Reducing Toxic Air Pollution in Lake Michigan

MAY 2001

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Acknowledgements:

This report was prepared by Delta Institute staff: Kate Blumberg, Timothy H. Brown, and Alex Johnson. The Delta Institute wishes to acknowledge and thank its partners in this project including Judy Beck of the U.S. Environmental Protection Agency, Dr. Mark Cohen of the National Oceanic and Atmospheric Administration, Dr. Thomas Holsen of Clarkson University, Dr. Keri Hornbuckle of the University of Iowa, John McDonald of the International Joint Commission, Todd Nettesheim of the U.S. Environmental Protection Agency, Dr. Trevor Scholtz of Ortech, and Steve Skavroneck, environmental consultant. The Delta Institute further thanks the members of the Lake Michigan Forum and the numerous workshop participants that helped generate and shape the material in this report, and the Joyce Foundation for funding the project.

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Contents

I. Introduction

The Great Lakes, and Lake Michigan in particular, have been a focus of atmospheric deposition research for several decades. Numerous government-funded studies, such as the Lake Michigan Mass Balance Study that has been on-going since 1994, have investigated how toxics enter the Great Lakes through the atmosphere. Toxics can enter the lakes in rain, attached to tiny particles, and as an exchange of gases. Toxics can travel through the atmosphere over long distances; this means that the sources of air toxics are local, regional, national, and international.

The research to date indicates that although water quality in the Great Lakes region has significantly improved since the 1970's, the atmosphere is a major source of on-going contamination. Even if all the contaminated sediments are cleaned up, lakewide contamination problems will persist due to atmospheric deposition, continuing to create negative public health, ecological, and economic impacts.

Although this issue is well studied by scientists, there is no environmental program dedicated to addressing air deposition of toxics. Acid rain, ozone, and regional haze all have specific and targeted programs, for which the Environmental Protection Agency (EPA) issues rules and standards to be met with specific timelines. For these programs, EPA provides guidance and funding to states and tribes to comply with those rules and requires State and Tribal Implementation Plans to describe how the problem will be addressed. This is not the case with air toxics, despite mandates within the Clean Air Act to protect public health and the environment from its effects.

There are, however, several air-related regulatory and non-regulatory tools that can and should be used to reduce toxic emissions and achieve water quality goals. This document presents a strategy that utilizes and maximizes the benefits from existing programs, available tools, and regional scientific expertise, in order to achieve quantifiable reductions of air deposition in the Lake Michigan basin. A concerted effort in Lake Michigan will provide significant experience in order to inform on-going air toxics efforts throughout the Great Lakes region and beyond.

The recommendations within this strategy aim to:

1. Set targets for the reduction of atmospheric deposition of toxic chemicals in Lake Michigan.
2. Develop a comprehensive inventory of regional air toxic sources.
3. Coordinate state and federal environmental programs to quantifiably reduce air toxic emissions.
4. Use regulatory and non-regulatory tools to reduce air toxics, including land use and transportation planning and promotion of energy conservation and efficiency.
5. Coordinate and target modeling and monitoring efforts in order to set goals, track reductions, and identify effective controls.
6. Organize a Lake Michigan Air Deposition of Toxics Task Force to oversee and advocate for the implementation of this strategy.

This document is based on ideas generated through a series of workshops held by the Delta Institute, in collaboration with EPA, the International Joint Commission (IJC), and the Lake Michigan Forum. The final workshop, held in Milwaukee in November 2000, focused on the use of atmospheric modeling to develop air toxics reduction strategies, using Lake Michigan as a test case. Seven scientific papers were commissioned for the workshop:

- *Transport and Deposition of Dioxin to Lake Michigan: A Case Study,* Mark Cohen
- *Lessons from Modeling Contaminants in Other Large Water Bodies: Identifying Origin and Time Response of HCHs in the Baltic Sea,* Frank Wania and Knut Breivik
- *A Modeling Assessment of the Impact of Pesticide Application Methods and Tilling Practices on Emissions to the Atmosphere,* M. Trevor Scholtz and Bill Van Heyst
- *Exchange of Atmospheric Chemicals with Urban Surface Waters: Controls on Long-Term Response Times,* Joel E. Baker
- *The Use of Receptor Models to Locate Atmospheric Pollutant Sources: PCBs in Chicago,* Ying-Kuang Hsu and Thomas M. Holsen
- *Polychlorinated Biphenyl Emissions to Urban Atmospheres: Enhanced Concentrations, Atmospheric Dynamics and Controlling Processes,* Steven J. Eisenreich
- *The Impact of Chicago on Lake Michigan: Results of the Lake Michigan Mass Balance Study,* Keri C. Hornbuckle and Mark L. Green

At the same workshop, the Delta Institute presented a preliminary draft of this air deposition strategy for Lake Michigan. This document incorporates comments on the original draft from workshop participants, presenters, and other interested parties.

The recommendations in this strategy have been adopted by the Lake Michigan Forum, a stakeholders group that provides input into the development and implementation of the Lakewide Management Plan (LaMP) for Lake Michigan — a process required by the Great Lakes Water Quality Agreement between the United States and Canada (GLWQA 1987). A major goal of the Lake Michigan LaMP is to take actions that will lead toward a more sustainable region (LaMP 2000). The Lake Michigan Forum believes that a concerted effort to reduce the impact of air toxics on public health and the environment is an important step toward sustainability. Addressing air toxics will require industry, agriculture and communities to reduce emissions, resulting in economic and programmatic efficiencies that will benefit the health of the region.

II. Lake Michigan Pollutants of Concern and Sources

The Lake Michigan Lakewide Management Plan (LaMP) 2000 presents a list of pollutants that are contributing to current water quality problems and ecosystem or human health impairments in the Lake Michigan basin. Table 1 presents Lake Michigan pollutants with a known air pathway and indicates other Great Lakes and Clean Air Act programs that also list the pollutants. Most of these contaminants bioaccumulate in the food chain, resulting in fish consumption advisories throughout the Lake Michigan basin. All the pollutants in Table 1, except atrazine, are also considered hazardous air pollutants (HAPs) under the Clean Air Act, which can indicate a public health threat through ambient or food chain exposure.

Table 1: Lake Michigan Pollutants

LaMP Status	LaMP Pollutant	LMMB[2]	GLATEI[3]	GLWQA[4]	Great Waters[5]	BTS Level 1[6]	HAPs[7]
Critical[1]	PCBs	X	X	X	X	X	X
	Chlordane	X	X	X	X	X	X
	DDT			X	X	X	X
	Mercury	X	X	X	X	X	X
	Dioxins & Furans		X		X	X	X
Of Concern[1]	Lead		X	X	X	X	X
	Cadmium		X	X	X		X
	Chromium		X	X			X
	Arsenic		X	X			X
	Hexachlorobenzene		X		X	X	X
	Toxaphene			X	X	X	X
	PAHs		X		X	Benzo(a)pyrene	X
Emerging[1]	Atrazine	X	X				

1. LaMP Pollutants are categorized as critical, of concern, or emerging. Pollutants identified as critical are associated with lakewide impairments, such as the inability to eat the fish. Pollutants of concern are associated with local or regional impairments. Emerging pollutants have characteristics that indicate a potential to affect the physical or biological integrity of Lake Michigan. (LaMP 2000)
2. The Lake Michigan Mass Balance (LMMB) is an intensive monitoring and modeling study of these four pollutants, including air, water, sediment, and biota sampling. (EPA 1997a)
3. The Great Lakes Air Toxics Emissions Inventory (GLATEI) is an ongoing inventory of for these pollutants in Great Lakes states and Ontario. (GLC 2000a)
4. The Great Lakes Water Quality Agreement (GLWQA) identified these pollutants as persistent toxic substances of concern to the Great Lakes. (GLWQA 1987)
5. These pollutants are identified as Great Waters Pollutants of Concern under section 112(m) of the 1990 Clean Air Act Amendments. (CAA 1990)
6. The Binational Toxics Strategy (BTS) identified these pollutants on their Level 1 list, which includes substances that are persistent, toxic and bioaccumulative. (BTS 1997)
7. The Clean Air Act (CAA) Section 112(b) identifies these pollutants as Hazardous Air Pollutants (HAPs). (CAA1990)

The list of Lake Michigan pollutants should not be considered exhaustive or static. EPA intends to evaluate the list of contaminants on an on-going basis to add emerging pollutants, with suspected current or possible future adverse impacts, and to remove pollutants as they are adequately addressed in the basin (LaMP 2000). Additional stakeholder input is needed to ensure that this list is kept current and that efforts address new and emerging pollutants of concern.

Table 2 presents the sectors identified as potential sources of air emissions for contaminants of concern. The primary source for this data is the Great Lakes Air Toxics Emissions Inventory (GLATEI), which collects emissions data from the Great Lakes states for all Lake Michigan pollutants, except the banned pesticide toxaphene. The National Toxics Inventory (NTI), EPA's Draft Dioxin Reassessment, the Lake Michigan LaMP 2000 Report, and the Great Waters Report to Congress provided additional information on quantified and suspected sources. Table 2 is useful in identifying likely source sectors for multiple pollutants of concern. Specific data including emissions estimates from GLATEI, NTI, and the Draft Dioxin Reassessment for the Lake Michigan states are included in the Appendix.

Table 2: Potential Sources of Air Toxics Releases in the Lake Michigan States

	PCBs	Mercury	Dioxin & Furan	Lead	Cadmium	Chromium	Arsenic	Hexachlorobenzene	7-PAH*	Benzo(a)pyrene*	Atrazine
Electric and other services (a,b,c,e)	X	X	X	X	X	X	X	X		X	
Residential fuel combustion (a,b,c,d,e)		X	X	X	X	X	X	X	X	X	
On road gas (a,b)		X		X	X	X	X		X		
On road diesel (a,b,e)		X	X	X	X	X	X	X	X		
Non-road including aviation (b,c,e)		X	X	X		X		X	X		
Gasoline marketing and distribution (a,b)				X							
Auto body refinishing (a,c)				X							
Paper mills and products (a,b,c)	X	X	X	X	X	X	X	X			
Chemical, solvent and pesticide production (a,b,c)			X	X	X	X		X			
Petroleum refining (a,b,c,e)			X		X	X	X	X	X	X	
Steel and iron (a,b,c,e)			X	X	X	X	X		X	X	
Aluminum and other nonferrous metals production (a,b,c,e)	X		X	X	X	X	X		X		
Fabricated metal products (a,b,d)	X			X	X	X				X	
Vehicle bodies and parts (a)				X		X	X				
Hospitals and medical waste incineration (b,c,d,e)	X	X	X	X	X			X			
Sewage and refuse, w/ municipal and hazardous waste incineration (a,b,c,d,e)	X	X	X	X	X	X	X	X			
Cement (a,b,c,d,e)	X	X	X	X	X	X		X		X	
Pesticide application (a,c,d)							X	X			X
Wildfires and prescribed burning (c,d,e)			X						X		
Barrel burning (d,e)			X					X	X	X	
Open burning of scrap tires, Landfill fires and landfills (b,c,d,e)	X		X						X		

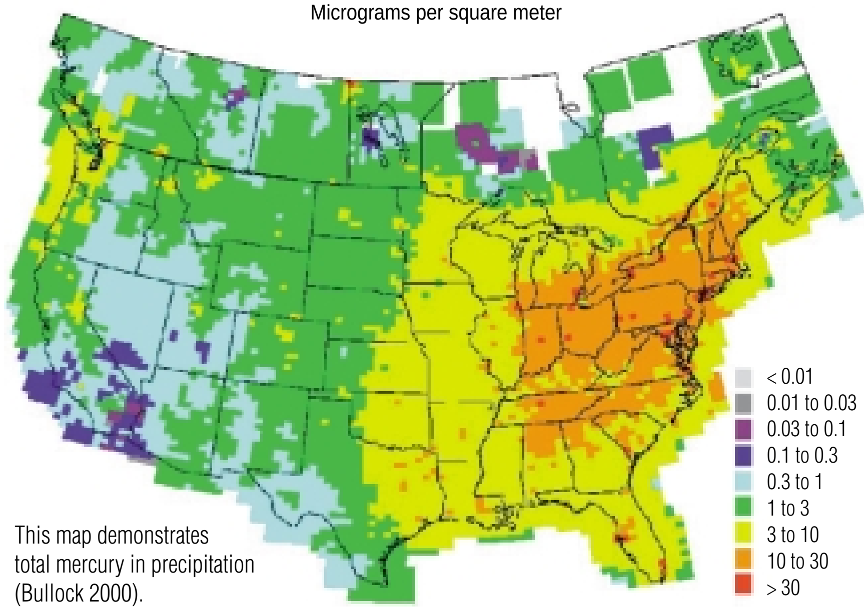
a. Great Lakes Regional Air Toxics Emissions Data for the 1996 Inventory (GLC 2000b)
b. 1990 Emissions Inventory of Section 112 (c)(6) Pollutants (EPA 1998a)
c. 1990 Emissions Inventory of Forty Potential Section 112(k) Pollutants (EPA 1999a)
d. 1993 and 1995 NTI data reported in Binational Toxics Strategy reports and The Great Waters report (BTS 1999a, BTS 1999b, BTS 1999c, BTS 1999d, BTS 1999e, BTS 2000, EPA 2000c)
e. Draft Dioxin Reassessment Documents (EPA 2000a)
* 7-PAH is a subset of the class of compounds, Polycyclic Aromatic Hydrocarbons (PAHs). Benzo(a)pyrene is one of the most studied of the PAHs and is also included in the 7-PAH subset.

III. Highlights of Recent Atmospheric Deposition Research

The Great Lakes has traditionally been a center for investigation into the processes, transport, and fate of toxic atmospheric deposition. As a result there is a great deal of information about how contaminants are transported and deposited to the Lakes, where they are coming from and from what categories of sources, and how they may be re-emitted into the atmosphere from the Lakes to be deposited again in another location. Below are a few of the highlights from the Lake Michigan Mass Balance Study and other recent research. Many of these studies point to the Chicago region as a major source area, due primarily to the fact that monitoring and modeling data are available for this region. The Chicago region should not necessarily be considered more or less of a source area than other urban industrial regions in the basin.

Figure 1: Wet Deposition – Total Hg from USA, Canada and Background

Micrograms per square meter



This map demonstrates total mercury in precipitation (Bullock 2000).

Mercury

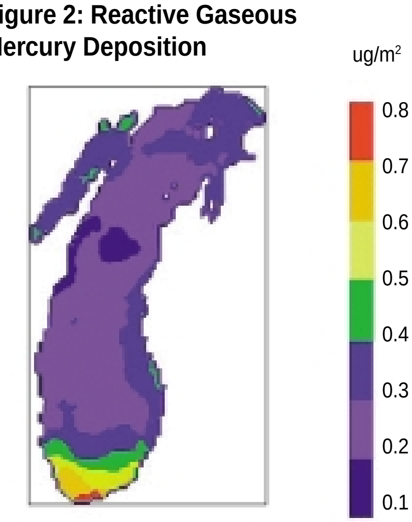
Mercury is an element that persists in the environment and never breaks down. Mercury cycles from land to air to water, and can travel for years in the upper atmosphere. Although mercury occurs naturally, human activities and uses have caused a dramatic increase in mercury in the atmosphere and environment. Each year, Lake Michigan receives a total of approximately 1,375 kg (3,031 lbs) of mercury, of which approximately 86% enters the lake through direct atmospheric deposition (EPA 2000b).

Mercury is a potent neurotoxin in humans and wildlife (ATSDR 1999). Methylmercury is a common and highly biologically available form of mercury, which quickly enters and accumulates in the aquatic food chain. Ninety to 100% of the mercury in fish is methylmercury. Concentrations of methylmercury in top predator fish are seven million times higher than dissolved methylmercury concentrations in the surrounding water, and 10 to 100 thousand times higher than total mercury concentrations in the water (EPA 1999b).

The most common human exposure to mercury is through consuming contaminated fish. Mercury can pass through the bloodstream and breast milk of pregnant or nursing women, impacting fetal or infant development (NAS 2000). Mercury levels in one out of ten women of child-bearing age are within or above one tenth of hazardous levels, indicating a narrow margin of safety (CDC 2001). In January 2001 the Food and Drug Administration released an advisory due to dangerous mercury levels in four supermarket varieties of ocean dwelling fish: swordfish, shark, king mackerel, and tilefish (FDA 2001). In the Great Lakes region, each of the Great Lakes and thousands of additional waterbodies have fish consumption advisories for mercury. Many of these lakes and rivers are isolated from human influences, suggesting the significance of air deposition.

Figure 1 demonstrates elevated levels of mercury in precipitation found in Lake Michigan and the Great Lakes region. Mercury levels measured from a downtown Chicago sampling site were an average of 16 times higher than EPA surface water standards set for protection of wildlife (Landis 1998). According to the Lake Michigan Mass Balance Study, 30% of direct atmospheric deposition to Lake Michigan originates in the Chicago region (LaMP 2000). Figure 2 demonstrates a visible plume from the lake's southern tip of reactive gaseous mercury, the type of mercury that is most likely to be deposited locally.

Figure 2: Reactive Gaseous Mercury Deposition



This map demonstrates the plume of mercury extending from the Chicago region (EPA 2000b).

Table 3: Annual Loadings to Lake Michigan

Reactive gaseous mercury	500 kg	1,116 lb
Mercury in precipitation	614 kg	1,354 lb
Mercury associated with particles	69 kg	152 lb
Mercury in tributaries	186 kg	410 lb

(Landis 1998, EPA 2000b)

Annually, a total of 1,189 kg (2,622 lbs) of mercury is deposited directly from the atmosphere to the lake. Another 186 kg (410 lb) enters the lake through tributaries, much of that also due to atmospheric deposition.

According to 1995 NTI data, fossil fuel burning accounts for over half of mercury emissions and waste incineration accounts for close to 40% (BTS 1999a). Hazardous, medical, and municipal waste incineration are subject to current or upcoming emissions control requirements. EPA recently issued a decision, finding it necessary to regulate mercury emissions from coal- and oil-fired electric utilities, the largest human-generated source of mercury emissions. Proposed regulations are due in 2003 (EPA 2000f).

PCBs

PCBs are a class of highly toxic, persistent and bioaccumulative compounds that were produced in the U.S. from 1927 to 1977 for insulating and cooling electrical equipment. New manufacturing and some uses were banned in 1979 but many of the PCBs originally produced remain in use (BTS 1999e). The significant pathway for human exposure is through consumption of PCB contaminated fish. There are fish consumption advisories throughout Lake Michigan (LaMP 2000). Atmospheric deposition accounts for over 80% of the PCBs that enter Lake Michigan. The total annual deposition of PCBs to Lake Michigan is approximately 3,200 kg (Hornbuckle and Green 2000).

Urban industrial areas, such as the Chicago region, are considered to be a major source of PCBs to Lake Michigan. The Chicago region contributes an average of 10% of the gas phase deposition of PCBs (Hornbuckle and Green 2000). Deposition of PCBs in the gas phase is dependent on temperature and wind direction. With winds from the south and higher temperatures, a plume of PCB deposition can extend from the Chicago region to cover the entire lake. Particle deposition of PCBs is also higher in urban areas but the deposition effects do not extend as far over the lake (LaMP 2000).

Figure 4 at the top of page 7 shows the impact of PCB from the Chicago region on four consecutive days over Lake Michigan, beginning with October 3,1994. Red represents deposition into the lake. On October 5th and 6th the winds were predominately southerly and a PCB plume was observed entering the lake. The temperature rose on October 6th, from a three-day average of 13.6ºC to 17.9ºC (56ºF to 64ºF), causing the plume to extend over almost the entire lake (Hornbuckle and Green 2000).

The variability in concentrations for atmospheric PCBs from the Chicago region and other sites is a clear indication of volatilization from uncontrolled sources. Figure 3 demonstrates PCB concentrations over time, comparing levels at a Chicago site with two examples of background sites: South Haven, a small city, and Sleeping Bear Dunes, a pristine site. A pattern of summer volatilization can be seen at each site but PCBs levels are typically elevated in the air of the Chicago region two to seven times higher than background levels (Simcik et al. 1997; Keeler 1994; Hsu and Holsen 2000). Potential high emissions sources within urban areas include landfills, sludge drying beds, transformer storage yards, incinerators, and other highly contaminated sites (Hsu and Holsen 2000).

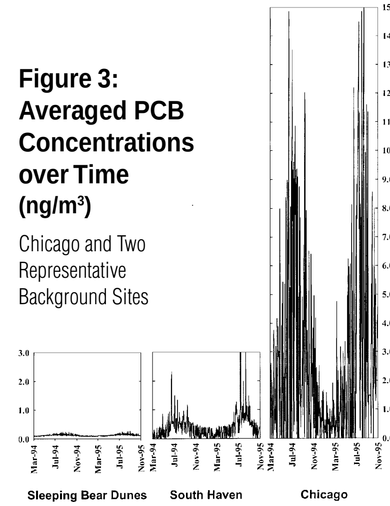


Figure 3: Averaged PCB Concentrations over Time (ng/m³)

Chicago and Two Representative Background Sites

This chart demonstrates the variability in concentrations for PCBs from the Chicago region and two background sites. Peak levels occur during summers (Green et al. 2000).

Table 4: Upwind/Downwind PCB Concentrations (Hsu and Holsen 2000)

Date	Site	PCB concentration ng/m³ upwind	downwind	Level of Elevation
7/6/99	Calumet East Drying Beds	2.87	5.47	1.9
8/13/98	CID Landfill	NA	5.13	10X over background
7/4/99		1.93	3.99	2.1
8/16/99		1.23	2.47	2.0
8/14/98	ComEd Transformer Storage Yard	NA	11.89	24X over background
8/15/99am		1.41	2.11	1.5
8/15/99pm		1.33	2.73	2.1
8/17/99am		NA	3.29	6X over background
7/20/00am		1.21	6.49	5.4
7/20/00pm		1.53	8.07	5.3

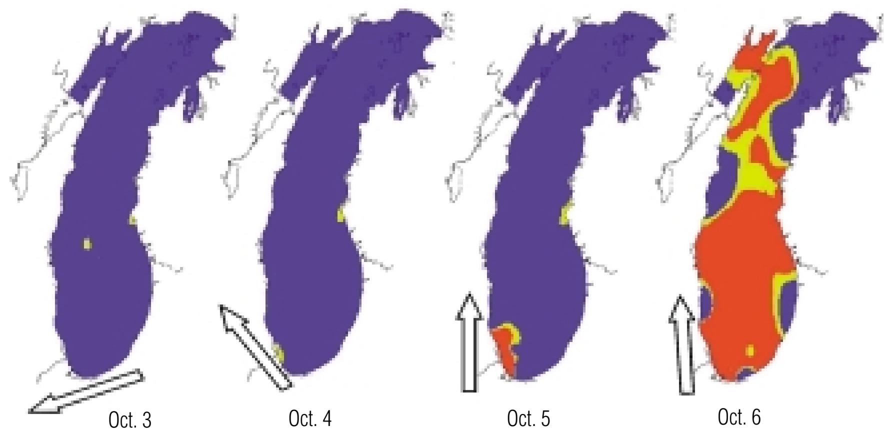


Figure 4: Net Gas Exchange of Total PCBs

Red indicates deposition into the lake. Arrows indicate wind direction

Higher temperatures and south winds on October 6 caused a PCB plume to extend over the entire lake (Hornbuckle and Green 2000).

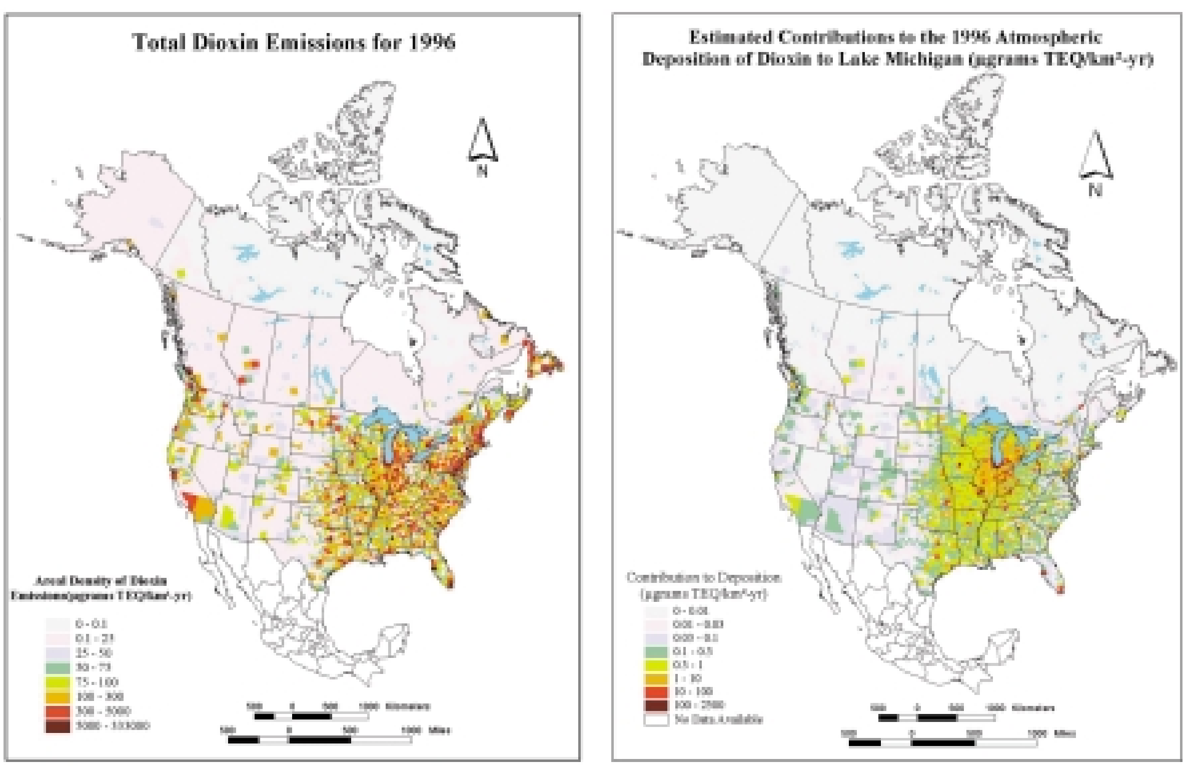
Recent monitoring and modeling efforts have been able to identify specific sources that are likely contributing to PCBs in the ambient atmosphere in the Chicago region. Upwind downwind air samples were used to confirm emissions from these sources. At the Calumet East sludge drying beds of the Metropolitan Wastewater Reclamation District of Chicago, the CID Landfill and a ComEd transformer storage yard in the Chicago region, downwind air samples show PCB levels to be elevated two to five times higher than in the upwind air, and up to 24 times higher than background levels (Hsu and Holsen 2000). Sources such as these may represent a significant fraction of the PCBs entering the air, which may then be deposited to the lake.

Dioxin

Dioxin is a bioaccumulative, persistent, and highly toxic byproduct of combustion and chemical processing. Based on a modeling analysis conducted with a 1996 emissions inventory, the latest year for which a comprehensive inventory was available, the estimated atmospheric deposition of dioxin to Lake Michigan was approximately 17 grams/year[1] (Cohen 2000). Although this may seem like a very small amount, 17 grams of dioxin is equivalent to one year of the World Health Organization's Tolerable Daily Intake of dioxin for 310 million people[2]. The atmosphere appears to account for the majority of the dioxin that enters Lake Michigan (Cohen et al. 1995; Pearson et al. 1998).

In Figure 5, the first map shows the total dioxin emissions in the United States and Canada and the second demonstrates the amount of dioxin

Figure 5: Maps Demonstrating Total Dioxin Emissions and Deposition to Lake Michigan (Cohen 2001)



[1] This figure is based upon toxic equivalents (TEQ), which measures dioxin congeners multiplied by their toxic equivalency factors to arrive at a total that is relative to toxicity rather than amount.

[2] The World Health Organization has determined that the Tolerable Daily Intake of dioxin is 1 to 4 pg per kg total body weight per day. The Tolerable Daily Intake of dioxin for 310 million people was arrived at by multiplying the midrange estimate of 2.5 pg by an average weight of 60 kg and then by 365 days. The estimated 17 grams is then divided by this number (WHO 2001).

from those sources that ends up in Lake Michigan. There are important source areas for dioxin concentrated in a broad region around the Lake Michigan Basin. The top source categories appear to be municipal and medical waste incineration, cement kilns burning hazardous waste, barrel burning, and secondary aluminum and copper smelting (Cohen 2000). According to EPA's draft Dioxin Reassessment, barrel burning of household or construction waste, which is an uncontrolled source of dioxin, is tied with municipal waste incineration as the top sources of emissions (EPA 2000a). Iron sintering and other metals production appear to be less important in EPA's draft Dioxin Reassessment but are considered to be major sources by other inventories, including the European Dioxin Inventory (Cohen 2000; European Commission 1997).

While dioxin is transported through the atmosphere from sources throughout the continent, closer sources are generally more important for deposition to the lake. Approximately 40% of the deposition of dioxin to Lake Michigan, a much higher portion than for any of the other Great Lakes, originates within 100km of the lake. Dioxin can also be transported great distances, with approximately 30% of the total deposited to Lake Michigan originating over 400 km from the lake (Cohen 2001).

Pesticides

Chlordane and DDT are two persistent pesticides cancelled in the United States (DDT in 1972 and Chlordane in 1988) due to concerns over wildlife and human health (EPA 2000g). Both continue to persist in the environment and bioaccumulate in Lake Michigan fish. There are fish advisories for each chemical in the Lake Michigan basin and the most significant pathway of human exposure is through eating contaminated fish (ATSDR 1995a, ATSDR 1995b).

Atmospheric deposition of DDT into Lake Michigan continues, although estimates of wet and dry deposition show a decreasing trend, from 64 kg (141 lb) in 1988 to 12 kg (26 lb) in 1996 (EPA 2000c). Locally elevated levels of DDT are found in South Haven, Michigan. This, along with the partially seasonal nature of flow patterns into and out of the Lakes, could be the result of volatilization from tillage of historically contaminated soils or from continued global uses (MDEQ 1998; LaMP 2000).

Chlordane levels in Lake Michigan lake trout have declined by 80% over the last 10 years, yet chlordane concentrations in fish from the southern portion of the lake continue to be higher than those observed anywhere else in the Great Lakes (LaMP 2000). While there is an annual net loss of chlordane components from the lake of approximately 26 g (57 lb), there continues to be chlordane deposition to the lake(EPA 2000b). Concentrations of chlordane found at monitoring sites in the Chicago region are higher, on average, than at any of the other sites around the lake (Hornbuckle and Green 2000).

Atrazine is one of the primary herbicides in current use in the Great Lakes region. Approximately 2,790 kg (6,151 lb) enter the lake each year through the atmosphere (LaMP 2000). EPA considers atrazine a possible carcinogen (EPA 1998b). Concentrations have been found in surface waters of the Lake Michigan basin above drinking water standards for human health (Peters 1998).

Concentrations of atrazine in the waters of Lake Michigan increased between the years 1991 to 1995, demonstrating a much greater persistence in cold lake waters than had been measured on agricultural fields (Rygwelski et al., 1999). Atrazine is capable of long range atmospheric transport. The atmosphere accounts for approximately 25% of inputs to Lake Michigan, and up to 95% of inputs to Lake Superior, where runoff and tributary loadings carry less of a contaminant burden (Rygwelski et al. 1999; Schottler and Eisenreich 1997). Atrazine concentrations in precipitation have remained constant over the past five years, consistent with steady sales (Miller et al. 2000). Total inputs from the atmosphere may be underestimated because gas phase atrazine cannot currently be measured and estimates are based solely on precipitation (Rygwelski et al. 1999; Schottler and Eisenreich 1997).

Monitoring studies have established that there are significant concentrations of many pesticides in the atmosphere over Lake Michigan from which estimates can be made of the deposition to the lake. The dominant source of pesticides in the atmosphere is treated agricultural lands. (Scholtz et al. 1999, EPA 2000b).

Options for managing the deposition of currently used pesticides to the Great Lakes include reducing use and altering methods of application. A reduction in emissions from agricultural soils will directly reduce the atmospheric burden of pesticides and their deposition to Lake Michigan. The method of application and subsequent tilling have a large impact on the emission to the atmosphere and offer a possible route for reducing deposition to Lake Michigan.

A computer model (Scholtz et al. 1997) has been used to study of the impact of pesticide application practices on the movement in soil of 20 substances with typical pesticide properties, and their emission from the soil surface to the atmosphere over a period of three years. This modeling study found that when sprayed onto the soil, 12 to 15 of the 20 substances studied lost between 50% and 92% of the applied material to the atmosphere through volatilization. This is contrasted with in-furrow application or soil incorporation that resulted in no losses to the atmosphere in excess of 50%. For persistent pesticides, tilling the soil resulted in additional significant releases (Scholtz and Van Heyst 2000).

PAHs

Loadings to Lake Michigan through dry particle deposition of 16-PAHs are estimated at approximately 5,000 kg/yr (11,000 lb/yr) (Franz et al., 1998). The Chicago region is considered to be a major source to the Lake, with air concentrations generally 10 times higher than at rural sites. A study of major sources of PAHs in the Chicago region's air found that the coke ovens and gasoline and diesel engines are the major contributors. Regulations in place for coke ovens should reduce emissions significantly, with a 94% reduction expected for coke oven emissions (LaMP 2000, EPA 2000f, Khalili et al., 1995).

Metals

There was a dramatic decline in lead loadings following the phase-out of leaded gasoline for consumer use (Volder et al. 1993, Cohen, 1997). Since that time wet deposition has continued to decrease but dry deposition may be increasing (IADN 2000, Hillery et al. 1998).

IV. Programs for Achieving Reductions

Reducing air toxics entering Lake Michigan will require emissions reductions from major sources. This will be achieved through regulatory and non-regulatory efforts that are supported by the ability to quantify reductions and relate them to the emissions inventory. Monitoring networks and models to measure and predict impacts to the environment and in communities will also be necessary.

Rather than create a new program to reduce air deposition of toxics, this strategy for Lake Michigan seeks to leverage resources and increase benefits of existing programs, ultimately achieving a level of coordination that will ensure that air deposition issues are incorporated across a range of relevant programs.

The following regulatory programs provide significant opportunities for the reduction of atmospheric deposition.

- **MACT Standards and Residual Risk.** Section 112 of the Clean Air Act requires that Maximum Available Control Technology (MACT) standards be established for major source categories of the 188 listed hazardous air pollutants (HAPs) (CAA 1990). These standards set emission limits for toxics based upon current technologies and practices employed by the best performing facilities in each source category. EPA has established standards for over 75% of the source categories and is anticipated to complete all MACT rules by 2003 (EPA 2000d). Because MACT standards were to be based purely on technology and were not designed to protect human health and the environment, Congress also mandated that EPA evaluate the residual risks for each source category after implementing MACT standards. If necessary to provide an ample margin of safety, promulgation of standards is required within 8 years of implementing each MACT rule, which may include additional controls of sources and pollutants that continue to present unacceptable risks. In order to appropriately characterize residual risks for many HAPs—especially in the Lake Michigan Basin—consideration of deposition of air toxics will be critical. The Residual Risk Program therefore presents both an opportunity to develop guidance and techniques for assessing the contribution of major point sources to deposition of toxics and regulations to achieve additional reductions of toxics necessary to reduce public health risks.

- **Urban Air Toxics.** EPA has proposed an Integrated Urban Air Toxics plan in response to several Clean Air Act requirements. Perhaps the most challenging of these mandates is to reduce the cancer incidence from the most problematic urban air toxics from area sources by 75%. The plan largely relies on MACT and Residual Risk to achieve necessary reductions in urban areas. It also recommends that urban initiatives address toxics from all sources—mobile, point, and area. In selecting the most problematic HAPs to target, EPA considered the multi-pathway exposure of some pollutants. As a result, many of the Lake Michigan pollutants are also being targeted under the Urban Air Toxics program, including mercury, PCBs and dioxins. (EPA 2000e) Thus, while EPA's strategy offers the challenge of considering impacts of atmospheric deposition in developing urban air toxics programs, it is also an opportunity for significant reductions in toxic deposition to Lake Michigan.

- **Total Maximum Daily Loads.** Section 303(d) of the Clean Water Act requires states to list waterways where water quality standards are not being met and to prepare a TMDL to achieve the standard. Lake Michigan and many of its tributaries are listed as impaired for both mercury and PCBs (LaMP 2000). For a TMDL, the maximum amount of pollutants that would allow water quality standards to be met must be apportioned among all sources including air, land runoff, sediment, and direct discharges. The air contributions to specific waterways have been very difficult to determine. This provides an opportunity to focus on regional efforts for modeling and toxics emissions reductions, which will benefit multiple listed waterways in the airshed.

- **Regional Haze.** Section 169(a) of the Clean Air Act establishes a national goal for reducing visibility problems (EPA 1999c). Under the program, states are required to submit to EPA State Implementation Plans to meet visibility goals. In order to meet these goals, states must reduce smog precursors, ozone and fine particulate matter, through control of many of the same source that emit toxics: combustion sources, motor vehicles, power plants, and factories (EPA 1999d). Through the Midwest Regional Planning Organization, the Lake Michigan Air Directors Consortium (LADCO) and the state of Ohio are conducting planning and technical efforts in the region to support their strategies for reducing haze or smog. This program presents an opportunity to integrate air toxics into haze monitoring and reduction efforts.

- **National Ambient Air Quality Standards for Ozone.** EPA's National Ambient Air Quality Standard for Ozone also requires states to submit State Implementation Plans. For years, LADCO has monitored ozone precursors in the Lake Michigan region and has run sophisticated models demonstrating the regional transport of ozone. In order to reduce ozone pollution, reductions in volatile organic compounds (VOCs) and nitrogen oxides (NOx) must be achieved. Pursuing VOC reductions through state regulatory programs and a range of non-regulatory efforts that nonattainment areas are advocating will also reduce toxics emissions. It is important to quantify the impacts on air toxics and deposition of these programs.

- **Great Waters Program.** Section 112 of the Clean Air Act requires EPA to research and evaluate atmospheric deposition to the great waters (Great Lakes, Lake Champlain, Chesapeake Bay and other coastal waters) and issue a biennial report to Congress that: quantifies atmospheric deposition to the great waters; assesses the environmental and public health effects of such pollution; identifies the sources of the pollution; examines whether the pollution is causing violations in environmental standards; and describes any revisions of the requirements, and limits necessary to protect public health and the environment. The program also requires EPA to determine the adequacy of existing regulations and programs for controlling toxic air contaminants and to propose necessary changes. (EPA 2000c)

In addition to these air programs, there are other non-air programs that are also likely to achieve emission reductions. These include:

- **Energy.** In response to the requirements of Section 112(n) of the Clean Air Act, EPA recently determined that mercury emissions from electric utilities present a significant public health problem and warrant future regulatory reduction efforts (EPA 2000f). Additionally, MACT and NOx control rules for non-utility boilers and other energy sources will impact a significant number of sources contributing to the deposition of toxics to Lake Michigan (EPA 1998c, EPA 1998d). Other opportunities for toxic reductions through energy efficiency exist as well, especially in an environment of volatile energy prices and utility deregulation. Promotion of energy efficiency activities through voluntary partnerships such as Energy Star programs, state energy public benefit programs, and sector-based initiatives such as the U.S. Department of Energy's Industries of the Future could be strategically targeted to maximize reductions of pollutants of concern and their deposition to Lake Michigan.

- **Transportation Conformity.** Transportation and land use planning activities also present an opportunity to strategically address an important source of toxics in the Lake Michigan area. Although these activities are local, transportation conformity analyses are required for ozone attainment and maintenance plans in all major urban areas in the Lake Michigan basin. These required activities have established comprehensive data collection protocols, sophisticated and improving modeling capabilities, a process for peer review and public input, and most importantly a requirement to establish declining emission budgets for VOCs and NOx. Coupled with recently adopted rules targeting diesel engines, fuels and other mobile sources, these planning activities present an opportunity to also target and reduce PAHs that are deposited to Lake Michigan.

Finally, many non-regulatory initiatives are underway to identify and demonstrate methods for achieving emission reductions. The U.S./Canadian Binational Toxics Strategy and EPA's Persistent Bioaccumulative Toxics Initiative are helping to facilitate reductions of PCBs; PAHs; pesticides including lindane, dieldrin, endosulfan, and DDT; and metals including lead, arsenic, and cadmium. The opportunity in this arena is to quantify the air deposition impacts of these initiatives and promote successful initiatives so that they are adopted at a scale that will have lasting regional impacts (BTS 1997).

V. Advancing Modeling, Monitoring, and Inventory Efforts

Coordinating monitoring, modeling and inventory efforts will help maximize the benefits from each. These technical tools are essential in order to understand what is being deposited to the lake, the effectiveness of current controls, and what more needs to be done in order to protect human and ecosystem health in the Lake Michigan basin.

A. Air Modeling Tools

Expertise in modeling air toxics has increased over the last several years as researchers have worked on the Lake Michigan Mass Balance Study and related projects. While there is significant modeling capacity, there are important barriers and obstacles to be overcome. For example, in 1999 the International Joint Commission held a moot court to explore the ability of existing legal tools to control atmospheric deposition in a case study that used models to demonstrate impacts to water quality from air sources. Although the point of the moot court was to debate water regulations to address air sources, the certainty of the models also came under scrutiny (IJC 2000). While scientific peer review of models is crucial, public support and acceptance of modeling is necessary in order to establish the political will for use of models in policy-making. In addition, in order to utilize air toxics models to support policy-making, EPA needs to offer guidance for modeling applications in the area of air toxics, as they have done for criteria pollutants.

EPA has recently created the Council of Regulatory and Environmental Modeling (CREM) to promote better communication within the agency and to establish policy regarding model development, application, and interpretation. CREM is creating an inventory of models used by EPA. Once complete, users of models will be asked how and why a particular model was chosen for a particular application and their experience with its use (Foley 2000). This process should include air toxics models, should help foster communication between policy makers and modelers, and should include non-EPA supported models. Comparison studies between models would also be useful to help evaluate uncertainties.

To effectively utilize air toxics modeling tools, it is equally important to clarify the questions that need answering from a policy perspective. For example, the Lake Michigan Mass Balance project is being used to identify reductions in pollution from air and water sources necessary to achieve a specific goal, such as lifting fish consumption advisories. Additional policy questions that need to be answered through modeling include:

- What level of air emission reduction from regional sources must be achieved to meet water quality and public health goals and is this possible with current regulations?
- What are the source types and regions (source-receptor relationships) of deposited pollutants?
- How much of the air toxics problem is from sources outside the region and what will be the impact on the region from national and international policy programs?
- What is the importance of atmospheric deposition relative to other sources?
- Since the Chicago region has been so widely studied by modelers and researchers, can it be generalized that the contribution of air toxics from other urban industrial centers is analogous to that of the Chicago region?
- How can the effectiveness of regulatory and nonregulatory tools in reducing atmospheric deposition problems be predicted and evaluated?

For the Lake Michigan region, the policy questions, such as those above, must be clearly identified. The challenge, then, will be to ensure that the technical capacity is in place to answer these policy questions on an on-going basis.

The level of certainty of models is linked to either the quality of emissions inventories and or completeness and reliability of monitoring data. When used in modeling, emissions inventories are generally the largest source of uncertainty (Cohen 2000). Expanded ambient, urban, and deposition monitoring is an on-going research need, with various sampling techniques required to support different types of models. Technical resources for inventories, monitoring, and modeling is and will be available through a range of related but uncoordinated programs (e.g., TMDL, Urban Air Toxics, Residual Risk, Lake Michigan Mass Balance, Regional Haze, ozone, etc.). Therefore, it is very important that a method for coordinating and leveraging technical resources be established. EPA's Office of Air and Radiation and the Great Lakes National Program Office could jointly play this coordinating role.

Recommendations:

- A modeling effort should be launched to predict the reductions in atmospheric deposition that are expected from existing regulatory programs. This information is necessary to determine the extent to which existing regulations will achieve water quality and public health goals in the region, and whether additional reduction goals must be set.

- The policy questions for which modeling support will be necessary to answer should be clearly identified. This process should include stakeholder input.

- Stronger links are needed between modelers and policy makers, including a concerted effort to inventory air toxics modeling tools and provide information on how they can be used to understand and reduce atmospheric deposition. EPA's Council of Regulatory and Environmental Modeling could facilitate this increased level of communication.

B. Toxics Monitoring

Comprehensive environmental monitoring—including ecological, ambient air, deposition and water quality—is essential to measure exposures, track emerging pollutants, assess progress, and develop and evaluate good models. Many of the monitoring networks currently in place will be critical to this work and additional new resources flowing into the region to monitor air toxics will be useful as well. Because most of these efforts are disjointed and designed to meet specific, narrowly focused programmatic objectives, many critical data gaps will remain.

The Integrated Air Deposition Network maintains two monitoring stations in the Lake Michigan basin, one in Chicago and one in Sleeping Bear Dunes National Lakeshore. These stations monitor for PCBs; many polycyclic aromatic hydrocarbons (PAH); and pesticides including lindane, dieldrin, endosulfan, and DDT (IADN 2000). A new National Dioxin Ambient Monitoring Network (NDAMN) was first deployed in the western states but will include monitoring in the Great Lakes basin as well, and the Mercury Deposition Network (MDN) collects samples of precipitation from many sites in the region, one site directly on Lake Michigan (NADP 2001). An extensive network of National Ambient Monitors and State/Local Ambient Monitors (NAMS/SLAMS) is in place in the region as well. Although these networks are designed to measure compliance with ambient air quality standards, they too can provide valuable information related to the transport of air pollution and be used to verify modeling results. Since 1995, these networks have been augmented with a regional Photochemical Assessment Modeling System (PAMS). PAMS data—which include speciated VOCs—will significantly enhance our understanding of sources and transport of air toxics in the region. New and additional fine particulate matter and visibility monitors will also contribute valuable data.

The monitoring committee of the Persistent Bioaccumulative Toxics Initiative is in the early stages of work to coordinate toxics monitoring, both nationally and regionally. Another significant opportunity is presented by efforts planned under the National Air Toxics Assessment (NATA). These efforts, coordinated by EPA's Office of Air Quality Planning and Standards, will result in an expanded national network of air toxic monitors (EPA 1999e). Already, significant new resources have been obligated to Lake Michigan states. These resources are targeted primarily to assessing ambient levels of some air toxics in urban areas. Little priority has been given to the valuable role these efforts could and should play in addressing the data needs of policy makers and air deposition modelers. In addition, new pollutants which are suspected of causing current or future ecosystem or human health problems need to be added to monitoring networks in order to identify trends and to build a set of data in order to study effects. All of these monitoring efforts could be better coordinated to fulfill multiple programmatic objectives (GLC 2000a).

Recommendations:

- All relevant monitoring efforts currently funded in the region should be inventoried to ensure that these efforts are sufficiently coordinated to optimize data on air toxics and deposition. This information should be shared with the Lake Michigan Coordinating Council.[3]

- A stakeholder participation process should accompany monitoring efforts to help ensure that a full range of policy needs will be supported by monitoring activities, including adequate monitoring for current and emerging pollutants of concern.

C. Emissions Inventories

The best emission inventory for air toxics in the region is the Great Lakes Air Toxics Emission Inventory (GLATEI). GLATEI is the first regional toxics inventory of its kind, a collaboration between the Great Lakes States and the Province of Ontario that began in 1987. The Great Lakes Commission (GLC) coordinates the development of GLATEI through grants from EPA. The inventory continues to evolve, improve, and expand the source sector coverage.

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[3]The Lake Michigan Monitoring Coordinating Council is an effort of state, tribal and federal agencies working in the Lake Michigan region to coordinate multi-media monitoring activities.

However, for GLATEI to be relied upon by researchers, policy-makers, and the public, consistency in state data is needed. States do conduct regional quality assurance, and protocols have been built into the inventory system to encourage consistency. In addition, better emissions factors are needed, along with the ability to collect emissions data on a regular basis. This includes information on distinct processes and levels of activity within a facility, effects of air pollution control equipment, facility shut downs, and new sources.

In order to ensure that the inventory is of high quality and useful to researchers and modelers, inventories should be developed with the end-users in mind. The GLC could play a valuable role in coordinating an on-going interaction between those that are building the inventory and the scientists and policy makers that will need to rely on this information. Further, more interaction between inventory managers and state, tribal, and EPA pollution prevention program managers would help to ensure that pollution prevention programs are targeted to source sectors responsible for the largest volume of air toxics emissions.

Source specific emissions tests can provide reliable and accurate emissions data but may not represent the range of emissions levels from a given facility or the variation from facility to facility. Although states can develop and use their own emissions factors based upon facility tests, these factors are not generally EPA-approved and, therefore, cannot be used with credibility by other states. Even EPA-approved emissions factors are often in error, because there can be large variability in emissions for certain contaminants, such as dioxin, due to even small changes in industrial activity. Some of these could be addressed through greater involvement from industry and municipalities.

While area and mobile sources and new source categories have been added to the regional inventory, there are still significant gaps for several pollutants. Important non-traditional sources, many of which do not fall under the traditional jurisdiction of air management programs, should be explicitly identified in the inventories by the end-users to help fill in the holes for several pollutants of concern. Recent research is showing that major ambient sources of PCBs to the air can be identified, quantified, and controlled, including transformer storage yards, sewage sludge spreading and drying, and possibly landfills (Hsu and Holsen 2000; Eisenreich 2000). There are also major gaps in the inventory for dioxin. Recent research has indicated that uncontrolled or not properly controlled burning can contribute significantly to dioxin emissions. Burn barrels are estimated to be a major source of dioxin, and other possibly significant sources include structural and vehicle fires that contain materials with PVC and/or other chlorinated materials, landfill fires, and landfill gas combustion (Cohen 2000). In order to include these sources in the inventory, emissions factors must exist and it is important to establish the relative magnitude of contributions.

Recommendations:

- Researcher input should be requested to assist in targeted inventory reconciliation efforts, and workshops should be held with inventory builders, policy-makers, pollution prevention managers, and the public to ensure the continuous improvement of GLATEI.

- Adequate public funds should be available to states to create toxics inventories. Funding for GLATEI is not stable and the source of funds is not inventory specific. These resources are essential for the development, documentation, updating, inspection and distribution of the inventory.

- Industry should be requested to help improve emissions inventories by providing data from emissions tests at their facilities. This information could be used to ensure that adequate emissions factors are available for all important source types of pollutants of concern to the Great Lakes.

- Public funding should be provided to develop methodologies for determining emissions from any potentially significant unquantified sources, such as wastewater treatment plants, landfills, contaminated sites, and transformer storage lots.

VI. Strategic Opportunities

The following sections present the initiatives recommended for leveraging regulatory and non-regulatory initiatives to reduce air toxics and deposition to Lake Michigan. These initiatives are not recommended as steps that must follow one another. Rather, they can and should be pursued on parallel and coordinated paths.

A. Urban Sources of Air Toxics

Recent research clearly demonstrates that working on urban sources of air toxics is essential from a Lake Michigan water quality perspective. For example, the Chicago region (including northwest Indiana) is the source of up to 20% of the PCB loading into Lake Michigan through the atmosphere. With higher temperatures and southerly winds the Chicago region becomes a significant source of air deposition not only in the near shore area but also throughout Lake Michigan (Hornbuckle and Green 2000, Franz et al. 1998, Offenburg and Baker 1997). It is likely that Milwaukee, Green Bay, and other urban centers in the region are similarly impacting the Lake.

Addressing urban sources of air toxics is important from both an environmental and public health perspective. EPA has been funding a Cumulative Risk Initiative in Cook County, Illinois, and Lake County, Indiana that describes the risk to children from the cumulative exposure to air toxics.

The most promising opportunity for approaching urban air toxics issues and linking environmental and public health concerns is EPA's Integrated Urban Air Toxics Program mandated by sections 112(k) and 112(c)(3) of the Clean Air Act. The goals of the program are to:

- Attain a 75-percent reduction in the incidence of cancer attributable to exposure to hazardous air pollutants (HAPs) emitted by stationary sources.
- Attain a substantial reduction in public health risk posed by HAP emissions from area sources.[4]
- Address disproportionate impacts of air toxics hazards across urban areas (EPA 1999f).

EPA has identified 33 HAPs as carcinogens that will be addressed by the Urban Air Toxics program. Each of the current Lake Michigan pollutants in Table 1 is on the list with the exceptions of chlordane, toxaphene, and atrazine. The program recognizes that the threat of air toxics is both from exposure to ambient air and from bioaccumulation in the food chain. Exposure through the food chain, generally measured through fish, presents a much greater risk for many Lake Michigan pollutants, including dioxin, mercury, and PCBs. The Urban Air Toxics program intends to identify additional regulatory measures that may be necessary after MACT standards are implemented and residual risks are addressed.

[4] According to EPA, area sources are those stationary sources that emit, or have the potential to emit, less than 10 tons per year of any one HAP or less than 25 tons per year of a combination of HAPs.

The Urban Air Toxics program acknowledges that there is variability within urban/industrial centers and that state, tribal and local programs will have different impacts on emission reduction. The program recognizes, therefore, that implementation will need to occur through a partnership among federal, state, tribal, and local governments. The program highlights the importance of public education and involvement. It also includes the development of a research strategy to identify key scientific questions for risk assessment and management of air toxics from all emission sources (EPA 2000h).

The Urban Air Toxics program includes the development of a National Air Toxics Assessment that will create a national air toxics monitoring network. EPA has already provided funds to LADCO to conduct the initial studies necessary to build the air toxics monitoring network in the Midwest (Batelle 2000).

Overall, the Urban Air Toxics program provides an opportunity for federal, state, tribal, local government, and stakeholders to work together to evaluate the extent to which existing programs will achieve emissions reductions, to take action on remaining risks, to address cumulative risks in urban/industrial areas, and reduce atmospheric deposition.

Recommendation:

An Urban Air Toxics partnership should be launched in the Lake Michigan region to achieve reductions in air toxics by coordinating a range of programs, including: the Urban Air Toxics program, Residual Risk, Cumulative Risk Initiative, TMDLs, Lake Michigan LaMP and Mass Balance, Regional Haze, and ozone. This effort would provide the opportunity for state, tribal and federal agencies, scientists, and stakeholders to work together on integrated multi-media strategies for air toxics and to implement strategies on a regional basis.

B. Agricultural Sources of Air Toxics

Atmospheric deposition research has shown that pesticides and herbicides can volatilize and can be transported over long distances to be deposited in the Great Lakes. The Integrated Air Deposition Network monitors for chlordane, which is still being deposited into Lake Michigan even though it is no longer produced or used in the United States. Detections of DDT at Michigan sites were found in patterns suggesting that past applications of DDT are still volatilizing into the atmosphere (Keeler 1994; MDEQ 1998). The Lake Michigan Mass Balance study has found that atrazine, a currently and widely used herbicide, is also deposited into Lake Michigan from the atmosphere.

There are currently many local, state, tribal, and federal programs assisting farmers and growers in better management of pesticides. Although research has demonstrated that methods of pesticide application influence volatilization and transport of chemicals (Scholtz and Van Heyst 2000), it is unclear whether these methods are communicated and promoted by agricultural assistance programs. More information is needed on how to incorporate air deposition concerns into agricultural best management practices and stewardship programs, such as Pesticide Environmental Stewardship and Sustainable Agricultural Research and Education, and the extent to which these practices can be promoted.

Discontinued pesticides are being collected through Clean Sweep programs in Lake Michigan states to prevent them from entering the ecosystem. These essential programs should be evaluated in order to ensure their effectiveness and to identify opportunities for sustained funding, oversight, and coordination.

Because of the mounting scientific evidence on atmospheric deposition and transport of pesticides and herbicides, there is also an opportunity to factor in long-range transport and deposition in the formal registration process required by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Under FIFRA, the highest risk aspects of pesticide application are required to be assessed. Short-range transport is considered but longer-range transport is not normally included in assessment of risk or possible harm, even though it may be important both because of persistence and high volume use. While EPA's Office of Pesticide Programs (OPP) is in the early stages of trying to determine the necessary models, data needs, and criteria to include intermediate and long-range atmospheric transport in risk assessments, there are complicating factors such as the rate of usage and the persistence of the chemical in water, soil, and air (LaMP TCC 2000).

One approach to assess risks associated with transport of pesticides would be to screen by volume of usage, then by persistence, including in-lake and tributary waters. This would require additional information and the creation of an inventory of pesticide and herbicide use in the region. Pesticide quantities are currently recorded at the point-of-sale but there are no inventories which incorporate quantities, areas, and application. The Wisconsin Strategic Pesticide Information Project is developing a Pesticide Database System, which should be evaluated in terms of its effectiveness and relevance for the rest of the Lake Michigan Basin (Wisconsin Strategic Pesticide Information Project 2000). This sort of an inventory will highlight needs for more effective pesticide management approaches as well as provide data for risk assessments that should be instituted for registration of agricultural chemicals of concern.

Recommendations:

- The risks associated with the volatilization and long-range transport potential should be incorporated into EPA's Office of Pesticides Programs (OPP) registration requirements. A range of current use agricultural chemicals should also be incorporated into IADN and/or other regional monitoring programs.

- A basin-wide inventory of pesticide use should be developed and the ability of existing technical assistance programs to address the volatilization and transport of pesticides through the air should be evaluated.

- Adequate and long-term funding should be provided for Clean Sweep and other agricultural pollution prevention programs in the Lake Michigan states.

C. Energy Conservation and Efficiency

As EPA's recent decision to regulate mercury emissions from coal-fired power plants demonstrates, energy generation and use is a significant source of air toxics. In addition to coal-fired power plants, of which there are more than 50 in the Lake Michigan states alone, non-utility industrial boilers, turbines, reciprocating engines and process heaters play a critical role in meeting the energy needs of our region. According to the 1994/95 National Toxics Inventory, utility, commercial/industrial, and residential boilers account for over half of total mercury emissions in the U.S., and significant sources of other metals, PAH, dioxin and furans, and PCBs (EPA 2000).

Energy efficiency and conservation efforts can result in quantifiable toxic emissions reductions from these facilities. For example, employing better steam management practices at existing industrial boilers would reduce fuel use by up to 20% (ICF Resources 1999). For most coal-fired facilities, this would reduce emissions of mercury by a similar percent. The promotion and adoption of efficiency and conservation practices is a win-win for the region: Facility owners get a lower energy bill and the toxic loading to the region is reduced.

Another win-win opportunity exists with combined heat and power (CHP). By significantly increasing the energy output of existing facilities, toxic emissions and fuel consumption can be reduced, and electric system reliability can be increased. Many CHP projects also result in switching from more polluting fuels such as coal to cleaner natural gas. Therefore, CHP could play important roles in both meeting the regions growing demand for energy and significantly reducing toxic emissions form energy generation.

As more attention is focused on energy policy and planning, emissions of other pollutants of concern deposited to the Great Lakes should receive consideration equal to that of emissions of mercury, ozone precursors, and greenhouse gases. Emission reduction factors and transport and deposition models should be developed for strategies that promote energy efficiency, new technologies, and CHP.

Recommendation:

- The Lake Michigan states should consider deposition of toxics in energy policy-making decisions. Any policies or investment decisions that impact the generation portfolio or demand for energy ultimately impact the quantity and location of toxic emissions from multiple sources in the region. These include policies that reduce barriers to—or reward—cleaner energy such as CHP and renewables; investment in transmission infrastructure that may result in importing electricity from older, dirtier fossil fueled facilities; and wider implementation of demand side management practices and technologies.

D. Land Use and Transportation Planning

Transportation planning is a logical arena in which to consider air deposition due to transportation policies, investments, and activities. Mobile sources emit PAHs, mercury, other metals, and are possible sources of dioxin. Conformity analyses already require extensive data collection and air emission modeling of criteria pollutants and their precursors. EPA also has congressional mandates, such as review under the National Environmental Protection Act and the Clean Water Act, to consider multimedia impacts of transportation projects and has committed to address mobile sources in the Integrated Urban Air Toxics program.

Current transportation models should be modified to predict emission of toxic pollutants of concern. Ideally, these added capabilities should address all mobile-related pollutants of concern in the Lake Michigan region and be incorporated into EPA's mobile emissions model (MOBILE 6). EPA could use these model outputs to work with local metropolitan planning organizations, public interest groups and other stakeholders to ensure that emissions of air toxics are adequately considered when developing, approving and funding local transportation plans.

Recommendation:

Protocols and recommendations for modifying transportation models to predict emissions of toxic pollutants of concern should be developed and used by EPA's Office of Transportation and Air Quality (OTAQ). Training on the protocols should be provided so that state inventories include accurate data from mobile sources.

E. Non-Regulatory Initiatives That Reduce Air Toxics

The concept of using voluntary agreements to work toward reducing use or release of toxic pollutants has been applied in a variety of source sectors in the Great Lakes. The Binational Toxics Strategy, for example, has reached voluntary agreements on reduction of Great Lakes toxics from the steel industry, the American Hospital Association and hospitals in Ontario, and the chlor-alkali industry (BTS 1999a). Some other voluntary efforts include air toxics reductions from industrial boilers through energy efficiency and conservation, and reductions from the metal finishing and printing sectors. The value of these voluntary activities is to demonstrate that it is possible to improve environmental quality within the day-to-day operations of facilities. Obviously regulatory programs will be relied upon to achieve environmental and public health protection, but there are also meaningful environmental improvements that can and should be made by responsible facilities that understand that protecting the environment also makes good business sense.

It is important to quantify the toxic emission reductions that come from these efforts and to broadcast the results in order to promote strategies that work. It is also important to quantify the benefits to facilities of implementing such strategies. In order to do so, a quantification methodology must be developed and incorporated into voluntary agreements on toxics reduction. The Binational Toxics Strategy provides an appropriate forum in which to develop such a methodology for initiatives that result directly from the Strategy, but that can also be utilized by voluntary efforts more broadly.

With the advent of ISO 14000 and similar standards and certification programs, and adoption of continuous quality improvement among leading corporations, Environmental Management Systems (EMS) are emerging as a potential new tool for environmental improvement at industrial facilities. Through these efforts, facilities often find that improving environmental performance results in resource efficiencies that can improve the bottom line (Illinois EPA 1999).

More experience is needed to fully evaluate the potential for EMS' to reduce emissions and improve environmental quality for ecosystems and within communities. Federal facilities provide an excellent opportunity to test the potential of EMS'. EPA's emphasis on persistent bioaccumulative toxic substances (PBTs) has influenced the General Services Administration's Planet GSA and EPA's Environmentally Preferable Purchasing Program (EPA 1995). Case studies and pilot projects resulting from these efforts have demonstrated that federal facilities can cost effectively—and significantly—reduce consumption and release of pollutants of concern to the environment. Further, these initiatives are supported by Executive Orders 12873, 13101 and 13148 that encourage all federal facilities and agencies to implement environmental purchasing programs, conserve energy, and reduce environmental impacts from transportation related activities. Complying with these executive orders will require EMS-like processes to be implemented at federal facilities. Compliance with these executive orders, together with implementation of EMS's by federal facilities in the region could yield significant environmental benefits that would serve as an example to other public and private sector facilities.

Opportunities with private sector facilities implementing EMS' should be pursued as well. Most EMS's include identifying "aspects and impacts" of the whole range of activities at a facility that may have environmental effects. There should be an opportunity to look beyond local air and water pollution impacts to also take into account air deposition in the Lake Michigan basin and beyond.

Recommendations:

- Methods for quantifying the air toxics emission reductions from agreements reached with private sector partners should be developed. The emissions reduction potential should be related to the toxics emissions inventory to demonstrate the regional impact of widespread implementation of the reduction measures.

- A public sector EMS initiative should be launched at a federal or state facility in the Lake Michigan region. This effort would evaluate toxic air emission reduction potential, among other environmental benefits, of pollution prevention and energy conservation and efficiency initiatives. The EMS could also evaluate impacts of plant activities relative to long-range transport and deposition of air toxics. A public sector EMS would generate a case study that could be promoted to other public sector facilities, but also to demonstrate to the private sector that broader ecosystem impacts from plant operations can effectively be evaluated and addressed in an EMS.

VII. Stakeholder Involvement

Stakeholder involvement must be an integral part of this strategy because the acceptance and usefulness of technical work on atmospheric deposition, including inventories, monitoring, and modeling, will increase if there is more interaction and communication between scientists and researchers and end users including policy makers and the public. Further, addressing atmospheric deposition requires coordination among several different programs. This is more likely to happen if stakeholders are involved to request the necessary level of coordination and to help identify opportunities for leveraging resources. New policies to address atmospheric deposition will need broad-based stakeholder buy-in if they are to be effectively implemented.

Finally, stakeholder input is needed to ensure that the list of Lake Michigan Pollutants is current and addresses emerging pollutants suspected of causing current or future ecosystem or human health problems, not only through persistence and bioaccumulation, but also through widespread and heavy use, low-level toxicities or effects that disrupt organism functioning, and synergistic effects with other chemical contaminants.

Recommendation:

- A Lake Michigan Air Toxics Deposition Task Force should be established to help advocate for the implementation of these recommendations. The Task Force should be affiliated with the Lake Michigan Forum and the Lake Michigan LaMP to help ensure that a coordinated air deposition strategy is pursued by EPA and the Lake Michigan states.

VIII. Evaluation and Reporting

The Lake Michigan LaMP process is committed to issuing a biennial report on the status of implementing the LaMP (LaMP 2000). This presents an appropriate opportunity to report on trends in atmospheric deposition, to set reduction targets, and to indicate progress made in implementing this strategy. This process will track the effectiveness of federal and state programs intended to reduce atmospheric deposition of toxics. It will also serve as a mechanism for evaluating the ongoing effectiveness of the strategy and making necessary changes. Biennial reports will help demonstrate how a specific region is making progress on atmospheric deposition, providing one example within the broader Great Lakes region.

Recommendation:

- The LaMP program should issue a status report on atmospheric deposition and progress made in its biennial report. The report should publish reduction targets and report on efforts, including this strategy, to achieve deposition reductions.

IX. Conclusion

Air deposition research indicates that the atmosphere is an important and complicated source of on-going toxic pollution for Lake Michigan. Unfortunately there is no specific EPA or state program that is explicitly designed to set and meet reduction targets for air toxics deposition in the region. However, there are various government programs that are pieces of the puzzle. In order to make progress on this issue and to protect public health and the environment from air deposition of toxics, EPA and state agencies will have to work together and make a commitment to address this problem. EPA through its funding and programmatic capabilities should play a leadership role on the issue and work with its state counterparts to encourage regional action. State organizations could be very helpful in coordinating technical resources; LADCO, for example, could initiate valuable modeling and monitoring efforts, and the Great Lakes Commission could work with researchers and the public to improve the Great Lakes Air Toxics Emissions Inventory.

As more research is conducted, either by EPA or academic researchers, the results must be made publicly available in a timely fashion. Public awareness of the research underway to understand this complex problem will help create the political will to respond with sound public policies.

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Appendix: Emissions Sources for Pollutants of Concern

This section includes, where available, data from 1990 through 1996 National Toxics Inventories and the 1996 data of the Great Lakes Air Toxics Emissions Inventory (GLATEI). For dioxin, the Draft Dioxin Reassessment released in 2000 is referenced. And additional data or comments which point to suspected or unquantified sources are included for most pollutants.

Because the Great Lakes states currently collect and estimate emissions data differently, there are many inconsistencies in the data below. The GLATEI data is generally considered to be the most comprehensive and reliable inventory available, but there are still many incompatibilities to be worked out regarding use of emissions factors and arriving at emissions estimates. Emissions data for all the Great Lakes states and the province of Ontario is compiled in GLATEI. In order to consolidate, the data below only includes Lake Michigan states.

Transformer Storage Yard – Ying-Kuang Hsu

PCBs

National Toxics Inventory Data

Major air sources for PCBs listed for:	1990	1993	1996
Hazardous waste incineration	17.7%	56.0%	70.5%
Municipal waste combustion	51.0%	-	-
Medical waste incineration	25.7%	-	-
Sewage sludge incineration	3.3%	10.3%	13.0%
Fabricated metal products	-	10.1%	12.7%
Industrial boilers: natural gas combustion	-	7.7%	-
Portland cement manufacture: all fuels	-	7.3%	-
Scrap and waste materials & refuse	-	3.9%	-
Scrap tire combustion	0.7%	2.1%	2.7%
Municipal landfills	-	-	1.2%
(EPA 1998; Meyer and Caplan 1999; LaMP 2000)			

1996 Great Lakes Toxics Emissions Inventory Data

Sources Accounting for 90% of PCB Air Emissions to the Lake Michigan States (lbs)							
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
2.0	0	2.0	0	0	Point	Primary aluminum	28%
2.0	0	0	2.0	0	Point	Sewerage systems	28%
1.9	0	0	0	1.9	Point	Converted paper products	27%
0.5	0	0	0.5	0	Point	Sanitary services	7%
7.06	Total PCB Emissions Reported for the Lake Michigan States					(GLC 2000b)	

Additional Comments

Based on recent research, the inventory of PCBs to the atmosphere from wastewater treatment plants in the Chicago region is 114 kg/yr (251 lb/yr) comparable to the EPA nationwide emissions inventory of 140 kg/yr (308 lb/yr) and 36 times the inventory reported by the Lake Michigan states (Hsu and Holsen 2000). Further sources of PCB emissions, which are not well quantified, include the following:

- Releases from leaks or spills from PCB-containing equipment, from poorly maintained or illegal hazardous waste sites, and from fires of transformers or other sites of past PCB uses;
- Inadvertent generation during production processes that involve carbon, chlorine, and elevated temperatures, such as the production of chlorinated solvents;
- Auto scrap burning;
- Volatilization from landfills, contaminated sites, water or sediments (EPA 1998a); and
- Volatilization from sewage sludge drying beds and transformer storage yards. (Hsu and Holsen 2000)

Because volatilization of PCBs from urban ambient sources occurs much more readily in warmer temperatures, remediation of these sites and demolition of contaminated structures should occur in cool weather. (Hornbuckle and Green 2000)

Chlordane

Great Lakes Toxic Emissions Inventory Data
Emissions data for chlordane is collected by GLATEI. No emissions reported by any of the Lake Michigan states but .94 lbs was reported by Ontario from sewerage systems (GLC 2000b).

Additional Comments
Sources of chlordane to the environment are associated primarily with historical applications and releases and include the following:

- Contaminated building materials from termiticide application;
- Soils to which chlordane was applied;
- Hazardous waste sites associated with manufacture, transfer or use;
- Long-range atmospheric transport from chlordane use abroad; and
- Current stockpiles. (LaMP 2000)

DDT

Great Lakes Toxic Emissions Inventory Data
GLATEI does not include data on DDT emissions.

Additional Comments
Global use trends generally show a decline (Loganathan and Kannan, 1994). However, measurable amounts of DDT and its metabolites are still found in the air, water, sediment and soil in and around the Great Lakes.

Known or suspected sources of DDT include:

- Historical applications;
- Atmospheric transport from manufacture and use abroad;
- Hazardous waste sites associated with manufacture, transfer, or use;
- DDT is also present in small quantities (<0.1%) in dicofol, a miticide registered for use in the U.S., Canada, and Europe. It is estimated that the use of difocol results in approximately 1000 pounds of DDT applied to U.S. croplands annually (LaMP 2000).

Mercury

National Toxics Inventory Data

Major source categories listed by the:	1990 NTI	1994/95 NTI
Utility boilers - coal (coal combustion, all types)	24.6%	33%
Medical waste incinerators	24.2%	10%
Municipal waste combustors	20.1%	19%
Chlorine production (chloralkali production)	4.8%	4%
Mobile sources: non-road vehicles and equipment	3.3%	-
Hazardous waste incineration/combustion	2.8%	4%
Chemical manufacturing: alkalies and chlorine	2.5%	-
Mobile sources: on-road vehicles	2.4%	-
Portland cement, excluding hazardous waste-fired	1.9%	3%
Hydrochloric acid production	1.4%	-
Commercial/industrial boilers (coal and oil)	1.0%	18%
Pulp and paper production	0.9%	1%
Sewage sludge incineration	0.9%	-
Residential boilers (coal and oil)	-	2%
(EPA 1998a; EPA 2000c)		

Chicago Incinerator – Lake Michigan Federation

Mercury Continued

1996 Great Lakes Toxic Emissions Inventory Data

Sources of 90% of Mercury Air Emissions in the Lake Michigan States (lbs)							
Total for Region	**IL**	**IN**	**MI**	**WI**	**Source Type**	**GLATEI Category Description**	**Regional % of Total**
20568	2422	6263	8975	2908	Point	Electric services	40.9%
7648	244	209	7195	0	Point	Refuse systems	15.2%
6430	6252	109	0	69	Area	Residential fuel combustion (not including wood)	12.8%
1915	468	1447	0	0	Point	General medical & surgical hospitals	3.8%
1283	17	0	69	1197	Point	Paper mills	2.5%
1150	1117	23	0	9	Mobile	Light duty gasoline vehicles	2.3%
1100	0	0	0	1100	Point	Alkalies and chlorine (Chlorine production in NTI)	2.2%
881	19	858	0	5	Point	Gray and ductile iron foundries	1.8%
856	463	279	0	114	Mobile	Heavy duty diesel vehicles	1.7%
441	60	381	0	0	Point	Cement, hydraulic	0.9%
424	287	9	72	55	Point	Colleges and universities	0.8%
422	38	0	61	323	Point	Electric and other services combined	0.8%
355	339	12	0	4	Mobile	Light duty gasoline trucks class 1	0.7%
351	141	210	0	0	Point	Blast furnaces and steel mills	0.7%
283	275	8	0	0	Point	Industrial organic chemicals	0.6%
275	84	185	6	0	Point	Petroleum refining	0.5%
272	272	0	0	0	Point	Unknown	0.5%
269	103	112	54	0	Point	Natural gas transmission	0.5%
223	213	10	0	0	Point	Wet corn milling	0.4%
219	207	0	0	12	Point	Lime	0.4%
50342	Total Mercury Emissions Reported for the Lake Michigan States					(GLC 2000b)	

Additional Comments

Other, possible sources include:

- Use of scrap steel and solid waste processing and transport; (BTS 1999a)
- Agricultural burning; and
- Landfills and sludge application. (EPA 1998a)

Dioxin & Furans

Draft Dioxin Reassessment Data

Sources Accounting for 90% of the National Dioxin (TEQ) Air Emissions	% of National Total	Confidence Rating
Backyard barrel burning	23%	U
Municipal waste incineration	23%	B
Landfill fires	22%	U
Medical waste incineration	9%	C
Nonferrous metals	6%	C
Forest fires	4%	C
Cement kilns	3%	C
Industrial and utility coal, oil and wood combustion	2%	B/C
Residential coal, oil and wood combustion	2%	B/U
Ferrous metal smelting/refining	2%	B/U
Diesel fuel combustion	<1%	C
Sewage sludge incineration	<1%	B
Other quantified and estimated sources	2%	B/C/U

Confidence Ratings:
B= Medium confidence rating, based on emissions averages
C= Low confidence rating, based on possibly nonrepresentative data
U = Preliminary estimate for an unquantified Source (EPA 2000a)

Additional Comments

Other possible sources of Dioxin and Furan include the following:

- Iron sintering plants; and
- Preservation of wood (European Commission 1997).

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for 90% of the Dioxin Air Emissions in the Lake Michigan States (lbs)							
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
0.0049	0	0	0	0.0049	Mobile	Heavy duty diesel vehicles	36.6%
0.0030	0	0	0.00002	0.0030	Point	Electric and other services combined	22.2%
0.0015	0.000001	0	0.0015	0	Point	Chemical preparations	11.1%
0.0007	0.00001	0.0006	0.0001	0.0001	Point	Electric services	5.5%
0.0007	0	0	0.0007	0	Point	Certificated air transportation (1977)	5.3%
0.0007	0	0	0	0.0007	Mobile	Light duty diesel vehicles	5.0%
0.0004	0.0003	0	0	0.0001	Area	Residential fuel combustion (not including wood)	2.9%
0.0002	0.0002	0	0	0	Point	Rental of railroad cars	1.6%
0.0134	Total Dioxin Emissions Reported by the Lake Michigan States (lbs)					(GLC 2000b)	

Sources Accounting for 90% of the Furan Air Emissions in the Lake Michigan States (lbs)							
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
23.71676	0	0	23.71676	0	Point	Paper mills	77.4%
2.86692	0.00002	0	2.86690	0	Point	Chemical preparations	9.4%
2.66978	0	0	2.66978	0	Point	Reconstituted wood products	8.7%
30.6445438	Total Furan Emissions Reported by the Lake Michigan States (lbs)					(GLC 2000b)	

Lead

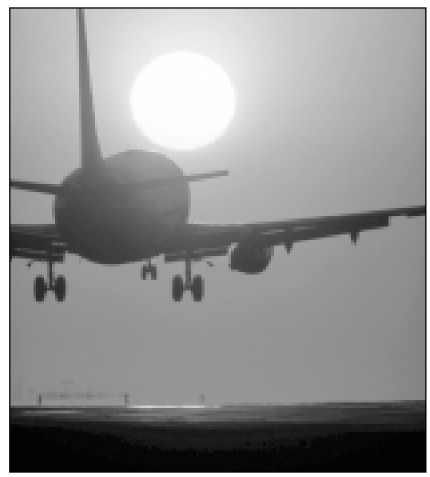
National Toxics Inventory Data

Top 90% of national air emissions for lead compounds in the 1990 NTI	
Mobile sources - aircraft	19%
On-road vehicles	13%
Primary lead smelting	7%
Steel wire and related products manufacturing	5%
Non-road vehicles and equipment	5%
Primary copper smelting	5%
Pulp and paper production	5%
Lead oxide in pigments	4%
Secondary lead smelting	3%
Hazardous waste incineration	3%
Stainless and non-stainless steel manufacture	3%
Municipal waste combustors	2%
Secondary copper	2%
Utility boilers - coal	2%
Medical waste incinerators	2%
Nonferrous metals production	3%
Storage batteries manufacturing	2%
Pressed and blown glass and glassware manufacturing	2%
Autobody refinishing paint shop	1%
Sewage sludge incineration	1%
Industrial boilers	1%
(EPA 1999a)	

Additional Comments

Sources of lead emissions that have not yet be adequately estimated include:

- Refueling and fuel combustion of aircraft. (EPA 1998a BTS 1999b)



Lead Continued

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for 90% of Lead Emissions in the Lake Michigan States (lbs)							
Total for Region	**IL**	**IN**	**MI**	**WI**	**Source Type**	**GLATEI Category Description**	**Regional % of Total**
88027	16516	26386	25356	19770	Point	Gray and ductile iron foundries	22.4%
43859	15621	24242	3194	802	Point	Electric services	11.2%
39927	3193	23315	12920	500	Point	Blast furnaces and steel mills	10.2%
28047	175	27872	0	0	Point	National security	7.1%
25177	4252	18855	2040	30	Point	Secondary nonferrous metals	6.4%
19790	8639	8022	0	3129	Mobile	Heavy duty diesel vehicles	5.0%
14751	11661	1925	1165	0	Point	Cement, hydraulic	3.8%
9999	3107	5432	0	1459	Point	Storage batteries	2.5%
8627	8602	0	0	25	Point	Steel wire and related products	2.2%
7162	148	6798	160	55	Point	Asphalt paving mixtures and blocks	1.8%
5124	0	5124	0	0	Point	General industrial machinery	1.3%
4851	0	0	4851	0	Point	Malleable iron foundries	1.2%
4766	0	0	12	4755	Point	Electric and other services combined	1.2%
3927	3672	255	0	0	Point	Fabricated metal products	1.0%
3594	3594	0	0	0	Point	Rental of railroad cars	0.9%
3050	0	3050	0	0	Point	Iron and steel forgings	0.8%
3035	3035	0	0	0	Point	Elementary and secondary schools	0.8%
3011	46	172	0	2793	Area	Residential fuel combustion (not including wood)	0.8%
2823	2823	0	0	0	Point	Nonferrous rolling and drawing	0.7%
2754	61	506	2187	0	Point	Motor vehicle parts and accessories	0.7%
2741	1790	951	0	0	Point	General medical & surgical hospitals	0.7%
2618	738	0	0	1879	Mobile	Light duty gasoline vehicles	0.7%
2405	0	2405	0	0	Mobile	Construction equipment	0.6%
2400	0	0	2400	0	Point	Trucking terminal facilities	0.6%
2305	105	0	2200	0	Point	Industrial machinery	0.6%
2268	85	2173	0	10	Point	Aluminum foundries	0.6%
2216	0	2216	0	0	Point	Plumbing fixture fittings and trim	0.6%
2126	0	2126	0	0	Point	Ammunition, exc. for small arms	0.5%
2003	3	0	2000	0	Point	General automotive repair shops	0.5%
1887	1876	11	0	0	Point	Tires and inner tubes	0.5%
1834	0	1834	0	0	Mobile	Farm machinery and equipment	0.5%
1787	1519	235	32	0	Point	Colleges and universities	0.5%
1726	1253	13	461	0	Point	Refuse systems	0.4%
1725	1725	0	0	0	Point	Gaskets, packing and sealing devices	0.4%
392820	Total Lead Emissions Reported by the Lake Michigan States					(GLC 2000b)	

Cadmium

National Toxics Inventory Data

Top 10 Source Categories for Cadmium in the 1990 NTI	% of Total Emissions
Secondary lead smelting	44%
Primary copper smelting	8%
Primary lead smelting	8%
Hazardous waste incineration	5%
Petroleum refineries	3%
Municipal waste combustors	2%
Secondary copper smelting	2%
Medical waste incinerators	2%
Cadmium refining and cadmium oxide production	2%
Industrial inorganic chemical manufacturing	2%
(EPA 1999a)	

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for 90% of Cadmium Emissions in Lake Michigan States (lbs)							
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
10655	3	0	10652	0	Point	Aluminum die-castings	20.3%
7169	4323	2846	0	0	Mobile	Light duty gasoline vehicle	13.7%
6166	899	4188	757	322	Point	Electric services	11.8%
5222	56	287	0	4878	Area	Residential fuel combustion (not including wood)	10.0%
3806	3806	0	0	0	Point	Fabricated metal products	7.3%
3214	92	19	3103	0	Point	Refuse systems	6.1%
2280	1297	983	0	0	Mobile	Light duty gasoline truck class 1	4.4%
1442	1439	0	0	2	Point	Metal coating and allied services	2.8%
1295	6	0	1	1289	Point	Electric and other services combined	2.5%
1102	597	505	0	0	Mobile	Heavy duty diesel vehicle	2.1%
902	555	347	0	0	Mobile	Light duty gasoline truck class 2	1.7%
814	814	0	0	0	Point	Inorganic pigments	1.6%
785	766	2	0	17	Point	Secondary nonferrous metals	1.5%
541	150	370	0	21	Point	Petroleum refining	1.0%
498	16	0	160	321	Point	Paper mills	1.0%
415	409	5	0	0	Point	Steel wire and related products	0.8%
391	4	373	0	14	Point	Gray and ductile iron foundries	0.7%
365	0	0	365	0	Point	Malleable iron foundries	0.7%
362	362	0	0	0	Point	Pressed and blown glass	0.7%
52376	Total Cadmium Emissions Reported by the Lake Michigan States					(GLC 2000b)	

Chromium

National Toxics Inventory Data

Top 10 Source Categories for Chromium in the 1990 NTI	% of Total Emissions
Hard chromium electroplating	17%
Utility boilers - coal	8%
Petroleum refining	8%
Stainless and non-stainless steel manufacture	4%

1990 NTI (cont.)	% of Total Emissions
Steel pipe and tubes manufacturing	4%
Steel and iron foundries	4%
Aerospace industries	3%
Fabricated plate work (boiler shops)	3%
Mobile sources: on-road vehicles	3%
Fabricated structural metal manufacturing	3%

(EPA 1999a)

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for 90% of Chromium Emissions in Lake Michigan States (lbs)							
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
32860	32854	0.04	0.2	5	Point	Steel wire and related products	12.8%
32410	4481	19979	6314	1636	Point	Electric services	12.6%
20931	3854	15200	1377	500	Point	Blast furnaces and steel mills	8.2%
14459	51	12649	1421	338	Point	Motor vehicle parts and accessories	5.6%
13328	292	1504	0	11532	Area	Residential fuel combustion (not wood)	5.2%
12181	7158	4678	0	346	Mobile	Light duty gas vehicles	4.7%
9240	5	5710	0	3524	Point	Gray and ductile iron foundries	3.6%
8227	0	8227	0	0	Point	Vehicular lighting equipment	3.2%
7761	5619	1626	0	516	Point	Plating and polishing	3.0%
7565	307	1377	0	5881	Point	Steel foundries	2.9%
6687	6391	229	67	0	Point	Colleges and universities	2.6%
5066	4610	456	0	0	Point	Cold finishing of steel shapes	2.0%
4863	3	10	675	4175	Point	Paper mills	1.9%
4341	11	0	31	4299	Point	Electric and other services combined	1.7%
4066	0	127	0	3939	Point	Steel investment foundries	1.6%
3930	2073	1839	0	19	Mobile	Heavy duty diesel vehicles	1.5%
3889	2158	1612	0	119	Mobile	Light duty gas class 1 trucks	1.5%
3709	1	1107	0	2601	Point	Minerals, ground or treated	1.4%
3093	3003	90	0	0	Point	Plumbing fixture fittings and trim	1.2%
2996	2995	1	0	0	Point	Ordnance and accessories	1.2%
2826	2505	173	148	0	Point	Cement, hydraulic	1.1%
2696	183	1321	270	922	Point	Paperboard mills	1.1%
2597	89	1	1685	822	Point	Motor vehicles and car bodies	1.0%
2513	20	0	2289	205	Point	Sewerage systems	1.0%
2505	1	2504	0	0	Point	Burial caskets	1.0%
2391	85	10	270	2026	Point	Chemical preparations	0.9%
2158	0	2158	0	0	Point	Public building & related furniture	0.8%
1740	0.1	1740	0	0	Point	Millwork	0.7%
1642	0	1641	0	1	Point	Truck and bus bodies	0.6%
1558	935	585	0	37	Mobile	Light duty gas class 2 trucks	0.6%
1551	819	550	182	0	Point	Pharmaceutical preparations	0.6%
1521	0.4	1000	0	521	Point	Manufacturing industries	0.6%
1438	653	292	0	494	Point	Internal combustion engines	0.6%
1281	1276	3	3	0	Point	Natural gas transmission	0.5%
1205	1180	25	0.01	0	Point	Industrial organic chemicals	0.5%
256696	Total Chromium Emissions Reported by the Lake Michigan States					(GLC 2000b)	

Arsenic

National Toxics Inventory Data

Top 10 Source Categories for Arsenic in the 1990 NTI	% of Total Emissions
Primary copper smelting	27%
Utility boilers - coal	19%
Petroleum refineries	15%
Primary lead smelting	7%
Pulp and paper production	5%
Food and agricultural products: cotton ginning	5%
Industrial boilers	5%
Pressed and blown glass and glassware manufacturing	3%
Hazardous waste incineration	2%
Secondary lead smelting	2%
(EPA 1999a)	

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for 90% of Arsenic Air Emissions in Lake Michigan States (lbs)

Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description	Regional % of Total
35576	6977	23234	4387	978	Point	Electric services	37.1%
26933	16230	10704	0	0	Mobile	Highway vehicles - light duty gas vehicles (cars)	28.1%
8548	4867	3681	0	0	Mobile	Highway vehicles - light duty gas class 1 trucks	8.9%
4154	2241	1910	0	2	Mobile	Highway vehicles - heavy duty diesel vehicles	4.3%
3388	2083	1305	0	0	Mobile	Highway vehicles - light duty gas class 2 trucks	3.5%
1641	0	0	15	1625	Point	Electric and other services combined	1.7%
1507	7	0	1225	276	Point	Motor vehicles and car bodies	1.6%
1478	183	0	259	1036	Point	Paper mills	1.5%
1339	28	949	93	269	Point	Paperboard mills	1.4%
1133	486	647	0	0	Mobile	Highway vehicles - heavy duty gas vehicles	1.2%
963	464	219	259	21	Point	Correctional institutions	1.0%
95846	Total Arsenic Emissions for the Lake Michigan States					(GLC 2000b)	

Hexachlorobenzene

National Toxics Inventory Data

Top National Source Categories for HCB Emissions	1990 NTI	1993 NTI
Utility coal combustion	30%	
Chlorinated solvents production	25%	23%
Pesticide manufacture	20%	18%
Tire manufacturing	19%	18%
Cyclic crude and intermediate production		17%
Chemical manufacturing: alkalies and chlorine		9%
Pesticide application	6%	6%
Chemicals and allied products manufacturing		2%
Hydrochloric acid production		2%
(EPA 1998a, BTS 1999d)		

1996 Great Lakes Toxic Emissions Inventory Data

HexachlorobenzeneEmissions Reported by Lake Michigan States (lbs)						
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description
1	0.9	0	0	0.1	Area	Pesticide application
1 lb	Total Hexachlorobenzene Emissions Reported by the Lake Michigan States					(GLC 2000b)

Additional Comments

Additional sources of HCB may include the following:

- Incomplete decomposition of chlorinated substances in municipal, medical, and hazardous waste, sewage sludge incinerators, cement and aggregate kilns, and backyard barrel burning;
- Wood preservation, as a major contaminant in pentachlorophenol, which is used to protect utility poles, railroad ties, and roadway guardrail posts;
- Sewage treatment plants; and
- Contaminated sites. (BTS 1999d; EPA 1998a)

Power Plant – Michigan Sea Grant Extension, Carole Y. Swinehart

Polycyclic Aromatic Hydrocarbons (PAHs)

National Toxics Inventory Data

Top 10 Source Categories for 7-PAH in the 1990 NTI	Percent of Total
Wildfires and prescribed burning[1]	8.3%
Residential wood combustion	28.7%
Primary aluminum production	7.1%
Coke ovens: charging, topside & door leaks	3.6%
Open burning of scrap tires[2]	2.6%
Commercial coal combustion	1.8%
Onroad vehicles	1.7%
Residential coal combustion	1.6%
Coke ovens: pushing, quenching & battery stacks	1.6%
Non-road vehicles & equipment – other[3]	1.2%
Included here	98.2%
(EPA 1998a)	

[1] Wildfires and prescribed burning are estimated to account for over 70% of 7-PAH emissions in EPA's 1993 National Toxics Inventory.

[2]Open burning of scrap tires accounts for 4% of 7-PAH in 1993 NTI (EPA 2000c).

[3]Includes 74 different types, such as agricultural, construction, and industrial equipment and vehicles.

1996 Great Lakes Toxic Emissions Inventory Data

Sources Accounting for the Top 90% of Benzo(a)pyrene Emissions to Lake Michigan States (lbs)							
Total for Region	**IL**	**IN**	**MI**	**WI**	**Source Type**	**GLATEI Category Description**	**Regional % of Total**
27861	10616	2493	4765	9986	Area	Residential wood combustion	32%
27467	18457	1439	7571	0	Point	Petroleum refining	32%
14735	0	0	0	14735	Area	Public owned treatment works	17%
8150	5276	2554	320	0	Point	Blast furnaces and steel mills	9%
86493	Total Benzo(a)pyrene Emissions Reported by the Lake Michigan States					(GLC 2000b)	

Additional Comments

Other sources of PAHs include:

- Open burning of scrap tires
- Coal combustion
- Commercial meat charbroiling
- Open trash burning (LaMP 2000).

Toxaphene

Comments

Known and suspected sources include the following:

- Historical applications;
- Atmospheric transport from current uses in other countries;
- Hazardous waste sites associated with manufacture, transfer, or use; and
- Current use as cattle dip for scabies control and emergency treatment of cotton, corn, and small grains (EPA 2000c).

Ridge Till Planting – Minnesota Extension Service, Don Breneman

Atrazine

1996 Great Lakes Toxic Emissions Inventory Data

Atrazine Emissions Reported by Lake Michigan States (lbs)						
Total for Region	IL	IN	MI	WI	Source Type	GLATEI Category Description
6,220,477	1710115	2335208	1858749	316404	Area	Pesticide application
6,220,477 lbs	Total Atrazine Emissions Reported by the Lake Michigan States					(GLC 2000b)