UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
U.S. ARMY	)	Docket No. 40-8838-MLA
	)	
(Jefferson Proving Ground Site)	)	

PREFILED TESTIMONY OF ADAM L. SCHWARTZMAN

Under penalty of perjury, I, Adam L. Schwartzman, declare as follows: I attest that the factual statements herein are true and correct to the best of my knowledge, information, and belief; and the opinions expressed herein are based on my best professional judgment.

Q.1. Please state your name and employment.

A.1. Adam L. Schwartzman. I am an Environmental Scientist in the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research.

Q.2 Are there any acronyms or abbreviations in your testimony that should be identified?

A.2. Yes, the following acronyms or short names have the meanings shown:

The "Staff" refers to the NRC Staff;
"STV" refers to Save the Valley, Inc, the intevenor;
"JPG" refers to Jefferson Proving Ground
"DU" refers to depleted uranium;
"FSP" refers to the Field Sampling Plan as amended and supplemented by the Army;
"APG" refers to Aberdeen Proving Ground;
"LANL" refers to Los Alamos National Laboratory;
"EIS" refers to Environmental Impact Statement;
"EA" refers to Environmental Assessment
"RESRAD" refers to Residual Activity family of computer codes; and
other references as noted in my answer no. 7.

Q.3. What are your job duties and responsibilities as an Environmental Scientist?

A.3. My responsibilities include evaluating issues and answering questions on a variety of environmental issues using and associated with environmental transport models (e.g., RESRAD family of codes). I also work with other offices within the NRC, contractors, and scientists at other Federal agencies (e.g., U.S. Department of Agriculture) on environmental transport-related research.

Q.4. Please provide an example of your work performed as part of your job duties.

A.4. As part of my job duties, I review and evaluate environmental transport-related models and documents, oversee the development and maintenance of the RESRAD family of codes for the NRC, conduct research and provide technical assistance to other offices within the NRC. I am currently participating on a Working Group to update a series of Regulatory Guides associated with environmental monitoring and the reporting of effluent data from nuclear power plants.

Q.5. Please describe your professional qualifications including education, training, work experience, and publications.

A.5. I received a B.S. in Biological Sciences (1997) and a M.S. in Environmental Toxicology (2001) from Clemson University, Clemson, South Carolina. The focus of my Master's thesis was on the performance of a model constructed wetland designed to remove copper and associated toxicity from liquid effluents. During the summer of 1996 and between May 1997 and August 1998 I assisted with a variety of field studies at the Savannah River Site as part of an Oak Ridge Institute of Science and Education fellowship.

During my first two years at the NRC I was a member of the Nuclear Safety Internship Program (renamed to Nuclear Safety Professional Development Program). As part of the internship program, I participated on a variety of different projects related to environmental transport issues while attending a predetermined curriculum of classes designed to provide a general understanding of the functions, activities, and responsibilities of the NRC. I also participated in two rotational assignments during this period. I spent four months evaluating computer codes used to evaluate transport issues regarding licensing and decommissioning of different NRC-licensed sites. I also spent four months as a Visiting Scientist at the U.S. Department of Agriculture in the Agricultural Research Service conducting field experiments on issues related to the movement of groundwater at the watershed-scale.

A list of past publications and presentations are included in my resume, which has been attached to this testimony as “Attachment A”.

Q.6. Please describe your involvement and responsibilities regarding the Staff’s review of the Jefferson Proving Ground application.

A.6. I have reviewed and am familiar with the technical issues pertaining to DU transport via air at JPG. I have specifically reviewed and am familiar with the STV Contention B-1 Basis “M” and Dr. Henshel’s testimony regarding air transport of DU and suggested air monitoring and sampling. After reviewing and analyzing this information, I have reached conclusions as to the validity of her arguments based on my professional opinion.

Q.7. Did you review or rely on any specific documents to prepare for or conduct your analysis and testimony?

A.7. In addition to the Army’s FSP as amended, STV’s Final Contentions, and the testimony of Dr. Henshel, I have reviewed the following items during the preparation of this affidavit:

(1) Williams, G.P., Hermes, A.M., Policastro, A.J., Hartmann, H.M., and Tomasko, D. 1998. Potential Health Impacts from Range Fires at Aberdeen Proving Ground. Report ANL/AED/TM-79, Argonne National Laboratory, Argonne, Illinois (“Williams 1998”);

(2) Memorandum from Corrine Shia of SAIC to Paul Cloud, the Jefferson Proving Ground (JPG) BRAC Environmental Coordinator and Joyce Kuykendall, RSO at APG, dated January 13, 2005 (ML070090201) ("Shia Memo"); and

(3) Whicker et al. (2006) Whicker, J.J., Pinder III, J.E., Breshears, J.D., Eberhart, C.F. 2006. From dust to dose: Effects of forest disturbance on increased inhalation exposure. Science of the Total Environment, 368, 519-530 ("Whicker 2006").

Q.8. Please state your conclusion for Basis "M".

A.8. STV argued that an air sampling plan is needed in the Field Sampling Plan due to the potential for migration of soil-bound DU. Their concern is over the potential for increased doses to the workers and public from inhalation and ingestion of DU-contaminated dust associated with controlled burns conducted at JPG. Although air is a potential exposure pathway to workers and offsite residents, it is my opinion that currently available scientific evidence from studies conducted at both APG and LANL do not support the need for a full-time air sampling program at JPG.

Q.9. Does the Field Sampling Plan include an air sampling component for the public health, and if not, why?

A.9. No, it does not. I believe that the U.S. Fish and Wildlife Service, managers of the Big Oaks National Wildlife Refuge, appear to have based their decision on the results of studies of controlled burns conducted by Williams et al. (1998) at APG, another DU contaminated site. The FSP adopted this conclusion and reasoning.

Q.10. Do you believe that air sampling should be included in the FSP?

A.10. I agree with the conclusion that a full-time air sampling program is not needed in the FSP at JPG because the studies discussed in my subsequent testimony demonstrate that workers and the public are expected to be protected from radiological doses due to air dispersion for the five year period of the license amendment.

Q.11. Does the data collected at APG support your conclusion that a full-time air sampling program is not needed at JPG?

A.11. Yes, it does. The Williams 1998 report evaluated issues similar to those being evaluated for JPG. The primary concern was that contaminants that had accumulated in the soils and vegetation at APG could be mobilized and transported in a smoke plume produced by fires on the site and pose health risks to workers onsite as well as individuals within close proximity to the site. A variety of parameters such as the uptake rate, deposition rate, size of fires, atmospheric conditions, and high but realistic soil concentrations were used to estimate dispersion and possible human exposure to DU. The Williams 1998 study concluded that range fires at APG do not pose significant risks to APG workers or the surrounding populations. Williams 1998 at 50.

Additional research and analysis was conducted to further confirm the conclusions made by the Williams 1998 study. These studies are discussed in a memorandum sent from Corrine Shia to Paul Cloud on January 13, 2005. Shia Memo at 3 - 4. This memo indicates that in October 2000 the Williams 1998 report was updated to include measured air emissions data collected from a controlled burn conducted at APG. Their results showed that model-predicted concentrations were one to two orders of magnitude greater then field-measured concentrations, concluding that the risk of adverse health effects was extremely small. A third report conducted at APG demonstrated that airborne radioactivity levels calculated from air emissions data collected during three controlled burns could not be distinguished from ambient concentrations and were considered not to pose a health risk. Shia Memo at 4. The use of conservative assumptions and the results of site-specific data collected from fires at APG confirm the conclusion that risks from the mobilization of DU from fires is extremely small. As a result of this analysis, the data does not support the need for a full-time air sampling program at JPG, a site similar to APG.

Q.12. Are you familiar with the LANL study, and if so please describe it.

A.12. Yes, I am familiar with it. One of the primary goals of the LANL study was to assess the potential for an increase in dose from uranium contaminated soils via wind-driven suspension resulting from a wildfire (e.g. the Cerro Grande Fire) and subsequent controlled burns for forest thinning at LANL. Whicker 2006 at 519. Measurements of uranium air concentrations were taken and compared with wind velocity and seasonal variations in vegetation cover to determine whether disturbances such as fire should be a concern because of a potential increased inhalation exposure.

Q.13. What are the conclusions of the LANL study?

A.13. The Whicker 2006 study concludes that although disturbances such as fires would likely increase contaminant transport, within the site-specific context of LANL, only a minimal dose potential from uranium inhalation by LANL workers following each disturbance will occur.

Q.14. Does the LANL data support your conclusion that a full-time air sampling program is not needed at JPG, and if so, how?

A.14. Yes, it does. The data in this study does show that doses associated with uranium attached to airborne particulates at the perimeter of LANL increased minimally. Basis "M" of Contention B-1 is misleading by referencing increases as percents and not actual doses to individuals. For example, although doses to workers from a "moderate" controlled burn increased 15% and by as much as 38% after more intensive fires, the actual increases in the dose were minimal. Further review of the study shows values calculated for the estimated average dose to workers on the site after a "moderate" controlled burn (including 2 standard deviations to consider post-disturbance conditions) were still < 1 μSv/yr (< 0.1 mrem/yr). The upper-bound dose rate for workers exposed to a "severely burned" site, was calculated to be 140 μSv/yr (14 mrem/yr), less than 1% of the annual dose limit for an occupational worker (5 X

10-4 μSv/yr; 5 X 10-3 mrem/yr).

These estimated dose rates suggest that despite increases in airborne concentrations following disturbances such as controlled burns or forest fires, the total doses received by workers and the public remain comparable to average background dose rates received from natural background sources (e.g., cosmic, terrestrial, radon). Whicker 2006 at 528.

Q.15. Should any air sampling for the FSP be completed at JPG during the alternate schedule period? Why or why not?

A.15. No, I do not believe it is necessary to make air sampling a part of the FSP. I believe that the studies I have cited support the conclusion that air transport of DU during this license amendment period is not a threat to the public health (i.e. hypothetical offsite receptors or workers at JPG) during the five year period of the license amendment.

<u>Rebuttal to STV's Prefiled Testimony of Dr. Henshel</u>

Q.16. Have you read the pre-filed direct testimony of Dr. Diane S. Henshel.?

A.16. I have read the portions of the prefiled direct testimony Dr. Henshel pertaining directly to air sampling. Specifically, this includes Section IV., Air Sampling, of the prefiled direct testimony.

Q.17. What is your opinion of Dr. Henshel's testimony?

A.17. After reading Dr. Henshel's pre-filed direct testimony numbered A.033 – A.037, it is my opinion that a full-scale air sampling program is not needed at this time.

Dr. Henshel's initial conclusion and reasoning are based on what she interprets as outdated data in the Williams 1998 report. According to Dr. Henshel's testimony, this report is the basis for the U.S. Fish and Wildlife Service's decision not to monitor air dispersion from controlled burns conducted on the JPG site. The study considers a variety of parameters, different atmospheric conditions, and high but realistic soil concentrations to conservatively estimate dispersion and possible human exposure to DU at APG. The report concludes that fires at APG do not pose significant health risks to workers or the surrounding population.

Dr. Henshel's testimony does not appear to consider any of the additional research that further confirms the conclusions made in the Williams 1998 report. The Shia Memo discusses two additional studies at APG that confirm the conclusions made by the Williams 1998 study. Shia Memo at 3 - 4. In October 2000, the Williams 1998 report was updated to include measured air emissions data from a controlled burn conducted at APG. The updated report, which used measured contaminant levels to calculate estimated ground-level contaminant concentrations showed that model predicted concentrations were one to two orders of magnitude greater then field measured concentrations and concluded that the risk of adverse health effects from the mobilization of contaminants from fires is extremely small. Results of a third study conducted at APG demonstrated that airborne radioactivity levels calculated from air emissions data collected during three controlled burns could not be distinguished from ambient concentrations and were considered not to pose a health risk. Shia Memo at 4. The conservative assumptions used in the Williams 1998 report to model the exposure of workers and the public from ground-level DU concentrations released into the air as a result of fires as well as site-specific data used to further evaluate human health impacts at APG confirm that the risks from the mobilization of DU from fires is extremely small.

Instead of using the Williams 1998 report and the related follow-on work at APG, Dr. Henshel references the results of studies conducted by scientists at LANL, a more arid ecosystem compared to both APG and JPG. Although the concentrations of airborne DU measured at the perimeter of the entirety of the LANL property following prescribed burns similar to those conducted in the DU Impact Area at JPG do show an increase in the percentage (14% on average) of airborne DU, the potential doses to LANL workers and members of the public are shown to be minimal as stated above in my response to Basis “M”.

The studies discussed above indicate that the risks associated with potential transport of

DU in the air from fires are negligible. Although analysis of the fires at LANL shows an increase in the percentage of airborne depleted uranium, the actual increase in dose is minimal. Experiments associated with the APG also indicated that airborne radioactivity levels could not be distinguished from ambient concentrations and can be considered not to pose a health risk. Neither of these reports provides enough information to justify the development of a full-scale air sampling program at JPG. The existing studies provide the data necessary to answer the question regarding potential doses to workers and the public at JPG without implementing a full-time, full-scale air sampling program at JPG, which is not necessary at this time.

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PREFILED TESTIMONY OF ADAM L. SCHWARTZMAN

I, Adam L. Schwartzman, do declare under penalty of perjury that my statements in the foregoing testimony and my attached statement of professional qualifications are true and correct to the best of my knowledge and belief.

/Original Signed By/
____
Adam L. Schwartzman

Executed at Rockville, MD
This 17th day of August, 2007.

Attachment A

Adam L. Schwartzman
United States Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
11555 Rockville Pike
Rockville, Maryland 20852

Education

M.S., Environmental Toxicology, December 2001
Clemson University, Clemson, SC
Thesis: Evaluating the Performance of a Model Constructed Wetland System Designed for Decreasing Concentrations and Bioavailability of Copper in Water

Oak Ridge Institute for Science and Education (ORISE) Fellowship, May 1997 – August 1998 & Summer 1996
Westinghouse Savannah River Company, Savannah River Site, SC

B.S., Biological Sciences, May 1997
Clemson University, Clemson, SC

Work Experience

Environmental Modeling Scientist / Project Manager, Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission, Rockville, Maryland, September 2004 – Current.

RESRAD Project Manager

- Coordinate project objectives and tasks with other NRC offices, Project Managers at the Department of Energy, and Argonne National Laboratory
- Interact with the user offices to insure that models contain the necessary functions required; work to improve the models based on the needs of the user offices
- Research and evaluate different scenarios, parameters, and assumptions used by the model to estimate doses to individuals associated with these scenarios
- Applied RESRAD to evaluate the impact of the fish consumption pathway on the overall dose to the public

Sorption Project Manager

- Coordinate the project objectives, tasks, and deliverables with other NRC offices and the United States Geological Survey staff performing the research
- Review and comment on draft reports and other deliverables, focusing on how this information can be used by the NRC staff

Utilize available models and data to answer questions from NRC staff and the public related to the transport of contaminants through various media via assorted environmental pathways and assess their impacts (i.e., dose)

Radiation Information Conference Session Organizer (for 2007 meeting)

- Develop a program that provides attendees with insights into the overall modeling process, estimation of parameters, identification of uncertainties, and use of monitoring information to evaluate results and understand dose estimates
- Coordinated with the speakers on the specific topics and other administrative arrangements
- Acted as a liaison between the session chair, speakers, and conference organizers

Work with other NRC staff to update and revise Regulatory Guides to meet current regulations and technologies

Environmental Modeling Scientist / Nuclear Safety Intern, Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission, Rockville, Maryland, May 2002 – September 2004.

Attended formal classroom training courses on a variety of topics related to nuclear power, health physics, emergency preparedness, statistics, and communications

Completed a rotational assignment in the Office of Nuclear Materials Safety and Safeguards
- Verified the Total Performance Analysis (TPA) code which was designed to evaluate a variety of scenarios associated with the possible licensing of the Yucca Mountain repository
- Used RESRAD to evaluate different scenarios and risks associated with the decommissioning of NRC-licensed sites
- Assisted in the ranking of the Key Technical Issues (KTIs) related to Yucca Mountain

Completed a rotational assignment as a Visiting Scientist at the United States Department of Agriculture's Agricultural Research Service, Beltsville, Maryland
- Conducted a series of field studies to evaluate uncertainty estimates associated with various groundwater recharge methods
- Performed tracer studies to evaluate the movement of groundwater in a field setting
- Evaluated surface-subsurface flow interactions in a field setting
- Utilized a variety of instruments (e.g., ISCO water sampler, groundwater wells, weather station) and computer software (e.g., Flowlink, HYDRUS, Mathcad) to collect and analyze environmental data (e.g., rainfall, evapotranspiration, groundwater samples, surface water runoff)

Developed and implemented an environmental effluent database accessible through the internet
- Assist with the design of the database structure
- Entered data from annual effluent reports submitted to the NRC from nuclear power plants
- Formulated and implemented a quality assurance/quality control program to evaluate the data entered into the database
- Publicized the content and availability of the database to stakeholders and the public
- Worked with Project Managers in the Office of Nuclear Reactor Regulation, NRC regional staff, and staff at the nuclear power plants to correct errors found in the effluent release reports

Research Assistant, Dr. John H. Rodgers, Jr., Clemson Institute of Environmental Toxicology, Department of Environmental Toxicology, Clemson University, Pendleton, SC, August 1998 – December 2001.

Evaluated the ability of a specifically designed model constructed wetland to remove aqueous copper concentrations and associated toxicity to *Ceriodaphnia dubia* from wastewater

- Measured copper concentrations associated with the inflow, outflow, sediment, and vegetation
- Investigated different techniques used to measure aqueous copper concentrations
- Evaluated wetland processes associated with the removal of copper from wastewater
- Assessed potential risks associated with the removal of copper from wastewater to organisms

Evaluated the effects of three forms of copper (copper sulfate, Cutrine-Plus, Clearigate) to algae (*Raphidocelis subcapitata)* and non-target organisms

Evaluated the influence of two plant species and two sediment types, in various combinations, on oxidation-reduction potential.

Conducted aqueous and sediment toxicity experiments

Maintained *Scirpus californicus, Chironomus tentans*, *Hyalella azteca*, *Daphnia magna*, *Ceriodaphnia dubia*, *Pimephales promelas*, and *Raphidocelis subcapitata* cultures, including set-up, maintenance, cleaning, feeding, and reference toxicity experiments

ORISE Fellowship, Dr. David Dunn, Environmental Analysis Section, Westinghouse Savannah River Technology Center, Savannah River Site, Aiken, SC, May 1997 – August 1998, Summer 1996.

Planned and implemented a groundwater surface water interface project

- Wrote the sampling and analysis plan
- Collected water samples and sent them for analysis; Measured water chemistry characteristics
- Entered results into a database used to analyze chemical interactions between ground and surface water and qualify the use of a multi-level water sampling well

Conducted a baseline chemical analysis of water quality indicators and collected sediment and water samples from an on-site lake

- Maintained records in spreadsheets
- Developed contour maps and graphs with the data to display results

Described a tritium plume in a riparian wetland

- Measured tritium levels in a riparian wetland
- Analyzed results in report “Tritium Sampling Along Transects in the Fourmile Branch Delta”

Measured water levels in wells along two seepage basins and compiled results in a summary report “Monitoring of Water Levels in Wetlands of Fourmile Branch Near F- and H-Areas of SRS, FY97”

Qualified the use of a field fluorometer to measure real-time dispersion rates of contaminants in streams via fluorescent tracer studies

Sampled sediment and water in a radioactive contaminated three square mile lake as part of a risk assessment

Assisted in the capturing of largemouth bass and dissecting of otoliths for analysis of fish age as well as the chemical history of the lake
Collected water samples at specific locations in the Savannah River Site for the Savannah River Ecology Laboratory, University of Georgia to track contaminant distribution

Assisted in electrofishing exercises on site streams in order to characterize the health of the individual streams using the Index of Biotic Integrity (IBI)

Updated a central database of bioconcentration factors across a wide range of wildlife and plant material by coordinating the collection of data from different investigators on the site

Awards

2001 International Paper Environmental Excellence Award

Society of Environmental Toxicology and Chemistry “Best Student Poster” for “Constructed Wetland Design for Decreasing Copper Bioavailability Associated with an Aqueous Matrix. “ November 2000.

Savannah River Technology Center Vice President’s Award for “A-01 Outfall Wetland Treatment Confirmation Study” March 2000.

Publications

Huddleston, III, G.M., J.H. Rodgers, Jr., S.M. Harmon, C.L. Murray-Gulde, A.L. Schwartzman, J.B. Gladden, W.L. Specht, and E.A. Nelson. *In Review*. Comparison of constructed wetland mesocosms for treatment of copper-contaminated wastewater. *Ecological Engineering*.

Murray, C.L., J.E. Heatley, and A.L. Schwartzman. 2002. Algicidal Effectiveness of Clearigate, Cutrine-Plus, and Copper Sulfate and Margins of Safety Associated with Their Use. *Archives of Environmental Contamination and Toxicology*. 43(1):19-27.

Schwartzman, A.L., 2001. Evaluating the Performance of a Model Constructed Wetland System Designed for Decreasing Concentrations and Bioavailability of Copper in Water. Thesis.

Dunn, D.L., K.L. Dixon, R.L. Nichols, A. Schwartzman, R. Roseberry. 1998. Using Stratasampler™ Multi-Level Wells to Examine the Hyporheic Zone Within a Riparian Wetland. WSRC-TR-98-00046. Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Dixon, K.L. and A.L. Schwartzman. 1997. Monitoring of the Water Levels in the Wetlands of Fourmile Branch near the F- and H-Areas of SRS: FY97. WSRC-TR-97-O0318. Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Friday, G.P., C.L. Cummins, and A.L. Schwartzman. 1996. Radiological Bioconcentration Factors for Aquatic, Terrestrial, and Wetland Ecosystems at the Savannah River Site (U). WSRC-TR-96-0231. Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Presentations

Dehmel, J.C., Schwartzman, A.L., and Lewis, D.E. (2005). Controlling the Release of Potentially Clearable Soils – An Overview of NRC Staff Analysis. Presented at the 50th Annual Meeting of the Health Physics Society. July 2005. Spokane, WA.

Schwartzman, A.L. (2004). Development of an Environmental Effluent Database. Presented at the 2004 Nuclear Safety Research Conference. October 2004. Washington, D.C.

Murray-Gulde, C.L., Heatley, J.E., Schwartzman, A.L. and Rodgers, Jr., J.H. (2001) Toxicity of Clearigate, Cutrine-Plus and Copper Sulfate to Raphidocelis subcapitata, Ceriodaphnia dubia and Pimephales promelas. Presented at the 22nd Annual Meeting of the Society of Environmental Toxicology and Chemistry. November 2001, Baltimore, MD.

Schwartzman, A.L., Huddleston, III, G.M., and Rodgers, Jr., J.H. (2000). The Role of *Scirpus californicus* (giant bulrush) in Constructed Wetlands for Remediation of Copper-Contaminated Wastewater. Presented at the 21st Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 2000, Nashville TN.

Huddleston, III, G.M., Schwartzman, A.L., and Rodgers, Jr., J.H. (2000). Constructed Wetland Design for Decreasing Copper Bioavailability Associated with an Aqueous Matrix. Presented at the 21st Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 2000, Nashville TN.

Schwartzman, A.L., Huddleston, III, G.M., and Rodgers, Jr., J.H. (2000). A Constructed Wetland Design for Decreasing Copper Bioavailability in an Aqueous Matrix. Clemson University Graduate Student Research Forum, April 2000, Clemson SC.

Schwartzman, A.L., Huddleston, III, G.M., and Rodgers, Jr., J.H. (2000). A Constructed Wetland Design for Decreasing Copper Bioavailability in an Aqueous Matrix. Carolinas Regional Society of Environmental Toxicology and Chemistry Annual Meeting, March 2000, Wilmington, NC.

Schwartzman, A.L., Mastin, B.J., and Rodgers Jr., J.H. (1999). The Role of Plants for Influencing Redox Potential in the Root Zone in Different Hydrosoils. Presented at the 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 1999, Philadelphia, PA.

Huddleston, G.M., Schwartzman, A.L., and Rodgers Jr., J.H. (1999). Risk Mitigation of a Complex Effluent Using Constructed Wetlands. Presented at the 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 1999, Philadelphia, PA.