BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

NOTICE

TO: Dorothy Gunn
Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

SEE ATTACHED SERVICE LIST

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the TESTIMONY OF RICHARD E. AYRES, THOMAS C. HORNSHAW, Ph.D., GERALD KEELER, Ph.D., DEBORAH RICE, Ph.D., CHRISTOPHER ROMAINE, JIM ROSS, JAMES E. STAUDT, Ph.D., and MARCIA WILLHITE, a copy of which is herewith served upon you.

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: _____
Gina Roccaforte
Assistant Counsel
Division of Legal Counsel

DATED: April 27, 2006

1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276
217/782-5544

THIS FILING IS SUBMITTED ON RECYCLED PAPER

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES (MERCURY)	)	

TESTIMONY OF RICHARD E. AYRES

Qualifications

My name is Richard Ayres. I am the principal in the Ayres Law Group, located at 1615 L Street, N.W., Suite 1350, Washington D.C. My legal practice concentrates on the Clean Air Act ("CAA"), with which I have been professionally involved since the first major federal clean air legislation was passed in 1970.

I graduated with honors in 1964 from Princeton University's undergraduate program in the Woodrow Wilson School of Public and International Affairs. In 1969 I received an Ll.B. from Yale Law School, together with an advanced degree in Political Science from Yale University.

In 1970, I co-founded the Natural Resources Defense Council ("NRDC"), now one of the leading environmental organizations in the world. I was one of two attorneys who headed the organization's Clean Air Act work. At NRDC, where I worked until 1991, I was involved in shaping the nation's clean air law and policies in all three branches of the federal government.

In 1991, I entered the private practice of law, becoming a partner in O'Melveny & Myers, a large international law firm headquartered in Los Angeles, where I headed the environmental department in the Washington office. In 1996, I became a partner in the large national law firm of Howrey Simon Arnold & White of Washington, D.C. In 2001, I opened my own law firm, which represents industry, State governments, and individuals, almost entirely in air pollution-related matters. My clients have included companies in automobile, diesel engine, transportation, electric power, oil, natural gas, chemical, pulp and paper, small engine and pollution control industries, as well as State governments and individuals. I represent clients before the federal Environmental Protection Agency (USEPA) and the federal courts.

In 2005, I was asked by the national organizations of State and local air pollution control officials, known as the State and Territorial Air Pollution Program Administrators ("STAPPA") and the Association of Local Air Pollution Control Officials ("ALAPCO"), to advise and assist them with developing a Model Rule for control of mercury emissions from large coal-fired electric generating plants. This project reflected widespread disenchantment among State and local air pollution officials with the mercury rule adopted by the USEPA. Under the direction of the organizations' mercury control

committee, I served as draftsman of the Model Rule document published in October, 2005.

Subsequently I was asked by the Illinois Environmental Protection Agency to assist the agency with the mercury control rule now before the Board. In that connection I have served as a resource and advisor to the staff of the Illinois EPA on the rule now before you.

I will testify regarding the legal and policy aspects of the federal mercury rule and the CAA, the STAPPA/ALAPCO Model Rule, and the Illinois mercury rule.

The Federal "Clean Air Mercury Rule" ("CAMR")

Since 1970, the CAA has provided for federal regulation of emissions of "hazardous air pollutants" ("HAPs"). In 1970, Congress directed USEPA to establish standards for HAPs that would "protect public health with an ample margin of safety." Clean Air Amendments of 1970, Section 112. In 1990, in response to USEPA's failure to implement the mandated program effectively, Congress amended Section 112 into its current form. 42 U.S.C. 7412.

The revised Section 112 directed USEPA to set technology-based emission limitations for all sources of HAPs. The law listed more than 180 HAPs, including mercury. For each source category of HAPs, USEPA was required to write "Maximum Available Control Technology" ("MACT") emission standards. § 7412(d). To the extent that a MACT standard is insufficient to protect public health, USEPA is also required to establish more stringent standards to protect public health with an ample margin of safety. § 7412(f).

With respect to electric generating units ("EGUs"), the largest category of mercury emitters, the CAA provides a special process. §7412(n). USEPA must conduct a study and report to Congress, not later than November 15, 1994, regarding the hazards to public health posed by mercury emissions from EGUs. If USEPA concludes that it is "appropriate and necessary," the agency must regulate mercury emissions from EGUs. §7412(n)(1)(B).

USEPA did not transmit the required report to Congress until 1998. Even then, the Final Report deferred making the finding whether regulating mercury emissions from EGUs was "appropriate and necessary."

Two years later, in 2000, USEPA finally issued a finding that "regulation of HAP emissions from coal- and oil-fired utility steam generating units under Section 112 is appropriate and necessary." At the same time, USEPA added these units to the list of sources that are subject to MACT standards under Section 112(c) the CAA.

Beginning in 2001, USEPA convened a stakeholder process under the Federal Advisory Committee Act ("FACA") to provide input on the federal mercury HAP standard. The FACA committee included representatives from federal, State and local governments, industry and environmental organizations. The Committee met 14 times over an 18 month period, thoroughly analyzing the issues involved in regulating emissions from EGUs.

In 2004, however, USEPA abruptly terminated the FACA committee and reversed regulatory course. It proposed, and then adopted, federal regulations that (1) removed coal and oil-fired EGUs from the list of HAP emitters under §112(c); (2) eschewed setting any MACT standard for EGUs; and, (3) adopted instead a mercury cap and trade program it described as a New Source Performance Standard ("NSPS") under Section 111, 42 U.S.C. 7411.

This "Clean Air Mercury Rule" ("CAMR"), as USEPA called it, ignored the advice of a FACA stakeholder committee, including State and local officials and representatives of the electric utility industry. State and local representatives in the FACA process had called for unit-by-unit emissions standards reflecting the greatest reduction in emissions technically feasible. They rejected emission trading for HAPs, which would not assure emissions reductions at every HAP source. And they encouraged USEPA to provide an enhanced role for States in implementing the standard. CAMR was contrary to this advice on every point.

CAMR broke entirely unprecedented legal and policy ground. As the comments submitted by Illinois EPA pointed out, USEPA's proposal for a "cap and trade" NSPS was unprecedented as policy and created unnecessary legal risks. In the 34 years preceding CAMR that Sections 111 or 112 have been in the CAA , the agency has never interpreted either of them in this way. Nothing in the language or legislative history of the CAA, previous EPA regulations, or court decisions supports the legal theory that HAPs can be regulated under a Section 111 NSPS, rather than by a HAP standard under Section 112. Prior to CAMR, USEPA had adopted MACT regulations under Section 112 for every one of the source categories of HAPs it had regulated.

Moreover, nothing in the language or history of the CAA, previous EPA regulations, or court decisions provided a legal basis for establishing a "cap and trade" NSPS. Since 1970, when NSPS came into the CAA, USEPA has always interpreted NSPS as requiring unit-by-unit technology-based standards, and has never attempted to adopt a standard implemented with a cap and trade program, nor claimed any such authority.

USEPA's new interpretation has very serious implications for air pollution control policy. Unlike Section 112, Section 111 does not provide authority to impose additional pollution reduction requirements if installation of available control technology is not sufficient to protect public health. So under the CAMR theory, USEPA would be powerless to require greater control of mercury emissions based on public health needs if the CAMR cap proved inadequate. Another consequence of adopting a cap and trade program is that the regulator cannot guarantee each unit will install available emission

control technologies. If the owner or operator wishes, he or she may comply with the CAMR cap at a given unit or plant using emission allowances rather than reducing pollution. Such a compliance strategy would not provide protection for public health for the people affected by the plant's emissions. When the pollutants in question are HAPs, a cap and trade program creates obvious questions of equity, and, depending on who lives in the area affected by the emissions, of environmental justice.

Illinois submitted comments that were critical of the USEPA proposal. The State pointed out that mercury is a highly potent neurotoxin, particularly harmful to developing fetuses and young children. Because of the presence of mercury in fish, all of Illinois' water bodies have fish consumption advisories. The State urged USEPA to adopt MACT standards for mercury emissions from EGUs under Section 112 of the CAA.

The State also commented that USEPA should adopt much more stringent mercury emission limitations. Illinois particularly criticized USEPA's proposal to require no emission reductions until 2018, other than whatever incidental "co-benefits" might flow from installation of emission controls for sulfur and nitrogen oxides after 2010. Illinois also criticized the proposed 2018 standard because, as USEPA acknowledged, "banking" of "early reduction allowances," might prevent the national CAMR "cap" from be achieved before 2028.

The State also opposed mercury emission trading, because of the potential for leaving some citizens less protected where EGUs decide to use mercury allowances for compliance rather than reducing emissions.

Finally, Illinois commented that any mercury rule should be fuel neutral, with a common standard for bituminous and subbituminous coal. The State noted that the limits for new sources using subbituminous coal in the USEPA proposal were so lax that they "are tantamount to no control."

USEPA received over 500,000 comments on its proposals – the most ever received by the agency on a regulatory proposal. They were overwhelmingly critical of the CAMR proposal. Most urged USEPA to abandon the cap and trade NSPS approach and return to the approach of setting MACT standards applicable to each EGU.

Members of the FACA committee commented that it had never discussed the notion of regulating mercury from EGUs with an NSPS under Section 111. They also noted that the NSPS USEPA proposed (and subsequently adopted) was more lenient than FACA representatives of the electric power industry had already agreed was reasonable.

In May, 2005, USEPA promulgated a model emission cap and trade program, and State-by-State mercury emission budgets, These budgets are applicable whether or not a State chooses to adopt the Model Rule. The national cap for 2010 is set at 38 tons; in 2018, a national cap of 15 tons takes effect. Because the rule allows for trading and banking, USEPA projects that even by 2020, emissions will still be 24.3 tons, reduced by only 50 per cent from the 1999 baseline. It is important to note that the existence of a statewide

emissions "cap" does not mean that mercury emissions from EGUs will necessarily ever be less than the cap. Under CAMR, owners of Illinois EGUs could meet some or all of their obligations by buying mercury allowances from outside the State rather than by reducing emissions. Moreover, CAMR provides that USEPA must issue additional allowances if the mercury allowance price exceeds a pre-established trigger.

CAMR does not require States to use the USEPA model "cap and trade" program or any other "cap and trade" program. States are required to submit a State Plan demonstrating that the State will meet the assigned mercury budget. States are therefore free to address the problem of mercury emissions from EGUs through alternative programs, including ones that require a percentage emission reduction from each EGU or establish a specific emission standard applicable to each EGU as the proposed Illinois program does.

Because of the deficiencies in the CAMR perceived by State air pollution control authorities, fourteen States, including Illinois, filed a Petition for Reconsideration with USEPA in May, 2003. The Petition asked USEPA to convene a proceeding to reconsider CAMR, and in the meantime to stay the effectiveness of its decision to remove coal and oil-fired units from the Section 112(c) list of sources of HAPs.

Senators from both parties also attempted to nullify CAMR by Congressional action. S.J. Res. 20, which would have overturned the NSPS "cap and trade" program and ordered USEPA to adopt MACT standards under Section 112(d) of the CAA was defeated narrowly in the Senate, by a 51-47 vote.

Illinois and other parties also filed petitions for review of CAMR in the United States Court of Appeals for the District of Columbia Circuit challenging the legality of CAMR. *State of Illinois v. Environmental Protection Agency,* Dkt. Nos. 05-1174 and 05-1189 (D.C. Cir.); *See also, State of New Jersey, et al., v. United States Environmental Protection Agency,* Dkt. No. 05-1097 and consolidated cases. These petitions ask the D.C. Circuit to invalidate CAMR and require USEPA to establish a standard under Section 112 of the CAA. They are currently pending.

The STAPPA/ALAPCO Model Rule

As previously described, the associations of State and local air pollution control officials, STAPPA/ALAPCO, were part of the FACA process. STAPPA/ALAPCO submitted comments strongly critical of the proposed CAMR on many of the same grounds cited by the Illinois EPA. When USEPA adopted CAMR over the objections of many State air pollution officials, STAPPA/ALAPCO formed a committee of State officials to develop an alternative model rule to provide guidance to States that wished to adopt a more effective rule than CAMR. The STAPPA/ALAPCO Model Rule represents the consensus of many State air pollution officials on a feasible and reasonable program for controlling mercury emissions from coal-fired EGUs. As STAPPA/ALAPCO described it,

> The STAPPA/ALAPCO mercury Model Rule ("Model Rule") for coal-fired electric generating units ("EGUs") is intended to provide State and local governments the tools needed to obtain reductions in mercury emissions required to meet the requirements of the Clean Air Act ("CAA"). The Model Rule would protect the public health using technologies that are available and rapidly entering the commercial market.

Though based on the accumulated knowledge of State and Local air pollution control officials regarding the state of the art in mercury emission reduction technology, these standards do not specify or require any particular technology or method. The objective is to identify achievable emission reductions that will protect public health, and to stimulate the rapid commercialization of additional mercury control technologies and methods to achieve those reductions.

In addition to Illinois , sixteen States – including Pennsylvania, Michigan, and Maryland – are currently considering or have already adopted alternatives to CAMR based on the Model Rule.

The Illinois EPA proposal is similar to the STAPPA/ALAPCO Model Rule in many respects. All of the following features of the Model Rule are found in the Illinois EPA proposed mercury rule. The Model Rule requires that owners and operators of EGUs expeditiously adopt available and reasonable emission reduction measures to protect public health. The Model Rule also phased in the standards over time. Similarly, the Model Rule provides owners and operators a number of options to give them greater flexibility in making the required emission reductions. The Model Rule specifies the same standard, regardless of coal type. It allows compliance with either a percentage reduction requirement or an emission standard related to the electrical output of the EGU.

One compliance option in the Model Rule would require 100 per cent of an owner or operator's EGUs to achieve 80 per cent capture of inlet mercury beginning December 31, 2008,[1] and increase mercury capture to 90-95 percent at each plant site by December 31, 2012. The second option would require an owner or operator to capture 90-95 per cent of inlet mercury, but compliance could be postponed to the end of 2012 for a group of units generating no more than 50 percent of the total electricity generated by the owner or operator upon agreement to take certain extra steps starting December 31, 2012: capture 90-95 percent of inlet mercury, and also meet specified standards for reducing emissions of sulfur oxides and nitrogen oxides.

Like the Illinois proposal, STAPPA/ALAPCO's Model Rule prohibits emission trading. Also like the proposed Illinois rule, the Model Rule allows compliance to be demonstrated by averaging among in-state plants in Phase I, and averaging at a plant site

[1] It should be noted that the Model Rule's percentage reduction standards are specified in terms of capture of "inlet" mercury, defined as average concentration of mercury in flue gas at the inlet of the emission control device immediately downstream of the boiler. Thus the Model Rule would give no credit for mercury removed by, e.g., pretreatment of coal ("coal washing"). Since the Illinois proposed rule does give credit for pretreatment, it cannot be said which is more stringent.

in Phase II. Compliance with the STAPPA/ALAPCO Model Rule is demonstrated on a rolling 12 month average, just as in the proposed Illinois rule. In order to prevent in-state EGU's from selling CAMR allowances to upwind States, which could defeat the objective of the rule, both the Illinois proposal and the STAPPA/ALAPCO Model Rule would not distribute federal CAMR allowances.

The 90-95 percent range in the emission limitation in the Model Rule is in recognition of today's uncertainty about the ultimate capability of technologies to remove mercury. The members of the STAPPA/ALAPCO committee were persuaded that, using currently demonstrated technologies, existing EGUs are capable of capturing at least 90 percent of inlet mercury on the timetables provided in the Model Rule. Some STAPPA/ALAPCO members were convinced that greater reductions – of at least 95 percent – can be achieved on the specified timetables. Indeed, Massachusetts' regulations already require 95 percent capture of inlet mercury by 2012. Experience with other pollution control technologies and methodologies suggests that pollution reduction efficiencies will turn out to be greater, and costs lower, than today's most optimistic predictions.

The Illinois Mercury Rule

As noted previously, the proposed Illinois Mercury Rule is patterned closely after the STAPPA/ALAPCO Model Rule. Its purpose is to address the serious health issues associated with mercury emissions, as emitted mercury works its way up the food chain to humans. Findings suggesting that the emissions from coal-fired power plants are limiting the personal and economic futures of a substantial numbers of kids being born in Illinois seems sufficient reason to apply reasonable measures to eliminate the emissions. As the TSD describes, the Illinois EPA has already taken steps to curtail exposures to mercury from almost every other significant mercury source category. The proposed regulation addresses the single source category that contributes the largest amount of mercury to the environment – electricity generation by coal-fired power plants.

a. Flexibility in the Illinois proposal

As the TSD and the testimony of the experts show, the proposed Illinois Mercury Rule achieves the maximum public health protection, while keeping the program flexible and economically reasonable. The proposed rule requires 90 percent reduction of mercury emissions, but this requirement is softened by important sources of flexibility in the program. First, the emission standard is expressed into ways: (1) as a percentage reduction of input mercury; and (2) as an emission output standard, in units of emissions allowed per unit of electricity production. The latter is crafted to allow owners and operators of EGUs to get credit towards meeting the standard for any operation, prior to combustion as well as in the boiler, that reduces mercury emitted from the power plant. By giving credit for coal washing, this provision assures that the playing field is leveled for Illinois bituminous coal, whose use is predicted to increase under the proposed Illinois Mercury Rule.

Second, the proposed Illinois Mercury Rule allows for in-state emissions averaging in both phases. In effect, the proposed mercury standard can be met on an Illinois "fleet" basis after 2009, and on a plant basis at the beginning of 2013.

Third, the proposed rule provides for an exemption for units that will be retired within a specified time. This exemption eliminates the possible unfairness of requiring investment in mercury control technology for a unit that has a very limited useful life.

The proposal does not include an exemption for units that claim technological inability to achieve one of the two standards in the rule. In this it parallels the STAPPA/ALAPCO Model Rule. The committee of air pollution officials who wrote the Model Rule concluded, after reviewing the state of the technology to control emissions of mercury from power plants, that the flexibility already in the Model Rule (which is very similar to that in the Illinois proposal) would be sufficient.

b. Architecture of the Illinois Program

An important question about the proposed Illinois program is whether it will gain the approval of USEPA under CAMR. Obviously, the proposed program differs in many respects from the CAMR. But CAMR does not require States to adopt a program exactly like the model cap and trade program provided by USEPA. It requires only that a State program be at least as demanding, in terms of emission reductions, as CAMR. The proposed Illinois program passes that test. Thus the mercury control program proposed by the Illinois EPA is consistent with the USEPA regulations. Because the Illinois EPA proposal will make substantially greater emission reductions on a more accelerated timetable than required to meet USEPA's emission cap for Illinois, USEPA is bound by CAMR to approve the Illinois regulation.

It might be asked whether, since Illinois has commented in favor of using a MACT standard under Section 112 of the CAA rather than USEPA's Section 111 NSPS approach, the State is therefore bound to fashion its standard using the process and criteria specified in Section 112. In my view, it is not. For many years the CAA has preserved the right of States to adopt more stringent requirements than requested by USEPA, *see* CAA Section 116, 42 USC 7416, and the courts have upheld this right. Moreover, in view of the fact that USEPA removed mercury from the list of HAPs under Section 112(c) of the CAA, it would be extremely difficult for the agency now to insist that the States must be bound by the strictures of that section.

Biographical Information for

Richard E. Ayres, Esq.

Richard Ayres graduated with honors in 1964 from Princeton University's undergraduate program in the Woodrow Wilson School of Public and International Affairs. In 1969 Mr. Ayres received an Ll.B. from Yale Law School, together with an advanced degree in Political Science from Yale University. He was an editor of the Yale Law Journal, and received the Perez Prize, a faculty award for the best student-authored article.

In 1970, Mr. Ayres co-founded the Natural Resources Defense Council (NRDC), now one of the leading environmental organizations in the world. At NRDC, where he worked until 1991, he was influential in shaping the nation's clean air policies in all three branches of the federal government.

In 1991, Mr. Ayres entered the private practice of law, becoming a partner in O'Melveny & Myers, a large international law firm, headquartered in Los Angeles. He headed the environmental department in the firm's Washington office. In 1996, he became a partner in the large national law firm of Howrey Simon Arnold & White of Washington, D.C. In 2001, Mr. Ayres opened his own law firm, which represents industry, state governments, and individuals, almost entirely in air pollution-related matters. His clients have included companies in automobile, diesel engine, transportation, electric power, oil, natural gas, chemical, pulp and paper, small engine and pollution control industries, as well as state governments and individuals. He represents clients before the U.S. EPA and the federal courts.

Mr. Ayres has handled nearly three dozen cases in the federal appellate courts, including the Supreme Court of the United States, and handled cases before the federal district courts. These cases involved the interpretation and enforcement of the Clean Air Act, the National Environmental Policy Act, and state common law doctrines. He argued *Train v. NRDC* (1975) and *Vermont Yankee Nuclear Power Corporation v. NRDC* (1977) before the Supreme Court. In 1980 Mr. Ayres achieved the largest single reduction in pollution in American history in litigation in multiple federal district courts n cases against the Tennessee Valley Authority (TVA), then the nation's largest emitter of sulfur oxides. The settlement resulted in a reduction of five percent of the entire national emissions of sulfur dioxide. In 1998 he represented a major manufacturer of diesel engines in the largest enforcement case ever brought by the government against manufacturers of engines and vehicles. And in 2002 Mr. Ayres was able to obtain a $20 million settlement for about 200 residents of a small village that allowed them to move away from a large power plant rather than suffer continued downwash of sulfuric acid mist and other pollutants.

Mr. Ayres has participated in many of the most important U.S. EPA rulemaking proceedings under the Clean Air Act since 1971. Among the more notable are: development of all 50 of the original State Implementation Plans; revisions to the

National Ambient Air Quality Standards in 1972, 1980, and 2006; regulation of the use of tall smokestacks by large electric power generating plants; emission standards for new coal-fired electric generating plants; standards for "reformulated" gasoline; adoption of emission trading guidance for States; standards for sulfur content of gasoline; development of open Market Emission Trading guidance; New Source Review; and several rulemakings involving regulation of chemicals that deplete the ozone layer.

Mr. Ayres has also had extensive experience with Congressional policymaking. During Congressional consideration of amendments to the Clean Air Act in 1977, 1980, and 1990, he led the National Clean Air Coalition, which included the major environmental and public health organizations, and labor unions, churches, and civic organizations. The Coalition successfully sought important additions to the national clean air program enacted by Congress in the 1970 Clean Air Amendments.

In 1977, the Coalition supported what became the Prevention of Significant Deterioration program, designed to manage emissions growth in the interests of preserving high quality air and maximizing the potential for economic growth. As a means of achieving these goals, the Coalition successfully advocated requirements that new emissions units be required to install state-of-the-art pollution control technology.

In 1990, the Coalition successfully urged the first President Bush and the Congress to adopt programs to control acid rain, reduce emissions of toxic chemicals, and cut emissions from new motor vehicles. The acid rain control program requires major reductions in sulfur oxides emissions from electric power plants. The hazardous emissions control program replaced a previously ineffective section of the Clean Air Act with a list of 189 toxic chemicals and instructions for EPA on how to control them. Motor vehicle standards enacted in 1990 have cut allowable emissions from new cars by more than 75 percent.

Mr. Ayres has served on a number of blue ribbon panels dealing with the nation's clean air policy. He was appointed by President Carter to the statutory National Commission on Air Quality in 1978. He was a member of the Carnegie Commission on Science, Technology, and Regulatory Decision Making from 1991-1994, which produced a major report on rulemaking in federal agencies. From 1992-2005 he was a member of the U.S. EPA's Clean Air Act Advisory Committee, and he currently serves on the Environmental Advisory Council to Mayor Tony Williams of Washington, D.C. In 1988, Mr. Ayres was recognized by the Yale Law School Association of Washington for outstanding service to the public interest. In 1989, he was honored by the Yale Law School Environmental Law Association for his role in creating the public interest law movement.

Mr. Ayres is currently a member of the Board of Trustees of the Vermont Law School, the Natural Resources Defense Council, and the Breakthrough Technologies Institute.

RELEVANT BIBLIOGRAPHY

Ayres, Richard and Mary Rose Kornreich, “Setting National Ambient Air Quality Standards,” in Martineau and Novello, eds., *The Clean Air Act Handbook* American Bar Ass’n, Section on Environment, Energy, and Resources (2004).

Ayres, Richard, “Expanding the Use of Environmental Trading Programs Into New Areas of Environmental Regulation,” 18 Pace Environmental Law Review 87 (Winter 2000).

Ayres, Richard, "The Clean Air Act: Performance and Prospects," 13 American Bar Association *Natural Resources and Environment* 379 (1998).

Ayres, Richard, Robert Rose, Alan C. Lloyd, and Robert Wichert, World Hydrogen Conference Paper, “Carbon Trading and Hydrogen – Possibilities and Pitfalls” (Bueso Aires, Argentina, 1998).

Ayres, Richard, "Developing a Market in Emission Credits Incrementally: An 'Open Market' paradigm for Market-Based Pollution Control," *Bureau of National Affairs Environment Reporter*, 1997.

O’Reilly, James T., Kim Burke, James Witt, William Luneberg, and Richard E. Ayres, *Clean Air Permitting Manual,* Clark Boardman Callaghan Environmental Law Series (March 1997)

Ayres, Richard and Richard Parker, "The Proposed WEPCO Rule: Making the Problem Fit the Solution," *Environmental Law Reporter*, 1992.

Ayres, Richard, and David Doniger, “New Source Standard for Power Plants II: Consider the Law,” 3 Harv. E. L. Rev. 563 (1979).

Ayres, Richard, “Environmental Pollution Control on Stationary Sources under the Clean Air Act Amendments of 1970,” 4 Ecol. L.Q. 441 (1975).

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES (MERCURY)	)	

TESTIMONY OF THOMAS C. HORNSHAW, Ph.D.

Qualifications

My name is Thomas C. Hornshaw. I am a Senior Public Service Administrator and the Manager of the Toxicity Assessment Unit of the Illinois Environmental Protection Agency (Agency, IEPA). I have been employed at the Agency since August of 1985, providing expertise to the Agency in the area of environmental toxicology. Major duties of my position include development and use of procedures for toxicity and risk assessments, review of toxicology and hazard information in support of Agency programs and actions, and critical review of risk assessments submitted to the Agency for various cleanup and permitting activities.

Also among my duties is one task that particularly qualifies me to participate in this rulemaking. I am the Agency's representative to the Illinois Fish Contaminant Monitoring Program (FCMP), and since 1996 I have been the chairman of this Program. In addition to the IEPA, four other state agencies participate in the FCMP, the Departments of Agriculture, Natural Resources, and Public Health, and the Illinois Emergency Management Agency. Each agency has specific duties, as detailed in a Memorandum of Agreement last renewed in 1989, with the Agency's tasks including laboratory analysis of all fish samples collected for the Program. As a result of my duties, I am familiar with the fish contaminant data generated for the FCMP, and maintain a database of these laboratory results.

I received Bachelor of Science (with honors) and Master of Science degrees in Fisheries Biology from Michigan State University, East Lansing, Michigan. I also received a dual Doctor of Philosophy degree from Michigan State University, in Animal Science and Environmental Toxicology. I am a member of the Society of Environmental Toxicology and Chemistry and Sigma Xi, the Scientific Research Society. I have authored or co-authored six papers published in peer-reviewed scientific journals, one report issued through the U.S. Environmental Protection Agency, and have written or co-written six articles which have appeared in trade journals. I have also presented sixteen posters and/or talks describing facets of my graduate work and my work at the Agency at various regional and national meetings. A more descriptive account of my work and educational background and a list of publications, posters, and talks is included in a Curriculum Vitae presented as Exhibit A to this testimony.

Testimonial Statement

My testimony today concerns two topics contained in the Agency's "Technical Support Document for Reducing Mercury Emissions from Coal-fired Electric Generating Units." I

provided for the Technical Support Document (TSD) a description of the operation of the FCMP (including discussion of the toxicity criteria used by the FCMP to issue sport fish consumption advisories), and an evaluation of whether Illinois anglers and their families could be at risk from consuming their catch. This testimony discusses these topics, and focuses especially on mercury in Illinois sport fish.

THE ILLINOIS FISH CONTAMINANT MONITORING PROGRAM

Operation of the FCMP – Section 4.2.1 of the TSD provides an overview of the procedures by which consumption advisories for Illinois sport fish are determined. The majority of these procedures derive from two documents, the "Illinois Fish Contaminant Monitoring Program Memorandum of Agreement" (MOA; 1989) (attached to this testimony as Exhibit B) and the "Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory" (Protocol; Anderson et al., 1993) (attached to the TSD as Document 1). The MOA was drawn up by the cooperating agencies to provide guidance for the activities needed to administer a credible fish advisory program. The Protocol was developed by staff from the health, natural resource, and environmental agencies of all eight Great Lakes states in response to a mandate from the Great Lakes governors to harmonize the sport fish advisories for the five Great Lakes. As described below, those procedures not addressed by these two documents or that have become outdated have been addressed by policy determinations adopted by the FCMP over time.

The FCMP performs three key functions: provide the fish contaminant information necessary for the Department of Public Health to issue sport fish consumption advisories; provide the IEPA with information needed to assess waters regarding the goals of the Clean Water Act; and provide the Department of Natural Resources with information needed to assess the ability of waters to support abundant, useful, and diverse fish communities. The main goal of the FCMP is to identify for Illinois anglers those species of fish and bodies of water which may pose the greatest risks to the anglers and their families, allowing them to avoid these risks by making informed judgments about the types and amounts of sport fish they eat.

Key elements of the procedures and policies followed by the FCMP to issue sport fish consumption advisories include:

- The MOA specifies tasks for the member agencies that allow the FCMP to evaluate contaminant levels in sufficient numbers and sizes of sport fish from most bodies of water accessible to anglers. The goal is to sample most accessible waters every five to ten years, except for waters already under advisory. In these cases, more frequent sampling is used to assess whether changes in the advisory are needed.

- The MOA specifies the collection of filet and whole fish samples from a network of 73 permanent stations to be sampled annually or biennially for monitoring of trends in contaminant levels over time, plus additional samples from across the state to evaluate important sport-fishing waters. However, trend-monitoring is no longer a goal of the FCMP and since 1993 only filet samples have been analyzed, and the permanent monitoring stations are now sampled at the same frequency as other stations.

- The MOA specifies collection of a core set of samples from each body of water, composites of filets from 3-5 fish of similar size for: two different sizes of bottom-feeders (preferably carp); one sample of an omnivorous species (preferably channel catfish); and one sample of a predatory species (preferably largemouth or smallmouth bass). These samples are analyzed for 14 bioaccumulative organic chemicals and mercury. If a sample is found to contain one or more of the analytes above a criterion, the FCMP has adopted a policy of requiring a second set of samples from the water, which should include two bottom-feeders, two omnivores, two predators, and one or more additional species to confirm the original findings and provide sufficient data for the issuance of advisories.

- The MOA specifies the use of the U.S. Food & Drug Administration's Action Levels as criteria for determining the need for advisories. However, the process developed in the Protocol has been used to replace the FDA criteria for Polychlorinated biphenyls (PCBs), Mercury, and Chlordane. The Protocol determines a Health Protection Value (HPV) for a contaminant, which is then used with five assumed meal frequencies : Unlimited (225 meals/year); One meal/week (52 meals/year); One meal/month (12 meals/year); One meal/two months (6 meals/year); and Do not eat (0 meals/year), to calculate the level of contaminant in fish that will not result in exceeding the HPV at each meal frequency. The HPVs for two target populations, critical health effects, and new criteria for methylmercury for the various meal frequencies are listed in the Table 4.3 of the TSD.

- The Protocol stresses the benefits of fish consumption; language relaying this message is included with all consumption advisories issued.

- The FCMP has adopted a policy that, except in extraordinary circumstances, two or more recent sampling events in a water body finding fish exceeding a level of concern for one or more contaminants are necessary for issuing or changing an advisory. Similarly, two or more recent samples finding no fish exceeding criteria are necessary for rescinding an advisory.

Toxicity Criteria for Methylmercury – The HPVs currently used by the FCMP for methylmercury are derived from USEPA criteria. In the past, the FCMP relied on a criterion for mercury in sport fish of 0.5 mg/kg developed by the Illinois Department of Public Health, with samples exceeding the criterion given "Do not eat" advice and samples below the criterion placed in the "Unlimited" category. With the adoption of the Protocol as the basis for developing sport fish advisories, it became necessary to revise this approach in order to make the mercury advisories consistent with the five categories of consumption advice specified in the Protocol. Since the Protocol did not contain a Health Protection Value (HPV) for mercury at that time, the FCMP adopted the USEPA's Reference Dose for methyl mercury of 0.0001 mg/kg/d as the HPV to be used in calculating the various concentrations in fish corresponding to the Protocol's meal frequencies. In adopting the Reference Dose as the HPV, the FCMP reasoned that the thorough review of the toxicity database for methyl mercury by the National Academy of Sciences, which formed the basis for USEPA's Reference Dose, provided an adequate justification for using the Reference Dose until the Great Lakes States could develop an HPV for use with the Protocol. It should be noted that the Great Lakes States have since adopted the Reference Dose as the HPV for methyl mercury in the Protocol.

Since the Reference Dose was derived specifically to protect the developing nervous system of the fetus and children, the FCMP has specified that the meal advice developed from it pertains to women of childbearing age and children less than 15 (the "sensitive" population in Table 4.3 of the TSD). In order to protect the "non-sensitive" population, women beyond childbearing age and adult men, the FCMP adopted for this population the previous USEPA Reference Dose for methylmercury. This Reference Dose, 0.0003 mg/kg/d, had been based on studies of the effects of methylmercury on adults, and is thus appropriate for determining the concentrations in fish corresponding to the Protocol's meal frequencies.

ARE ILLINOIS ANGLERS AT RISK FROM CONSUMING THEIR CATCH?

An important question addressed in the TSD is whether Illinois anglers and their families eat enough of their catch to present a health risk, since it could be reasoned that the sport fish advisories issued by the FCMP should prevent people from eating too much contaminated fish. Both the Illinois Department of Natural Resources and the Illinois Natural History Survey conduct surveys of Illinois anglers, but unfortunately neither includes questions concerning consumption of their catch. Therefore, this question had to be answered by indirect means, and I reviewed reports of several surveys reporting on seafood consumption patterns by the general public and by anglers to answer this question.

National Surveys – Several national surveys have been conducted to evaluate fish and shellfish consumption by the general public. Even though these surveys were conducted for different purposes over different time frames, using different methodologies, the range of national per capita fish and shellfish consumption rates is very consistent among studies considered to be valid. These values range from 10 grams per day (g/d) to 17.9 g/d, or approximately 16-28 eight-ounce meals per year [see Table 2 within Document 5 attached to TSD].

Most surveys of the general population contain persons who eat no fish, but a few also contain information on respondents that had consumed fish during the survey period. These "consumers only" data provide a more reasonable estimate of fish and shellfish consumption by persons who eat seafood. For example, Pao et al. (1982) evaluated the "consumers only" data from the 1977-1978 USDA Nationwide Food Consumption Survey (NFCS) (USDA, 1983), and found that the mean overall fish and shellfish consumption rate for consumers was 48 g/d, or approximately 77 eight-ounce meals/year, versus the rate for the general population from the NFCS of 12 g/d (19 meals/yr). Another study by Popkin et al. (1989) provides additional data that may be particularly relevant to evaluating potential risks due to seafood consumption. This study reviewed data for female "consumers only" of childbearing age (ages 19-50) from both the NFCS and the 1985-1986 USDA Continuing Survey of Food Intake by Individuals (CSFII) (USDA, 1987; USDA 1988). This study found that these female consumers reported an average consumption of fish and shellfish of 111 g/d (approximately 178 meals/year) from the NFCS data and 88.2 g/d (141 meals/year) from the CSFII data.

Surveys of Consumers of Sport Fish – The literature regarding persons who eat sport-caught fish is limited in comparison to studies of the general population's consumption of all types of seafood. As is the case for the "consumers only" populations discussed above, anglers consume

more seafood meals per year than the general population [see Table 6 within Document 5 attached to TSD]. This table shows that mean levels of fish consumption in these studies range from 12.3 to 63.2 g/d (approximately 19-101 eight-ounce meals/year). Most of these studies also provide high-end rates of sport fish consumption (95th or 96th percentiles, or maximum reported), which range from 17.9 to 220 g/d (28-353 meals/year).

Studies of sport fish consumption by angler cohorts in Michigan and California provide the most thorough evaluations of consumers of sport fish. The studies of Michigan anglers (the Michigan Sport Anglers study; West et al., 1992, 1993, Murray and Burmaster, 1994) provide data for total amounts of fish and self-caught fish consumed by various sub-groups of the cohort [see Table 8 within Document 5 attached to TSD]. From the table, it can be seen that this group also consumes much more fish than the general population, with mean and 95th percentile rates as high as 61.3 and 123.9 g/d (99 and 199 meals/year), respectively. Particularly relevant for describing at-risk populations is the information regarding females (ages not specified), with mean and 95th percentile of total fish consumption reported to be 42.3 and 85.7 g/d (68 and 138 meals/year), respectively.

The studies of California anglers provide very similar results, although this study evaluated consumption of marine fish. These studies (the 1991-1992 Santa Monica Bay Seafood Consumption Study; SCCWRP and MBC, 1994, Allen, et al., 1996) reported an overall mean consumption rate by Bay anglers of 49.6 g/d (80 meals/year), which is consistent with the mean values for the Michigan anglers from Table 8. The Santa Monica Bay Study also includes data on various ethnic groups that demonstrate considerable variability; the 90th percentiles ranged from a low of 64.3 g/d (103 meals/year) for Hispanics to a high of 173.6 g/d (279 meals/year) for "Other" (primarily Pacific Islanders) anglers.

Study of Illinois Lake Michigan Anglers – Using Illinois Natural History Survey data from creel surveys of anglers fishing the Illinois portion of Lake Michigan from 1987 to 1993, Pellettieri et al. (1996) evaluated the potential for these anglers to exceed the Health Protection Value (HPV) adopted by the Great Lakes states for daily intake of polychlorinated biphenyls (PCBs) of 3.5 micrograms per day (ug/d) as a result of their consumption of sport-caught fish from Lake Michigan. This study used data from Illinois and Wisconsin to determine PCB levels in five commonly caught species (yellow perch, brown and rainbow trout, and coho and chinook salmon). These calculated PCB concentrations were then combined with the five meal consumption frequencies chosen by the Great Lakes states for issuing consumption advice (Unlimited = 225 meals/year; One meal/week = 52 meals/year; One meal/month = 12 meals/year; 6 meals/year; and Do not eat) to estimate anglers' intakes of PCBs for nine survey time periods covering spring, summer, and fall. The study found that if anglers consume their catch at the Unlimited rate, the acceptable daily PCB intake would be exceeded for all time periods (range of intakes 7.27 to 71.85 ug/d), and even consumption at the One meal/week rate would exceed the limit in four time periods (those periods when more highly contaminated salmon were most likely to be caught; range 1.67 to 16.60 ug/d).

Are Anglers at Risk? – This review of fish consumption literature provides convincing evidence that sport anglers may consume amounts of sport-caught fish that could allow them and their families to exceed health-based limits for chemical contaminants in their catch. The

literature regarding anglers' consumption of their catch strongly suggests that a subset of these anglers have meal frequencies that put them well above the recommended rates for even fairly low levels of contamination. For example, even the mean rates of consumption for sport-caught fish, in the range of 60-80 meals/year based on the Michigan and California studies, exceed the recommended meal frequency of One meal/week for lower levels of contamination. These consumption rates also exceed the Illinois Fish Contaminant Monitoring Program's state-wide advisory for mercury, which recommends that women of child-bearing age and children under 15 limit their consumption of predator species to no more than one meal/week.

If anglers at the upper end of the meal frequency distribution are eating relatively contaminated fish, the risks to the anglers and their families are even greater. This is clearly illustrated by the upper percentile results noted above, with high-end consumers of sport fish eating 100 to 300+ meals/year. Such consumption rates would place these anglers and their families at risk from even low levels of contamination in their catch, and if contaminant levels are moderate or high the risks are correspondingly elevated. This is further demonstrated by the results from the Illinois Lake Michigan anglers, who were found to exceed recommended levels of PCB intake at the Unlimited meal frequency and even the One meal/week rate for some time periods. Thus, it can be said with a high level of confidence that it is possible for anglers and their families to consume enough sport fish to put themselves and their families at risk from chemical contaminants in their catch.

Concluding Statement

This concludes my portion of the Agency's testimony for reducing mercury emissions from coal-fired electric generating units.

Exhibit A

CURRICULUM VITAE

THOMAS C. HORNSHAW

EDUCATION: Ph.D., Animal Science and Environmental Toxicology, 1985. M.S., 1981, and B.S., 1976, Fisheries Biology, Michigan State University.

EXPERIENCE: Senior Public Service Administrator, Illinois Environmental Protection Agency, 1985 - Present.

Graduate Research Assistant, Department of Animal Science, Michigan State University, 1981 - 1984.

Graduate Research Assistant, Department of Fisheries and Wildlife, Michigan State University, 1978 - 1981.

Student Aide, Water Quality Division, Biology Section, Michigan Department of Natural Resources, 1976 - 1977.

FIELDS OF EXPERIENCE: At the Illinois Environmental Protection Agency, Dr. Hornshaw's major duties include the management of the Toxicity Assessment Unit; development and use of procedures for human and environmental exposure assessments and risk assessments; review of toxicological data and hazard information in support of Agency programs and actions; and critical review of remedial investigation and risk assessment documents submitted to the Agency during hazardous waste site investigations and cleanups. Dr. Hornshaw was a member of the Agency's Cleanup Objectives Team until 1993, when that Team's functions were assumed by the Toxicity Assessment Unit. As a member of the Air Toxics Action Committee, he participated in the development of Illinois= Air Toxics rules. He is one of the Agency's representatives to the Great Lakes Toxic Substances Control Agreement (member of the Fish Advisory Task Force) and is the Chair of the multi-agency Illinois Fish Contaminant Monitoring Program. Dr. Hornshaw is also a member of the National Advisory Committee for Acute Exposure Guidance Levels, moderated by USEPA, whose task is the development of action levels for use in unplanned air releases of hazardous chemicals. In an earlier assignment at the Agency, Dr. Hornshaw assisted in the development of bioassay protocols and quality assurance procedures for the Biomonitoring Unit.

As part of his duties during his Ph.D. research at Michigan State University, Dr. Hornshaw conducted experiments to develop protocols for mammalian wildlife dietary LC_{50} and reproduction tests, using mink and European ferrets as representative mammalian carnivores. He has published four papers in scientific journals as a result of this research, and the protocols developed from these studies have been published by USEPA.

As part of his duties during his M.S. research at Michigan State, Dr. Hornshaw conducted experiments to assess the suitability of several species of Great Lakes fish for animal feed, testing the fish in reproduction trials with mink. He quantitated levels of polychlorinated biphenyls in fish, mink fat, and mink milk as a portion of this research, and published the

results of these studies in a scientific journal. These results were also published in several trade journals serving the fur industry. He has authored or co-authored articles detailing the results of several other studies sponsored by the fur industry in these trade journals.

After receiving his Bachelor's degree from Michigan State, Dr. Hornshaw worked as a student aide in the Biology Section of the Water Quality Division of Michigan's Department of Natural Resources. His duties included assisting staff aquatic biologists in the collection of fish, water, sediment, and benthos samples, in laboratory work, in data handling, and in reporting requirements. His field experience included sample collection and identification from inland lakes, Great Lakes, and rivers and streams.

HONORS: Bachelor of Science, with honors; Member, Sigma Xi, the Scientific Research Society.

AFFILIATIONS: Member, Society of Environmental Toxicology and Chemistry.

THESES:

Hornshaw, T. C. 1984. Development of Dietary LC_{50} and Reproduction Test Protocols Using Mink and Ferrets as Representative Mammalian Carnivores. Ph.D. Thesis, Michigan State University, East Lansing, MI. 212pp.

Hornshaw, T. C. 1981. Renewed Use of Underutilized Species of Great Lakes Fish for Animal Feed. M.S. Thesis, Michigan State University, East Lansing, MI. 45pp.

PUBLICATIONS (Peer Reviewed):

Ringer, R. K., Hornshaw, T. C., and Aulerich, R. J. Mammalian Wildlife (Mink and Ferret) Toxicity Test Protocols (LC_{50}, Reproduction, and Secondary Toxicity). U.S. Environmental Protection Agency Report No. EPA/600/3-91/043. July 1991. NTIS Document # PB91-216507.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1987. Toxicity of thiram (tetramethylthiuram disulfide) to mink and European ferrets. Bull. Environ. Contam. Toxicol. 38: 618 - 626.

Hornshaw, T. C., Ringer, R. K., Aulerich, R. J., and Casper, H. H. 1986. Toxicity of sodium monofluoroacetate (Compound 1080) to mink and European ferrets. Environ. Toxicol. Chem. 5: 213 - 223.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1986. Toxicity of o-cresol to mink and European ferrets. Environ. Toxicol. Chem. 5: 713 - 720.

Hornshaw, T. C., Safronoff, J., Ringer, R. K., and Aulerich, R. J. 1986. LC_{50} test results in polychlorinated biphenyl-fed mink: age, season, and diet comparisons. Arch. Environ. Contam. Toxicol. 15: 717 - 723.

Bleavins, M. R., Aulerich, R. J., Hochstein, J. R., Hornshaw, T. C., and Napolitano, A. C. 1983. Effects of excessive dietary zinc on the intra- uterine and postnatal development of mink. J. Nutr. 113: 2360 - 2367.

Hornshaw, T. C., Aulerich, R. J., and Johnson, H. E. 1983. Feeding Great Lakes fish to mink: effects on mink and accumulation and elimination of PCBs by mink. J. Toxicol. Environ. Health 11: 933 - 946.

PUBLICATIONS (Trade Journals):

Hornshaw, T. 1992. Illinois' Air Toxics selection process described. National Air Toxics Information Clearinghouse (NATICH) Newsletter. USEPA Office of Air Quality Planning and Standards, Research Triangle Park, NC. January, 1992.

Aulerich, R. J., Napolitano, A. C., and Hornshaw, T. C. 1986. How supplemental copper affects mink kit hemoglobin concentration. In The Fur Rancher Blue Book of Fur Farming. Communications Marketing, Inc., Eden Prairie, MN. pp. 42 - 46.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1985. Mineral concentrations in the hair of natural dark and pastel mink. Scientifur 9(3): 216 - 219.

Aulerich, R. J., Napolitano, A. C., and Hornshaw, T. C. 1985. Effect of supplemental copper on mink kit hemoglobin concentration. Fur Farmer's Gazette of the United Kingdom 35(4): 8 - 11.

Hornshaw, T. C., Aulerich, R. J., Johnson, H. E., and Ringer, R. K. 1982. How suitable are today's Great Lakes fish for use in feeding mink? Fur Rancher 62(9): 21 - 23.

Hornshaw, T. C., and Aulerich, R. J. 1980. Can Great Lakes fish again be fed safely to mink? In The Fur Rancher Blue Book of Fur Farming. Communications Marketing, Inc., Eden Prairie, MN. pp. 48 - 49.

PRESENTATIONS:

Hornshaw, T.C. “Background Metals and PAHs – Panel Discussion.” Session Chair and Panel Member at the Midwestern States Risk Assessment Symposium, August 25-27, 2004, Indianapolis, IN.

Hornshaw, T.C. “Vapor Intrusion Action Levels – Panel Discussion.” Panel Member at the Midwestern States Risk Assessment Symposium, July 24-26, 2002, Indianapolis, IN.

Hornshaw, T. C. AThe Illinois Strategy for Endocrine Disruptors.@ Talk presented at The Endocrine Disruptor Debate: Environmental Chemicals and Reproductive and Developmental Health, October 17, 1997, St. Paul, MN.

Hornshaw, T. C. ARisk Pathways and Exposure Potential as Critical Factors in the Determination of Remedial Objectives.@ Talk presented at the Science for Environmental Professionals and Attorneys Conference, January 8, 1997, Chicago, IL.

Exhibit A

Hornshaw, T. C. APotential Health Effects of Triazine Herbicides and Their Metabolites in Community Water Supplies.@ Talk presented at the 1996 Illinois Agricultural Pesticides Conference, January 3-4, 1996, Champaign, IL.

Hornshaw, T. C. "The Illinois Fish Contaminant Monitoring Program." Talk presented at the Biannual Meeting of the Federal-State Toxicology and Risk Assessment Committee (FSTRAC), November 6-8, 1991, Chicago, IL.

Hornshaw, T. C. "Assessing Exposure to Toxic Air Releases from a Chemical Facility: Illinois Acrylonitrile Exposure Assessment." Talk presented at the National Governors' Association Conference on Assessing Exposure to Toxic Contaminants: Issues and Problems Facing State Government, March 29, 1989, Salt Lake City, UT.

Hornshaw, T. C. "Risk Assessment from State Point of View." Talk presented at the 1st Annual Hazardous Materials Management Conference/Central, March 16, 1988, Chicago, IL.

Perino, J. V., Whitaker, J. B., and Hornshaw, T. C. Technical aspects of an aquatic toxicological testing program at a state regulatory agency. Poster presented at the 1st Annual Meeting of the Ozark-Prairie Chapter of the Society of Environmental Toxicology and Chemistry, April 24-26, 1986, Columbia, MO.

Hornshaw, T. C. "Illinois EPA's Aquatic Toxicity Testing Program." Talk presented to the Illinois Environmental Consensus Forum. December 12, 1985. Springfield, IL.

Aulerich, R. J., Bursian, S. J., Nachreiner, R. F., Olson, B. A., Hochstein, J. R., Hornshaw, T. C., and Koudele, K. A. Toxicological manifestations of dietary exposure to 3,4,5,3', 4', 5' - hexachlorobiphenyl in mink. Poster presented at the 24th Annual Meeting of the Society of Toxicology, March 18-22, 1985, San Diego, CA.

Hornshaw, T. C. "Effects of Feeding Great Lakes Fish to Mink." Talk presented at the Great Lakes Commercial Fisheries Workshop, March 12, 1985, Mackinaw City, MI.

Hornshaw, T. C., Safronoff, J., Aulerich, R. J., and Ringer, R. K. Development and validation of dietary LC_{50} test protocols for wildlife mammalian carnivores using mink and ferrets. Poster presented at the 5th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 4-7, 1984, Arlington, VA.

Hornshaw, T. C., Ringer, R. K., and Aulerich, R. J. Toxicity of thiram to mink and European ferrets. Poster presented at the 23rd Annual Meeting of the Society of Toxicology, March 12-16, 1984, Atlanta, GA.

Hornshaw, T. C., Ringer, R. K., and Aulerich, R. J. Toxicity of sodium monofluoroacetate (Compound 1080) to mink. Poster presented at the 22nd Annual Meeting of the Society of Toxicology, March 6-11, 1983, Las Vegas, NV.

Hornshaw, T. C., Aulerich, R. J., Johnson, H. E., and Ringer, R. K. Suitability of today's

Great Lakes fish for animal feed. Poster presented at the International Symposium on PCBs in the Great Lakes, March 15-17, 1982, East Lansing, MI.

Exhibit No. B

ILLINOIS FISH CONTAMINANT MONITORING PROGRAM

MEMORANDUM OF AGREEMENT

Illinois Environmental Protection Agency

Project Officer Roger A Kaneva

Date 11/7/89

Illinois Department of Conservation

Project Officer Mike Conlin

Date 11/27/89

Illinois Department of Public Health

Project Officer Robert A Schultz

Date 11-29-89

Illinois Department of Agriculture

Project Officer J Keeney

Date 12-6-89

CONTENTS

PROJECT NAME: Illinois Fish Contaminant Monitoring Program
PROJECT INITIATION DATE: January 1977 (Revised 1987)
OBJECTIVES AND SCOPE STATEMENT:

In Illinois, contaminant levels in fish are monitored via a cooperative program with the Illinois Environmental Protection Agency (IEPA), Illinois Department of Conservation (IDOC), Illinois Department of Public Health (IDPH), and the Illinois Department of Agriculture (IDOA). The objectives of the Illinois Fish Contaminant Monitoring Program are:

1) To investigate and detect the presence and build-up of toxic and potentially hazardous substances in fish, encompassing both fish toxicity and public health implications.

2) To determine the impact of fish contaminants upon the suitability of aquatic environments for supporting abundant, useful, and diverse communities of fish life in streams and impoundments of Illinois.

3) To aid in the location of sources of toxic material discharges and evaluate long-term effects of source controls and land use changes.

An Agency needs to notify the committee of any differences made to the agreement.

DATA USAGE:

The data generated by this program will be used to achieve the above objectives in the following ways:

1) The comparison of composite fillet data for compliance with action levels set by the U.S. Food and Drug Administration. The USFDA action levels regulating commercial fisheries are the criteria adopted at the state level for Illinois in the issuing of sport fish consumption advisories. The list of parameters and the USFDA action levels used for this comparison are as follows:

Parameter	USFDA Action Level	Lab Detection Limits
Dieldrin	0.3 ppm	0.01
DDT and Analogs	5.0 ppm	0.01
Polychlorinated Biphenyls (PCB's)	2.0 ppm	0.10
Aldrin	0.3 ppm	0.01
Endrin	0.3 ppm	0.01
Methoxychlor	**	0.01
Heptachlor	0.3 ppm	0.01
Heptachlor Epoxide	0.3 ppm	0.01
Chlordane	0.3 ppm	0.01
Lindane	**	0.01
Benzene Hexachloride (BHC)	0.5 ppm	0.01
Toxaphane	5.0 ppm	1.00
Mirex	0.1 ppm	0.05
Hexachlorobenzene (HCB)	**	0.01

**No established USFDA Action level in fish

2) Whole fish data will be used primarily for detecting trends and new contaminants not routinely analyzed for. As new contaminants are identified and trends in the concentration of routine contaminants are defined, the program shall adjust its sampling to meet these changes. (IJC, 1982)

3) Whole and/or composite fillet data will be used to identify lakes and streams with significant fish contaminant problems requiring more intensive investigation. These follow-up investigations will be designed to assess in greater detail, (i) the extent of the contamination, (ii) the potential sources of the contamination, and (iii) the development of a mitigation strategy.

MONITORING NETWORK DESIGN AND RATIONALE:

The statewide monitoring network consists of the following sub-networks:

1) A total of 73 permanent stream stations are sampled biennially. (See Appendix 1). These stations were designed to coincide, where feasible, with the Illinois EPA's Ambient Water Quality Monitoring Network (AWQMN), where water quality and water quantity data is collected routinely. Station accessibility and sample representativeness were also considerations in site selection and are based primarily on previous experience of IDOC district biologists (See Appendix 2 Map). Composite fillet samples are collected at all 73 permanent stream stations. Whole fish samples are collected at 32 of the 73 stations (identified in Appendix 1). The selection of the stations where whole fish are collected in addition to composite fillet samples was designed to coincide with USEPA's National Water Quality Surveillance System (NWQSS) stations. The NWQSS stations are a sub-network included in IEPA's AWQMN, but include routine monitoring of sediment and macroinvertebrate populations, as well as more comprehensive water quality data and water quantity data. As a result, the whole fish samples that are used in detecting trends are collected at stations where additional water, sediment, and macroinvertebrate data are available.

2) Approximately 36 non-permanent stream stations are sampled annually. These locations vary yearly in conjunction with the cooperative IEPA/IDOC Basin Assessment Program. The purpose of this sub-network is to look at fish contaminant results more intensively throughout a given basin than is provided through the permanent stream networks. In addition, fish contaminant data are used in conjunction with water quality, water quantity, sediment, macroinvertebrate, and stream habitat data collected at approximately the same time, at each station. The sample types collected at all non-permanent stream stations are composite fillet samples for comparison to USFDA action levels. Site selection is determined by IEPA and IDOC to coincide with objectives of the cooperative Basin Assessment Program.

3) A total of 20 lake stations are sampled annually (See Appendix 1). These include the major impoundments throughout the state and the major harbor areas in Illinois' portion of Lake Michigan. As a supplement to the State-wide Fish Contaminant Monitoring Program, IEPA, IDOC and IDPH also participate with USEPA and other Great Lakes Basin States in the implementation of the Great Lakes Fish Monitoring Strategy (GLFMS).

MONITORING PARAMETERS AND THEIR FREQUENCY OF COLLECTION:

A total of 20 pesticide/PCB analyses are performed on all composite fillet and whole fish samples. These analyses comprise the 14 parameters, including related isomers, listed on page 1. The percent lipid or fat content is also determined for each sample. The estimated number of samples and resulting analyses routinely generated per year can be found in Appendix 3. In addition to the 20 pesticide/PCB analyses on whole fish, a gas chromatography/mass spectrometry "wide scan" analysis is also performed on up to 25 whole fish samples per year. The stations in which whole fish samples are analyzed by GC/MS "wide scan" procedures are identified in Appendix 1. The "wide scans" include up to 50 additional parameters, including both volatile and semi-volatile constituents. Their purpose is to aid in the identification of new contaminants of potential concern. Based on this information, it may be necessary at some point in the future, to expand or revise the list of parameters being analyzed routinely.

Additional analyses may include mercury, dioxin (2, 3, 7, 8-TCDD), and other related dioxin isomers on a selected or as needed basis. Other heavy metals are not routinely analyzed in fish tissue. Even though metal complexes may be present in fish tissue, metallic ions rarely accumulate in fish tissue to high levels, and are more readily obseved and monitored in water and sediment (IJC, 1982).

SAMPLING PROCEDURES/QUALITY CONTROL:

The Illinois Department of Conservation - Division of Fisheries is responsible for the collection and preparation of all fish samples from those stations identified in Appendix 1. Composite fillet and whole fish samples are collected and processed during the course of scheduled annual stream and lake fish population sampling, and follow the guidelines below.

1) Collection of Composite Filet Samples

A total of 5 or more fish of a species of roughly similar size and weight comprise each composite fillet sample. For example, don't use 4 flathead catfish of 2 pounds each and 1 of 12 pounds in preparing one composite fillet sample of 5 fish. A minimum of 4 composite fillet samples are obtained at each station using the following species groups:

A. Inland Lakes and Streams

Composite 1

Predatory Species	Size
Largemouth Bass	2 lbs. and larger
Walleye or Sauger	2 lbs. and larger
Northern Pike	2 lbs. and larger
White Bass	1 1/2 lbs. and larger
Crappie (White, Black)	3/4 lbs. and larger

Composite 2

Omnivorous Species	Size
Channel Catfish	2 lbs. and larger
Blue Catfish	2 lbs. and larger
Flathead Catfish	2 lbs. and larger
Bullhead (species)	1 lb. and larger
Bluegill	1/4 lbs. and larger

Composite 3 and 4

Bottom Feeder Species	Size
Carp	3 lbs. and larger
Buffalo (species)	3 lbs. and larger
Carpsuckers	3 lbs. and larger

A replicate composite fillet sample is collected from the bottom feeders' group, resulting in the 4 composite fillet samples required at each station. The first species in each group should be used if available; other species are substituted according to the size requirement.

Additional composite fillet samples may be collected and submitted for analysis at the discretion of the District or Project biologist. For example, if white bass are important components of the creel in a given lake, the biologist may wish to submit a white bass composite fillet sample in addition to the largemouth bass sample, etc.

B. Lake Michigan Species

Composite fillet samples from Lake Michigan are obtained for a minimum of 5 lake species: Coho salmon, Chinook salmon, Rainbow trout, Brown trout, and Lake trout. Additional samples of other species any be submitted at the discretion of the IDOC Lake Michigan Program Manager. Four composite fillet samples for each species are prepared based upon the ranges of size at the time of collection. A composite fillet sample from Lake Michigan consists of at least 5 fish per size group. Samples are to be grouped according to the indicated length ranges by species.

Species	Length Ranges (inches)			
	1	2	3	4
Coho salmon	21	21-24	25-27	27
Chinook salmon	25	25-30	31-35	35
Rainbow trout	10-15	16-20	21-25	25
Brown trout	10-15	16-20	21-25	25
Lake trout	20	21-25	25	--

2) Preparation and Identification of Composite Fillet Samples:

IDOC biologists collecting the samples are to complete the following field information on the Field/Lab form. (See Appendix 7)

a) Station Code
b) Date
c) Collector's Name
d) Sampling Location (i.e., upstream of Rt 121 Br., etc.)
e) Stream or Lake Name
f) Sampling Techniques
g) Weather Conditions
h) Fish Species
i) Individual Wts. and lengths of Fish In Sample
j) Sample Type (Whole or Filet)
k) Comments or Unusual Conditions

The composite fillet samples are prepared by removing the scales and leaving the skin on the fish. Then, fillet to remove bones. If the fillet is too large, select a section from the anterior, middle and posterior portion of the fillet and place them in the composite sample. The total weight of the composite sample (all 5 fish) must range from 1 to 5 pounds. Keep the sample as clean as possible to avoid contamination. Composite fillet samples from catfish are prepared by removing skin and then filleting the fish to remove bones. The size of the composite sample must range from 1 to 5 pounds. Each composite fillet sample is securely wrapped in aluminum foil and labeled with a pre-printed, adhesive label (See Appendix 8). There are two pre-printed labels with the same sample number. One label is placed on the outside of each fish sample, and the other placed on the accompanying Field/Lab form in the area designated. This is essential so that the laboratories completing the analysis can identify each composite sample with the correct station. All composite samples collected from a sampling station are placed in an air tight plastic bag; this will help prevent contamination of samples and loss of identification numbers on pre-printed labels. The Field/Lab forms are not to be placed inside the plastic bags with the fish samples. The samples are then kept on ice, or dry ice during field sampling and frozen as soon as possible upon completion of field sampling.

3) Collection of Whole Fish Samples

IDOC biologists collect whole fish samples from specified contaminant stations (See Appendix 1). One whole fish sample is provided for each of the 4 composite fillet samples, with the whole fish sample being representative of the individual fish that comprise the composite fillet sample. A total of 41 lake or stream stations include whole fish sampling.

4) Preparation and Identification of Whole Fish Samples

The IDOC biologist completes the same field information on the Field/Lab form as described earlier for composite fillet samples. Securely wrap each whole fish sample in aluminum foil and label with the pre-printed, adhesive labels. Again, as with the composite sample, place one label on the outside of each whole fish, and the other label with the same pre-printed number on the appropriate Field/Lab forms in the area designated. All whole fish from a sampling station are placed in an air tight plastic bag and kept on ice, or dry ice, during field sampling. The samples are frozen as soon as possible upon completion of field sampling.

FOLLOW UP AND SPECIAL REQUESTS/STUDIES

1) Follow up Studies - These studies are designed to provide more extensive data results in those areas where potential fish contaminant problems exist. They will be conducted on an "as needed" basis and will include 50-100 supplemental samples per year (see Appendix 3). Sample analyses will be performed by IEPA laboratories to insure as much consistency as possible with data generated from the routine network stations. Collection of these samples may include either IDOC and/or IEPA biologists. Sample collections from additional sources (i.e. other States on boundary waters, U.S. Army Corp. of Engineers, U.S. Fish and Wildlife Service, or local governments such as MSD of Greater Chicago) may be utilized in follow up studies if the sampling protocols and field QA procedures documented in this agreement are used.

2) Commercial Requests - These samples are collected by IDOC at waterbodies which have been requested to be opened for commercial fishing. IDOC will contact IEPA for assignment of station codes and documentation of sampling locations prior to the collection of these samples. In addition, the words COMMERCIAL FISH REQUEST should appear across the top of the Field/Lab sample sheet to clearly distinguish these samples from routine ones. These samples will be analyzed by the IEPA laboratory.

3) Special Studies - The special studies provide a wide range of additional data and information which cannot normally be provided by the routine network data. For example, these studies may involve further addressing seasonal and species variability concerns which will add to the overall knowledge and understanding of contaminant levels in fish. They may also involve remedial investigation work at the request of IEPA, Division of

Land Pollution Control. The IDOA and IDPH laboratories will provide the analytical needs for these studies in the support of the overall Fish Contaminant Monitoring Program. It is these laboratories or Private Contract Laboratories that will determine the necessary laboratory capabilities, as well as any other laboratory considerations, at the time of the design of such studies.

SAMPLE CHAIN OF CUSTODY PROCEDURES:

1) Delivery of Samples to IEPA

All whole and fillet samples collected from the network are delivered directly to IEPA, Division of Water Pollution Control, Planning Section. The address and contacts are as follows:

IEPA
DWPC - Planning Section
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276

Contact: Laurie Moyer
phone (217)782-3362

Transportation of samples to the Planning Section is routinely coordinated between the IDOC biologists and IDPH regional staff. (See Appendix 4). However, in certain instances, the IDOC biologist may deliver samples directly or coordinate delivery with IEPA regional staff (see Appendix 6) at their convenience. Planning Section staff is to be notified prior to any delivery. When custody of fish samples is transferred to Planning Section staff, the following quality assurance checks are implemented:

a) Insure all whole fish samples are wrapped in aluminum foil and placed in plastic bags per sampling guidelines.

b) Matching I.D. tags are firmly affixed to both the Field/Lab form and each whole fish sample. (I.D. tags on fish sample should be taped).

c) Each Field/Lab form has all the necessary field information required.

d) Insure the whole fish samples targeted for "wide scan" analysis are prepared in the following manner:

The stations in which whole fish samples will be analyzed by GC/MS "wide scan" procedures are identified below: (See also Appendix 1)

A01	Ohio R.	B07	Wabash R.
D23	Illinois R.	E26	Sanagmon R.
D73	Illinois R.	F01	Kankakee R.
M04	Mississippi R.	J83	Mississippi R.
O17	Kaskaskia R.	L97	Mississippi R.
P22	Rock River	DT38	Fox R.

The wide scan analysis will be performed on the whole fish representing the bottom feeders group from these stations. Usually this species will be carp. One whole fish from this group, plus a replicate whole fish are routinely collected by IDOC. Therefore, additional samples are not necessary; the 2 whole fish representing the bottom feeders from the above 12 stations are targeted for wide scan analysis plus the 14 routine parameters. These samples require the Special Organic Analysis form (Appendix 9) to be completed by IEPA personnel as well as the Field/Lab form (Appendix 7) to be completed by IDOC.

Upon completion of these Q.A. checks, the Field/Lab form is signed and dated in the appropriate space by the person transporting the sample. All fish samples delivered are checked onto a sample log maintained by IEPA quality assurance staff. Samples remain frozen until delivery to IEPA laboratories, at which time the laboratory receiving agent initials the data form and date of sample receipt.

2) Prioritizing Analyses to Laboratory

Priority of analyses to laboratory will be coordinated by DWPC Planning Section.

3) Delivery of Fish Samples to Tissue Bank

Tissue banking is of value for retrospective analyses of contaminant levels and past human exposure (IJC, 1982). All whole and composite fillet samples analyzed by the participating laboratories are to be inventoried into the tissue bank. The laboratories are to provide a 250 gram ground subsample, from whole or composite fillet samples which have been analyzed, to be stored. IEPA is responsible for the storage, transportation, and maintenance of the tissue bank samples. Each bottle containing a tissue bank sample needs to have the corresponding lab I.D. number issued to each Field/Lab form clearly written on the outside of the bottle in permanent ink. This will insure proper identification of the sample.

The tissue bank is located at:

Mid State Meat Company
2879 North 31st Street
Springfield, Illinois
217/525-0160

For the inventory list of fish in the tissue bank, and transportation arrangements contact:

IEPA
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276
Attention: Laurie Moyer
217/782-3362

LABORATORY CALIBRATION PROCEDURES AND QUALITY CONTROL:

1) IEPA Laboratory

All calibration and quality control procedures used in the fish analyses by the IEPA laboratory are referenced in the IEPA Laboratory Methods Manual, Volume II (Page 3-1 thru 3-17). Copies of the documented procedures can be made available upon request. The IEPA laboratory, will participate in QA/QC efforts with other States and Federal Agencies as needed. An in-house QA/QC program consisting of duplicates and blanks QC samples comprising 1 of every 10 analyses (10%), will insure precision and accuracy. In addition, the IEPA laboratory will maintain participation in the USFDA spike sample testing program. (See Performance and Systems Audit).

DATA DISSEMINATION:

1) Data Handling of Composite Fillet Samples

All fish are taken by Planning Section Staff to the IEPA laboratory. When the IEPA laboratory has completed the analysis and entered the data into LIMS (Laboratory Information Management System), the completed field/lab forms are returned to Planning Section Staff. This information is then ready for entry into STORET (STORage and RETrieval). For any data that shows excursions, IEPA Staff will forward copies of the field/lab forms to IDOC and IDPH. All data will be transferred via SAS (Statistical Analysis System) program format printout on a regular basis.

2) Data Handling for Whole Fish Samples

All laboratory results for whole fish samples analyzed by IEPA labs are forwarded to the Planning Section staff where the same procedures outlined above for composite fillet samples are implemented.

DATA MANAGEMENT QUALITY CONTROL

The Field/Lab forms received by IEPA data management personnel are checked in on a program check-list and reviewed for missing or illegible values, station code errors, etc. These forms are held until the fish contaminant data is printed from LIMS (Laboratory Information Management System) each week by ISD (Information Systems Division) to a pre-edit report for verification against these forms. Fish contaminant data are then transferred by ISD into a STORET dataset. The datasets are printed out and compared with the original format to assure transfer of all data. Preliminary data editing is performed to correct errors discovered through the %store procedure. When error-free, the datasets are stored final. The data is then accessed to see if the storage run was successful. The data retrieved are verified from original lab forms and data printouts. Any errors are corrected, missing data added, etc. The corrections are checked and the procedure repeated as necessary until an error-free copy is obtained.

DATA REPRESENTATIVENESS; COMPARABILITY; COMPLETENESS:

Data comparability must be assured by a) frequent interagency communication and review of sampling, analytical and assessment methodologies, and b) implementation of a quality assurance program which includes field, laboratory and data management quality control (IJC, 1982). Data representativeness and completeness need to be assured through an established evaluation process of the monitoring program, altering the program as required (IJC, 1982). At a minimum, an annual meeting of the participating agencies will be conducted where these quality assurance characteristics are addressed.

DATA VALIDATION:

The validation of data for the Fish Contaminant Monitoring Program is the prime responsibility of each participating Agency's quality assurance personnel. This process includes checks for internal consistencies, inter-agency consistencies, proper sample identification, sample delivery errors, etc.

PERFORMANCE AND SYSTEM AUDITS:

Spiked fish flesh samples obtained from U.S. Food and Drug Administration are utilized as a performance audit for the participating laboratories. The procedures used are as follows:

1) Each participating laboratory receives 125 grams of fish composite and an ampul containing a spiking solution from USFDA.

2) The ampul is weighed and compared to the weight recorded on the enclosed weight sheet. Any deviations greater than 25 mg are reported to Joseph Weishaar, USFDA, phone 612/349-3934.

3) The fish composite is thawed and mixed.

4) To 50 grams of the fish in a blender, 5.0 ml of spiking solution are added.

5) The 50 grams of spiked fish, along with a 50 gram unspiked portion, are analyzed for chlorinated pesticides.

6) Results for both of these samples, worksheets, and chromatograms are sent to:

IEPA
Division of Water Pollution Control
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276
Attention: Laurie Moyer
(217)782-3362

7) The results of these samples from all of the participating laboratories are statistically summarized. Each laboratory is assigned an I.D. number known only to their laboratory, for comparison with other participants' results.

ADVISORIES/NEWS RELEASES AND REPORTS:

Review of data results for purposes of issuing sport fish consumptive advisories will be accomplished through an inter-Agency committee. Draft advisories, prior to release by IDPH, will be forwarded to DWPC Planning, OCS (Office of Chemical Safety), and IDOC with adequate time for comments and review prior to final approval by the Inter-Agency Committee. After a committee review, and at such other times as may be deemed necessary or advisable by IDPH, IDPH will issue news releases and advisories in the performance of duties in protecting the public health.

IDPH will have the primary responsibility for responding to public and media inquiries regarding advisories, IDOC and OCS will also be available to assist with these inquiries.

IDOC will annually publish a list of those waterbodies where consumptive advisories exist in the "Guide To Illinois Fishing Regulations". This guide is available when purchasing fishing licenses. In addition, OCS will publish and distribute upon request, the pamphlet "Guide To Eating Illinois Sport Fish".

The data results will be published biennually by IEPA in the "Illinois Water Quality Report", 305(b). This report will also periodically include information relating to observed trends in contaminant concentrations. It is the IEPA's responsibility to update and revise this document.

KEY TERMS/DEFINITIONS

1) Accuracy -- Conformance with a known value.

2) Composite Fillet Sample -- Fish sample prepared by removing the scales and bones from the edible portion of the fish.

3) Field/Lab Form -- Sample sheet used in the Fish Contaminant Monitoring Program which records field, lab analysis, and computer coded information.

4) New Contaminants -- Parameters which are not analyzed on a regular basis as part of the Fish Contaminant Monitoring Program.

5) Non-permanent Stream Station -- A site location where fish are collected which varies yearly, depending on station locations in the IEPA/IDOC Basin Assessment Program.

6) Performance Audit -- Independently collected measurement data using performance evaluation samples (i.e., spiked fish flesh samples).

7) Permanent Stream Station -- A site location which remains fixed in the same river reach where fish are collected.

8) Precision -- The reproducibility of repeated measurements.

9) Pre-printed Adhesive Labels -- I.D. tags used for fish samples.

10) Quality Assurance -- A term used to describe programs and the sets of procedures including, but not limited to quality control procedures, which are necessary to assure data reliability.

11) Quality Control -- A term used to describe the routine procedures used to regulate measurements and produce data of satisfactory quality.

12) Routine Contaminants -- The 14 parameters which are analyzed in every fish sample. (See Page 2).

13) Significant Fish Contaminant Problem -- For general purposes, a sample set of fish collected from a given water body which contain 30% or greater excursions of USFDA action levels for any given parameter.

14) STORET -- USEPA storage and retrieval database used for fish data generated by the Fish Contaminant Monitoring Program in Illinois.

15) Systems Audit -- A review of the total production process which includes on-site reviews of field and laboratory's operational systems and physical facilities for sampling, calibration, and measurement protocols.

16) Tissue Bank -- Storage for separate fish samples, for which analysis values have been determined from a sub-sample, used for retrospective analyses of contaminant levels and past human exposures.

17) USFDA Action Level -- Concentration of a particular chemical which cannot be exceeded in fish sold for human consumption.

18) Wide Scan Analysis -- IEPA laboratory procedure used to identify contaminants not routinely analyzed for.

REFERENCES:

1. International Joint Commission, 1982. Proceedings of the roundtable on the surveillance and monitoring requirements for assessing human health hazards posed by contaminants in the Great Lakes Basin ecosystem.

2. IEPA, 1982. Laboratories methods manual.

3. IEPA, 1979. Field Methods Manual. Division of Water Pollution Control.

4. Friedman, Linda C., and Erdmann, David E., 1982, Quality assurance practices for the chemical and biological analyses of water and fluvial sediments: U.S. Geological Survey Techniques of Water Resources Inv., Book 5, Chap. A6 p. 71.

5. USFDA, 1987. Compliance policy guide 7141.01.

Fish Contaminant Monitoring Program

APPENDIX 1. STATION DESCRIPTION FOR THE 73 PERMANENT STREAM STATIONS AND LAKE STATIONS
ODD Year Schedule for Permanent Stream Stations

Station I.D. Code	River or Stream	Verbal Description	Legal Description			USGS Map Number
**A01	Ohio River	Pope Co. at Golconda	T13S	R7E	S30NW	277C
*A08	Ohio River	Gallatin Co. - Rt. 56 Br. at Shawneetown	T9S	R10E	S32SW	275B
*AK02	Lusk Creek	Pope Co., SE of Eddyville, IL	T12S	R6E	S16SE	278A
AT04	Saline River	Gallatin Co., Rt. 1 Bridge	T9S	R8E	S26SE	274A
*AT99	Saline River	7 mi, S of Eldorado - below confluence of Mid. and So. Fork	T9S	R7E	S27SW	274B
*ATF04	Saline River	Saline Co. - Rt 45 Br near Texas City	T7S	R7E	S25NW	261B
D09	Illinois River	Rt. 17 Br at Lacon - RM 189.0-189.5	T30N	R3W	S26SE	078C
**D23	Illinois River	Marseilles - RM 244-246	T33N	R4E	S13SW	060C
D26	Illinois River	Dresdan Dam tailwater - R.M. 271.5	T34N	R8E	S26NW	059A
*D30	Illinois River	Peoria Water intake - R.M. 166.0-166.5	T9N	R8E	S26SE	108A
D36	Illinois River	Starved Rock Dam tailwater - R.M. 231	T33N	R2E	S22NW	061C
D25	Illinois River	Conf. 2 mi. N. Bath - §R.M. 113.2	T21N	R9W	S32SE	139B
**D73	Illinois River	LaGrange Dam tailwater - R.M. 79.7-80.2	T17N	R13W	S11SW	162A
*D22	Illinois River	U.S. 36 Br. at Florence - R.M. 55.5-56.5	T5S	R2W	S15NE	169A
D93	Illinois River	Bridge Island near Pearl - R.M. 43.0-43.5	T12N	R14W	S25NW	194A
D98	Illinois River	Mouth of Otter Creek - R.M. 14.5-15.5	T7N	R13W	S7SN	197D
DG05	LaMoine River	1.8 mi. NE of Cooperstown	T1S	R2W	S13NW	162A
DJ01	Spoon River	Rt. 100, south of Lewistown	T4N	R3E	S29NW	127
G01	DesPlaines River	I-55 near Channahon	T34N	R9E	S16SE	058B
G08	DesPlaines River	Russel Rd near Wisconsin Line	T46N	R11E	S3SE	007B
GL09	Salt Creek	Cook Co. - Wolf Road	T39N	R12E	S32SW	032C
*008	Kaskaskia River	U.S. 51 Br. at Vandalia	T6N	R1E	S16SE	217
011	Kaskaskia River	Rt. 16 Br. at Shelbyville below dam	T11N	R4E	S8SW	187A
**017	Kaskaskia River	Rt. 133 at Chesterville	T15N	R7E	S35SW	178
097	Kaskaskia River	3 Mile SW of Baldwin	T4S	R7W	S29NE	251B
*040	Kaskaskia River	1.0 mile N of New Athens	T2S	R7W	S22SW	246D
OT05	West Okaw River	4.0 miles NW of Kirksville	T14N	R4E	S35SE	177C
P23	Rock River	Rockford Dam tailwater R.M. 136.6	T44N	R2E	S26NW	012D
**P22	Rock River	Rockton Dam tailwater R.M. 159.2	T46N	R1E	S24NW	012A
P25	Rock River	Steel Dam tailwater in Milan R.M. 5	T17N	R2W	S13SE	068A
P20	Rock River	Rt. 2, at Grand Detour	T22N	R9E	S14SW	038
*P24	Rock River	Prophetstown State Park R.M. 49	T20N	R5E	S33SE	046B
*PB04	Green River	Rt. 82, at Geneseo	T17N	R3E	S4SW	066B
PQC06	So. and No. Br. Kishwaukee R	2 mi. S; 1 mi. W of Cherry Valley	T43N	R2E	S15SW	025C

* - Whole fish sample as well as composite fillet sample
** - 2 Whole fish representing bottom feeders for GC/MS "wide scan" analysis.

Fish Contaminant Monitoring Program

APPENDIX 1. STATION DESCRIPTION FOR THE 73 PERMANENT STREAM STATIONS AND LAKE STATIONS
EVEN Year Schedule for Permanent Stream Stations

Station I.D. Code	River or Stream	Verbal Description	Legal Description			USGS Map Number
B01	Wabash River	Wabash Co. - Mt. Carmel Dam	T1S	R12W	S28NW	238A
B03	Wabash River	Rt. 141 Br. near New Haven	T7S	R11E	S6NW	260A
B05	Wabash River	Lawrence Co. - Vincennes, Indiana	T3N	R10W	S3SE	235A
**B07	Wabash River	Rt. 46 Br. near New Harmony, Indiana	T4S	R14W	S35SE	213
B98	Wabash River	Crawford Co. - Merom, Indiana	T7N	R10W	S18NW	209D
B99	Wabash River	Clark Co. - 1/2 mi. N. of Darwin	T10N	R11W	S23SE	182D
BE15	Embarras River	Rt. 121 Br. at Greenup	T9N	R9E	S25W	207B
*BP01	Vermilion River	Br. 3.5 mi SE of Danville	T19N	R11W	S27NW	149D
BP99	Vermilion River	Vermilion Co. - N. of Catlin	T19N	R11W	S8SW	149C
C08	Little Wabash River	Hedge Br., 1 mi. N. of Rt. 15	T2S	R9E	S5SW	239C
*C20	Little Wabash River	Possum Br., 1.5 mi S of Carmi	T5S	R9E	S25SE	258C
CA05	Skillet Fork	Rt. 15 Br., 1 mi. N. of Wayne City	T2S	R6E	S7SW	241D
*E19	Sangamon River	Local Br., upstream Rt. 150 NE Mahomet	T20N	R7E	S15SW	146B
E05	Sangamon River	Lincoln Trail Br., 5 mi SE of Niantic	T16N	R1E	S32NE	156
*E25	Sangamon River	Rt. 97, north of Oakford	T19N	R8W	S3SE	140C
**E26	Sangamon River	Rt. 36, at Riverton	T16N	R4W	S9NW	158D
E95	Sangamon River	Local bridge 2 mi E, 1.5 mi. S of Oreana	T17N	R3E	S23SE	155A
EI11	Salt Creek	Rt. 66 Bridge 1 mi. S. Lincoln	T19N	R3W	S2NE	142B
**F01	Kankakee River	I-55 Br. 3 mi. NW of Wilmington	T33N	R9E	S9SE	058C
F03	Kankakee River	State-Line Rd. Br.	T31N	R10W	S1SW	085A
*F02	Kankakee River	Momence Island Park in Momence	T31N	R13E	S24NE	085B
*F10	Kankakee River	Davis Creek Conflu.	T31N	R11E	S23NE	084B
I98	Mississippi River	Liberty Island Side Channel - R.M. 100.2-102.8	T8S	R6W	S13SW	266C
I02	Mississippi River	Angelo Towhead - R.M. 1.4-5.0	T17S	R1E	S31NW	288B
**M04	Mississippi River	Rt. 136 Br. at Fulton - R.M. 520	T22N	R3E	S29SE	041C
J96	Mississippi River	Ft. Chartres Main Channel - R.M. 132-133	T5S	R10W	S24SW	250C
J82	Mississippi River	Chain-O-Rocks tailwater - R.M. 190.3	T4N	R10W	S35NW	221C
*K02	Mississippi River	Lock and Dam 25 tailwater - R.M. 241	T12S	R2W	S19SE	223B
**J83	Mississippi River	Lock and Dam 26 tailwater - R.M. 202.6	T5N	R10W	S14NE	221B
*K98	Mississippi River	Willow Slough - R.M. 330	T1S	R9W	S28NW	165B
K04	Mississippi River	Keokuk, Iowa - R.M. 364	T5N	R9W	S30SW	132A
**L97	Mississippi River	Slough off Andalusia Slough - R.M. 465	T17N	R4W	S29NW	069A
N06	Big Muddy River	Rt. 14 Br., 3 mi. S of Benton	T6S	R2E	S15SW	263B
*N99	Big Muddy River	Rattlesnake Ferry riffle area-4 mi. E. of Grand Tower	T10S	R3W	S27NW	270B
NJ07	Casey Fork	Rt. 37 Br., 3 mi. S. of Mt. Vernon	T3S	R3E	S17NW	242C
*DT35	Fox River	Rt. 173 Br., near Wisconsin Line	T46N	R9E	S10SW	008B
DT03	Fox River	Rt. 34 Br. near Oswego				
DT46	Fox River	I-80 Br. near Ottawa	T34N	R4E	S32NW	061A
DT06	Fox River	RT. 62 Br., near Algonquin	T43N	R8E	S34NW	027A

* - Whole fish sample as well as composite fillet sample
** - 2 Whole fish representing bottom feeders for GC/MS "wide scan" analysis.

12/87

APPENDIX 1. STATION DESCRIPTION FOR THE 73 PERMANENT STREAM STATIONS AND LAKE STATIONS

Lakes - 20 Lake Stations Sampled Annually

Station I.D. Code	Lake Name
**QZB-02	Lake Michigan - Waukegan Harbor area
**Q-02	Lake Michigan - includes Jackson, Diversey, Montrose, Trident, and Great Lakes Naval Station Harbor
RO-B04-A	Lake Carlyle
*RN-A06-A1	Crab Orchard Lake - near Carterville
*RN-A06-A2	Crab Orchard Lake - east of Rt. 148 Br., SW of Marion
RN-B01-B1	Rend Lake
*RO-B02-C	Lake Shelbyville
RT-B01-D	Fox Chain of Lakes - Lake Catherine
RT-B01-F	Fox Chain of Lakes - Fox Lake
RT-B01-I	Fox Chain of Lakes - Channel Lake
*RE-A05-F	Lake Springfield
*RN-B09-E	Cedar Lake
RN-A08-C	Kincaid Lake
*RE-B02-A	Lake Decatur
RB-A03-D	Lake Vermilion
RE-A06-B	Lake Sangchris
RO-A04-ZA	Highland Silver Lake
*RE-A04-C	Lake Taylorville
RD-B-02-U	Lake DePue (sampled during odd years only)
RE-A04-I	Clinton Lake

* - Whole fish sample as well as composite fillet sample.
** - 2 whole fish representing bottom feeders for GC/MS "wide scan" analysis.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES (MERCURY)	)	

TESTIMONY OF GERALD J. KEELER, PH.D.

Prepared by

_____

Gerald J. Keeler, Ph.D.
2880 Baylis Drive
Ann Arbor, MI 48108

April 23, 2006

Qualifications

The opinions presented here stem from my understanding of mercury as an environmental contaminant which are based upon my education and extensive experience as an environmental researcher for the past two decades. I graduated from the Honor's Program at Boston College in 1982 with a B.S. in Physics, and received my M.S. and Ph.D. in Atmospheric Sciences from the College of Engineering at the University of Michigan in Ann Arbor in 1983 and 1987, respectively. From 1987-1990 I received Post-Doctoral Training at the Harvard School of Public Health and was a Visiting Scientist at the Massachusetts Institute of Technology working in the Nuclear Reactor Laboratory on studies related to tracking pollutant transport and atmospheric chemistry. Since June of 1990 I have been a Professor at the University of Michigan conducting research and teaching in the areas of air pollution, exposure assessment, atmospheric chemistry and deposition, environmental measurements, and the fate and transport of contaminants with a focus on mercury and mercury compounds emitted to the environment. Over the past 16 years I have performed many scientific studies on environmental mercury funded by the National Science Foundation (NSF), NOAA, various offices of the US EPA (Great Lakes National Program Office, Regions II, IV, and V, as well as the Office of Research and Development), and for the States of Michigan, Massachusetts, Vermont, Wisconsin, and Florida Department of Environmental Protection. I have given key note and invited scientific presentations for the USEPA, Environmental Council of States, New England Governors and Canadian Premiers Conference, and at other environmental policy meetings in the US, Canada and in Europe, focused on mercury. In addition, I was invited to testify in front of the House Science Committee at a Special Session on ***Acid Deposition and Mercury*** in 2001. Lastly, I served on the Ste of Michigan Electric Utility Workgroup, which brought together representatives from the utility sector and the MI DEQ to investigate ways to reduce mercury emissions from coal-fired power plants.

I have authored or co-authored over 100 peer-reviewed scientific papers on the sources, transport, chemistry, and deposition of atmospheric pollutants with a majority of them focusing on mercury. In addition, I have authored or co-authored a similar number of scientific and project reports and was lead author on the sources of HAPS to the Great Waters prepared for the USEPA.

A copy of my Curriculum Vitae is provided in Attachment A which details my educational and professional background including a complete list of my scientific publications. In forming my opinions I keep current with scientific papers published in the peer-reviewed literature as well as government reports, conference proceedings, and scientific textbooks dealing with the subject matter. I also drew heavily upon my research activities over the past two decades that have dealt specifically on mercury pollution and the peer-reviewed results within those publications.

Purpose of Testimony

I have prepared this testimony on behalf of the Illinois Environmental Protection Agency (IL EPA, the Agency). I was asked by the Agency to prepare a state-of-the-art assessment of the sources of mercury deposition to the Great Lakes and to specifically discuss the importance of coal-fired utilities on the deposition of mercury to the region.

Summary

Sources of atmospheric mercury deposition

Major anthropogenic mercury sources in the Great Lakes Region and preliminary estimates of their annual emissions into the atmosphere have been reported. Sources include: fossil fuel utility boilers, municipal and hospital waste incinerators, iron and steel production, coke production, lime production, hazardous waste recycling facilities, and secondary copper, petroleum refining, and mobile sources. However, the sources of mercury are numerous and many are not well characterized. An accurate emissions inventory that includes speciated anthropogenic as well as natural mercury sources is currently not available.

Mercury emissions from coal burning utilities make it the largest source category within the US today and new rules have just been issued by the Federal Government in an effort to control these emissions. The relationship between the emissions of mercury to the atmosphere from any one plant and the amount received at any receptor is complex. Defining the sources of mercury impacting a receptor can be accomplished using various modeling techniques. One approach that has been successful in determining the contributions of Hg from various sources is based on observations made at sampling or receptor sites. This method has the major benefit of not requiring speciated mercury emissions rates from all the major sources which are likely to impact the receptor site. Source receptor relationships have been developed for mercury in wet deposition and for ambient particulate phase mercury to date. Published studies have revealed that mercury levels in precipitation and in the particulate phase can be quantitatively apportioned to their source.

The sources of atmospheric mercury deposition can be determined in both urban and rural areas if the relevant data is collected on the proper time scales. Our studies in Detroit, MI revealed that when mercury measurements taken with other criteria pollutants, e.g. ozone, and meteorological parameters allowed for an apportionment the sources of mercury observed at that monitoring site. Regional sources of oxidized mercury in photochemically active air masses as well source contributions from local coal combustion and motor vehicle emission sources were important in Detroit. This finding is applicable to many of the major urban areas in the Great Lakes region which have a similar density of industrial and mobile sources contributing to the elevated levels measured in these areas. Furthermore, the levels of mercury in urban runoff can be directly related to the wet and dry deposited mercury from the atmosphere which comprises a large non-point source of contamination to surface waters in the Great Lakes. Our studies have shown that the highest levels of mercury in the ambient air, as well as in wet deposition, can be related to its source using source tracers and meteorological analysis.

Impact of Coal-fired Utilities

In a 1998 Report to Congress, the U.S. Environmental Protection Agency (EPA) identified coal-fired utility boilers as the largest source of domestic anthropogenic mercury emissions to the atmosphere and provided evidence of a causal link between such releases and the presence of methylmercury in fish tissue. At that time, EPA recognized that the

Ohio River Valley contained a high density of coal-fired utility boilers and that monitoring of atmospheric mercury deposition was not being conducted in that area. The University of Michigan initiated a mercury monitoring and source apportionment study with the USEPA to investigate the impact of local and regional coal combustion sources on atmospheric mercury deposition in the Ohio River Valley. The first results of this study clearly identified coal combustion sources as the dominant source of the mercury deposition.

The relative importance of domestic coal combustion sources to atmospheric mercury deposition in the U.S. and the efficacy of the CAMR cap and trade approach to decrease Hg in fish is the topic of an ongoing debate. At the center of this debate is the question of the relative importance of Hg emissions from domestic coal-fired utility boilers to atmospheric deposition into sensitive aquatic and terrestrial ecosystems. As part of the CAMR development process, EPA used the Community Multi-scale Air Quality model (CMAQ), an Eulerian dispersion model, to estimate the impact of domestic mercury sources on atmospheric deposition for CY2001. While extremely useful, all contemporary deterministic or source-oriented models (e.g., CMAQ) are limited by the large uncertainties in emission inventories including the lack of speciated mercury emissions profiles, atmospheric mercury chemistry, and accurate wet and dry deposition parameterizations. Receptor models differ from source-oriented models in that they use statistical methods for which implementation only relies upon observations of deposition at a location or receptor. Deterministic and receptor modeling source apportionment approaches are independent and complementary.

Multivariate statistical receptor models have been successfully used to apportion the sources of Hg deposited in S. Florida and the sources of other chemical compounds elsewhere. These techniques have the advantage of not requiring prior measurements of source profiles or emission inventories. The latest receptor models were applied to the precipitation chemistry data collected at Steubenville, Ohio to determine the sources contributing to Hg in wet deposition.

Coal combustion was clearly dominant in terms of explaining the mercury deposition (~70%). While there are several large steel manufacturing facilities in the Steubenville, OH–Wheeling, WV area as well as plants to the east in Pittsburgh but iron-steel production was not a significant contributor to mercury deposition (< 1%) at this site. An unidentified phosphorous source as well as an oil combustion/incineration source were found to be a significant minor contributor to mercury deposition (2 and 6% respectively). A meteorological analysis corroborates that a substantial amount of the mercury deposition found at the Steubenville site was due to local and regional sources.

The large temporal variability and range of concentrations (20 fold) among the event samples in Steubenville also point to strong local and/or regional source influence. This is consistent with previous findings that a large range in concentration for similar rainfall amounts can be attributed to variability in impacts by local sources and to the variation in distance between the sources and the receptor site. Because the multivariate statistical analysis points to ~70% of the Hg in the wet deposition as originating from a coal combustion source, all analysis indicate the major contribution from local and regional

coal-burning sources.

The importance of coal combustion on the levels of particulate Hg was also quantified as part of the GLAMAP. The major sources contributing to the ambient Hg were located in the large urban/industrial areas and along the Ohio River Valley. A combined receptor modeling and transport modeling approach was able to spatially identify the Ohio River Valley region from northeastern Ohio to Illinois as the dominate source region contributing to the ambient levels of mercury in the Great Lakes Region measured during the two-year study. This is consistent with the findings from the study of the sources of wet deposition in Steubenville discussed above.

Conclusion

Some of the highest concentrations of mercury in precipitation, and in the ambient air in vapor and particulate forms have been observed in the Great Lakes region, which is consistent with our understanding of the impact of the high mercury emissions density in the major urban/source areas in the Midwest region, including the large number of coal-fired utilizes. Measurement studies have reported significant south to north gradients in the levels and deposition of mercury, and air mass transport from known source areas could explain the majority of the variability in the mercury deposition recorded. Local air mass stagnation and synoptic-scale meteorological transport strongly influenced the day-to-day variability in the mercury levels and deposition. The lowest mercury levels and wet deposition are associated with transport from the lowest mercury emissions areas.

Source-receptor studies have recently been completed that indicate that coal-fired utilities contributed ~70% of the mercury wet deposition measured at a site in eastern Ohio over a two-year period from 2003-2004. This finding is not unexpected as the Steubenville site was selected due to its close proximity to a number of large coal-fired power plants. The deposition of mercury is heavily influenced by a few large precipitation events that contributing significantly to the annual deposition and these events are associated with emissions from local/regional sources. Elevated ambient mercury levels near large sources suggest that dry deposition would also be elevated and likely to be similar in magnitude to the wet deposition. Thus, reductions in emissions from coal combustion sources in the region would have a significant impact on the amount of mercury deposited via both wet and dry deposition.

More specifically, there are 21 coal-fired power plants Illinois, which constitute the largest source of uncontrolled mercury emissions in the State, emitting close to 4 tons per year of mercury into the atmosphere. The State's coal-fired power plants are scattered throughout Illinois, with many located near major bodies of water. The states location relative to the Great Lakes makes its coal-fired power plants especially important with respect to loadings of mercury to the large lakes and the many downwind, in-land lakes which have been identified as impaired water bodies due to the levels of mercury found in fish. Areas with elevated mercury deposition due to emissions related to coal combustion have been identified and it is not clear whether the EPA emissions trading program will eliminate these “hot spots” or prevent future areas with high loadings of mercury from the atmosphere.

Attachment 1

Curriculum Vitae
Gerald J. Keeler

Curriculum Vitae
Gerald J. Keeler

EDUCATION

1987 Ph.D. Atmospheric Sciences, University of Michigan, Ann Arbor
1983 M.S. Atmospheric Sciences, University of Michigan, Ann Arbor
1982 B.S. Physics, Boston College, Chestnut Hill, MA

Positions at University of Michigan

Professor, University of Michigan, Department of Environmental Health Sciences, SPH, Ann Arbor, Michigan. (2003 – present)

Professor, University of Michigan, Department of Atmospheric, Oceanic, and Space Sciences, COE, Ann Arbor, Michigan. (2003 – present)

Professor, University of Michigan, Department of Geological Sciences, LS&A, Ann Arbor, Michigan. (2003 – present)

Director, Global Change Laboratory, University of Michigan, College of Engineering, Ann Arbor, Michigan. (2000 – 2004)

Associate Director, Institute for Environmental Sciences, Engineering, and Technology, University of Michigan, College of Engineering, Ann Arbor. (1998 – 2000)

Associate Professor, University of Michigan, Department of Environmental Health Sciences, SPH, Ann Arbor, Michigan. (1996 – 2003)

Associate Professor, University of Michigan, Department of Atmospheric, Oceanic, and Space Sciences, COE, Ann Arbor, Michigan. (1996 – 2003)

Research Scientist, Center for Great Lakes and Aquatic Sciences, UM. (1991 – 2001)

Director, EPA Air Pollution Training Center at the University of Michigan (1990 – 2000)

Director, *University of Michigan Air Quality Laboratory (UMAQL).* (1990 – present)

Assistant Professor, University of Michigan, Department of Environmental Health Sciences, School of Public Health, Ann Arbor, Michigan. (1990 – 1996)

Assistant Professor, University of Michigan, Department of Atmospheric, Oceanic, and Space Sciences, COE, Ann Arbor, Michigan. (1993 – 1996)

Positions at Other Institutions

Visiting Scientist, MIT Nuclear Reactor Laboratory, Cambridge, MA. (1987 – 1991)

Research Associate, Harvard School of Public Health, Boston, MA. (1987 – 1990)

HONORS AND AWARDS

1998 Excellence in Research Award-Dept. of AOSS, College of Engineering, UM
1994 Alumni Merit Award-University of Michigan (UM), College of Engineering
1993 Research Partnership Award, Rackham School of Graduate Studies, UM
1982 Boston College Honor's Program Graduate

PROFESSIONAL ACTIVITIES

Member, Michigan Environmental Science Board ***(Selected by Governor 1/2004)***
Member, Michigan Governor's Relative Risk Task Force on Air Quality
Member, Michigan Mercury Electric Utility Workgroup
Member, American Association for Aerosol Research
-Past Member Atmospheric Aerosols Working Group
Member American Chemical Society (ACS)
Member American Meteorological Society (AMS)
Member International Society of Exposure Analysis (ISEA)
Chair, Technical Review Committee USEPA
Mercury Report to Congress, Exposure and Health Effects Review Panel

JOURNAL & PROPOSAL REVIEWS AND NATIONAL/PROFESSIONAL ADVISING

Atmospheric Environment
-Guest Assoc. Editor for Special Edition on Mercury
Aerosol Science & Technology
Air and Waste Management
Biogeochemistry
Environmental Science & Technology
Environmental Health Perspectives
Journal of Geophysical Research-Atmospheres
Journal of Environmental Monitoring
Science of the Total Environment
Tellus
U.S. EPA Competitive Grants Program
U.S. EPA STAR Grants Program
U.S. EPA Office of International Affairs (Washington, D.C.)
Water, Air and Soil Pollution

INTERNATIONAL

Technical Advisory Committee, *International Conference on Mercury as a Global Pollutant-4th*, Hamburg, Germany August, 1996.

Technical Advisory Committee, *International Conference on Mercury as a Global Pollutant-5th*, Rio de Janeiro, Brazil, May 23-28. 1999.

Technical Steering Committee, *International Conference on Heavy Metals in the Environment*, August 6-10, Ann Arbor, Michigan. 2000.

Technical Advisory Committee, *International Conference on Mercury as a Global Pollutant-6th*, Minimata, Japan October 22-29, 2001.

Technical Advisory Committee, *International Conference on Mercury as a Global Pollutant-7th*, Ljubljana, Slovenia June 27-July 2, 2004.

Graduate student mentorship - Principal Advisor for past 15 years (29)

Mary Azizian, Carl Lamborg, Steve Mischler, Jamal Hashim, Zailina Hashim, Lisa Cleckner, Marion Hoyer, Ganda Glinsorn, Tamar Krantz, Janet Burke, Tim Dvonch, Amy Gildemeister, Matt Landis, Elizabeth Malcolm, Anne Rea, Alan Vette, Ron Albelak, Yolada Yaipairoon, Masako Morishita, Mary Lynam, Fuyuen Yip, Ali Kamal, Sang Yoon, Sheryl Kennedy, Bian Liu, Li-Hao Young, Emily Christainson, Lynne Gratz.

GRANTS AND CONTRACTS

Dr. Keeler has been awarded more than 85 competitive grants and contracts from the agencies listed below, with research expenditures > $1 million per year for the past 12 years.

RESEARCH FUNDING HISTORY

City of Detroit
Environment Canada
Ford Motor Company
Great Lakes National Program Office of the US EPA
Health Effects Institute (HEI)
Health and Welfare Canada
Lake Superior Basin Trust Fund
Michigan Great Lakes Protection Fund
Michigan Life Sciences Corridor
Northeast States for Coordinated Air Research (NESCAUM)
Ontario Ministry of the Environment
Regional Great Lakes Protection Fund-Chicago
State of Massachusetts
State of Michigan Department of Environmental Quality
-Air Quality Division, Surface Water Quality Division
State of Florida Department of Environmental Protection
State of Vermont Environmental Protection
State of Wisconsin Department of Natural Resources
U.S. Department of Energy
U.S. National Science Foundation
U.S. National Institute of Health
U.S. National Institute of Environmental Health Sciences
U.S. EPA Office of Research and Development
U.S. EPA Region I, II, IV, V
U.S. EPA Office of Air Quality Planning and Standards (OAQPS)

U.S. National Atmospheric and Oceanic Administration (NOAA)

PUBLICATIONS

PEER REVIEWED PUBLICATIONS

1. Pierson, W.R., Brachaczek, W.W., Gorse, R.A., Jr., Japar, S.H., Norbeck, J.M. and Keeler, G.J. Acid rain and atmospheric chemistry at Allegheny Mountain. *Environmental Science and Technology* **21**, 679-691. 1987.

2. Keeler, G.J., Brachaczek, W.W., Gorse, R.A., Jr., Japar, S.M. and Pierson, W.R. Effect of ambient humidity on dichotomous sampler coarse/fine ratios. *Atmospheric Environment* **22**, 1715-1720. 1988.

3. Pierson, W.R., Brachaczek, W.W., Gorse, R.A., Jr, Japar, S.H., Norbeck, J.M. and Keeler, G.J. Atmospheric acidity measurements on Allegheny Mountain and the origins of ambient acidity in the Northeastern United States. *Atmospheric Environment* **23**, 431-450. 1989.

4. Spengler, J.D., Keeler, G.J., Koutrakis, P., Ryan, P.B., Raizenne, M. and Franklin, C.A. Exposures to acidic aerosols. *Environmental Health Perspectives*, **79,** 43-51. 1989.

5. Small, M.J., Boyd, C., Keeler, G.J. and Marinicio, R.J. Stochastic simulation of meteorological variability for long-range atmospheric transport: II-Long term statistical models. *Atmospheric Environment* **23,** 2825-2840. 1989.

6. Vossler, T.L., Lewis, C.W., Stevens, R.K., Dzubay, T.G., Gordon, G.E, Tuncel, S.G., Russworm, G.M. and Keeler, G.J. Composition and origin of summertime air pollutants at Deep Creek Lake, Maryland. *Atmospheric Environment* **23**, 1715-1720. 1989.

7. Keeler, G.J. and Samson, P.J. On the spatial representativeness of trace element ratios. *Environmental Science and Technology* **23**, 1358-1364. 1989.

8. Keeler, G.J., Japar, S.M., Brachaczek, W.W., Gorse, R.A., Jr. and Pierson, W.R. The sources of aerosol elemental carbon at Allegheny Mountain. *Atmospheric Environment* **24A**, 2795-2805. 1990.

9. Keeler, G.J., Spengler, J.D., Koutrakis, P., Allen.G.A., Raizenne, M. and Stern, B. Transported acidic aerosols measured in southern Ontario. *Atmospheric Environment* **24A,** 2935-2950. 1990.

10. Brauer, M., Koutrakis, P., Keeler, G.J. and Spengler, J.D. Indoor and outdoor concentrations of acidic aerosols and gases. *Journal of Air and Waste Management Association* **41**, 171-181. 1991.

11. Keeler, G.J., Spengler, J.D. and Castillo, R. Acid aerosol measurements at a suburban Connecticut site. *Atmospheric Environment* **24A**, 2915-2923. 1991.

12. Koutrakis, P., Wolfson, J.W., Brauer, M., Spengler, J.D., Keeler, G.J. and Slater, J.L. Determinations of aerosol strong acidity losses due to interactions of collected particles: Results from laboratory and field studies. *Atmospheric Environment* **26A**, 87-996. 1992.

13. Hoyer, M.E., Keeler, G.J. and Ball, J.C. Detection of oxidative mutagens in an urban air particulate extract: A preliminary study. *Mutation Research* **283**, 295-299. 1992.

14. Holsen, T.M., Noll, K.E., Fang, G.C., Lee, W.J., Lin, J.M. and Keeler, G.J. Dry Deposition and particle size distributions measured during Lake Michigan Urban Air Toxics study. *Environmental Science and Technology* **27**, 1141-1150. 1992.

15. *Pirrone, N.* and Keeler, G.J. Deposition of trace metals in urban and rural areas in the Lake Michigan Basin. *Water Science & Technology* **28**, 261-271. 1993.

16. Akereddu, F.A., Barrie, L.A., Olson, M.P., OOkawa, K.K., Pacyna, J.M. and Keeler, G.J. The Flux of anthropogenic trace metals into the Arctic the mid-latitudes in 1979/80. *Atmospheric Environment* **27A**, 711-723. 1994.

18. Keeler, G.J. and Pierson, W.R. Regional trace element and sulfate transport. *Atmospheric Environment* **27A**, 761-772. 1994.

19. *Pirrone, N.*, Keeler, G.J., and Warner, P. Trends of ambient concentrations and deposition fluxes of particulate trace metals in Detroit 1982 to 1992. *Science of the total environment* **162**, 43-61. 1995.

20. *Graney, J.R.*, Halliday, A.N., Keeler, G.J., Nriagu, J.O., Robbins, J.A. and Norton, S.A. Isotopic record of lead pollution in lake sediments from the northeastern United States. *Geochim. Cosmochim. Acta.* **59**, 9647-9658. 1995.

21. *Pirrone, N.*, Keeler, G.J. and Holsen, T.M. Dry Deposition of trace elements over Lake Michigan: A hybrid-receptor deposition modeling approach. *Environmental Science and Technology* **29**, 2112-2122. 1995.

22. *Pirrone, N.* and Keeler, G.J. and Holsen, T.M. Dry Deposition of semivolatile organic compounds to Lake Michigan. *Environmental Science and Technology* **29**, 2123-2132. 1995.

23. *Pirrone, N.*, Keeler, G.J., Nriagu, J.O. and Warner, P. Historical trends of airborne trace metals in Detroit from 1971 to 1992. *Water, Air and Soil Pollution* **88**, 145-165. 1995.

24. Keeler, G.J., Glinsorn, G.G. and Pirrone, N. Particulate mercury in the atmosphere: Its significance, transport, transformation and sources. *Water, Air and Soil Pollution* **80**, 159-168. 1995.

25. Dvonch, J.T., Vette, A.F., Keeler, G.J., Evans, G. and Stevens, R.K. An intensive multi-site pilot study investigating atmospheric mercury in Broward County, Florida. *Water, Air and Soil Pollution* **80**, 169-178. 1995.

26. Hoyer, M., Burke, J. Rea, A. and Keeler, G.J. Atmospheric sources, transport and deposition of mercury in Michigan: Two years of event precipitation. *Water, Air and Soil Pollution* **80**, 199-208. 1995.

27. Burke, J., Hoyer, M., Keeler, G.J. and Scherbatskoy, T. Wet deposition of mercury and ambient mercury concentrations at a site in the Lake Champlain Basin. *Water, Air and Soil Pollution* **80**, 353-362. 1995.

28. Cleckner, L.B., Esseks, E., Meier, P.G. and Keeler, G.J. Mercury concentrations in two Great Waters. *Water, Air and Soil Pollution* **80**, 581-584. 1995.

29. Pacyna, J.M. and Keeler, G.J. The origin of mercury in the Arctic. *Water, Air and Soil Pollution* **80**, 621-632. 1995.

30. *Pirrone, N.*, Glinsorn, G. and Keeler, G.J. Ambient levels and dry deposition fluxes of mercury to Lakes Huron, Erie, and St. Claire. *Water, Air and Soil Pollution*, **80**,179-188. 1995.

31. *Pirrone, N.*, Keeler, G.J., Nriagu, J.O. and Warner, P.O. Historical Trends of Airborne Trace Metals in Detroit from 1971 to 1992. *Water, Air and Soil Pollution*, **88**, 145-165. 1996.

32. Brian, R., Tang, Y., Brook, J.R., Vincent, R. and Keeler, G.J. Aqueous extraction of airborne particulates collected on Hi-vol. Teflon filters. *Journal of Environmental Analytical Chemistry* **63,** 315-322. 1996.

33. Rea, A. W., Keeler, G.J. and Scherbatskoy, T. The cycling of mercury in throughfall and litterfall in a northern mixed hardwood forest. *Atmospheric Environment* **30**, 3257-3264. 1996.

34. *Pirrone, N.* and Keeler, G.J. A Preliminary Assessment of the Urban Pollution in the Great Lakes Region. *Science of the total environment*, **189**, 91-98. 1996.

35. *Pirrone, N.*, Keeler, G.J. and Nriagu, J.O. Regional differences in worldwide emissions of mercury to the atmosphere. *Atmospheric Environment* **30**, 2981-2987. 1996.

36. *Pirrone, N.* and Keeler, G.J. The Rouge River watershed pollution by trace elements: atmospheric deposition and emissions sources. *Water Science and Technology* **33**, 259-265. 1996.

37. Keeler, G.J. and Pirrone, N. Atmospheric transport and deposition of trace elements to Lake Erie from Urban areas. *Water Science and Technology* **33**, 267-275. 1996.

38. Landis, M.S. and Keeler, G.J. A Critical Evaluation of an Automatic Wet-Only Precipitation Collector for Mercury and Trace Element Determinations. *Environmental Science and Technology* **31**, 2610-2615. 1997.

39. Rea, A. and Keeler, G.J**.** Microwave digestion and analysis of foliage for total mercury by cold vapor atomic fluorescence spectroscopy. *Biogeochemistry* **40**, 115-123. 1998.

40. *Pirrone, N.*, Keeler, G.J., Nriagu, J.O. and Allegrini, I. Historical Records of Mercury Pollution in North America. *Atmospheric Environment* **32**, 929-940. 1998.

40. Sofuoglu, S.C., Paode, R.D., Sivadechathep, J., Noll K.E., Holsen, T.M. and Keeler, G.J. Dry Deposition Fluxes and Atmospheric Size Distributions of Mass, A1, and Mg Measured in Southern Lake Michigan during AEOLOS. *Aerosol Science and Technology* **29**:4, 281-293. 1998

41. Hashim, Z., Hashim, J.H., Mancy, K.H., Keeler, G.J., Burton, M. Inhalation exposure assessment of lead on urban and suburban children in the Klang Valley, Malaysia. *Journal of Ensearch*. **9**,15-19. 1996.

42. Hashim, J.H., Hashim, Z., Keeler, G.J., Mancy, K.H. Influence of meteorological variables on atmospheric lead in the Klang Valley, Malaysia. *Journal of Ensearch*. **10(3/4),** 189-194. 1997.

43. Paode, R.D., Sofuoglu, S.C., Sivadechathep, J., Noll, K.E., Holsen, T.M. and Keeler, G.J. Dry Deposition Fluxes and Mass Size Distributions of Pb, Cu, and Zn Measured in Southern Lake Michigan during AEOLOS. *Environmental Science and Technology* **32**, 1629-1635. 1998.

44. Dvonch, J.T., Graney, J.R., Marsik, F.J., Keeler, G.J. and Stevens, R.K. An Investigation of Source-Receptor Relationships for Mercury in South Florida Using Event Precipitation Data. *The Science of the Total Environment* **213**, 95-108. 1997.

45. Scherbatskoy, T., Shanley, J.B. and Keeler, G.J. Factors controlling mercury transport in an upland forested catchment. *Water, Air, and Soil Pollution **105***, 427-438. 1998.

46. Dvonch, J.T., Graney, J.R., Keeler, G.J., and Stevens, R.K. Utilization of Elemental Tracers to Source Apportion Mercury in South Florida Precipitation. *Environmental Science and Technology* **33**, 4522-4527. 1999.

47. Vincent, J.H., Ramachandran, G., Thomassen, Y. and Keeler, G.J. Application of Recent Advances in Aerosol Sampling Science Towards the Development of Improved Sampling Devices: The Way Ahead. *Journal of Environmental Monitoring* **1**, 285-292. 1999.

48. Clark, N.M., Brown, R.W., Parker, E., Robins, T.G., Remick, D.G., Philbert, M.A., Keeler, G.J. and Israel, B.A. Childhood Asthma. *Environmental Health Perspectives* **107**, 421-429. 1999.

49. Albalak, R., Keeler, G.J., Frisancho, A.R. and Haber, M.J. Assessment of PM10 concentrations from domestic biomass fuel combustion in two rural Bolivian highland villages. *Environmental Science and Technology* **33**, 2505-2509. 1999.

50. Albalak, R., Frisancho, A.R. and Keeler, G.J. Domestic biomass fuel combustion and chronic bronchitis in two rural Bolivian villages. *Thorax* **54**, 1104-1108. 1999.

51. Rea, A.W., Lindberg, S.E., and Keeler, G.J. Assessment of dry deposition and foliar leaching of mercury and selected trace elements based on washed foliar and surrogate surfaces. *Environmental Science and Technology* **34**, 2418-2425. 2000.

52. Robbins, J.A., Holmes, C., Halley, R., Bothner, M., Shinn, E., Graney, J., Keeler, G.J., tenBrink, M., Orlandini, K.A., Rudnick, D. Time-averaged Fluxes of lead and fallout radionuclides to Sediments in Florida Bay. *J. Geophysical Research*. **105**:28,805-28,821. 2000.

53. Munthe, J., Wangberg, I, Pirrone, N., Ivergeldt, A., Ferarra, R., Costa, P., Ebinghaus, R., Feng, X., Gardfelt, K., Keeler, G.J., Lanzillotta, E., Lindberg, S.E., Lu, J., Mamane, Y., Nucaro, E., Prestbo, E., Schmolke, S., Schroeder, W.H., Sommar, J., Sprovieri, F., Stevens, R. K., Stratton, W., Tuncel, G., Urba. A. Intercomparison of methods for sampling and analysis of atmospheric mercury species *Atmospheric Environment* 35, 3453-3462. 2001.

54. Thornberry, T., Town, M., Carroll, M. A., Keeler, G. J., Silman, S., Bertman, S.B., Pippin, M.R., Ostling, K., Grossenbacher, J.W., Shepson, P.B., Cooper, O.R. and Moody, J.L. PROPHET'98 meteorological overview and air mass classification. *J. Geophysical Research- Atmospheres*. **106**, p. 24359-24386. 2001.

55. Rea, A.W., Lindberg, S.E. and Keeler, G.J. Dry deposition and foliar leaching of mercury and selected trace elements in deciduous forest throughfall. *Atmospheric Environment* **35**, *3453-3462.* 2001.

56. Faloona, I., Tan, D., Brune, W., Hurst, J., Barket, D., Couch, T.L., Shepson, P., Apel, E., Riemer, D., Thornberry, T., Carroll, M., Silman, S., Keeler, G.J., Sagady, J., Hooper, D., Paterson, K., Lamb, B. and Westberg, H. Nighttime observations of prodigous hydroxyl radicals above a deciduous forest canopy. *J. Geophysical Research- Atmospheres*. **106**, p. 24315-24333. 2001.

57. Rea, A.W., Lindberg, S.E., Scherbatskoy, T. and Keeler, G.J. Mercury accumulation over time in two northern mixed-hardwood forests. *Water, Air and Soil Pollution* p **133**, 49-67. 2002.

58. *Zhang, H.*, Lindberg, S.E., Marsik, F.J., Keeler, G.J. Mercury air/surface exchange kinetics of background soils of the Tahquamenon River watershed in the Michigan Upper Peninsula. *Water, Air and Soil Pollution* **126**, 151-169. 2001.

59. Atasi, K.Z., Fujita, G., Le Platte, G., Hufnagel, C., Keeler, G.J., Graney, J., Chen, T. Impact of Atmospheric Deposition on Surface Water Runoff of Mercury, Cadmium and PCBs. *Water Science and Technology* **43**, p 223-229. 2001.

60. Keeler, G.J., Dvonch, J.T., Yip, F.Y., Parker, E. A., Israel, B.A., Marsik, F.J., Morishita, M., Barres, J.A., Robins, T.G., Brakefield-Caldwell, W., Sam, M. Assessment of Personal Exposures to Particulate Matter (PM) Among Asthmatic Children in Detroit, Michigan as part of Community Action Against Asthma (CAAA). *Environmental Health Perspectives* 110 (suppl 2):173-181. 2002.

61. Malcolm, E. and Keeler, G.J. Measurements of Mercury in Dew: Atmospheric Removal of Mercury Species to a Wetted Surface. *Environmental Science and Technology,* **36**, 2815 - 2821, 2002.

62. Landis, M.S. and Keeler, G.J. Atmospheric Mercury Deposition to Lake Michigan during the Lake Michigan Mass Balance Study. *Environ. Sci. Technol*. **36,** 4518-4524**,** *2*002.

63. Lynam, M.M. and Keeler, G.J. Comparison of methods for particulate phase mercury analysis: techniques and sampling artifacts. *Fresnius Journal of Analytical Chemistry* **374**, 1009-1014. 2002.

64. Vette, A.F., Landis, M.S. and Keeler, G.J. Deposition and emission of gaseous mercury to and from Lake Michigan during the Lake Michigan Mass Balance Study. *Environ. Sci. Technol*. **36**, 4525-4532. 2002.

65. Landis, M.S., Vette, A. and Keeler, G.J. Atmospheric Mercury Deposition in the Lake Michigan Basin: Influence of the Chicago/Gary Urban Area. *Environ. Sci. Technol*. **36,** 4508-4517**,** *2*002.

66. Utsunimiya, S., Jensen, K.A., Keeler, G.J. and Ewing, R.C. Uraninite and Fullerene in Atmospheric Particulates. *Environmental Science and Technology*, **36**, 4943-4947. 2002.

67. Harkema, J., Keeler, GJ, Wagner, JG, Marsik, F, and EB Barr, Effects of concentrated airborne particles on the lungs of rats with allergic airway disease: inhalation toxicology studies in a Detroit community using a mobile air research laboratory. *Am. J. Respir.Crit. Care Med*., **165**(8): p. A69. 2002.

68. Parker, E.A., Israel, B.A., Caldwell-Brakefield, W., Keeler, G.J., Lewis, T.C., Ramirez, E., Robins, R., Rowe, Z. and Williams, M. Community Action Against Asthma: Examining the partnership process of a community-based participatory research project. *Environ. Health Perspec.* 111, 223-231, 2003.

69. Lu, J.Y, Schroeder, W.H and Keeler, G.J. Field intercomparison studies for evaluation and validation of the AeminiSamplR technique for sampling and analysis of total particulate mercury in the atmosphere. *STOTEN. 304, 115-125. 2003.*

70. Malcolm, E.G., Keeler, G.J., Lawson, S. and Sherbatskoy, T. Mercury and trace elements in cloud water collected on Mt. Mansfield, VT. *J. Environ. Monitor.* **5**,584-590, 2003.

71. Malcolm, E.G., Keeler, G.J. and Landis, M.S. The effects of the coastal environment on the mercury cycle. *J. Geophys. Res.* **108**, 4357-4366. 2003.

72. Lawson, S.T., Scherbatskoy, T.D., Malcolm, E.G., Keeler, G.J. Cloud water deposition and throughfall chemistry in a high elevation spruce-fir forest at Mt. Mansfield, Vermont. *Journal of Environmental Monitoring*, **5**:578-583. 2003.

73. Lewis, T.C., Robins, T.G., Dvonch, J.T., Brakefield-Caldwell, W., Keeler, G.J., Mentz, G.B., Lin, X., Parker, E.A., Israel, B.A., Gonzalez, L., and Williams, M. Community Action Against Asthma: Examining the Partnership Process of a CBPR Project. *Journal of General Internal Medicine,* **18**(7):558-567 (2003).

74. Graney, J.R., Dvonch, J.T. and Keeler, G.J. Use of elemental tracers to source apportion mercury in south Florida aerosols. *Atmos. Environ.* **38**, 1715-1726. 2004.

75. Landis, M.S., Keeler, G.J., Al-Wali, K.I. and Stevens, R.K. Divalent inorganic reactive mercury emissions from a mercury cell chlor-alkali plant and its impact on near-field atmospheric dry deposition. *Atmos. Environ.* **38**, 613-622. 2004.

76. Utsunomiya, S., Jensen, K.A., Keeler, G.J. and Ewing, R.C. Direct identification of trace metals in fine and ultrafine particles in the Detroit urban atmosphere. *Environ. Sci. Technol*. **38,** 2289-2297, 2004.

77. Dvonch, J.T., Brook, R.D., Keeler, G.J., Rajagopalan, S., D'Alecy, L.D., Marsik, F.M., Morishita, M., Yip, F.Y., Brook, J.E., Timm, E.J., Wagner, J.W. and Harkema , J.R. Effects of concentrated fine particles on rate plasma levels of asymmetric dimethylarginine. *Inhalation Toxicology*, **16**, 473-480, 2004.

78. Morishita, M., Keeler, G.J., Wagner, J.G., Marsik, F.J., Timm, E.J., Dvonch J.T., Harkema, J.R. Pulmonary Retention of Particulate Matter is Associated with Airway Inflammation in Allergic Rats Exposed to Air Pollution in Urban Detroit. *Inhalation Toxicology* **16**, 663-674. 2004.

79. Young, L-H. and Keeler, G.J. Characterization of Ultrafine Particle Number Concentration and Size Distribution During a Summer Campaign in Southwest Detroit. *J. Air & Waste Management Assoc.* **54**, 1079-1090, 2004.

80. Yip, F.Y., Keeler, G.J., Dvonch, J.T., Robins, T.G., Parker, E. A., Israel, B.A., Brakefield-Caldwell, W. Personal exposures to particulate matter among children with asthma in Detroit, Michigan. *Atmos. Environ.* **38**, 5227-5236. 2004.

81. Keeler, G.J., Gratz, L. and Al-Wali, K. Influences on the Long-term Atmospheric Mercury Wet Deposition at Underhill, Vermont. *Ecotoxicology*, **14**, 71-83. 2005.

82. Gildemeister, A.E., Keeler, G.J. and Graney, J.R. Source proximity reflected in spatial and temporal variability in particle and vapor phase Hg concentrations in Detroit, MI. *Atmos. Environ.* **38**, 5227-5236. 2005.

83. Miller, E.K., Van Arsdale, A., Keeler, G. J., Chalmers, A. Poissant, L. and Kammen, N. Estimation and Mapping of Wet and Dry Mercury Deposition Across Northeastern North America. *Ecotoxicology*, **14**, 53-70. 2005.

84. VanArsdale, A., Weiss, J., Keeler, G.J. and Miller, E. Patterns of mercury deposition in northeastern North America (1996-2002). *Ecotoxicology*, **14**, 84-101. 2005.

85. Dvonch, J.T., Marsik, F.J. and Keeler, G.J. The Use of WSR-88D Radar Data for Source-Apportionment of Wet-Deposition Measurements from the 1995 SoFAMMS. *Journal of Climate and Applied Meteorology*. 1421-1435, 2005.

86. Malcolm, E.G., Keeler, G.J. and Landis, M.S. Evidence for a sampling artifact for particulate-phase mercury in the marine environment. *Atmos. Environ.* In Press, 2005.

87. Marsik, F.J., Keeler, G.J., Lindberg, S.E., Zhang, H. The air-surface exchange of gaseous mercury over a mixed sawgrass-cattail stand within the Florida Everglades. *Environ. Sci. Technol*. **39,** 2005.

88. Lynam, M.M. and Keeler, G.J. Automated speciated mercury measurements in Michigan, *Environ. Sci. Technol*. **39,** 3289-3299, 2005.

89. Gilliland, F., Avol, E., Kinney, P., Jerrett, M., Dvonch, J.T., Lurmann, F., Buckley, T., Breysse, P., Keeler, G., McConnell, R. Air pollution exposure assessment for

epidemiologic studies of pregnant women and children: lessons learned from the NIEHS/EPA Children's Environmental Health Centers. *Environ Health Perspectives*, 113(10):1447-1454, *2005.*

90. Lewis, T.C., Robins, T.G., Dvonch, J.T., Keeler, G.J., Yip, F.Y., Mentz, G.B., Lin, X., Parker, E.A., Israel, B.A., Gonzalez, L., and Hill, Y. Air Pollution Associated Changes in Lung Function Among Asthmatic Children in Detroit. *Environmental Health Perspectives*, 113(8): 1068-1075, 2005.

91. Lynam, M.M. and Keeler, G.J. Artifacts associated with the measurement of particulate mercury in an urban environment: the influence of elevated ozone concentrations. *Environ. Sci. Technol*. **38**, 3081-3088, 2005.

92. Dvonch, J.T., Keeler, G.J., Lynam, M., Marsik, F.J. and Barres, J.A. The Production of Reactive Gaseous Mercury (RGM) in Ambient Air and its Removal by Precipitation. Submitted, *Journal of Environmental Monitoring*, 2005.

93. Morishita, M., Keeler, G.J., Wagner, J.G., Marsik, F.J., Timm, E.J., Dvonch J.T., Harkema, J.R. Source identification of ambient PM2.5 for community-level exposures in urban Detroit, Michigan. *Submitted, Atmos. Environ.*, 2005.

94. Dvonch, J.T., Keeler, G.J., Yip, F.Y. Spatial and temporal assessment of real time PM 2.5 mass and black carbon in Detroit, MI (2000-2002). *Submitted, Atmos. Environ.,* 2005.

95. Lynam, M.M. and Keeler, G.J. Source-receptor relationships for elemental and reactive gaseous mercury in Detroit, Michigan. In Press, *Environ. Sci. Technol*., 2005.

96. Keeler, G.J., Christainson, E.M., Dvonch, J.T., Landis, M. Norris, G. Source of mercury wet deposition in Eastern Ohio, USA. Submitted to *Environ. Sci. Technol*., 2005.

CHAPTER OF BOOKS - PEER REVIEWED

1. Keeler, G.J., Samson, P.J. and Small, M.J. Representativeness of precipitation data in regional-scale acid deposition modeling. In: Meteorology of Acid Deposition, P.J. Samson, Ed. Air Pollution Control Association, Pittsburgh, PA. 1984.

2. Samson, P.J., Moody, J.L., Kahl, J. and Keeler, G.J. Uncertainties in quantifying source-receptor relationships for atmospheric acids. In: The Chemistry of Multi-Phase Systems in the Atmosphere, W. Jeaschke and V.A. Mohnen, Eds. D.Reidel Publishers. 1984.

3. Pierson, W.R., Brachaczek, W.W., Gorse, R.A., Japar, S.M., Norbeck, J.M. and Keeler, G.J. Acid deposition and atmospheric chemistry at Allegheny Mountain. In: The Chemistry of Acid Rain: Sources and Atmospheric Processes. Johnson and Gordon, Eds. 1987.

4. Gorse, R.A., Jr., Brachaczek, W.W., Japar, S.H., Keeler, G.J. and Pierson, W.R. Source apportionment or rural elemental carbon using several multivariate statistical analysis approaches to receptor modeling. In: Receptor Models in Air

Resources Management, Watson, J.G., Ed. Air and Waste Management Association, ISBN 0-923204-01-6. 1988.

5. Koutrakis, P., Keeler, G.J., Spengler, J.D. and Lowenthal, D.H. Analysis of simulated data using specific rotation factor analysis. In: Receptor Models in Air Resources Management, Watson, J.G., Ed. Air and Waste Management Association, ISBN 0-923204-01-6. 1988.
6. Keeler, G.J. and Samson, P.J. On the representativeness of trace element ratios. In: Control and Fate of Atmospheric Trace Metals. NATO, Pacyna and Ottar, Eds. 1989.
7. Keeler, G.J., Hoyer, M.E. and Lamborg, C.H. Measurements of atmospheric mercury in the Great Lakes Basin. In:Mercury as a Global Pollutant: Towards Integration and Synthesis (Huckabee, J. and Watras, C. Eds), Lewis Publishers, Boca Raton, FL. 1994.
8. Lamborg, C., Hoyer, M.E. and Keeler, G.J. Particulate-phase mercury in the atmosphere: collection/analysis method development and applications. In: Mercury as a Global Pollutant: Towards Integration and Synthesis (Huckabee, J. and Watras, C. Eds), Lewis Publishers, Boca Raton, FL. 1994.
9. *Pirrone, N.* and Keeler, G.J. Deposition flux of polycyclic aromatic hydrocarbons to Lake Michigan. In: Air Pollution Measurements, Methods and Monitoring Studies. AWMA, Pittsburgh, PA, pp. 1-16. 1994.
10. Keeler, G.J. and Hoyer, M.E. Atmospheric mercury in the Great Lakes Region. In: Atmospheric Deposition of Contaminants to the Great Lakes and Coastal Waters (Baker, J. Ed), SETAC Sponsored Book, Lewis Publishers, N.Y., 1997.
11. *Pirrone, N.* and Keeler, G.J. Modeling atmospheric deposition and gas exchange of hazardous air pollutants to Lake Michigan. In: Atmospheric Deposition of Contaminants to the Great Lakes and Coastal Waters (Baker, J. Ed), SETAC Sponsored Book, Lewis Publishers, N.Y. 1996.
12. Scherbatskoy, T. and Keeler, G.J. Atmospheric mercury deposition and cycling in the Lake Champlain Basin of Vermont. In: Atmospheric Deposition of Contaminants to the Great Lakes and Coastal Waters (Baker, J. Ed), SETAC Sponsored Book, Lewis Publishers, N.Y. 1996.
13. Shanley, J.B., Donlon, A.F., Scherbatskoy, T. and Keeler, G.J.: Mercury cycling and transport in the Lake Champlain basin, in T.O. Manley and P. Manley (ed.), Lake Champlain --Research and Progress Toward Management, American Geophysical Union, Washington, DC. 1999.
14. Keeler, G.J. and Dvonch, J.T. Source-Receptor Relationships for Mercury: Monitoring and Measurement. Proceedings:EPA Conference on "*Source Emission and Ambient Air Monitoring of Mercury*", September 13-14, 1999, Bloomington, Minnesota. 2000.
15. Dvonch, J.T., Landis, M.S., Marsik, F.M. and Keeler, G.J. Mercury Wet Deposition Sampling: Applications and Implementation. Proceedings: EPA Conference on

"Source Emission and Ambient Air Monitoring of Mercury", September 13-14, 1999, Bloomington, Minnesota. 2000.

16. Keeler, G.J. and Dvonch, J.T. Atmospheric Mercury: A Decade of Observations in the Great Lakes. *In:* Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes and Human Exposures around the World. N. Pirrone and K. Mahaffey Eds. Kluwer Ltd. 2005.

OTHER CITABLE PUBLICATIONS

1. Dvonch, J.T., Keeler, G.J. and Brook, J. Solubilization of Ambient Trace Metals through Interactions with Atmospheric Acids. Conference Proceedings from *"Ninth International Conference on Heavy Metals in the Environment"*, September 12-16, Toronto, Ontario, 85-88. (1993)
2. Marsik, F.J., Dvonch, J.T., Keeler, G.J., Landis, M.S. and Graney, J.R. The Use of WSR-88D Radar Data for Source-Apportionment of Wet-Deposition Measurements from the 1995 SoFAMMS. Conference Proceedings from American Meteorological Society *"Third Conference on Atmospheric Chemistry"*, February 2-7, Long Beach, California, 147-51. (1997)
3. Keeler, G.J. *Workshop on Source Emission and Ambient Air Monitoring of Mercury*, EPA/625/R-00/002, United States Environmental Protection Agency, Office of Research and Development, Washington, DC, pp. 84-85. (2000)
4. Dvonch, J.T., Marsik, F.J., Keeler, G.J., Robins, T.G., Yip, F. and Morishita, M. Field Comparison of $PM_{2.5}$ TEOM and $PM_{2.5}$ Manual Filter-Based Measurement Methods in Urban Atmospheres. *Journal of Aerosol Science*, 31**,** Suppl 1, S190-S191. (2000)
5. Yip, F.Y., Dvonch, J.T., Robins, T.G., Parker, E., Morishita, M. and Keeler, G.J. Measurements of Indoor, Outdoor, and Personal Exposure to Particulate Matter Among Asthmatic Children in Detroit, Michigan. Proceedings: Air and Waste Management Association's Conference *"International Symposium on Measurement of Toxic and Related Air Pollutants"*, September 12-14, 2000, RTP, North Carolina. (2001)

RECENT GOVERNMENT, UNIVERSITY, OR INDUSTRIAL REPORTS

1. Atkeson, T., Axelrad, D., Pollman, C. and Keeler, G.J. Integrating atmospheric mercury deposition and aquatic cycling in the Florida Everglades: An approach for conducting a total maximum daily load analysis for atmospherically derived pollutant. Final Report to the USEPA, October, 2002.
2. Keeler, G.J., Marsik, F. and Barres, J.A. Development and Specifications of an Automated Sequential Precipitation Sampler (ASPS). Submitted to Department of Environmental Protection, State of Florida, Tallahassee, FL. and the US EPA-NERL, Research Triangle Park, N.C. (2001)
3. Keeler, G.J., Marsik, F.J., Al-Wali, K. and Dvonch, J.T. Modeled Deposition of Speciated Mercury to the SFWMD Water Conservation Area 3A: 22 June 1995 to

21 June 1996. Project Description and Results. Submitted to Region IV, US EPA, Athens, GA. (2000)

4. Keeler, G.J., Marsik, F.J., Morishita, M. and Dvonch, J.T. Characterization of the Fine Particulate Mass Concentrator and Ambient PM in southwest Detroit: Report of Findings from Year 1. Submitted to: Health Effects Institute, Cambridge, MA. (2001).
5. Keeler, G.J., Xu, Xiaohong, and Al-Wali, K. Development, Evaluation and Application of a Model for Investigating Atmospheric Transport and Fate of Mercury. Final Report, USEPA National Exposure Research Laboratory, Research Triangle Park, N.C. (2001).
6. Harkema, J., Keeler, G.J., Marsik, F.J., Morishita, M. and Dvonch, J.T. Effects of concentrated air particulates on rats with asthma. Health Effects Institute, Cambridge, MA. (2004).

INVITED PRESENTATIONS (Since 1995)

1. Keeler, G. J. Atmospheric deposition processes in south Florida. Presented to: State of Florida - Department of Natural Resource Protection (November, 1995).
2. Keeler, G. J. **Key Note** – Sources of mercury in the Florida Everglades. Friends of the Everglades, Conference on Mercury in the Florida Everglades Miami, Florida (February, 1996).
3. Keeler, G. J. Atmospheric transport and deposition processes in S. Florida. Presented at: EPRI and the State of Florida - Department of Natural Resource Protection, (April,1996).
4. Keeler, G. J. **Key Note** – Sources of mercury to the global environment. US Geological Survey, Conference on Mercury in the Environment. Denver, Colorado (July, 1996).
5. Keeler, G. J. Mercury speciation and deposition to Lake Superior. Wisconsin DNR, Mercury in Lake Superior Workshop (September, 1997).
6. Keeler, G. J. Mercury in the atmosphere. Presented at: Pollution probe-Mercury Elimination and Reduction Symposium, Toronto, Canada, (May 1997).
7. Keeler, G. J. **Key Note** – New England Governors and Canadian Premiers Conference. Portland, ME Mercury Measurement Technology. (February 1998).
8. Keeler, G. J. The University of Michigan Alumni Association. Environmental Concerns in the Great Lakes and Florida Everglades. (April 28, 1998).
9. Keeler, G. J. Mercury Modeling and Measurements for the 21st Century. Presented at: Conference on Air Quality (Mercury, Trace Elements, and Particulate Matter) sponsored by Energy & Environmental Research Center, McLean, Virginia. (Dec 1-4, 1998).
10. Keeler, G. J. Urban Air Toxics and Atmospheric Mercury. Presented at: Atmospheric Deposition of Toxics: Integrating Science and Policy, Chicago, Illinois. (May 6-7, 1999)

11. Keeler, G. J. Atmospheric Modeling in South Florida: Assessing the sources of Hg to the Everglades Ecosystem. Presented at: Florida Mercury Research Meeting, (May 18-21, 1998)
12. Keeler, G. J. Sampling and Analysis Methods for speciation of mercury in the atmosphere. Presented: Instituto sull Inquinamento Atmosferico-CNR, Italy (July 1, 1998)
13. Keeler, G. J. Science Experts Workshops on Mercury in North America Diagnosing the sources of Hg deposited in the Great Lakes Region. Las Vegas, N.V. (October 6-8, 1998)
14. Keeler, G.J. Measurement Technology for speciated mercury determinations in the environment. Mercury Monitoring: Air Source Assessment, Ambient Air, and Deposition. US EPA. Chicago, January 18, 2001 (Jan. 16, 2001)
15. Keeler, G. J., **Key Note** – EPA Workshop on the Fate, transport, and transformation of mercury in aquatic and terrestrial environments. West Palm, FL. (May 8-10, 2001)
16. Keeler, G. J. **Key Note** – Source-Receptor Relationships for Atmospheric Mercury. The Environmental Council of the States (ECOS) Mercury Workshop, St. Louis, Missouri. (October 18, 2000)
17. Keeler, G. J. Atmospheric Deposition Processes and Uncertainties: Applications to the Great Lakes. Presented at: Delta Institute Workshop on Atmospheric Deposition of Toxics: Integrating Science and Policy, Milwaukee, WI. (October 20, 2000).
18. Keeler, G. J. Measurement Technology for speciated mercury determinations in the environment. Mercury Monitoring: Air Source Assessment, Ambient Air, and Deposition. US EPA Region V. Chicago, January 18, 2001 (Jan. 16, 2001)
19. Harkema, J R, Keeler, G J, Wagner, J G, Marsik, F and Barr, E B. Effects Of Concentrated Airborne Particles on the Lungs of Rats with pre-existing Airway Disease: Inhalation Toxicology Studies in a Detroit Community Using a Mobile Air Research Laboratory. Presented at: Health Effects Institute 2001 Annual Conference, Washington, D.C. (May 1, 2001)
20. Keeler, G.J. **Key Note** – EPA Workshop on the Fate, transport, and transformation of mercury in aquatic and terrestrial environments. West Palm, FL. (May 8-10, 2001)
21. Keeler, G.J. **Invited to Present Testimony** before the **House Science Committee**, Hearing on Acid Deposition and Mercury. Washington, D.C. (May 3, 2001)
22. Keeler, G.J. **Key Note** – An Integrated modeling/measurement approach for development of policies to protect the coastal environment, ELOISE Annual Conference, Calabria, Italy. (September, 2001)
23. Keeler, G.J. Environmental Measurements and Particulate Matter Exposure of Asthmatic Children Living in Urban Communities. Invited Seminar Presented at the Research Conference for the Center for Childhood Asthma in the Urban

Environment, Bloomsberg School of Public Health, John's Hopkins November 30, 2001.

24. Keeler, G.J. Source Apportionment Methods for Toxicological Studies. Presented at: Health Effects Institute Annual Meeting, Special Session Honoring Dr. Glenn Cass, Seattle, Washington. (April 28-May 2, 2002).
25. Keeler, G.J. Long Range Transport of PBTs to the Great Lakes. Presented at: The Great Lakes Binational Toxics Strategy's Long-Range Transport Workshop, Ann Arbor, Michigan (September, 2003).
26. Keeler, G.J. Atmospheric Mercury Deposition at Underhill, VT from 1991-2002. Presented at: USDA Northeastern Research Station Workshop Portland, Maine (Dec. 3-5, 2003).
27. Keeler, G.J. Mercury Deposition in the Great Lakes Ragion. Presented at: The Great Lakes: Assessing Ecosystem Health Through Partnerships. The Institute of Water Research, Michigan State University (March 11, 2004).
28. Keeler, G.J. Atmospheric Chemistry and Deposition of Mercury in the Great Lakes Region. Presented at: International Workshop on Harmonization of Mercury Measurement Methods and Models to Assess Source-Receptor Impact on Air Quality and Human Health, May 2004. CNR-Institute for Atmospheric Pollution, Italy.
29. Keeler, G.J. and Dvonch, J.T. Atmospheric Mercury: A decade of observations in the Great Lakes. Presented at: International Conference on Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes and Human Exposure Around the World. Maratea, Italy, May, 2004.
30. Keeler, G.J. and Christianson, M.G. Sources and Fate of Mercury Emissions in Urban Areas. Presented at: CRC Mobile Source Air Toxics Workshop: Advances in Field Measurements, Modeling and Data Analysis, Scottsdale, Arizona, November 30-December 2, 2004.
31. Keeler, G.J. Challenges associated with analysis of complex mixtures in urban atmospheres. Presented at: International Conference on Complex Mixtures: toxicological effects of inhaled complex mixtures on the respiratory system feasibility and limitations. Barcelona, Spain, 23-26 April, 2005.

OTHER CONFERENCE PRESENTATIONS SINCE 1999

1. Gildemeister, A.E., Graney, J., Keeler, G.J., Atassi, K., and Hufnagel, C. *The influence of local atmospheric mercury sources on mercury levels measured in urban runoff*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
2. Iverfeldt, A., Munthe, J., Ferrara, R., Pirrone, N, Berg, T., Costa, P, Ebinghaus, R., Kock, H., Sommar, J., Feng, X., Gardefelt, K., Stevens, R., Keeler, G., Mamane, Y, Tuncel, G., Nicaro, E., Sprovieri, F., Lanzillotta, E., Schmolke, S., Urba, A., and Wangberg, I. 1999. *Intercomparison for atmospheric mercury measurement*

in Tuscany, Italy, 27th of June to 3rd of July. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. *1999.*

3. Dvonch, J.T., Keeler, G.J., Graney, J.R., and Marsik, F.J. *Utilization of event precipitation data to source apportion mercury wet deposited in South Florida.* Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
4. Landis, M.S., and Keeler, G.J. *Assessing the atmospheric deposition of mercury to Lake Michigan: The importance of the Chicago/Gary Urban area on wet and dry deposition*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
5. Prestbo, E.M., Stevens, R.K., Lindberg, S., Schaedlich, F.A., Schneeberger, D.R., and Keeler, G.J. *Design and performance of an atmospheric reference standard of Hg^0 and $HgCl_2$ and its use to evaluate several state-of-the-art Hg speciation measurement methods*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
6. Lindberg, S.E., Stratton, W.J., Prestbo, E., Keeler, G.J., Stevens, R., Schaedlich, F., and Atkeson, T. *Concentrations and behavior of reactive gaseous mercury in ambient air: Initial tests of an automated sampling approach.* Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
7. Stevens, R.K., Schaedlich, F.H., Schneeberger, D.R., Prestbo, E., Lindberg, S., and Keeler, G.J. *Automated instruement designed to measure Hg^0 and reactive gaseous mercury in near real time: Design and operational characteristics*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
8. Malcolm, E.G., and Keeler, G.J. *The potential importance of dew, frost, fog and cloud water to the environmental mercury cycle*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
9. Graney, J.R., Keeler, G.J., Landis, M.S., Christensen, J.N. and Halliday, A.N. *Environmental applications of novel instrumentation for measurement of lead isotope ratios in precipitation samples from the Great Lakes region.* 42nd Conference of the International Association of Great Lakes Research. Cleveland, Ohio. 1999.
10. Gildemeister, A.E., Graney, J., Keeler, G.J., Atassi, K., and Hufnagel, C. *The influence of local atmospheric mercury sources on mercury levels measured in urban runoff*. Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999.
11. Dvonch, J.T., Keeler, G.J., Graney, J.R., and Marsik, F.J. *Utilization of event precipitation data to source apportion mercury wet deposited in South Florida.* Presented at Mercury as a Global Pollutant: 5th International conference. Rio de Janeiro, Brazil, May 23-28. 1999

12. Marsik, F.J., Keeler, G.J., Malcolm, E., Dvonch, J.T., Barres, J., Lindberg, S.E., Zhang, H., Stevens, R.K. and Landis, M. Air-Surface Exchange of Mercury Over a Mixed Sawgrass and Cattail Stand Within the Florida Everglades. Accepted for Presentation at: *"International Conference on Heavy Metals in the Environment"*, August 6-10, Ann Arbor, Michigan. 2000.
13. Landis, M.S., Stevens, R.K., Luke, W., and Keeler, G.J. 2000. Investigating the Influence of Long-range Transport on Mercury Deposition in South Florida. Paper presented at the *International Conference on Heavy Metals in the Environment,* Ann Arbor, MI. August 5-7, 2000.
14. Lynam, M.M., Dvonch, J.T., Keeler, G.J., Landis, M.S. and Stevens, R.K. Measurement of Particulate and Reactive Gaseous Mercury, RGM, in the Ambient Air: Methods Development. Accepted for Presentation at: *"International Conference on Heavy Metals in the Environment"*, August 6-10, Ann Arbor, Michigan. 2000.
15. Keeler, G.J., Dvonch, J.T., Barres, J.A, Landis, M.S. and Stevens, R.K. Real-World Emissions of Mercury from Automobiles: The 1998 Fort McHenry Traffic Tunnel Study. Accepted for Presentation at: *"International Conference on Heavy Metals in the Environment"*, August 6-10, Ann Arbor, Michigan. 2000.
16. Dvonch, J.T., Keeler, G.J., Barres, J.A., Marsik, F.J., Lynam, M., Malcolm, E., Landis, M.S. and Stevens, R.K. Near Real Time Observations of the Removal of Ambient Reactive Gaseous Mercury by Precipitation. Accepted for Presentation at: *"International Conference on Heavy Metals in the Environment"*, August 6-10, Ann Arbor, Michigan. 2000.
17. Dvonch, J.T., Marsik, F.J., Keeler, G.J., Robins, T.G., Yip, F. and Morishita, M. Field Comparison of $PM_{2.5}$ TEOM and $PM_{2.5}$ Manual Filter-Based Measurement Methods in Urban Atmospheres. Presented at: *"European Aerosol Conference 2000"*, September 4-8, Dublin, Ireland. 2000.
18. Yip, F.Y., Dvonch, J.T., Robins, T.G., Parker, E., Morishita, M. and Keeler, G.J. Measurements of Indoor, Outdoor, and Personal Exposure to Particulate Matter Among Asthmatic Children in Detroit, Michigan. Presented at: *"International Symposium on Measurement of Toxic and Related Air Pollutants"*, Sept. 12-14, Research Triangle Park, North Carolina. 2000.
19. Graney, J.R**.,** Keeler, G.J. and Christensen, J.N. Environmental Applications of MC-ICPMS: Using Lead Isotope Ratios From Precipitation Samples to Help Constrain Pollutant Source and Fate in the Great Lakes and South Florida Regions. Presented at: *"International Symposium on Measurement of Toxic and Related Air Pollutants"*, September 12-14, Research Triangle Park, North Carolina. 2000.
20. Dvonch, J.T., Marsik, F.J., Keeler, G.J., Robins, T.G., Yip, F. and Morishita, M. Field Comparison of PM-2.5 TEOM and PM-2.5 Manual Filter-Based Measurement Methods in Urban Atmospheres. Presented at: American Association for Aerosol Research *"AAAR 2000 – Nineteenth Annual Conference"*, St. Louis, Missouri. Nov. 6-10, 2000.

21. Lynam, M. M. and Keeler, G. J. Speciation of Mercury in the Ambient Air in an Urban Environment. Presented at: 23rd Midwest Environmental Chemistry Workshop, Kalamazoo, MI. October 7-8, 2000.
22. Dvonch, J.T., Marsik, F.J., Keeler, G.J., Robins, T.G., Yip, F. and Morishita, M. Field Comparison of PM-2.5 TEOM and PM-2.5 Manual Filter-Based Measurement Methods in Urban Atmospheres. Presented at: American Association for Aerosol Research "AAAR 2000 - Nineteenth Annual Conference", Nov. 6-10, St. Louis, Missouri. 2000.
23. Lynam, M. M. and Keeler, G. J. Near Real Time Measurement of Mercury Species in Ambient Air in an Urban Environment. Presented at the 221st American Chemical Society National Meeting, San Diego, CA. April 1-5, 2001.
24. Keeler, G.J., Marsik, F.J., Al-Wali, K. and Dvonch, J.T. Atmospheric Mercury Chemistry and Deposition Model Development. Presentation at: *"South Florida Mercury Science Program Annual Workshop"*, May 7, West Palm, Florida. 2001.
25. Yip, F.Y., Dvonch, J.T., Robins, T.G., Parker, E., Morishita, M., Brakefield-Caldwell, W., Sam, M. and Keeler, G.J. Assessment of Personal Exposures to Particulate Matter (PM) Among Asthmatic Children in Detroit, Michigan. Presentation at: American Public Health Association *"One World – Global Health: 129th APHA Annual Meeting and Exposition"*, October 21-25, Atlanta, Georgia. 2001.
26. Malcolm, E. G. and Keeler, G.J. The influence of clouds and the marine environment on atmospheric mercury chemistry and cycling. Poster for presentation at the US EPA STAR Annual Conference, July 2001.
27. Malcolm, E.G., Keeler, G. J., Landis, M.S., Xu X.H., Sillman, S., Quintal, K., Stevens, R.K., Bullock, O. R., Jr. Atmospheric Mercury Chemistry in the Marine Environment. Paper for presentation at the 6th International Conference on Mercury as a Global Pollutant, Minamata, Japan, October 2001.
28. Keeler, G.J. Measurements of PM exposures of asthmatic children in Detroit. International Society of Exposure Analysis Meeting, Charleston, S.C., Nov. 5, 2001.
29. Marsik, F.J., Keeler, G.J., Lindberg, S.E. and Zhang, H. The air-surface exchange of elemental Hg over a mixed sawgrass-cattail stand with the Florida Everglades. Presented at: American Chemical Society Annual Meeting, Orlando, Florida, April 8-12, 2002.
30. Lynam, M. M. and Keeler, G. J. Atmospheric Mercury Measurements in Detroit. Abstract submitted for oral presentation at the 34th Central Regional Meeting of the American Chemical Society to be held at Eastern Michigan University, June 2002.
31. Morishita, M., Keeler, G.J., Marsik, F.J., Dvonch, J.T., Young, L.H., Kamal, A.S., Wagner, J.G., Harkema, J.R. (2004) Assessment of Source Contributions to Urban Ambient PM2.5 in Detroit, Michigan. Presented at: American Association for Aerosol Research *AAAR 2004 – 23rd Annual Conference*, October 4-8, Atlanta, Georgi.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES (MERCURY)	)	

TESTIMONY OF DEBORAH RICE, Ph.D.

Qualifications

My name is Deborah Rice. I am providing testimony for the Illinois Environmental Protection Agency as an independent expert.

I have a Ph.D. in toxicology from the University of Rochester in Rochester, NY. My particular area of expertise is developmental neurotoxicology, which is the study of the effects of exposure to environmental chemicals on the developing nervous system. I am currently a toxicologist with the Environmental and Occupational Health Program of the Maine Center for Disease Control and Prevention. In that capacity, I am involved in making decisions about public health, taking into consideration all the possible ramifications of regulation or guidance involving exposure to chemicals through food, water, or air. Prior to moving to Maine, I was a senior risk assessor at the U.S. Environmental Protection Agency (EPA) in Washington, D.C. In that capacity, I was an author, along with two colleagues, of the 2001 EPA document for the derivation of the reference dose (RfD) for methylmercury based on an expert review by the National Research Council (NRC). An RfD is an allowable daily intake of a chemical that is believed to be without appreciable risk of harm when ingested over the lifetime of an individual. Before becoming a risk assessor, I was a research scientist at Health Canada. I studied the behavioral effects of exposure to methylmercury prenatally or after birth for over 20 years.

I have published over 125 original research papers and review articles, 30 of them specifically related to the health effects of methylmercury. I have delivered over 100 invited presentations, with over 30 of them addressing methylmercury neurotoxicity. I was invited to testify before the U.S. Senate Committee on Environment and Public

Works concerning the health effects of methylmercury in 2003. In 2005 and 2006, I testified as an expert witness for the State of California in a lawsuit brought under Proposition 65 concerning the dangers of ingesting fish containing methylmercury.

Introduction

In this testimony, I will discuss several issues. First, there is substantial evidence for deleterious effects on neuropsychological function as a consequence of prenatal exposure to methylmercury, and this information was used in development of an acceptable daily intake level for methylmercury by the U.S. Environmental Protection Agency. Second, methylmercury exposure is also associated with adverse cardiovascular events in men, including heart attack and death. Third, the amount of methylmercury in the body at which adverse effects have been observed in various studies overlaps the amount of methylmercury in individuals in the United States. And finally, monetization of the costs of exposure to methylmercury in the U.S. population has included only some of the effects of methylmercury exposure.

Neuropsychological Effects of Developmental Methylmercury Exposure

The adverse health consequences to the nervous system of methylmercury exposure in humans were recognized in the 1950s with the tragic episode of poisoning in Minamata Bay in Japan, in which it also became clear that the fetus was more sensitive to the neurotoxic effects of methylmercury than was the adult. A similar pattern of damage was apparent in subsequent episodes of poisoning in Japan and Iraq. These observations focused the research community on the question of whether exposure to concentrations of methylmercury present in the environment might be producing neurotoxic effects that were not clinically apparent.

Since the outbreaks of fetal methylmercury poisoning, hundreds of studies have been performed in animals to characterize the effects of methylmercury and elucidate the mechanisms by which methylmercury impairs the developing brain. Adverse effects in animals include sensory and motor deficits, memory deficits, and cognitive delays.

Methylmercury interferes with multiple neurochemical and physiological processes in the developing brain, and these effects are well characterized.

Over half a dozen cross-sectional studies have been performed around the world to explore the effects of environmental methylmercury intake on the development of the child. In these studies, the hair mercury level of the mother or child was determined at the time the child was tested for nervous system impairment. Studies in the Philippines, Poland, the Canadian Arctic, Ecuador, Brazil, French Guiana and Madeira all found adverse effects related to the methylmercury levels in the children's bodies. These included auditory and visual effects, memory deficits, deficits in visuospatial ability, and changes in motor function.

Analysis by the National Research Council of the National Academy of Science

In addition to the above studies, there have been three major longitudinal prospective studies on the effects of methylmercury exposure to the mother on the neuropsychological function of the child: in the Faroe Islands in the North Atlantic, in the Seychelles Islands in the Indian Ocean, and in New Zealand. In these studies, mothers were recruited into the study before giving birth or shortly thereafter. The children were then tested at multiple times during development. Methylmercury concentrations in the mothers' hair or umbilical cord blood were analyzed, providing a measure of prenatal exposure of the child to methylmercury. Two of these studies reported adverse effects associated with methylmercury exposure, whereas the Seychelles Islands study did not. Impairment included decreased IQ and deficits in memory, language processing, attention, and fine motor coordination. An expert panel was convened in 2000 by the National Research Council (NRC) National Academy of Sciences to review the toxicological effects of methylmercury, and to determine whether the RfD derived in 1995 by the US Environmental Protection Agency was scientifically justified. The panel evaluated all three studies in their expert review, concluding that all three studies were well designed and executed. They modeled the relationship between the amount of methylmercury in the mother's body and the performance of the child on a number of neuropsychological tests. From this analysis, they calculated a defined adverse effect

level from several types of behavior in each of the three studies. These adverse effect levels represent a doubling of the number of children that would perform in the abnormally low range of function. The NRC panel also calculated an overall adverse effect level of methylmercury in the mother's body for all three of the studies combined, including the negative Seychelles study. Thus the results of all three studies were included in a quantitative manner by the NRC.

The Environmental Protection Agency (EPA) used the analyses of the NRC in the derivation of a reference dose, or RfD, for methylmercury in 2001. The RfD is a daily intake level designed to be without deleterious effects over a lifetime. The EPA divided the defined deleterious effect levels calculated by the NRC by a factor of 10 in its RfD derivation. There are three points that need to be made in this regard. First, the EPA performed the relevant calculations for a number of measurements for each of the two studies that found deleterious effects a well as the integrative analysis that included all three studies modeled by the NRC, including the negative Seychelles study. The RfD is 0.10 ug/kg/day based on the Faroe Islands study alone or the integrative analysis of all three studies. The RfD would be lower than 0.10 ug/kg/day if only the New Zealand study had been considered. Second, the factor of 10 does not represent a safety factor of 10, since the starting point was a level that doubled the number of low-performing children. Third, there is no evidence of a threshold below which there are no adverse effects. In fact, there is evidence from both the Faroe Islands and New Zealand studies that the change in adverse effect in the child as a function of maternal methylmercury level may be greater at lower maternal methylmercury levels than at higher ones. Therefore, the so-called safety factor almost certainly is less than 10, and may be closer to non-existent, based on the NRC analyses. Babies born to women above the RfD may be at actual risk for adverse effects.

Information available since the NRC review and EPA RfD derivation

Several scientific endeavors have provided a fuller understanding of the effects of developmental exposure to methylmercury on neuropsychological function since the NRC review in 2000. One of these is a study of infants of women living in western

Massachusetts. Hair of the mothers at the time of birth was analyzed for mercury. When the babies were six months old, they were assessed on a test of visual short-term memory that is predictive of IQ at older ages. Higher mercury levels in the hair of the mothers predicted poorer memory in the infant. For every 1 part per million (ppm) increase in maternal hair mercury, there was a 7.5 point decrease in the baby's score. The hair mercury levels of the mothers were typical of those in the U.S. This study provides evidence that exposure to methylmercury is having deleterious effects on neuropsychological function of U.S. children. It also provides further evidence that the EPA RfD does not include a substantial safety factor, since the majority of the mothers in the Massachusetts study had hair mercury levels below those associated with the RfD.

An important analysis of the three large epidemiological studies reviewed by the NRC was performed by Dr. Louise Ryan of Harvard University for the U.S. EPA. She analyzed the relationship between the amount of methylmercury in the mother's body at the time of birth and the IQ of the children. For all three studies, increased hair mercury in the mother was associated with a decrease in IQ in the child. The results were virtually identical for all three studies. For each 1 ppm increase in maternal hair mercury, there was a 0.12 to 0.13 point decrease in IQ. This was true for the study in the Seychelles Islands, which was reported to identify no deleterious effects of methylmercury, as well as the studies in the Faroe Islands and New Zealand, which found adverse effects. It is important to recognize that the modeling performed by Dr. Ryan, which determined the relationship between the mothers' mercury level and IQ of the child, is different from simply determining whether results are statistically significant, which was the focus of the original publications by the investigators of the studies. This analysis provides evidence that the effects in the three large epidemiological studies are not discordant, but rather reveal deficits in IQ of the same magnitude.

Finally, a recent analysis of the benefits of fish consumption was performed by the Harvard Center for Risk Analysis, funded by the fishing industry. As part of that exercise, the loss of children's IQ related to methylmercury intake through consumption of fish by mothers during pregnancy in the U.S. was estimated. The loss of IQ due to

methylmercury intake was greater than any potential benefit from the omega-3 fatty acids in fish under several theoretical patterns of fish intake.

Cardiovascular Effects of Methylmercury

There is evidence from several studies that the body burden of methylmercury is associated with cardiovascular or coronary heart disease, including heart attack and death. Studies in Finnish men found an association between hair mercury levels and myocardial infarction, cardiovascular disease, and death. In addition, there was a relationship in these men between increased hair mercury levels and increased thickness of the carotid artery, a risk factor for adverse cardiovascular events. A large multicenter study in eight European countries and Israel also found an association between myocardial infarction and the body burden of methylmercury in men. In a study of male health professionals in the U.S., a non-statistically significant relationship was found between coronary heart disease and toenail mercury levels after dentists were excluded from the analysis. A large percentage of the study participants were dentists who were exposed to mercury vapor in their dental practice and had high levels of mercury in their bodies. The results of this last study suggest that methylmercury but not other forms of mercury produces effects on cardiovascular function.

There is also evidence that methylmercury affects cardiovascular function in children. In the study in the Faroe Islands, prenatal exposure to methylmercury was associated with increased systolic and diastolic blood pressure and decreased heart rate variability when the children were seven years old. At 14 years of age, the effects on blood pressure were no longer apparent, but the effect on heart rate variability was still present. Increased blood pressure and decreased variability in heart rate in response to changes in activity or postural position are both predictors of adverse cardiac events in adults.

Methylmercury Levels in the U.S.

The RfD for methylmercury derived by the U.S. EPA is associated with a methylmercury concentration in cord blood of 5.8 ug in a liter of blood (5.8 ug/L). The

corresponding methylmercury concentration in the mother's blood would be 3.4 ug/L, since the fetal blood has 70% more mercury than that of the mother. In the overall U.S. population of women of childbearing age, about 16% have blood levels greater than that associated with the RfD. For women identifying themselves as Asian, Pacific Islander, or Native American, 27% have blood mercury levels above the RfD. These women eat at least twice as many fish meals as other ethnic groups. The percentage of women with levels of mercury higher than the RfD may be even greater for groups that eat large amounts of fish. Numerous studies have documented that the amount of methylmercury in the bodies of individuals is dependent upon the amount of fish consumed.

The average body burdens of mercury in the mothers in the three large epidemiological studies is higher than the average in the U.S. population. However, there is overlap between body burdens in those studies and women of childbearing age in the U.S. Moreover, there is no evidence of a threshold in those studies: that is, no level of methylmercury in the mother's body below which there are no adverse effects in the children. In addition, the recent study in Massachusetts found adverse effects in infants associated with mercury levels in the mother in the general U.S. population. For cardiovascular effects, the body burdens at which adverse effects were found are within the range of those in the U.S. These comparisons suggest that adverse effects on neuropsychological function in children and cardiovascular effects in adults are occurring in the U.S. population as a consequence of ingestion of methylmercury.

Societal Cost

The cost associated with the loss of IQ produced by methylmercury have been estimated based on lost wages associated with decreased IQ. There is an established correlation between IQ and lifetime earnings, so that lost wages resulting from a lowered IQ can be calculated. In addition, a downward shift in the distribution of IQs in the U.S. population would also result in an increase in the number of individuals defined as being mentally retarded. This would incur costs including increased education and medical costs.

However, lost wages are only a portion of the costs associated with decreased IQ associated with exposure to methylmercury. The IQ of an individual is predictive of many life outcomes in addition to lifetime earning. Such an analysis was performed for a number of adverse societal outcomes. This analysis relied on a national database in which the IQ of over 12,000 individuals, along with multiple demographic variables, were measured in 1979 in individuals between 14-22 years of age by the U.S. Department of Labor. Individuals were then interviewed each year. A 3% increase in IQ was associated with a 12% reduction in low-birth-weight births, a 15% reduction in out-of-wedlock births, an 18% reduction in welfare dependency, a 28% reduction in the high school dropout rate, a 25% reduction in the poverty rate, and a 25% reduction in the number of males who were interviewed in jail in a yearly interview. These effects are of enormous importance to society as well as to the individuals. These effects of IQ could be readily monetized, but to my knowledge they have not been in the context of exposure to environmental chemicals.

Developmental exposure to methylmercury has neuropsychological effects in addition to those on IQ. Adverse effects on language, memory and attention are also related to methylmercury exposure. These abilities are not assessed in IQ tests, and yet deficits in these abilities would have important consequences for the child in a classroom setting as well as later in life. These consequences of methylmercury exposure have not been monetized.

The cost of cardiovascular effects of methylmercury exposure have also not been addressed. In an estimate of monetary costs of lead exposure performed by EPA in the mid 1980s, the cost of cardiovascular disease was greater than that for lost wages associated with the IQ decremement produced by lead. Whether that is also the case for methylmercury is unclear. However, this cost could add significantly to the monetary burden produced by methylmercury exposure.

Summary

In summary, there are four points I would like the Board to keep in mind. First, there is compelling evidence that methylmercury exposure produces neuropsycholgical

deficits in children as a result of prenatal exposure. Second, several studies have also found an association between the amount of methylmercury in the body and adverse cardiac events in men. Third, the body burdens of methylmercury at which adverse effects occur include those of individuals in the United States. Fourth, the societal costs of methylmercury exposure include lost wages and other adverse social consequences of decreased IQ, independent costs associated with other adverse effects on cognition, and costs associated with cardiovascular disease and death in men.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

TESTIMONY OF CHRISTOPHER ROMAINE

Qualifications

My name is Christopher Romaine. I am here today for the Illinois Environmental Protection Agency (Agency), where I am the Manager of the Construction Unit in the Permit Section in the Bureau of Air.

I have a Bachelor of Science degree in engineering from Brown University and have completed coursework towards a Masters Degree in Environmental Engineering from Southern Illinois University. I am a Registered Professional Engineer in the State of Illinois.

I joined the Agency in June 1976, at a junior level in the Permit Section in the Division of Air Pollution Control. I am currently the Manager of the Construction Unit in the Permit Section. I previously served as the Manager of the New Source Review Unit, Manager of the Utility Unit, and Manager of the Joint Utility/Construction Unit, all in the Permit Section.

In particular, in 1999, I became Manager of the Utility Unit in the Permit Section, after about a year and a half serving as the Acting Manager. As the Manager of the Utility Unit, I supervised the staff of engineers who reviewed air pollution control permit applications involving electric power plants, including applications for proposed new power plants, construction permit applications for projects at existing power plants, and applications for operating permits for power plants. My involvement in the permitting of coal-fired power plants has continued to the present day. When the Joint Utility/Construction Unit was formed in 2001, consolidating the separate Utility and Construction Units, I continued to supervise the engineers who worked on power plant applications. It is only recently, with the issuance of the Clean Air Act Permit

Program (CAAPP) Permits to Illinois' coal-fired power plants, that formal responsibility for future work on CAAPP applications for power plants has bunitn to be transferred over to the CAAPP Unit in the Permit Section. However, the Construction Unit continues to process construction permit applications involving power plants.

In addition to my duties related to permitting, in my tenure with the Agency, I have assisted in developing a number of runitlatory programs for stationary sources. These programs include Nonattainment New Source Review (NA NSR) for proposed construction projects in nonattainment areas, Reasonable Available Control Technology (RACT) for volatile organic material emissions for certain categories of emissions units, the Clean Air Act Permit Program (CAAPP), and the Emissions Reduction Market System (ERMS).

The purpose of my testimony on the proposed rule is to provide additional explanation for various provisions of the proposed rules.

Definitions

Many of the definitions in proposed 35 IAC 225.130 are transferred over from CAMR. The proposed rule also includes definitions for five terms that are not found in CAMR: Averaging Demonstration, Gross Electrical Output, Input Mercury, Output-Based Emission Standard, and Rolling 12-Month Basis. Definitions of these terms were developed by the Agency to facilitate the understanding and implementation of the proposed rules. With the exception of the definition of "Rolling 12-Month Basis," these definitions are self-explanatory.

The definition of "Rolling 12-Month Basis" is less apparent, especially as it also addresses two exceptions to the general approach to the compliance time periods associated with the proposed emission standards. The general approach to the compliance time period for the emission standards in the proposed rules is use of 12 successive months of data, that is, compliance is determined on a rolling 12-month basis. The data from the particular month for which a compliance determination is being made and the data for the previous 11 months are combined to make the determination of compliance. The first exception to this approach is for months in

which a unit does not operate when compliance is being determined for an individual unit. The proposed rule would not include a month in which such a unit does not operate in the compliance determination. Instead, the compliance determination in subsequent months would "skip" a month in which the unit did not operate and would be based on data from 12 months in which the unit actually operated. This is consistent with the approach taken by USEPA to compliance determinations for mercury emissions under the New Source Performance Standards for Electric Utility Steam Generating Units, which are also made on a 12-month rolling basis. (Refer to 40 CFR 60.50Da(h)(2)(iii).) The second exception is the approach to a month in which a unit does not operate when compliance is being determined for a group of units on an aggregate basis. When compliance is being determined on an aggregate basis, the proposed rule would only skip a month in which all units covered by the compliance demonstration do not operate. Compliance determinations would include months in which any of the units covered by a demonstration is operated, as is necessary so that a compliance determination is made for each month in which any unit in the group is operated.

Incidentally, one consequence of applying the emission standards in the proposed rules on a rolling 12-month basis is that compliance with the numerical emission standards will not be able to be determined for the first 11 months after July 1, 2009, when the standards become "effective." The earliest date that the first formal determinations of compliance with these standards can occur is July 1, 2010. This is the earliest date on which a total 12 months of data will be available for an existing unit or group of units, from which compliance with the emission standards can be numerically determined.

Compliance Requirements

The compliance requirements set forth in proposed 35 IAC 225.210 summarize the obligations that would apply to the operation of a unit under the proposed rules. This Section reflects the approach to such matters in CAMR, with the specific provisions paralleling the relevant provisions in CAMR.

Permitting Provisions

The permitting requirements set forth in proposed 35 IAC 225.220 address the implications of the proposed rules for permitting. Like the compliance requirements in proposed 35 IAC 225.210, this Section is based on provision found in CAMR. However, unlike CAMR, proposed 35 IAC 225.220 would not require sources to obtain separate mercury budget permits for units subject to the proposed rules. The requirements of the proposed rules would be addressed in other required permits for the units, most commonly CAAPP Permits, along with the other applicable emission standards and requirements that apply to the units. As related to control of mercury emissions, those permits and the applications for such permits would have to address the informational and procedural requirements that USEPA has determined are appropriate for these application and permit under CAMR. For example, the applications such permits must include the Identification Number assigned to the source by the federal office of Runitlatory Information Systems, the identification of the units at the source, the intended approach to required monitoring under the rules, and the intended approach to compliance with the emissions standards under the rules.

Emission Standards for Units at Existing Sources

Proposed 35 IAC 225.230 sets forth the mercury emission standards for units at existing sources. At a basic level, these standards require that mercury emissions from an existing unit either not exceed 0.0080 lb mercury/GWh gross electrical output or be controlled by a minimum of 90-percent reduction from input mercury. The proposed rules have an emission standard expressed in terms of electrical output, as well as an emission standard expressed in terms of the reduction in input mercury, to specifically address units that are burning washed Illinois basin coal, as has been discussed in detail in the testimony of other Agency witnesses. These standards take effect beginning July 1, 2009. However, as already explained, because the standards apply on a rolling 12-month basis, the earliest that a formal determination of compliance could be made with these standards would be July 1, 2010.

Proposed 35 IAC 225.230 becomes complicated because it addressed how these basic standards would actually be applied to a unit or units at source under difference circumstances. It also includes specific equations setting forth how relevant data is to be handled for the purpose of determining compliance with the applicable emission standards.

The simplest circumstance is that compliance with the emission standards is demonstrated for an individual unit and the applicable emission standard does not change during the particular 12-month rolling period. In such case, as addressed by proposed 35 IAC 225.230(a), compliance can be directly determined in the terms of the applicable standard. If the unit is complying with the output based standard, the total emissions of mercury during the 12-month long compliance time period would be divided by the total gross electrical output during the same period. The result would be the actual mercury emission of the unit, in lbs per GWh, which would then be compared to the applicable standard, 0.0080 lb/GWh. If the unit is complying with the emission reduction standard, the total emissions of mercury during the 12-month long compliance time period would be compared to the total amount of input mercury during the same period. The result would be expressed as the reduction efficiency for input mercury, in percent, which would then be compared to the applicable standard, 90 percent.

The next circumstance, as addressed by proposed 35 IAC 225.230(b), is that compliance with the emission standards is demonstrated for an individual unit and the applicable emission standard does change during the particular 12-month rolling period. This circumstance must be considered since a source could switch the coal supply to a unit during a 12-month period, going to Illinois basin coal from western coal or vice versa. In this circumstance, it is not possible to directly determine compliance in terms of an applicable emission standard, since both standards applied during the 12-month period. To address this circumstance, the actual performance of the unit is evaluated by comparing the actual emissions of mercury for the 12-month period to the allowable emission of mercury during the same period. If the actual emissions for the 12-month period are equal to or less than the allowable emissions for the 12-month period, a unit would be in compliance. This restructuring of the compliance demonstration does not effect the determination of actual emissions. However, the allowable emissions must be calculated. For a month in which the source elected to comply with the output based standard, the allowable

emissions are calculated as the product of the gross electrical output for the month and the output based standard, i.e., 0.008 lb/GWh. For a month in which the source elected to comply with the reduction standard, the allowable emissions are calculated as the product of the input mercury and the allowed emissions after the required reduction, i.e., 0.10. The allowable emissions for the 12-month long rolling period are the sum of the allowable emissions for each month.

The next circumstance, as addressed by proposed 35 IAC 225.230(c), is that compliance with the emission standards must be demonstrated for two or more units at a plant as a group because mercury emission data is only available for the units as a group. This circumstance occurs because certain units share common stacks. For these units, mercury emission monitoring will be most reliably and economically conducted with a single emissions monitoring system in the common stack. This is the approach to emissions monitoring that is already being used for such units for sulfur dioxide (SO_2) and nitrogen oxide (NOx) emissions under the Acid Rain and NOx Trading Programs. In this circumstance, it will be necessary to approach the units for the purpose of demonstrating compliance as if they were a single unit. Given the need to combine data for gross electrical output or input mercury from two or more units, it will likely be easiest if the compliance demonstration is carried out by comparing the actual and allowable emissions of mercury during each 12-month long compliance time period.

The last circumstance, as addressed by proposed 35 IAC 225.230(d), is that a source elects to demonstrate compliance on a source-wide basis. In this circumstance, the compliance demonstration must be carried out by comparing the total actual and allowable emissions of mercury of all the units at the source for each 12-month long compliance time period. The proposed rules further specify that if a source has elected to show compliance on a source-wide basis and fails to show compliance, all units shall be considered to be out of compliance for the final month of the 12-month rolling period. This approach was taken because a single source will be responsible for all units covered by the compliance demonstration. It is not necessary to specifically assign culpabity for noncompliance to a particular unit, and indeed noncompliance can be broadly attributed to the collective performance of the units.

Averaging Demonstrations for Existing Units

Proposed 35 IAC 225.232 provides the additional flexibility that is present in the proposed rules for Phase 1, through December 31, 2013. (In fact, when one considers the consequences of the 12-month rolling compliance time period, this additional flexibility is really only available through January 31, 2013.) This additional flexibility is present during Phase 1 as companies with existing sources can also show compliance with the proposed standards using system-wide compliance demonstrations or "averaging demonstrations." These compliance demonstration would include units at more than one source. Under these compliance demonstrations, compliance would be determined by comparing the total actual and allowable emissions of mercury of all the units covered by the averaging demonstration for each 12-month long compliance time period.

In order for a source to be included in an averaging demonstration, the source by itself must also comply with one of the following emission standards on a source-wide basis for the period covered by the demonstration: (1) An emission standard of 0.020 lb mercury/GWh gross electrical output; or (2) A minimum 75-percent reduction of input mercury. This assures that technology for control of mercury emissions is utilized on each source, and most likely each unit, that is covered by a multi-source compliance demonstration. In addition, while averaging demonstrations can be used through December 31, 2013, companies will have to be taking any actions that are needed to show compliance on a source-wide basis, without reliance on an averaging demonstration, well before December 31, 2013. This is because the first 12-month rolling period after averaging demonstrations cease to be available will actually cover the 12-month period from February 1, 2012 through January 31, 2013.

Companies with more than one plant can only participate in averaging demonstrations that include other plants that they own or operate. Companies or organizations with only a single plant subject toe the proposed rules (i.e., City, Water, Light & Power, City of Springfield; Electric Energy, Inc.; Kincaid Generating Station; and Southern Illinois Power Cooperative/Marion Generating Station) can only participate in demonstrations with other companies or organizations that only have a single plant. In addition, for a company or

organization with only a single plant, participation in averaging demonstrations must be authorized through federally enforceable permit conditions for each plant participating in the demonstration. This is intended to assure that the role and the responsibilities of the different entities involved in the averaging demonstration are well defined.

If averaging is used to demonstrate compliance, the effect of a failure to demonstrate compliance will be that the compliance status of each plant will be determined as if the plant were not covered by an averaging demonstration.

Existing Units Scheduled for Permanent Shutdown

Proposed 35 IAC 225.235 contains provisions that would allow a source to obtain an exemption from the proposed emission standards for an existing unit that will be permanently shut down soon after July 1, 2009. This exemption was included in the rules because the cost for installation of activated carbon injection systems were not believed to be warranted for units that would shortly be permanently shut down. An unit for which such an exemption had been obtained could not be included when determining whether any other units at a plant or other plants are in compliance with the proposed emission standards.

This exemption specifically responds to the circumstances of City Water, Light and Power (CWLP), the municipally owned and operated power supply for the residents of the City of Springfield. CWLP has submitted a construction permit application to build a new coal-fired generating unit, Dallman Unit 4, at its existing power plant adjacent to Lake Springfield. The new unit is being developed to meet the future power needs of Springfield. The new unit would also replace the two Lakeside Units at the plant, which are the oldest units now at the plant and would be permanently shut down after new Dallman 4 is constructed and operational. As part of the air pollution control permitting for new Dallman Unit 4, CWLP is relying upon decreases in emissions from the shut down of the Lakeside Units

Different dates are proposed for when existing units must be scheduled to be shut down to qualify for exemption from the emission standards, depending on the circumstances of the shut

down. For existing units for which the owner operator is constructing a new unit or other generating units to specifically replace the existing units, like CWLP's two Lakeside Units, the existing units must be scheduled to be shut down by December 31, 2011. For existing units for which the owner or operator is not constructing a new unit or other generating units to specifically replace the existing units, the existing units must be scheduled to be shut down a year earlier, by December 31, 2010 to qualify for the exemption. This distinction was made because construction of a new generating unit is a challenging and lengthy undertaking. The source that is replacing a unit should be provided more time to carry out the construction of a replacement unit than the source that is only retiring a unit and relying on other existing units, which are already operating, to make up for the shut down unit. This distinction also recognizes the significant efforts and commitment of a source that is actively engaged in developing a replacement unit.

The exemption does include a provision for unforeseen events that would delay the scheduled shut down of an exempted unit. A source must permanently shut down the unit by the applicable date, unless the source submits a demonstration to Agency before such date showing that circumstances beyond its reasonable control (such as protracted delays in construction activity for the new replacement units, unanticipated outage of another unit, or protracted shakedown of a replacement unit) have occurred that interfere with the plan for permanent shut down of the existing unit. In such circumstances, the deadline for shut down of the existing unit may be extended for up to one year if the unit is not being replaced or up to 18 months if the unit is being replaced, provided, however, that after December 31, 2012, the existing unit shall only operate as a back-up unit.

Procedural requirements accompany the exemption to ensure that reliance upon the exemption is carefully considered by sources and occurs in a timely manner. These requirements also ensure that the exemption is not abused by sources. By the effective date of the proposed emission standards, June 30, 2009, a source must notify the Agency that it is planning to permanently shut down the unit. In addition, the source must have applied for a construction permit or be actively pursuing a federally enforceable agreement that requires the unit to be permanently shut down as required to qualify for the exemption. The source must also have applied for revisions to the

operating permit(s) for the unit to include provisions that terminate the authorization to operate the unit in a manner consistent with the exemption. By July 1, 2010, the earliest date that compliance with the proposed emission standards can be shown, the requirement to permanently shut down a source must be embodied in a federally enforceable permit or other enforceable agreement.

Lastly, the exemption specifies that if unit for which the exemption is relied upon is not shut down in a timely manner, the unit shall thereafter be considered a new unit for the purposes of the proposed rules. This is a final measure to prevent abuse of the exemption.

Emission Standards for New Sources

Proposed 35 IAC 225.237 sets forth the mercury emission standards for units at new sources. While the standards are numerically identical to those for units at existing source, units at new sources must comply with applicable emission standards on an individual, unit-by-unit basis. Unlike the provisions for units at existing sources, compliance cannot be shown on a source-wide basis or, as allowed during Phase 1 of the proposed rules, with an averaging demonstration. This is appropriate because the units at new sources will be controlled with Best Available Control Technology (BACT) under the federal rules for Prevention of Significant Deterioration (PSD) 40 CFR 52.21. As a result, control of mercury emissions through co-benefit will be maximized. Activated carbon injection systems can also be installed on these units as original equipment, so as to maximize the capabilities of this technology to control mercury emissions.

The effective date of the emission standards for new units is set to match the effective date of the mercury emission standard that also applies to new units under the federal New Source Performance Standards (NSPS) for Electric Utility Steam Generating Units, 40 CFR 60.45Da. This was done for administrative convenience, so that the compliance determinations under the NSPS and proposed rules for new units start at the same time and continue on the same schedule. Since the emission standard of the NSPS does not immediately become effective upon initial startup of a new unit, this approach also allows time for the shakedown of the new unit as related to the control of mercury emissions and the orderly shakedown and certification of the

continuous emissions monitoring system for mercury. During the period before the emission standards take effect, a source is under the general obligation to operate a unit in accordance with good air pollution control practices to minimize emissions.

Emissions Monitoring

As explained in the Technical Support Document, the requirements in the proposed rule for monitoring of mercury emissions are essentially identical to the monitoring that would be required under CAMR. Accordingly, the proposed rule refers to the provisions for emissions monitoring adopted by USEPA at 40 CFR Part 75, Subpart I, Hg Mass Emission Provisions, and 40 CFR Part 75, Appendix K, Quality Assurance and Operating Procedures for Sorbent Trap Monitoring Systems. The proposed rule also allows use of the excepted "low mass" monitoring methodology, as adopted by USEPA at 40 CFR 75.81(b), for units that have annual emissions of no more than 29.0 pounds of mercury. Other aspects of the proposed rule related to emissions monitoring are also consistent with provisions of the CAMR. For example, the owner or operator of an existing unit must begin monitoring for mercury emissions no later than January 1, 2009, as would be required under CAMR. Emissions monitors must be certified and generally operated as would be required under CAMR. Any alternative emission monitoring methods must be approved by USEPA. The technical feasibility of the required monitoring for mercury emissions was addressed by USEPA as part of its rulemaking to adopt the CAMR. (For example, refer to 70 FR 28633, May 18, 2005.)

Other Monitoring Requirements

The proposed rule also includes requirements for monitoring that is not directly related to mercury emissions but is necessary to determine compliance with the proposed emission standards. The owner or operator of a unit complying with the output-based emission standard would be "required" to conduct operational monitoring for the electrical output from the unit, as measured at the generator. Since accurate information on electrical output is already needed by a source for operational reasons and this data is readily collected by wattmeters designed for this specific purpose, the proposed rule does not specify particular monitoring methodology that must

be used for the collection of this data. The rule also does not require that this data be collected until this data is needed to determine compliance.

The owner or operator of a unit complying with the 90 percent reduction standard would be required to conduct analyses of the coal being burned in the unit to determine its mercury content. This information would then be used to determine the amount of mercury in the coal going into the unit so that the mercury removal efficiency achieved by the control devices on the unit could be calculated, as necessary to determine compliance with the 90 percent reduction standard. While most sources that will be subject to this proposed rule already collect and analyze coal samples on a routine basis for operational reasons, this activity does not extend to analysis for mercury content. The provisions for coal sampling in the proposed rule are intended to ensure an accurate determination of the input mercury to the subject units. Since the mercury content of coal varies, even when coming from a single mine and coal seam, and the amount of coal consumed by an UNIT can vary from day to day, daily sampling of the coal supply to units is necessary. The coal supply must be sampled at a point after long-term storage, where the sample will be representative of the coal being burned in the unit on the day that the sample is taken. This location for coal sampling was selected after consultation with industry representatives to provide flexibility in the point at which samples are collected while ensuring that the resulting data accurately reflects the coal that is actually being burned in a unit. Certain ASTM Methods were selected for the required analyses of coal. For mercury, these are ASTM D6414-01, “Standard Test Method for Total Mercury in Coal and Coal Combustion Residues by Acid Extraction or Wet Oxidation/Cold Vapor Atomic Absorption,” and ASTM D3684-01, “Standard Test Method for Total Mercury in Coal by the Oxygen Bomb Combustion/Atomic Absorption Method.” These methods were chosen by the Agency after consultation with industry representatives and experts on coal analysis because these methods are accurate, sources and commercial laboratories are familiar with these methods, and the costs of these methods are reasonable. The proposed rule would require that a source begin collecting and analyzing coal samples at least 30 days before data is needed to determine compliance, if it is reasonably possible to do so. This approach was taken to reasonably ensure that data is being properly collected when it is finally needed for the purpose of determining compliance. However, if a unit has been out of service, such that meaningful sampling and analysis of the coal supply could

not be conducted in advance of the time at which data is needed, a source must begin to conduct this monitoring when the unit is returned to service.

Conclusion

In conclusion, I hope that my testimony shows that the provisions of the proposed rules have been carefully considered and developed to carry out the objectives for the proposed rulemaking.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES (MERCURY)	)	

TESTIMONY OF JIM ROSS

Qualifications

My name is Jim Ross and I am here today representing the Illinois Environmental Protection Agency (Illinois EPA) where I am the Division of Air Pollution Control Manager in the Bureau of Air.

I have a Bachelors of Science Degree in Mechanical Engineering from Southern Illinois University at Carbondale. I have completed numerous environmental courses over the years including the study of emissions and controls of each of the criteria air pollutants, many hazardous air pollutants, as well as several courses on the background and implementation of environmental regulations. I have also provided training on air pollution permitting and regulations to Illinois EPA and United States Environmental Protection Agency (U. S. EPA) staff, and persons from industry, environmental consulting firms, environmental organizations, and the general public.

I joined the Illinois EPA in May of 1988 as a permit engineer in the Permit Section of the Division of Air Pollution Control. I became manager of the Clean Air Act Permit Program (CAAPP) Unit in May of 1997, after about a year and a half as acting CAAPP Unit manager. The CAAPP is Illinois' version of the federal mandated Title V program of the Clean Air Act that requires permits for all major sources of air pollution. In January of 2003 I became acting manager of the Permit Section and remained so until March of 2004. A short time after this I transferred over to the Illinois EPA's Office of Emergency Response where I was manager of the Emergency Operations Unit. I

remained in this position until October of 2005 when I returned to the Bureau of Air in my current position.

In addition to currently being the Division of Air Pollution Control Manager, I am also an Illinois EPA Duty Officer which requires me to be on call 24 hours a day, seven days a week during several periods throughout the year. In this capacity, I am responsible for ensuring Illinois EPA's response to emergencies incidents anywhere in the State, especially those involving hazardous materials, oil spills, disasters, and issues of homeland security.

In my 18 years with the Illinois EPA I have been involved with detailed review of Illinois' industrial processes and their emissions of air pollutants and the measures and controls used to mitigate these emissions. This review has included on-site visits to a wide-variety of processes, including steel mills, large chemical plants, refineries, and several coal-fired power plants. I have helped develop and implement several major programs and rules since their inception including the CAAPP and Illinois' volatile organic material trading program for the greater Chicago area, i.e., the Emissions Reduction Market System. As Permit Section Manager I oversaw the permitting of over 6,000 facilities in the State. Of note is that I was deeply involved in the CAAPP permitting of Illinois' 22 coal-fired power plants, including representing the Illinois EPA at several of the public hearings on the proposed permits.

In my current position as Division Manager, I supervise a large staff of over 150 engineers, specialists, and administrative support personnel in developing, monitoring, and enforcing the State and Federal air pollution control requirements. In particular, and more recently, I have been overseeing the Illinois EPA's efforts in the development of several rulemaking efforts, including the proposed Illinois mercury rule.

My testimony will provide background information and a broad overview of the development of Illinois' proposed mercury rule. I will address some of the measures the Illinois EPA took during rule development to ensure that we relied on accurate and

current information as we crafted the rule. In my testimony I will often refer to the Technical Support Document (TSD) that accompanied the proposed rule and therefore request that its contents be incorporated herein by reference. I would like to note that the Illinois EPA performed significant outreach to stakeholders on the proposed rule, including holding five weekly stakeholder outreach meetings where we presented information on our findings, updated stakeholders on the rule, requested feedback on issues, and held question and answer sessions. We also provided regular mail and e-mail addresses to allow interested parties to submit comments and questions that were answered at the stakeholder meetings. In addition, we repeatedly offered to meet with any stakeholders in smaller groups to discuss the rule and related issues, and in fact held several such meetings.

Introduction

On January 5, 2006, Illinois Governor Rod R. Blagojevich announced an aggressive proposal to reduce mercury emissions from Illinois coal-fired power plants by 90 percent beginning mid 2009. The Governor's proposal is intended to require coal-fired power plants in Illinois to achieve greater reductions of mercury more quickly than that proposed in May 2005 by the U. S. EPA under the federal Clean Air Mercury Rule (CAMR). The Governor's proposal is now characterized in the proposed mercury rule that the Illinois EPA filed with the Illinois Pollution Control Board (Board) in March and which is the subject of this hearing.

Illinois is not alone in seeking to go beyond the federal CAMR. Other states have made similar decisions. At least five states have adopted mercury reduction programs that "go beyond" CAMR in their reduction target or timeframe for obtaining reductions, and a number of other states have announced their intentions to do so as well.

Mercury

Mercury is a persistent, bioaccumulative neurotoxin that presents a serious threat to the health and welfare to the citizens of Illinois and nationwide.

Mercury is a naturally occurring trace element found in the environment, and a pollutant that is released to the environment by both natural and man-made (anthropogenic) activities, including the combustion of coal to produce electricity. Mercury is contained in small amounts in all forms of coal that are burned at Illinois power plants. The combustion of coal at power plants represents the largest source category of anthropogenic mercury emissions in the U.S. As the coal is burned in a boiler at a power plant, the mercury is released into the exhaust flue stream and travels through existing ductwork and control devices until it is finally emitted through a stack into the atmosphere.

Various natural processes, including volcanic eruptions, the weathering of rocks, and under sea vents can release mercury from the Earth's crust into water bodies, soils, and the atmosphere.

Fate of Mercury in the Environment

Mercury is released into the atmosphere from anthropogenic emission sources such as coal-fired power plants as either a gas or attached to minute solid particles. These emissions can contaminate the environment both locally near the point of release and many miles away. Mercury emissions in the air are transferred to the earth’s surface via wet or dry deposition processes. Deposition is the process where mercury is transferred from the atmosphere and deposited onto the earth in either wet or dry form. The wet forms can fall to earth as rain, snow, or fog whereas the dry forms are particulates.

Mercury that is directly deposited or finds its way into the aquatic systems transforms into methylmercury through a series of chemical reactions involving microbial activity.

Methylmercury is toxic and is the most common organic form of mercury found in the environment. It is very soluble and bioaccumulates within the tissues of wildlife (fish, aquatic invertebrates, mammals) as well as humans. Bioaccumulation occurs when an organism's rate of uptake of a substance exceeds its rate of elimination. Fish become contaminated as they feed on contaminated food sources such as plankton or smaller fish. Humans are contaminated as a result of eating contaminated fish.

A key concept in understanding the need and methods for mercury control is that although mercury air emissions are the target for reductions, the ultimate goal is to reduce methylmercury levels in waterbodies and hence, fish tissue.

The Illinois EPA retained the services of Dr. Gerald Keeler to assist us with understanding mercury deposition and to provide technical information on deposition issues. Dr. Keeler will be providing testimony as the hearing proceeds.

Health and Environmental Impacts of Mercury Contamination

Unborn children, infants and young children are at greatest risk from mercury. Fetal exposure to excessive levels of mercury has been linked to mental retardation, cerebral palsy, lower IQ, slowed motor function, deafness, blindness, cardiovascular disease, and other health problems. Recent studies indicate that as many as 10 percent of children born in the United States have been exposed to excessive levels of mercury in the womb. Because of the risk mercury poses to unborn children and infants, mercury exposure is of particular concern for pregnant women and women of childbearing age who may become pregnant. Section 3 of the TSD for the proposed mercury rule provides a detailed discussion that further addresses the mercury impacts on human health.

Fish consumption advisories are issued when concentrations above human health-based limits of one or more of contaminants such as PCBs, chlordane, and mercury are detected in fish tissue. There is a statewide advisory for predator fish in Illinois waters due to methylmercury. Fish consumption use is associated with all waterbodies in the state and

therefore it is commonly stated that all waterbodies in the State have a fish consumption advisory in place for mercury. When fish in a particular lake, river or stream are not safe for unlimited consumption because of mercury, a State is obligated to list that waterbody as impaired. According to the latest (2004) Illinois list of impaired waters, there are 61 river segments (1,034 miles) and 8 lakes (6,264 acres) that have mercury listed as a potential cause of impairment due to restrictions on fish consumption.

Our review of fish consumption literature provides convincing evidence that sport anglers currently consume amounts of sport-caught fish that could cause them and their families to exceed health-based limits for mercury contamination. The literature regarding anglers' consumption of their catch strongly suggests that a subset of these anglers have meal frequencies that exceed the state-wide fish consumption advisory for mercury, putting them well above the recommended rates for even fairly low levels of contamination.

Mercury contamination and the associated harmful effects are logically not limited to humans. Detrimental effects from suspected mercury poisoning have been observed in wildlife such as eagles, hawks, loon chicks, foxes, raccoons, opossums, and otters. Wildlife that feed on contaminated fish are likely to become contaminated. Likewise, the fish themselves are subject to mercury 's harmful effects.

The Illinois EPA retained the services of Dr. Deborah Rice, a toxicologist with a background in the health effects of mercury, to assist us with understanding the human health effects of mercury and to provide technical information on such effects. Dr. Rice will be providing testimony in the hearing.

Illinois Coal-Fired Power Plants and Mercury

Today, around 40% of Illinois' electricity comes from coal-fired power plants. Illinois is home to 21 coal-fired power plants that would be affected by the proposed rule, most of which are over 25 years old. There are a total of 59 electric generating units operating at

these 21 plants. These coal-fired power plants emit an estimated 7,022 pounds per year of mercury into the atmosphere in 2002. We estimate that these power plants make up around 71% of Illinois' man-made mercury emissions. The State's fleet of power plants are scattered throughout Illinois, with many located near major bodies of water.

The TSD, Section 5 in particular, discusses the relationship of mercury emissions from sources like power plants on such issues as local and downwind environmental impacts. Illinois EPA believes that the reduction in mercury emissions proposed by the rule will result in significant reductions of mercury deposition and methylmercury levels in Illinois waters and fish. This belief is reinforced by actual measured reductions in methylmercury fish tissue contents in Florida and Massachusetts that directly coincide with measures taken to reduce mercury emissions from nearby sources.

Dr. Keeler assisted the Illinois EPA in understanding the potential for local impacts from power plants and will be providing testimony on this issue.

Because mercury is of such a significant concern to human health and the environment, Illinois has adopted legislation and/or implemented a number of programs to reduce mercury emissions to the environment from sources other than coal-fired power plants (see Section 6.3 of the TSD). Illinois' coal-fired power plants constitute the largest source of uncontrolled mercury emissions in the State.

Regulatory Background of Mercury Control

The 1970 federal Clean Air Act (CAA) called for federal regulation of Hazardous Air Pollutants (HAPs). The United States Congress revised the HAPs program in 1990 to mandate the U. S. EPA to establish technology-based emissions limitations for sources of HAPs. Congress targeted 180 HAPs, including mercury, and required the development of Maximum Achievable Control Technology (MACT) standards for sources of these HAPs. The source category that includes coal-fired power plants (i.e., electric utility steam generating units) received special treatment in that instead of imposing MACT

standards immediately, U. S. EPA was tasked with performing a study on emissions from these sources. The study results were then to be used to determine if regulating these sources under Section 112 of the CAA was "appropriate and necessary".

The final report on the study was given to Congress in February of 1998 and concluded that mercury emissions were the HAP of greatest concern, but the report deferred making a determination on whether controlling such emissions was "appropriate and necessary" until further research could be done. Around two years later in 2000, following a large information collection effort on mercury emissions from power plants, the U. S. EPA issued a finding that regulation of HAP emissions from coal-fired power plants is "appropriate and necessary" under Section 112 of the CAA. This finding was significant in that it required MACT standards for mercury emissions from power plants. The finding was also controversial and unsuccessful court challenges followed.

In August 2001, U.S. EPA sponsored a one-and-a–half year stakeholder process under the Federal Advisory Committee Act (FACA) tasked with providing guidance on the MACT for power plants to the U. S. EPA. The workgroup was comprised of federal, state and local officials and representatives of industry and environmental organizations and was commonly referred to as the Utility MACT Working Group. This workgroup issued a final report on October 2002 that outlined the various positions of the stakeholders. Of note is that state and local agency representatives reiterated the need for a mercury control program that incorporated the most stringent control of mercury that is technically feasible, no trading of toxics, and enhanced ability for states to implement the standards.

On January 30, 2004, U. S. EPA published a notice of proposed rulemaking setting forth three alternative regulatory approaches to reducing emissions of mercury from coal-fired power plants. In two of the three alternatives, U. S. EPA proposed to rescind its regulatory finding, which would require MACT-level control of mercury emissions, and instead impose statewide mercury emissions budgets to regulate power plants that could be met through a cap and trade program.

In response to the proposed rules, the Illinois EPA submitted comments, making the following key points:

- Mercury is a powerful neurotoxin that needs to be regulated under Section 112 of the CAA and as such, the mercury emissions from power plants must be subject to a MACT standard;

- Mercury limits must be more stringent than set forth in the proposed U. S. EPA rule;

- Any mercury rule for power plants must be fuel neutral, without favoring coal from any particular region of the country, and thus there should be a common standard for bituminous and subbituminous coal;

- Illinois EPA opposes emissions trading of mercury allowances unless the units involved in trading can demonstrate that mercury hot spots are prevented; and

- Mercury emission reductions can and should occur by 2010.

The comments also stated that U. S. EPA gave insufficient support for its extended compliance deadline of 2018, which U. S. EPA acknowledged could extend compliance out to 2025 or 2030 due to banking elements of the trading program.

In April 2004, U. S. EPA reversed the regulatory course it established in 2000 for regulation of mercury emissions under 112 and announced two key proposals: (1) to remove the source category containing coal-fired power plants from the list of HAP emitters under section 112 of the CAA, and, (2) to adopt a cap-and-trade program under Section 111 of the CAA instead of MACT standards under Section 112 of the CAA. This regulatory approach adopted none of Illinois EPA's key points on mercury control.

On March 15, 2005, U. S. EPA issued the CAMR to permanently cap and reduce mercury emissions from coal-fired power plants. Notably, CAMR did not apply a MACT standard to mercury emissions from coal-fired power plants, and instead created a market-based cap-and-trade program to reduce nationwide power plant emissions of mercury in two separate phases. The first phase sets an emissions cap of 38 tons in 2010 that is to be achieved by mercury reductions occurring as a "co-benefit" of requirements for reducing sulfur dioxide (SO_2) and nitrogen oxides (NOx) emissions under the federal Clean Air Interstate Rule (CAIR). No mercury specific controls are required in this first phase. The second phase begins in 2018 and requires coal-fired power plants to meet a reduced cap of 15 tons. Illinois' budget, or cap, under CAMR is 1.594 tons per year of mercury for Phase I and 0.629 tons per year for Phase II. U. S. EPA estimates that CAMR provides mercury emission reductions from Illinois coal-fired power plants of approximately 47 percent by 2010 and 79 percent by 2018.

After review of CAMR, the Illinois EPA determined that CAMR will not result in timely and sufficient reductions of mercury and that the rule contained biased allocation methods that favored non-Illinois coals and thus impeded Illinois' efforts to encourage use of clean-coal technologies involving Illinois coal. Illinois EPA requested that the Illinois Attorney General's Office file an appeal of CAMR and the related U. S. EPA actions. On May 27, 2005, the State of Illinois filed Petitions for Review with the United States Court of Appeals for the District of Columbia Circuit challenging both CAMR. Thirteen other states also filed one or more appeals of the CAMR and related actions. These appeals are pending.

Illinois is not required to adopt the CAMR, but must submit a state plan to achieve the statewide mercury emissions budget called for in the rule and must demonstrate that Illinois' plan will require achieve at least as much reduction as CAMR. Illinois' plan is afforded the ability to forego trading and the other aspects of a cap-and-trade program. However, if Illinois' submittal is not timely and deemed acceptable by the U. S. EPA, then CAMR will be imposed upon Illinois. Illinois' plan is due to the U. S. EPA by no later than November 17, 2006.

In addition to, but separate from, the above actions, the Illinois General Assembly adopted Section 9.10 of the Illinois Environmental Protection Act (Act) which required the Illinois EPA to study and issue findings on the potential need for mercury reductions, along with other pollutants from fossil-fuel fired electric generating units like those at coal-fired power plants. Accordingly, in September 2004, the Illinois EPA published the *Section 9.10 Report* entitled "*Fossil Fuel-Fired Power Plants: Report to the House and Senate Environment and Energy Committees*." The *Section 9.10 Report* indicated that control of mercury emissions was necessary; however, the specific level of control was not delineated. The report also concluded that certainty was needed at the federal level before Illinois could reasonably determine how it should proceed. Federal direction on mercury control became clear only upon the issuance of CAMR in March of 2005 and hence only then could Illinois proceed to form its strategy and move forward in the development of the current proposed mercury rule.

The Illinois EPA determined that the appropriate method to protect the public health and environment while meeting federal requirements was to adopt reasonable state-specific mercury reduction requirements for Illinois' coal-fired power plants.

The Illinois EPA retained the services of Richard Ayres of the Ayres Law Group to assist with regulatory background issues. Mr. Ayres will be providing testimony in the hearing.

Rule Development Considerations

In developing the proposed mercury rule, Illinois EPA took several steps, including consulting recognized experts, holding discussions with stakeholders and interested parties, conducting research and literature reviews, and utilizing internal experts and staff.

A key finding was that mercury control technologies have advanced significantly over the last several years (e.g., use of halogenated sorbents) resulting in both a reduction in costs

and increased effectiveness. The trend is one where technological advances and vendor expansion should continue to lead to decreasing costs and increasing control efficiencies and options.

The Illinois EPA relied on several basic principles as guidance in developing the proposed rule:

- The need to protect human health, fish and wildlife, and the environment from the harmful effects of mercury and methylmercury;

- The need to control the unregulated mercury emissions from Illinois' coal-fired power plants to the greatest level possible and as quickly as possible in a cost-effective manner;

- Must consider the latest control technology that has been shown effective in controlling mercury emissions and which can be reasonably employed, in a cost effective manner, across the full fleet of Illinois power plants and coal types;

- Must ensure that the required mercury reductions occur both in Illinois and at every power plant in Illinois to address local impacts;

- The rule needs to incorporate flexibility in complying with the proposed standards to assist in widespread compliance and to help reduce compliance costs; and

- The proposed rule must be consistent with the Governor's proposal to reduce mercury emissions in Illinois by 90 percent.

We also sought to ensure that the rule would not encourage the use of non-Illinois coal and interfere with actions to promote the use of Illinois coal in clean-coal technology

applications. Therefore, the rule does not treat sources differently or establish different requirements based on the type of coal being used. This is contrary to CAMR, which established State mercury budgets, as well as proposes a baseline allocation scheme, that provides higher allowances for units burning coal types other than bituminous. Furthermore, credit for mercury removal from coal washing was given by establishing an output-based limit that accounts for mercury removal during pre-combustion processes such as coal washing. This attribute of the rule is consistent with Illinois' mercury reduction goals and also benefits users of Illinois coal since washing of coal is currently only practiced for bituminous coals.

Careful consideration was given to the effect mercury control requirements will have on Illinois' economy, including consumers, jobs, and the power sector. Illinois carefully selected an achievable, reasonable, and cost-effective mercury reduction target. Section 8 of the TSD provides a detailed discussion of data supporting 90 percent reduction as an achievable and reasonable level of mercury control for Illinois power plants. Section 8 also shows that the costs of controlling mercury are consistent with Illinois' goals. In addition, we looked into the amount of mercury reduction in fish tissue levels needed to get below fish consumption advisory levels (see Section 4.3 of the TSD). The mercury reduction amount required for a selected species (i.e., largemouth bass) in order to reach unlimited consumption levels by childbearing age women and children less than 15 years of age, the most sensitive and restrictive sub-population, is about 90%. Moreover, a November 2005 mercury control model rule proposed by State and Territorial Air Pollution Administrators (STAPPA) and Association of Local Air Pollution Control Officials (ALAPCO) provided two options, both of which had initial phase 1 compliance dates set at the end of 2008 and required final cuts in mercury equivalent to 90-95% by the end of 2012. Illinois also reviewed the actions of several States that have selected compliance dates earlier than 2009 as well as mercury reduction requirements of 90% or greater (see Section 6.2 of TSD).

The Illinois EPA retained the service of Dr. James Staudt of Andover Technology Partners to assist us in understanding the state-of-the-art in mercury controls, levels of

mercury reductions obtainable under different control configurations, and associated costs. Dr. Staudt will be providing testimony in the hearing.

In addition to the detailed mercury control and cost analysis performed in Section 8 of the TSD document by Illinois' technical expert, Dr. Staudt, Illinois utilized the services of ICF Resources Incorporated (ICF) to evaluate the economic impact of the proposed rule on Illinois' electricity rates and affected power plants. While there are some additional costs predicted from the proposed rule when compared to CAMR, the costs are deemed to be reasonable in light of the concerns presented by mercury pollution and the potential benefits of mercury control.

Illinois EPA determined that it can achieve the required mercury reductions proposed by Governor Blagojevich and give compliance flexibility to sources. Giving flexibility serves to reduce compliance costs and increase the probability of widespread compliance.

Flexibility provided by the proposed rule includes the following:

- The source has the option of complying with either a mercury reduction efficiency or an output based emission rate;

- The proposed rule does not prescribe how compliance with the selected standard is to be achieved, instead, the affected source makes the ultimate decision on how compliance is obtained;

- The proposed rule phases in standards over a period of 3 ½ years, with a less restrictive standard in phase one;

- The rule allows a source to demonstrate compliance by both system-wide and plant-wide averaging in phase 1, and plant-wide averaging in phase 2; and

- The rule allows for sources that commit to shutdown within a certain timetable to avoid installing controls.

We also addressed the issue of "hot spots" by not allowing trading, or the banking or purchase of emissions allowances, and by requiring mercury reductions at all power plants. Ensuring emission reductions take place in Illinois and at all locations where power plants exists should reduce local impacts and hot spots.

Finally, we addressed the issue of units targeted for permanent shutdown or replacement within a relatively short timeframe after the initial compliance date. These units are able to apply for an extension that provides extra time in the case of circumstances beyond control that cause delay. During the extension period, such units are not required to comply with the control requirements and are likewise excluded from compliance calculations. This provision is intended to allow sources to avoid unnecessary costs and expenditure of resources. Once such units are permanently shutdown they will obviously emit no mercury and any interim level of control achieved between the compliance period and final shutdown would likely have been minimal.

Proposed Illinois Mercury Rule

The proposed rule requires mercury reductions from Illinois' coal-fired power plants in two phases. During phase I, which begins on July 1, 2009, coal-fired power plants must comply with either an output-based emission standard of 0.0080 lbs mercury/GWh, or a minimum 90-percent reduction of input mercury, both on a rolling 12-month basis. However, plants with the same owner/operator may elect to comply with the limit on a system-wide basis by averaging across their entire fleet of plants in Illinois, provided that each plant meets a minimum output-based emission standard of 0.020 lbs mercury/GWh or a minimum 75-percent reduction of input mercury. In Phase II, beginning January 1, 2013, plants must comply with either an output-based emission standard of 0.0080 lbs mercury/GWh or a minimum 90-percent reduction of input mercury, both on a rolling 12-

month basis. The rule does not allow for the trading, purchasing or the banking of allowances.

The proposed rule has provisions for an extension from compliance with the standards for units that will be permanently shutdown or replaced within a relatively short timeframe after the initial compliance date.

The monitoring requirements of the proposed rule are essentially the same as those outlined in the model federal CAMR. However, in addition to monitoring outlet mercury emissions, the proposed Illinois mercury rule also requires sources complying with the rule via the 90 percent reduction option to measure the input mercury in order to determine the removal efficiency. This is accomplished through coal analysis.

Effect of the Proposed Illinois Mercury Rule

The mercury reductions obtained from Illinois' proposed rule will be beyond those of the federal CAMR and will occur more quickly. Whereas CAMR would cap Illinois' annual mercury emissions at 3,188 pounds by 2010 through 2017, the proposed Illinois rule results in annual mercury emissions of only around 770 pounds beginning mid-2009. Therefore, the proposed rule is anticipated to eliminate approximately 2,418 additional pounds per year of harmful mercury pollution, and do so six months earlier than the federal CAMR. The reductions obtained under the proposed Illinois rule will likewise be greater than those required in Phase II of CAMR, which does not go into effect until 2018. The CAMR budget for Illinois in Phase II is 1,258 pounds per year, but with banking allowed under CAMR, it is not expected that actual emission reductions will occur until 2020 or later. Compared to CAMR, the proposed Illinois rule should result in 488 fewer pounds of mercury emissions per year about seven years sooner. It is important to note that CAMR is a cap and trade program and therefore, under CAMR, Illinois power plants could postpone or avoid some mercury reductions through the purchase or banking of allowances, an option not allowed under Illinois' proposed rule.

Over time, Illinois expects to see reductions in mercury water deposition to Illinois' lakes and streams and corresponding methylmercury decreases in Illinois fish tissues, making fish caught in Illinois waters safer to eat.

We also expect to see significant benefits to human health, although it is difficult to estimate a dollar value for such things as improvements in IQ and less cardiovascular disease. There could also be several recognized benefits to Illinois beyond the expected public health benefits that come with a reduction in water and fish methylmercury levels. Such benefits include support for existing and the potential for additional jobs resulting from the installation and operating requirements of additional pollution control devices. There also exists a potential for an increase in tourism and recreational fishing as mercury levels drop in fish, bringing an associated positive impact to local economies and the State overall. With a possible increase in the use of bituminous coal, there should be a positive economic impact on the Illinois coal industry and Illinois coal mining jobs.

Economic Considerations

In evaluating the economic impacts of the proposed rule, Illinois EPA consulted and retained the services of experts, stakeholders and interested parties, conducted literature reviews, and utilized internal staff.

In order to better understand the economic effects of the proposed mercury rule, Illinois retained the services of ICF. ICF conducted a study evaluating the economic impacts of the proposed mercury rule using the Integrated Planning Model (IPM®). This study focused on the impacts of the proposed mercury rule in terms of costs to the power sector and costs to electricity consumers.

Of significant importance is that a "more stringent" rule than that being proposed was modeled and therefore the results are considered conservative. Illinois EPA discussed modeling parameters with ICF prior to the modeling and it was determined that where the modeling inputs allowed discretion, we would err on the side of being conservative.

Some examples of this are that the IPM was unable to reflect the mid-year phase 1 compliance date of July 1, 2009 and therefore for modeling we moved the compliance date up to January 1, 2009, 6 months sooner than what the proposed Illinois rule requires. Also, the IPM model assumed a mass emissions cap on each and every unit where the rule does not cap emissions but requires compliance with a standard that allows for growth in electricity generation. Emission caps as used in the IPM Model are more stringent than a percent reduction control requirement or emissions rate since they also limit growth. As a result, the plant output might be severely limited depending upon the cap. This implicit limit to the plant output could create a situation where the modeling forecasts the plant is no longer economically viable whereas it might be viable under a 90% reduction requirement or 0.0080 lbs Hg/GWh emissions rate that allows output growth. For accurate assessment of what the modeling predicts, it is critical that the modeling results be viewed in context, i.e., taking the above into consideration.

ICF prepared a comprehensive report for the Illinois EPA in which it provides a summary of the modeling results and identifies what it feels are the principal findings of the study. Of note is that modeling shows only a 1 - 3.5% increase in retail electricity prices and costs across all sectors (i.e., residential, industrial and commercial) from the proposed rule relative to the CAMR. On an average bill basis, residential customers in Illinois would pay less than $1.50 per month more under the proposed Illinois rule relative to CAMR across the study horizon.

IPM modeling predicts that two power plants may be adversely impacted to the extent that some small, older coal-fired units are retired, potentially resulting in some corresponding job loss. Note that economic experts consulted by the Illinois EPA who have reviewed the IPM modeling believe that the modeling is not accurate in predicting the retirement of these plants as a result of the proposed rule. The modeling also forecasts an increase in the use of bituminous coal as a direct result of the proposed mercury rule. This increase should have a positive impact on Illinois coal related operations, such as Illinois coal mines and jobs, since most of the bituminous coal fired in Illinois is mined in Illinois. The modeling further shows a corresponding decrease in the

use of subbituminous coal, which is mined in western states. Of particular interest is that were Illinois to implement CAMR instead of the proposed mercury rule, IPM modeling shows a decrease in bituminous coal use.

I would also like to mention some of the other issues reviewed and discussed in the TSD, specifically in section 10. The Illinois EPA found that there would be no significant adverse impact to the safety and reliability of the electricity distribution grid as a result of the proposed rule. We also found that there could be significant economic benefits as a result of the proposed rule in the form of support for existing jobs and potential for new jobs in the pollution control device installation industry, fishing industry, and Illinois' coal industry.

The Illinois EPA retained the services of Synapse Energy Economics, Inc. (Synapse) to review the modeling performed and to testify before the Board on issues related to the IPM modeling. In addition, Synapse was asked to assist the Illinois EPA in understanding a wide range of economic issues related to the proposed rule and to provide testimony on these issues where needed. These include the potential effect of the proposed rule on the reliability of the electricity grid, Illinois jobs, consumer electric rates, competitiveness of coal-fired power plants, potential for retirement of coal-fired units, and costs to the power sector. In particular, due to the serious nature of any potential unit retirements and loss of competitiveness of Illinois' coal-fired owner plants in comparison to other states, the Illinois EPA requested further review of these issues by its economic experts, i.e., Synapse. The Illinois EPA also believed that these issues warranted further review due to the conservative representation of the proposed rule by the modeling and the corresponding potential for the modeling results to overestimate any negative impacts. Synapse will be providing testimony in the hearing.

The above considerations focus on the economic impacts associated with issues outside of public health benefits. However, when evaluating the appropriateness of the potential costs of any rule, the costs associated with the rule must be measured against the costs to society of continued contamination from the targeted pollutant and the intimately related

monetized health benefits expected from reduced emissions. Illinois reviewed the numerous studies on the monetized health benefits of mercury control of coal-fired power plants nationwide and found that the annual benefits are conservatively estimated in the range of $10.4 to $288 million. Notably, in the rule development process of the federal CAMR, the U. S. EPA may not have recognized the full societal cost benefit of controlling mercury emissions. This is highlighted by the fact that U. S. EPA did not consider the results of the Harvard/NESCAUM study as well as other recent studies in its analysis of the full benefits of mercury control. Illinois' expert on the health effects of mercury, Dr. Rice, found that the costs to society from cognitive deficits in adults, accelerated aging, and impairment of elderly to live independently due to methylmercury exposure have not been monetized. Therefore, the costs to society from mercury pollution from coal-fired power plants, although extremely large, may be substantially underestimated. The preponderance of available information indicates potentially huge monetized health benefits from mercury control.

Conclusion

Recent advances in mercury control technology have improved control efficiencies and reduced the costs to control mercury. The federal CAMR does not account for these advances and does not go far enough, fast enough in reducing the emissions of this highly toxic pollutant. Illinois coal-fired power plants are the largest source of man-made mercury emissions in the State and as such, the proposed rule aims to eliminate as much of the mercury emissions from these sources as is reasonably possible, and to do so as quickly as possible. The Illinois EPA used several avenues, including the retention of services of nationally recognized mercury and economic experts, in order to obtain the latest, most accurate information on mercury and mercury controls, as well as to assist in rule development and impact analyses. We feel that the proposed rule provides for deep, attainable cuts in mercury emissions while providing compliance flexibility and other measures designed to minimize costs to affected sources. The non-public health economic implications of the proposed rule, although difficult to forecast, are variable with some potential benefits provided in the area of jobs and increased recreational

activity and possible negative impacts such as increased costs to the power sector and the potential for the retirement of some coal-fired units. The impact to Illinois consumer electricity bills should be minimal. The potential benefits to the public health of Illinois citizens from the proposed rule are substantial, as the harmful effects from mercury to IQ and cardiovascular systems, to name a few, are lessened. We expect to see lower mercury deposition to Illinois waterbodies and corresponding decreases in methylmercury fish levels, making fish caught in Illinois safer to eat. In summary, the need has been identified, the technology is available, and the costs are reasonable and therefore we urge the Illinois Pollution Control Board to adopt the proposed rule for mercury control. Thank you for allowing me to testify on behalf of the Illinois EPA.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

TESTIMONY OF JAMES E. STAUDT, Ph.D.

I, James E. Staudt, am testifying on behalf of the Illinois Environmental Protection Agency ("Illinois EPA") as an expert in this electric power plant mercury emissions rule development.

My testimony addresses the current state-of-the-art of mercury emissions control technology for coal-fired power plants and the potential use of these control technologies by Illinois coal-fired power plants to comply with the rule that has been proposed by Illinois EPA.

I. BACKGROUND AND QUALIFICATIONS

I am currently the president of Andover Technology Partners (“ATP”). As president of ATP, I have advised power plants, equipment suppliers and government agencies on ways to comply with emissions regulations in cost-effective ways. For nearly twenty years, I have focused on pollutant control technologies, including mercury emissions control. For the past nine years (since 1997) I have been a consultant with my own business – Andover Technology Partners. My primary area of business as a consultant is associated with my expertise relating to the performance and cost of air pollution control on power plants. Clients have included the United States Environmental Protection Agency ("USEPA"), power plant owners, technology suppliers, and others. I have published several papers and reports, including papers in peer-reviewed journals and reports issued by USEPA, on mercury control technology and the cost of controlling mercury on power plants. Several of these papers have been coauthored with staff of

the USEPA. For most of the period from 1988 to 1997 I was employed by companies that provided air pollution control technology (Research Cottrell and Fuel Tech) or power plant and refinery gas analyzers (Spectrum Diagnostix, a subsidiary of Physical Sciences that was acquired by Western Research). Over this period, as an employee of these companies I sold, designed, and commissioned air pollution control technology at numerous power plants and industrial facilities.

I received my M.S. (1986) and Ph.D. (1987) in Mechanical Engineering from the Massachusetts Institute of Technology. I received my B.S. in Mechanical Engineering from the U.S. Naval Academy in 1979. From 1979 to 1984 I served as a commissioned officer in the U.S. Navy in the Engineering Department of a nuclear-powered aircraft carrier.

II. SUMMARY OF TESTIMONY

My testimony addresses how mercury emissions from coal power plants can be controlled and what those controls are expected to cost for Illinois power plants to comply with the proposed mercury control rule. By reference, my testimony includes Section 8 of the Technical Support Document (TSD): Technological Feasibility of Controlling Mercury Emissions from Coal-fired Power Plants in Illinois.

Mercury Emissions From Coal Fired Power Plants

The mercury emissions from a coal-fired power plant are the result of the mercury content in the coal that is burned and the extent that processes in the boiler prevent the mercury from being released with the exhaust gases of the power plant. Mercury may be removed from the coal prior to combustion of the coal. This may be achieved by coal cleaning or by some other treatment of the coal. Or, mercury may be removed from the boiler flue gases by Air Pollution Control (APC) equipment. Sometimes the APC equipment that removes the mercury is equipment that is installed primarily to remove other pollutants, such as Particle Matter (PM) or acid gases in a

Flue Gas Desulfurization system (FGD, also called SO_2 scrubbers). Mercury removal in this manner is called co-benefit mercury removal. Mercury may also be removed by air pollution control systems that are specifically designed to remove mercury from the flue gases.

Mercury Removal from Coal

Run of mine (ROM) bituminous coal is frequently cleaned for the following purposes:

- Removal of impurities to improve the heating value of the coal
- Reduction of transportation costs for coal to the power plant and ash from the power plant
- Maintenance of ash content in coal supply within contract requirements
- Removal of sulfur, mainly as pyrites, lowering SO_2 emissions when the coal is burned.

However, cleaning ROM coal will provide the added benefit of removing mercury from the coal. This is because mercury in the coal is preferentially associated with pyrites and other non-combustible materials that are removed in coal washing.

Illinois bituminous coal is washed and some of the mercury is removed in the washing. However, most of the coal burned in Illinois is subbituminous coal from the western US that is not washed because it is naturally low in sulfur and ash. For this reason and because of the higher energy content of bituminous coal, mercury content of bituminous coal as fired in Illinois power plants is typically below that of subbituminous coals on a heating-value equivalent basis.

Mercury Behavior In the Furnace and Cobenefit Capture

Mercury that is present in trace amounts in the coal is released from the coal during combustion. At furnace conditions, the released mercury is present in a gaseous state in the elemental form that is denoted as Hg^o. As the combustion exhaust gases cool in the boiler, chemistry shifts to favor an oxidized, or ionic, form of mercury, denoted as Hg^{2+}. Some of the Hg^{2+} is adsorbed onto particles to form Hg_p. The Hg_p is readily captured in PM emission control devices that all IL coal power plants are equipped with – ESPs or fabric filters. Hg^{2+} is water soluble and can be captured by FGD systems if they are installed. However, not all of the Hg^o becomes Hg^{2+} or Hg_p due to limitations on the chemistry that result from several factors, such as concentration of

chlorine (the most common form of Hg^{2+} is $HgCl_2$), flue gas temperature, and other factors. As a result of this, the level of cobenefit mercury capture in the PM emission control devices or SO_2 scrubbers may vary based upon the type of equipment, the constituents in the coal, and other factors. NOx controls, such as Selective Catalytic Reduction (SCR) and combustion staging, can enhance the capture that is achieved in PM or SO_2 controls. Results of measurements of co-benefit mercury removal rates taken in response to the U.S. EPA's Information Collection Request (ICR) as part of the development of the federal Clean Air Mercury Rule and subsequent test programs since the ICR program showed that:

- For pulverized-coal boilers firing bituminous coal and equipped with SCR, and ESP, and wet FGD, co-benefit mercury capture is about 90%.
- For pulverized-coal boilers firing bituminous coal and equipped with an ESP co-benefit mercury capture will usually be in the range of about 30%-50%.
- For boilers firing bituminous coal in a circulating fluidized bed (CFB) arrangement with a fabric filter, co-benefit mercury capture over 90% is achieved.
- For pulverized-coal boilers firing subbituminous coal and equipped with only an ESP, low co-benefit mercury capture is likely.
- For pulverized-coal boilers firing any kind of coal and equipped with only a hot-side ESP, co-benefit mercury capture is likely to be low.

Cobenefit controls may be optimized through a variety of techniques that are described in more detail in the TSD. Depending upon the fuel being fired and the boiler's configuration, optimization methods can significantly improve cobenefit mercury removal.

Mercury-Specific Controls, Especially Sorbent Injection

The previous section addressed the important factors impacting mercury capture by co-benefit from NOx, PM or SO_2 control technologies. As discussed, boilers that fire subbituminous coal – which there currently are many of in Illinois – are not likely to achieve high levels of mercury removal from co-benefits alone. Some of the bituminous coal fired boilers may not achieve adequately low mercury emissions by co-benefits alone. Therefore, these plants may need

additional controls to achieve the levels of mercury removal that are being required in the proposed rule.

Although many mercury control methods are under development, sorbent injection is clearly the most developed. It is the only approach that has been tested on several coal-fired boilers firing a wide range of fuels. Power companies have entered contracts for commercial systems. Moreover, injection of sorbent, particularly Powdered Activated Carbon (PAC), has been used for mercury control on hundreds of municipal waste combustors for several years. The equipment is fairly simple, relatively easy to install, relatively inexpensive in capital cost, and it is well understood. The sorbent, PAC, is widely available from several suppliers.

There are three ways that the sorbent can be admitted to the gas stream:

- Normal sorbent injection – upstream of the existing ESP or fabric filter and the most inexpensive approach. Typical capital cost is around $2/KW
- TOXECON – An acronym for TOXic Emission CONtrol device. This entails retrofitting a fabric filter downstream of the existing ESP and injecting the sorbent into the gas stream between the ESP and the fabric filter with the fabric filter capturing the sorbent. This approach has been shown to work very effectively to provide over 90% removal for any fuel. It also keeps captured fly ash segregated from captured sorbent, an advantage for plants that market their fly ash. However, this is a more costly approach, with higher capital cost than normal sorbent injection.
- TOXECON-II. This is a newer approach that entails injecting the sorbent between fields of the ESP. Upstream ESP fields capture most of the fly ash and downstream ESP fields capture the sorbent and a small amount of fly ash. This approach can have advantages for power plants that sell their fly ash.

Sorbent injection technology for mercury control from coal-fired boilers has been a very active area of research because the low capital cost of the technology and ease of retrofit make it an attractive retrofit control method. The Technical Support Document lists over three dozen full scale field trials on operating electric utility boilers that I am aware of – all but a few having been completed. These tests have been on a wide range of coals and boiler configurations.

Some tests have lasted only a few days, some for over 30 days of continuous operation and at least one for over a year. Virtually all of this testing has been in the last five years and most in the last 2-3 years. So, the technology has advanced rapidly over the last few years and experience from just a few years ago may be obsolete. This is especially true when considering the new sorbents that have been developed specifically for use on coal-fired boilers.

Although untreated PAC, as is used in municipal waste incinerators, has been tested and shown to be effective in some coal-fired boiler applications, experience has shown that for most coal-fired boiler applications PAC sorbents that are treated with halogens on the surface of the PAC are much more effective. Unlike untreated PACs, which have a wide range of industrial applications, halogenated PAC sorbents were specifically formulated to address the mercury capture needs of coal-fired boilers. As a result, halogenated PAC sorbents are the current state-of-the-art for most applications and few users would consider untreated PAC for high removal rates except possibly where a fabric filter was installed.

Controlling Mercury from IL Units

It is my opinion that all of the coal-fired units in the state of Illinois are capable of meeting the requirements of the proposed mercury control rule. Because of the different coal types and boiler configurations, not all units will use the same approach.

Most of the boilers in IL fire subbituminous coal. For subbituminous coals, such as Powder River Basin coals that are used widely in Illinois, halogenated PAC has been shown to be very effective at several full-scale coal-fired boiler installations providing 90% or more removal. At several sites injection of the halogenated PAC has shown that it provides over 90% mercury removal at treatment rates of about 3 pounds of sorbent per million actual cubic feet of flue gas (lb/MMacf) when injected upstream of a cold-side ESP. This testing includes at least two 30-day continuous trials. This treatment rate for 90% or more removal is equivalent to about 200 pounds per hour of sorbent on a 300 MW plant at full load, or about $160/hour in sorbent cost with sorbent priced at about $0.80/lb. When injected upstream of a fabric filter, as will be possible on a few units that plan to retrofit fabric filters, the sorbent requirements are far less and the mercury removal is even higher. For subbituminous coal, the results of the field trials with

halogenated PAC sorbent at various sites have been remarkably consistent from site to site. The consistency of these results from site to site suggests high confidence in the performance on other units firing similar fuels, such as many of the PRB fired units in Illinois.

For those bituminous coal units that are equipped with SCR and FGD, they are likely already achieving close to 90% removal or the output based limit of 0.008 lb/GWhr. Those that are not already at these levels of control are close enough that they can achieve the remainder through an optimization method, such as a scrubber chemical additive, which will be a modest cost. Or, these units may use sorbent injection to achieve the very modest incremental reduction needed. Those pulverized coal units firing bituminous coal that are not equipped with SCR and FGD are firing medium sulfur coal or will be equipped with fabric filters. Full-scale tests have shown that halogenated sorbents can achieve high removal rates on medium sulfur coal, albeit at slightly higher injection concentrations than for PRB fuels. Combined with some cobenefit removal, over 90% mercury removal with halogenated sorbent injection in the range of 6-7 lb/MMacf has been shown at several units. In the case of Vermillion, they are under consent decree to install a fabric filter. With the fabric filter they will have very high cobenefit mercury removal – close to 90% - and will readily achieve over 90% removal with sorbent injection. There is also a bituminous unit at Marion that uses CFB technology and a fabric filter. Most likely, this unit already achieves over 90% mercury removal. But, it could easily add sorbent injection to achieve over 90% removal if needed.

There are two units in Illinois – Waukegan 7 and Will County 3 - that are equipped with hot-side ESPs and have not announced plans to install fabric filters. Using a TOXECON system, these units can readily achieve 90% or more mercury removal. Although TOXECON is more costly than a normal sorbent injection system, a TOXECON system offers advantages with regard to PM emissions control and also segregates the fly ash from the collected sorbent.

Cost of the IL Rule Compared to USEPA's CAMR

USEPA's CAMR rule sets a 2010 allowance cap that requires IL plants to remove about 70% of the mercury in the coal or purchase the equivalent number of mercury allowances. A stricter cap is required in 2018. Because a mercury allowance market does not exist yet and prices are very

uncertain, relying on allowances for compliance with CAMR in 2010 is very risky. Moreover, subbituminous units are among the least expensive units to control with sorbent injection. As a result, I expect that most or all of the subbituminous units in IL will install sorbent injection regardless of an IL mercury rule. Therefore, the cost of the IL rule over that of CAMR during the period from 2010 to 2018 is only the incremental cost from 70% control to 90% control and is mainly the cost of additional sorbent. When comparing the cost of complying with the proposed IL rule with the cost of complying with CAMR, I determined that the state-wide incremental cost of the IL rule over CAMR was roughly $32-$37 million per year spread across all of the Illinois units for the period 2010-2018.

In 2018 the CAMR allowance cap is such that it will require about 90% or more mercury removal from the coal or purchase of an equivalent number of allowances. Therefore, in 2018 the IL rule incurs little or no additional cost of compliance over CAMR.

Costs are Likely to Be Less in the Future

The state-of-the-art of mercury sorbent technology is improving. As discussed in the TSD, there are several emerging sorbent technologies that may improve mercury capture performance beyond what is possible with the currently available halogenated PACs and thereby reduce the cost of control. Most of these sorbents are designed to work with the same PAC injection systems that utilities would install for compliance with the IL rule. So, investments in hardware will not be wasted if utilities switch to newer, improved sorbents in the future. Therefore, it is likely that in 2009 and beyond the mercury removal technology performance will be greater than it is now and the cost will be less than what I have estimated with today’s state-of-the-art.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

TESTIMONY OF MARCIA WILLHITE

My name is Marcia Willhite. I have been employed by the Illinois EPA as the Chief of the Bureau of Water for 5 years. In my capacity as Bureau Chief, I oversee water pollution control, drinking water, groundwater, watershed management and state revolving fund programs for the State. Prior to coming to Illinois, I worked for 13 years in air quality including program management at the state level in Texas and at the local level in Lincoln, Nebraska. I have a Bachelor of Science in Wildlife Biology from Eastern Kentucky University and Master of Science in Toxicology from the University of Kentucky.

My testimony today will describe how mercury-impaired waters are identified in Illinois, what the federal Clean Water Act requires for addressing impaired waters and related information.

Clean Water Act Requirements

High mercury levels in fish tissue pose a public health risk, but their presence also imposes a regulatory requirement for Illinois under the federal Clean Water Act (CWA). The CWA has a goal that all waters be "fishable and swimmable." Arguably, if the fish that are caught are not safe to eat, the "fishable"goal is not being met.

In addition, the CWA establishes a framework designed to protect the "beneficial uses" of the water resources of the state. Each state has the responsibility to set water quality standards that protect these beneficial uses. Fish consumption is one type of beneficial use and all rivers, lakes and streams in Illinois have been designated for this use. Illinois has established a water quality standard of 0.12 micrograms total mercury per liter of water for protection of human health due to accumulation of mercury in fish tissue. In addition, the Illinois EPA and its partner agencies that comprise the Illinois Fish Contaminant Monitoring Program have established levels for mercury in fish tissue that define various types of fish consumption advisories. More information on this will be provided in other testimony.

Section 305(b) of the Clean Water Act requires that states report the resource quality of their waters in terms of the degree to which the designated beneficial uses of those waters are attained. Section 303(d) of the Clean Water Act requires states to submit to USEPA a list of water quality-limited waters (i.e. waters where uses are impaired), the pollutants

causing impairment to those waters and a priority ranking for the development of Total Maximum Daily Load (TMDL) calculation.

The Clean Water Act requires that a TMDL be developed for each pollutant causing impairment of a 303(d)-listed waterbody. The establishment of a TMDL sets the pollutant reduction goal necessary to improve impaired waters. TMDL calculations determine the amount of a pollutant a waterbody can assimilate without exceeding the state's water quality standards or impairing the waterbody's designated uses. It determines the load (i.e., quantity) of any given pollutant that can be allowed in a particular water body. A TMDL, in general, must consider all potential sources of pollutants, whether point or nonpoint. It also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

Impairment of Fish Consumption Use/Identification of Impaired Waters

The assessment of whether a waterbody is supporting the fish consumption use is based on water body-specific fish-tissue data and resulting fish-consumption advisories issued by the Illinois Fish Contaminant Monitoring Program. If it is determined that a waterbody is "not supporting" the fish consumption use, then that waterbody is identified as impaired and is placed on the 303(d) list. The Illinois Fish Contaminant Monitoring Program has issued a statewide general fish-consumption advisory of "no more than one meal per week of predator fish" for pregnant or nursing women, women of childbearing age, and children less than 15 years of age attributable to mercury. This statewide advisory is based on methyl mercury being found routinely at levels of concern in predator fish tissues collected from throughout the state. However, Illinois EPA does not assess fish-consumption use as impaired in all waters of the state based on the statewide fish-consumption advisory for mercury. Only those waterbodies where fish tissue data have been collected and analysis shows mercury levels of concern are identified as impaired.

When fish in a particular lake, river or stream are not safe for unlimited consumption because of contamination levels, a state is obligated to list that waterbody as impaired due to the requirements of Section 303(d) of the federal Clean Water Act. According to the latest (2004) Illinois list of impaired waters, there are 61 river segments (1034 miles) and 8 lakes (6264 acres) that have mercury listed as a potential cause of impairment due to restrictions on fish consumption.

The listing of a number of Illinois rivers and lakes as being impaired for fish consumption use due to mercury triggers a requirement that the state develop a TMDL to address the impairment for each river or lake. As discussed previously, Illinois EPA will need to determine what is the maximum amount of mercury loading from point sources (such as wastewater treatment plants) and from nonpoint sources (such as atmospheric deposition), in consideration of a margin of safety and seasonal variation, that can be introduced into each impaired river or lake and still prevent mercury accumulation in fish tissue to unsafe levels.

Amount of Reduction In Fish Tissue Needed

Illinois EPA has identified what amount of reduction in fish tissue levels of mercury that would be needed to get below advisory levels, i.e. what is the "target" for eliminating the impairment. An analysis of fish tissue data collected statewide over the last 20 years was conducted. We selected the target concentration for mercury at the 95th percentile of the largemouth bass data and calculated the necessary reduction in mercury needed to achieve 0.05 mg/kg, the highest acceptable level of mercury in fish tissue for unlimited consumption (i.e., the percent reduction needed to guarantee that 95% of all largemouth bass can be eaten in unlimited quantities by even the most sensitive sub-population.) At this level of protection, fish consumption would no longer be an impaired use, currently impaired waters would not be identified in under Section 303(d) as such and the need to develop mercury TMDLs will have been eliminated. It was determined that a 90 % reduction in fish tissue levels of mercury is required for unlimited consumption by childbearing age women and children under 15 years of age, the most sensitive and restrictive sub-population.

Contribution from Point Sources

In order to evaluate the loading of mercury, particularly to impaired waters, Illinois EPA conducted an analysis of existing Agency data. Discharge monitoring information from regulated point sources (NPDES permit holders) for the period of September 1986 through July 2005 was obtained from the Illinois EPA Permit Compliance System (PCS). It was determined that the total of all wastewater discharges to receiving streams and rivers in Illinois provide an average annual loading of 45 pounds of mercury per year. This, in comparison, was only 0.64 % of the total annual emissions (2002) of mercury (7022 pounds per year) from coal-fired power plants in Illinois. Of note, several of the lakes in Illinois that are listed for fish consumption impairment due to mercury, and that have the highest fish tissue levels of mercury detected in the state, have no point source discharges into the water at all.

Contribution from Atmospheric Deposition

Loading from atmospheric deposition of mercury to any impaired Illinois lake, river or stream has not yet been determined. The single Illinois site that is part of the national Mercury Deposition Monitoring Network is not located close enough to an impaired waterbody to be useful. Other testimony will be provided on what is known about atmospheric deposition. However, other states that have drafted TMDLs on mercury-impaired waters (i.e., Georgia, Minnesota, Maryland) have allocated a high percentage of loading as coming from atmospheric deposition.

Response of Fish Tissue Mercury Levels in Key Waterbodies in Other States to Local Reductions in Mercury Emissions

Even without developing a TMDL for mercury, some states have found significant reductions in fish tissue levels in key impaired waters following large reductions in air emissions of mercury from sources within the state.

Florida

The State of Florida recognized in the late 1980's that mercury was a problem in the Everglades and it set about to resolve that problem. It was determined that atmospheric deposition of mercury was contributing 98% of mercury loading to the Everglades. State and federal requirements reduced total emissions by about 70% in the 1990's. From its experience over the last decade, Florida has concluded that reduction in local atmospheric emissions of mercury has led to >75% declines in the tissues of fish and wildlife in less than 15 years since peak deposition.

Massachusetts

Like most states in the Eastern United States, Massachusetts has a statewide fish consumption advisory due to mercury. However, modeling and monitoring identified a deposition "hotspot" in northeastern Massachusetts. Atmospheric deposition of mercury from fossil fuel combustion and medical waste incineration were identified as significant contributors of mercury loading to northeastern Massachusetts.

Medical waste incinerator controls were implemented in the late 1990's. Between 2000 and 2003, mercury air emissions from incinerator sources in the state were reduced by approximately 90%. Followup sampling of fish tissue from waters in northeastern Massachusetts revealed that between 1999 and 2004, levels of mercury in yellow perch and largemouth bass declined by 32% and 25% respectively.

Summary

In summary, Illinois has mercury-contaminated fish in many lakes and rivers to the degree that the public is advised to limit consumption. Illinois is obligated to address this situation under the Clean Water Act. In order to assure that 95% of largemouth bass in Illinois waters may be consumed in unlimited quantities by sensitive subpopulations, a 90% reduction of mercury in fish tissue is needed. Direct discharges of mercury to water comprise a small amount of loading. Atmospheric deposition of mercury can be an important source of loading to impaired waters and Illinois air emission sources may contribute a notable portion of deposition within Illinois. Other testimony has noted that coal-fired power plants are the largest source of mercury emissions in the state. Other states have documented significant decreases in fish tissue levels of mercury shortly following substantial reductions in air emissions of mercury that were depositing in impaired waterbodies within their borders.

To the extent that mercury emissions from Illinois coal-fired power plants are being deposited in impaired lakes and rivers, a key strategy is to reduce those emissions to the greatest extent possible. The federal Clean Air Mercury Rule may only accomplish a 70% reduction in mercury emissions overall in the region, and there will likely be some coal-fired units that are not required to control at all if Illinois were to implement a trading program. Failure to control particular units that significantly contribute to local deposition means that that source of loading will remain and elevated levels of mercury in fish tissue will continue. The proposed Illinois rule would require across-the-board reductions of mercury emissions to the greatest degree possible and will hence address those emissions that are depositing locally to impaired waters in the State.

STATE OF ILLINOIS)
) **SS**
COUNTY OF SANGAMON)
)

CERTIFICATE OF SERVICE

I, the undersigned, an attorney, state that I have served electronically the attached TESTIMONY OF RICHARD E. AYRES, THOMAS C. HORNSHAW, Ph.D., GERALD KEELER, Ph.D., DEBORAH RICE, Ph.D., CHRISTOPHER ROMAINE, JIM ROSS, JAMES E. STAUDT, Ph.D., and MARCIA WILLHITE, upon the following person:

Dorothy Gunn
Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

and mailing it by first-class mail from Springfield, Illinois, with sufficient postage affixed to the following persons:

SEE ATTACHED SERVICE LIST

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY,

_____
Gina Roccaforte
Assistant Counsel
Division of Legal Counsel

Dated: April 27, 2006

1021 North Grand Avenue East
Springfield, Illinois 62794-9276
(217) 782-5544

SERVICE LIST 06-25

Marie Tipsord
Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

James T. Harrington
David L. Rieser
McGuire Woods LLP
77 West Wacker, Suite 4100
Chicago, IL 60601

Bill S. Forcade
Jenner & Block LLP
One IBM Plaza
Chicago, IL 60611

William A. Murray
Special Assistant Corporation Counsel
Office of Public Utilities
800 East Monroe
Springfield, IL 62757

S. David Farris
Environmental, Health and Safety Manager
Office of Public Utilities
City of Springfield
201 East Lake Shore Drive
Springfield, IL 62757

Faith E. Bugel
Howard A. Lerner
Meleah Geertsma
Environmental Law and Policy Center
35 East Wacker Drive
Suite 1300
Chicago, IL 60601

Keith I. Harley
Chicago Legal Clinic
205 West Monroe Street, 4th Floor
Chicago, IL 60606

Christopher W. Newcomb
Karaganis, White & Magel, Ltd.
414 North Orleans Street
Suite 810
Chicago, IL 60610

Katherine D. Hodge
N. LaDonna Driver
Hodge Dwyer Zeman
3150 Roland Avenue
Post Office Box 5776
Springfield, IL 62705-5776

Kathleen C. Bassi
Sheldon A. Zabel
Stephen J. Bonebrake
Joshua R. More
Glenna L. Gilbert
Schiff Hardin LLP
6600 Sears Tower
233 South Wacker Drive
Chicago, IL 60606

Bruce Nilles
Attorney
Sierra Club
214 N. Henry Street, Suite 203
Madison, WI 53703