossroads for undergraduate environmental study (2008 -).
34. External Reviewer, Tenure and Promotion Committee, College of Engineering (Oct. 2008).
35. Faculty advisor, Students for Jamaica, Blue Mountain Project, University of Michigan Medical School, Dec. 2008 - Jan. 2009)
36. Chair, Provost’s committee, 3 year review of the Graham Environmental Sustainability Institute, Jan. – Mar. 2009.
37. Member, Advisory Board, Center for Global Health, Sept. 2009 -
40. Faculty Associate, Center for Global Health (Feb. 2011-)
41. Member, Council of Fellows, The Cooperative Institute for Limnology and Ecosystems Research (CILER/NOAA) (July 2011 -)
42. Member, ADVANCE Committee for mentoring new faculty, Civil and Environmental Engineering (Feb. 2013).
43. Member, Planet Blue Team (energy conservation/sustainability) (Mar. 2011 - present).
44. Chair, SPH Planet Blue Advisory Committee to the Dean (May 2011 - 2013).
45. Member, Tenure and Promotion Committee, Mechanical Engineering, College of Engineering (2014)

12.5.3 School of Public Health, University of Michigan
2. Member, Ad-hoc Committee for the Internal Review of the School of Public Health (1993-4).
4. Member (alternate), Advisory Committee on Academic Programs, School of Public Health (1998-2003).
6. Member, Web Implementation Committee (2000-1).
7. Member, Public Health Information Services Advisory (PHISA) Committee (2000-5).
8. Member, Merit Database Review Subcommittee, Public Health Information Services Advisory (PHISA) Committee (March–May, 2003)
10. Chair, SPH Ad Hoc Committee on Academic Conduct (April – May, 2003).
11. Member, Informatics and Information Technology Committee, also Informatics Subcommittee (Sept – May, 2006).
12. Member, Global Public Health Advisory Committee (Dec., 2009 - present).
13. Member, Curriculum Subcommittee, Global Public Health (Sept. 2010 - present).

12.5.4 Department of Environmental Health Sciences, University of Michigan
1. Member, Governance Committee (1989-).
2. Member and Equal Opportunity Liaison Officer, Faculty Search Committee (1990).
3. Member, Curriculum Committee (1990-2000).
4. Organizer, equipment and infrastructure upgrade and maintenance. Includes ventilation systems, machine shop renovation, research and teaching instrument maintenance, computer networking, etc. (1990-).
5. Member and Chemical Hazards Safety Officer, Safety Committee (1991-4).
6. Promotions and student recruitment, including writing and editing brochures, initiating contact with potential students, etc. (1991-).
9. Director, Hazardous Substances Academic Training Program (1993-).
11. Member, Toxicology Faculty Search Committee (1995-6).
12. Chair, Curriculum Committee (1995-6).
18. Member, Admissions Committee (1999-00).
19. Member, Executive Committee (1999-).
20. Mentor, Environmental Toxicology Training Program (2000-).
21. Coordinator, SPH Staff Recognition Awards (April, 2000; April, 2001).
27. Member, Retreat Planning Committee (April 2003).
32. Member, Risk Sciences and Communication Faculty Search Committee (Sept. 2004 – Apr. 2005)
33. Member, EHS Chair Faculty Search Committee (Aug. 2004 - Apr. 2005)
35. Member, Admissions Committee (2005-)
36. Member, Doctoral Committee (2005-6)
37. Member, OJ/OC Planning Committee (2005-)
38. Panelist, 42nd Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Nov. 3-4, 2005).
40. Member, Academic Programs Committee (2007-8)
41. Chair, Professional Program Curriculum Committee (2008-11)
43. Member, Strategic Planning Committee (2007-8)
44. Member, Academic Degree (MS/PhD) Committee (2014-5)
45. Co-Chair, Admissions and Recruitment Committee (2014-5)

12.6 Community Service
12.6.1 International Service
1. Reviewer, Design of ambient air quality monitoring network for Mexico City, Movimiento Ecologista Mexicano, A.C., Mexico City, Mexico (1988).
5. Wastewater Engineer/Public Health Specialist, Conference on Scientific Research In The Egyptian Universities And Its Role In Solving Developmental And Environmental Problems, Cairo, Egypt (July 1995).
10. Advisor, South Durban Air Quality Monitoring Project, Metropolitan Council, Durban, South Africa. (Feb. 2001-6).
12. Advisor, collaborator, for Dr. Patel at RS University, Raipur, India on project “VOC Studies in Central India,” (July- 2003)
14. Advisor for Dr. Rajen Naidoo at University of Natal, Durban, South Africa on curriculum development in Environmental Health under Fogarty Activity (Aug. 2003).
15. Chair, Resolutions Committee, 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa (Feb. 23-27, 2003).
17. Member, Advisory Board, Center for Occupational and Environmental Health, University of KwaZulu Natal, Durban, South Africa, 2003-
24. Host and Facilitator, Fulbright Scholar Program for Prof. Fausto Freire, University of Coimbra, Portugal, to visit University of Michigan, 2007-8. (awarded)
25. Host and Facilitator, Fulbright Scholar Program for Prof. Mahmoud M. Abdel-Salam, Department of Environmental Sciences, Alexandria University, Alexandria, Egypt, 2007-8 (pending).
27. External Examiner, Ph.D., University of Kuopio, Finland, October, 2007.
28. External Evaluator, Department of Environmental Health, Faculty of Health Sciences, University of Botswana, Botswana (Oct.-Nov. 2008).
29. External Evaluator of 3 PhD proposals, Department of Mechanical Engineering, University of Coimbra (Portugal), August, 2009.
30. External Reviewer, Tenure and Promotion, National University of Singapore, Singapore (Dec. 2010).
32. External Examiner, Ph.D., Indian Institute of Technology, New Delhi, India (March, 2011).
33. External Reviewer, Tenure and Promotion, Universiti Sains Malaysia, Palau Pinang, Malaysia. (May, 2011).
34. Member, Program Committee, Energy for Sustainability Multidisciplinary Conference EfS, Faculty of Science and Technology, Coimbra, Portugal, 8-10 September 2013.
36. External Reviewer, Promotion Committee, Dalla Lana School of Public Health, University of Toronto, Canada. (Feb., 2014).
2. Participant, Workshop on Intermedia Contaminants, UCLA, Santa Monica, CA (August 1988).
10. Member, Advisory Board, Great Lakes Environmental Justice Program (1997-).
13. External Reviewer, Tenure and Promotion Committee, St. Louis University (Sept. 1999).
14. Member, Robert E. Dougherty Educational Foundation (administers scholarships in the area of wood science, technology and forest products) (1999 -).
15. External Reviewer, Tenure and Promotion Committee, University of Illinois (July, 2000).
16. Member, Science Advisory Committee, Ecology Center and the Michigan Environmental Council (Nov. 2000-
21. External Reviewer, Committee on Appointments and Promotions, Johns Hopkins University (Sept. 2007).
22. External Reviewer, Tenure and Promotion Committee, University of California, Davis, CA (Aug. 2008).
23. External Reviewer, Tenure and Promotion Committee, Clarkson University, Potsdam NY (Sept. 2008).
24. External Reviewer, Tenure and Promotion Committee, Ohio State University, Columbus, OH (Jan. 2009).
27. External Reviewer, Tenure and Promotion Committee, Stanford University, Stanford, CA (Feb. 2010).
28. Member, Board of Directors, Ecology Center, Ann Arbor, MI (June 2010 – June 2013).
30. External Reviewer, Tenure and Promotion Committee, Tufts University, Medford, MA (July, 2011).

12.6.2 State
1. Testimony prepared and delivered to Michigan Department of Natural Resources concerning proposed Carleton Farms waste management facility in Sumpter Township, MI (August 1991).
2. Testimony prepared for United States vs. BASF-Inmont Corp. et al., DJ90-11-3-289, concerning the Remedial Design, Remedial Action Plan, Scope of Work (SOW) and Consent Decree for the Metamora Landfill National Priorities List Site (September 1991).
5. Technical Advisor, Technical Assistance Grant Program, Metamora Landfill National Priorities List Site, Metamora, MI (1994-8).
6. Participant, Table Top Emergency Incident Planning Exercise, Washtenaw County, MI (September 1995).
8. Technical expert (indoor air quality), Michigan Education Association (Feb. – May 1998).
10. Member, Community Council, Environmental Health of Arab Americans in Metro Detroit, Arab Community Center for Economic and Social Services, Dearborn, MI (2000-).
12. Testimony to Michigan Department of Environmental Quality on proposed Ypsilanti Wastewater Incineration facility (March, 2003)
14. Board Member, Community Advisor Panel, CHASS, Detroit, MI (Nov. 2003 - )
19. Member, Environmental Justice Resource Group, Department of Environmental Quality, State of Michigan. Jan. 2009-
21. Member, Michigan Department of Environmental Quality, Air Toxics Workgroup, Lansing, MI, 2012-13
24. Member, Transportation Coordinating Committee, Southeast Michigan Council of Governments (SEMCOG Metropolitan Planning Organization), Detroit, MI (Sept. 2014-)
12.6.3 Press Interviews/Articles (partial list)

*Interviews/articles with media regarding hazardous waste, and ambient and indoor air quality, including:*

5. Lapeer County Press, July 8, 1992 (Hazardous waste).
8. Detroit Free Press, November 25, 1992 (Fire and air pollution, Mike Williams).
17. The University Record - Dec. 1995 (Campus environmental management program).
20. Dallas Morning News - June 1, 1996 (Hazardous waste incineration).
30. WAMC/Northeast Public Radio, Sept. 13, 2000 (NY, NH, etc.) (Health effects of air pollution).
32. WNEM-TV, CBS affiliate, Saginaw, MI, April 2000 (Indoor air cleaners and ozone).
34. The Mercury, Durban, South Africa, March 1, 2002 (‘Pollution levels linked to asthma’)
35. The Mercury, Durban, South Africa, November, 2002 (‘Air Pollution levels linked to asthma’)
36. CourtTV.com, February, 2003 (‘Indoor air quality and mold’)
37. Findings, UM School of Public Health, Fall/Winter 2003 (‘Research Steers South Africa Toward Environmental Change’)
42. Houston Chronicle, Houston, TX ('In Harm's Way. Troubled neighbors’ by Dina Cappiello), March 27, 2005.
43. Houston Chronicle, Houston, TX ('En El Paso Del Daño - Cómo medimos y evaluamos la calidad del aire’) Miércoles 26 de enero de 2005
44. The Mercury, Durban, South Africa ('Tackling pollution - Researchers from the University of Natal are hoping to pinpoint links between sickness and the air which people are forced to breathe’ by Tony Carnie, April 2005.
46. Detroit Metro Times, Detroit, MI (Environmental Impacts of the Second International Crossing in Detroit), April 17, 2006.
47. The Mercury, Durban, South Africa (Durban Health Study), Aug. 4, 2006.
53. WDET Radio, Detroit Michigan, (EPA Study on Air Quality, Asthmatics and Roadways, 10 minute interview), July 2, 2009.
55. University of Michigan Record Update - online, June 7, 2010, June 15, 2010
56. Edmonton.Journal.com ("Fort Saskatchewan residents sicker than neighbors: Prof") June 09, 2010
57. Edmonton Journal ("Experts criticize upgrader proposal" by Hanneke Brooymans) June 09, 2010
58. The Globe and Mail ("Delay refinery until health effects are studied, Alberta regulators urged") June 12, 2010.
63. Dirkseen Senate Office Building, Senate Energy and Public Works Committee; briefing to Senators Barbara Boxer and Sheldon Whitehouse on "Human Health Impacts of Tar Sands Production and Refining," Also briefing to Senate staffers and press (3 events) Feb. 26, 2014.
12.6.4 Local Assistance and Advising (selected)
Pro bono advice to citizens, nonprofit groups, local government, industry, etc., regarding hazardous substances, soil and groundwater, and air quality, including:
4. Technical Advisory Committee, Metamora National Priority List Superfund Site, Metamora, MI, 1993-.
10. Indoor air quality, gasoline exposure, etc., in Flint, MI, 1994-5.
12. Soil contamination from landfill at school grounds; Madison Heights, Oakland County, MI, March - April, 1996.

13 CONSULTING (selected)
16. Technical Expert, developments and applications in indoor air sampling including particulate and bioaerosols, Pall Gelman Laboratory, Inc. (August, 1999).

14 RESEARCH AND TRAINING FUNDING HISTORY

14.1 Awarded Research Grants and Contracts: External

1. Synthetic Fuels Corporation, Ambient Monitoring near Synfuel Plants, S. Batterman (Consultant), $50,000 (total costs), 6/20/84 - 6/19/85.
2. Environmental Protection Agency, Assessment of Air Quality Models and Their Applications, S. Batterman (Consultant) $300,000 (total costs), 9/20/84 - 9/20/86.
4. McDonald Douglas Astronautics Co., Assessment of Fate of Particles and Gases Released from a Manned Space Station, S. Batterman (CoInv), $60,000 (total costs), 3/1/87 - 12/31/88.
6. Houston Area Research Council, Evaluating In Situ Treatment Processes for Hazardous Waste, S. Batterman (PI), $12,000 (direct costs of computer access grant), 6/2/87 - 12/31/88.
7. Environmental Protection Agency, Variability of Soil and Street Dust in the Philadelphia Area, S. Batterman (PI), $1,000 (direct costs), 9/1/87 - 12/31/87.
10. Advanced Technology Program, Texas Coordinating Board, Synthesis of Hydraulic and Pneumatic Controls for Hazardous Site Remediation, S. Batterman (PI), $383,000 (direct costs), 6/1/88 - 9/1/89.
15. Johnson's Corp., Investigation of Fungal Volatiles, S. Batterman (CoInv), $30,000 (total costs), 9/1/90 - 9/1/92.
18. US Department of Energy, Measurements of Vadose Zone Transport Properties, S. Batterman (PI), $95,964 (total costs), 2/1/93 - 1/30/95.
19. NIOSH, "Biological Monitoring of Methanol Exposures," $432,000 (total costs), S. Batterman (CoInv), 1/1/93 - 6/31/95.
26. Michigan Small Business Research Program, Continuous Monitoring of Volatile Organic Compounds (VOCs) Affecting Indoor Air Quality in Laboratory and Industrial Environments, S. Batterman (Co-Inv), $100,000 ($15,000 subcontract to UM), 8/12/96 - 5/12/97. Grant No. 801P6001063.
28. NSF, Use of High Speed Gas Chromatography to Monitor Microbial VOCs, S. Batterman (Co-Inv), $75,000, ($27,000 subcontract to UM), 2/15/97 - 9/15/97.
29. Foundation for Research Development (Pretoria, South Africa), Cape Air Quality Project, E. Cairncross (PI), S. Batterman (Team member), R42,000 (US ~$10,000) 1/1/97-1/1/98.
30. Center for Indoor Air Research (Batterman), Gas Phase Filtration for VOC and Oxidant Removal: Laboratory and Field Assessment, S. Batterman (PI), 8%, $381,985, 9/1/99 - 8/30/01.
31. US Agency for International Development, Faculty, Curriculum and Research Development Related to Cleaner Production Technologies and Advanced and Smart Materials: A Tertiary Education Linkage Project Between The University of Michigan and The Peninsula Technikon, S. Batterman (PI), South Africa, 8%, $460,000, 6/1/99 – 5/30/03.
32. MyIndoorAir, Inc. Analysis and Presentation of IAQ Monitoring Data, S. Batterman (PI), $2,500, 9/1/00- 5/1/01.
33. Precision Air, Indoor Air Quality in the Work Environment, S. Batterman (PI), $10,290, 12/1/00 – 12/31/01.
34. Durban Metro Council (South Africa), “Air Contaminant Exposures, Acute Symptoms and Disease Aggravation Among Learners and Teachers at The Settlers School in South Durban,” T. Robins (PI), S. Batterman (Co-PI), 200,000 R (approximately $30,000) plus numerous in-kind contributions, 2/1/2001 – 12/31/01.
35. NIOSH R01, “Microanalytical system for indoor VOC monitoring, E. Zellers (PI), S. Batterman (Co-Inv), $782,546 (total ), $550,000 (direct), 4/1/02 – 3/31/05.
36. NSF, Sustainable Infrastructure Materials and Systems: Integration of microstructure tailoring and life cycle analysis of engineered cementitious composites (ECC). G Keolian (PI), S. Batterman (Co-Inv). $106,000 (NSF), $156,036 (total), 9/1/02 – 8/30/03.
37. CDC, “Ambient Air Pollution and Adverse Birth Outcomes: A Linked Analysis: Linking Chronic Disease and Environmental Data Sources,” R.Wahl (PI), Batterman directs UM subcontract, 10/1/02 – 9/30/05, $165,000 (approximately)
38. NIOSH, “Indoor Air Quality in Public Schools: An Assessment of Exposures and Symptoms of Teachers”, S. Batterman (PI), A. Franzblau (Co-PI), $33,000 (direct), 12/1/02 – 6/30/03.
39. American Chemistry Council “Understanding Exposure to Volatile Organic Air Toxics”, S. Batterman (PI), $899,385, 6/1/03 – 5/30/06.
40. NSF, Sustainable Infrastructure Materials and Systems: Integration of Microstructure Tailoring and Life Cycle Analysis of Engineered Cementitious Composites, G. Keolian (PI), S. Batterman (Co-Inv). $2,000,000, 9/1/03 – 8/30/08.
41. NIH R21, ”Health, Pollution & Economic Development in South Durban,” S. Batterman (PI), $266,083 total, 7/1/03 – 6/30/05.
42. Durban Metro Council, “The Health Status And Risk Factors Associated With Adverse Health Outcomes Among The Durban South Community Durban Metro, South Africa,” R. Naidoo (PI), S. Batterman (Co-PI) 6/1/03 – 5/30-05, $800,000 (direct).


46. US Civilian Research and Development Foundation, “Sources, Transport and Impacts of PBDEs In The Russian Arctic,” S. Batterman (PI), $49,150, 5/1/06 – 9/30/08

47. US EPA (Mickey Leland National Urban Air Toxics Research Center), “Distribution and Determinants of VOCs”, S. Batterman (PI), 11/1/06-10/30/07, $50,000.

48. NIEHS RO1, “A Community Based Participatory Research Intervention for Childhood Asthma Using Air Filters and Air Conditioners,” E. Parker (PI), S. Batterman (Co-Inv), 7/1/07-6/30/12, $2,000,000 (direct).

49. NIEHS RO1, “Role of Diesel and Other Vehicular Exhaust in Exacerbation of Childhood Asthma,” T. Robins (PI), S. Batterman (Co-Inv), 9/1/07-8/30/12, $2,900,000 (direct).


51. NIEHS RO1, “Mechanisms of Inflammation in Gestational Membranes, 7/1/08 – 6/30/13, R. Loch-Carruso (PI), S. Batterman (Co-Inv), $1,500,000.


57. NIEHS P30, "Core Center in Environmental Health - Lifestage Exposures and Adult Disease”, H. Hu (PI), S. Batterman (Co-Inv). 7/1/11 – 6/30/15, $2,400,000 (direct).

58. FCT, "Indoor Environment and Health Related Quality of Life in Elderly Assisted Living Residences,” A. Mendes (PI) Financiamento do Fundo Social Europeu e de fundos nacionais do MCTES. Grant from FCT to University of Porto (Portugal), including field work, 6 months of study at University of Michigan for a doctoral student.

59. Fulbright Scholar Award, In Public/Global Health at the University of Coimbra, Coimbra, Portugal. April 2011.


61. NIEHS, “Community Action to Promote Healthy Environments”. Batterman, Schultz (Co-PIs), 1/1/14 – 12/31/19, $2,300,000 (direct).

62. US EPA, "Environmental Quality, Health and Learning in Conventional and High Performance School Buildings,” S. Batterman (PI), 10/1/14 - 12/31/17, $1,000,000

14.2 Awarded Training Grants and Scholarships: External

63. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Award, S. Batterman (PI), $181,000 recommended for 2/1/93 - 6/30/95, $42,000 awarded for 2/93 – 6/30/94.


72. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $59,434 (total costs), 6/30/00- 7/1/01.

73. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $493,693 recommended for 6/30/01-7/1/05, $76,500 awarded for 6/30/01-7/1/02.

74. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/02-7/1/03.

75. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/03-7/1/04.

76. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/04-7/1/05.

77. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $450,000 recommended for 6/30/05-7/1/08, $72,500 awarded for 6/30/05-7/1/06.

78. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $450,000 recommended for 6/30/05-7/1/08, $72,500 awarded for 6/30/05-7/1/06.


80. Michigan Education Resource Center, National Institute for Occupational Safety and Health, Pilot Project, Post-doctoral training for Jo-Yu Chin,


82. S. Batterman (PI), $1,640,000 6/30/10- 7/1/11. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.

83. S. Batterman (PI), $1,640,000 6/30/11- 7/1/12. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.

84. S. Batterman (PI), $1,640,000 6/30/10- 7/1/11. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.


86. Michigan Bloodspot Environmental Epidemiology Project, Program Round 1, “Investigation and assessment of the use of blood spots for retrospective exposure estimation of persistent organic contaminants, including chlorinated and brominated compounds, in human blood.” S. Batterman, PI, $25,000, 2013-4. The overall goals of the proposed project are to refine the analytical approaches used to measure retrospective exposures of persistent organic pollutants (POPs) from archived newborn dried blood spots (DBS), and to ensure that methods are valid and meet quality assurance goals.
87. Michigan Bloodspot Environmental Epidemiology Project, Program Round 2, “Advanced Methods for Analysis of Persistent Organic Pollutants in Dried Blood Spots.” S. Batterman, PI, $25,000, 2014-5. The overall goals of the proposed project are to refine the analytical approaches used to measure retrospective exposures of persistent organic pollutants (POPs) from archived newborn dried blood spots (DBS), and to ensure that methods are valid and meet quality assurance goals.

88. NIOSH Educational and Research Center, Dried Blood Spot (DBS) Sampling for Biomonitoring in Occupational Settings.” S. Batterman, PI, $20,000, 7/12/14 – 6/30/15. This pilot project has four specific aims: (1) measurement of BFR levels in blood of workers from electronics/foam recycling facilities; (2) comparison of measurements using DBS and conventional venous blood samples; (3) comparison of BFR levels among waste/recycling workers to those of the general public; and (4) investigation of barriers and opportunities of using DBSs in occupational settings.

14.3 Awarded Grants and Contracts: Internal (all direct costs):

89. Research Incentive Fund, Texas A&M University, Professional Development in Hazardous and Solid Waste Modeling and Assessment, S. Batterman (PI), $2,340 (direct costs), 6/11/87.
91. Center for Teaching Excellence, Texas A&M University, Incentive Grant: Case Study of Hazardous Waste Facility Siting, S. Batterman (PI), $1,000, 4/15/87.
93. Department of Civil Engineering, Texas A&M University, Funds for Gas Chromatograph/Mass Spectrometer, S. Batterman (PI), $2,500, 10/31/88.
94. School of Public Health, University of Michigan, Laboratory Equipment Funds, S. Batterman (PI), $78,000, 9/1/89.
95. Interdisciplinary Grant Program, Office of Vice President for Research, University of Michigan, Deposition and Flux Measurements of Hydrocarbons Using Fast Response Analyzers, S. Batterman (PI), $30,000, 11/1/89 - 5/1/90.
96. School of Public Health, University of Michigan, Repair Funds for Gas Chromatograph/Mass Spectrometer, S. Batterman (PI), $8,000, 12/2/91.
97. Rackham Faculty Grant, University of Michigan, Assessment and Apportionment of Urban Toxics, S. Batterman (PI), $9,968, 5/1/92 - 4/30/95.
98. International Institute, University of Michigan, Fund for Conferences And Workshops, Workshop and Course on Air Quality Modeling, Monitoring and Control in South Africa, S. Batterman (PI), $1,850, 6/1/97-8/1/97.
100. Office of the Vice President for Research and Development, University of Michigan, “Core Research Facilities and Equipment Grant,” S. Batterman (PI), $100,000, 9/10/98.
104. Graham Environmental Sustainability Institute, “Sustainable Control of Water-Associated Diseases – A Systems Approach,” S. Batterman, PI, $5,000, 2/1/08-12/31/08.
105. Graham Environmental Sustainability Institute, “Climate-induced shifts in distributions and environmental health risks of pesticides and other persistent organic pollutants in Arctic ecosystems,” S. Batterman, PI, $20,000. 1/1/11 – 12/31/11.
106. Graham Environmental Sustainability Institute, ”Regional, Spatial and Temporal Mapping of Air Pollution In Detroit”, S. Batterman, PI, $40,000, 4/1/11-3/31/13.
University of Michigan, M-Cubed Project. "Environment and epigenetics in ALS." Feldman (PI), B. Callaghan (Co-Inv), S. Batterman (Co-Inv), $50,000, 6/1/13-5/30/14.