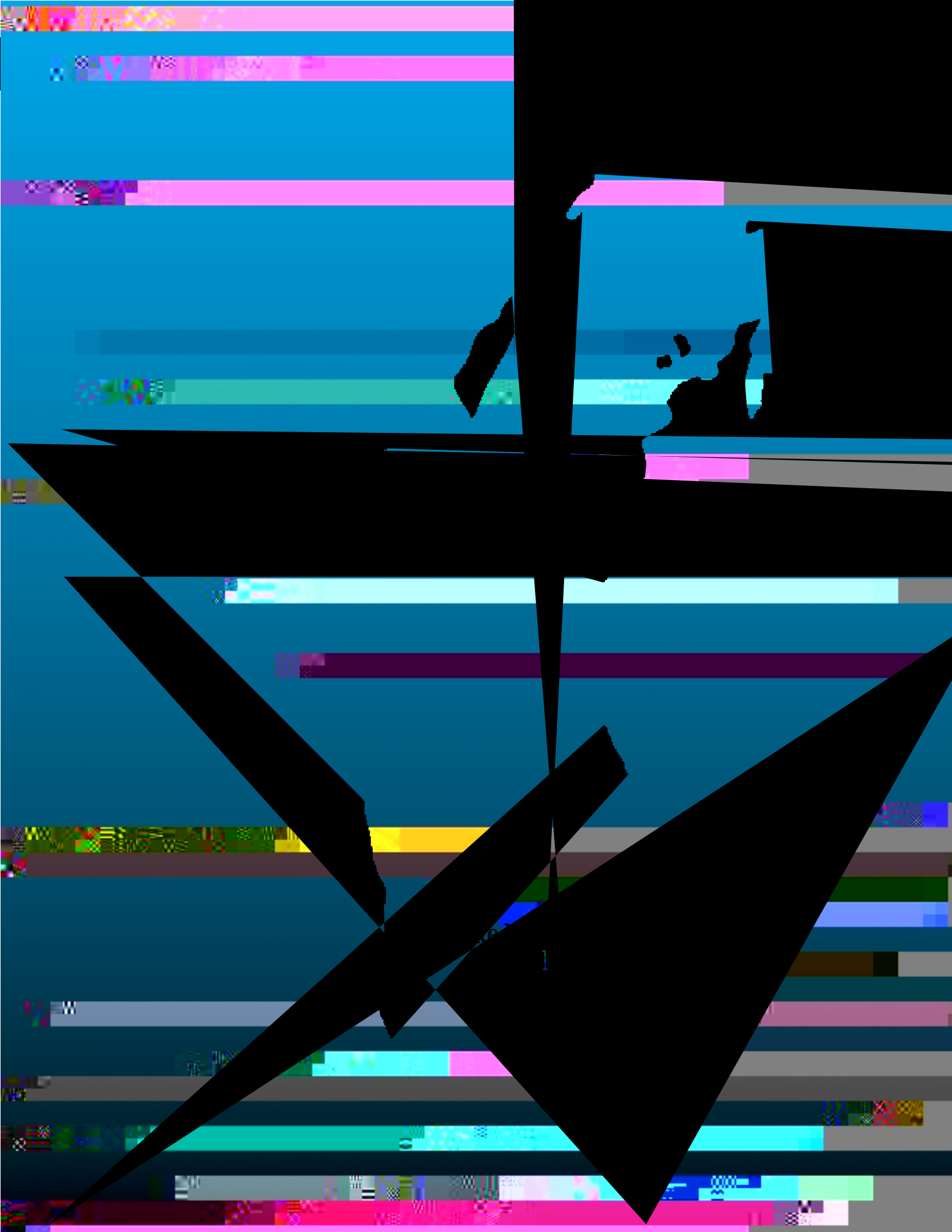

Reducing To ic Air Pollution in Lake Michigan

C t t

I. I t d c t

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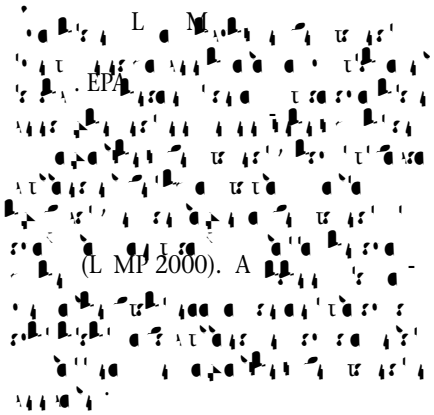
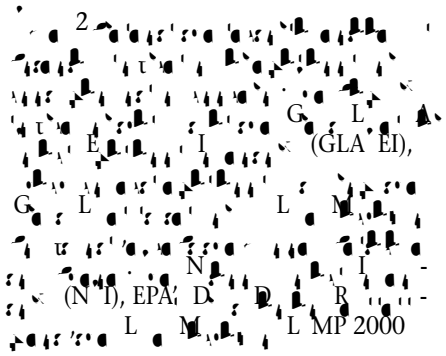
II. La M ch a P ll t a t C c a d S c T

Table 1: Lake Michigan Pollutants

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

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)





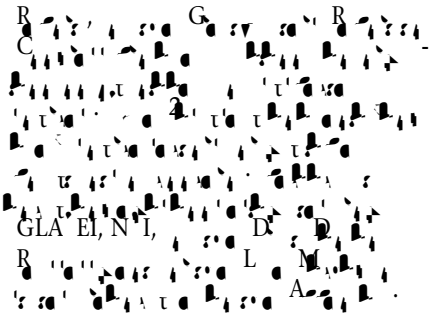


Table 2: Potential So[redacted]

	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.

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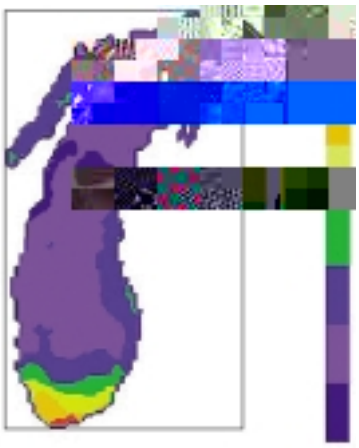

Table 3: Annual Loadings to Lake Michigan

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)

A 1,189 (2,622) . A 186 (410)

A 1995 N I 40% (B 1999). H / . EPA . R 2003 (EPA 2000).

PCBs

PCB 1927 1977 N 1979 PCB (B 1999). PCB L M (L MP 2000). A 80% PCB L M PCB L M 3,200 (H G 2000).

C PCB L M C 10%

PCB (H G 2000). D PCB PCB C . P PCB (L MP 2000).

F 4 7 PCB C L M O 3,1994. R O O 5 6 PCB O 6 13.6 C 17.9 C (56 F 64 F), (H G 2000).

PCB C /

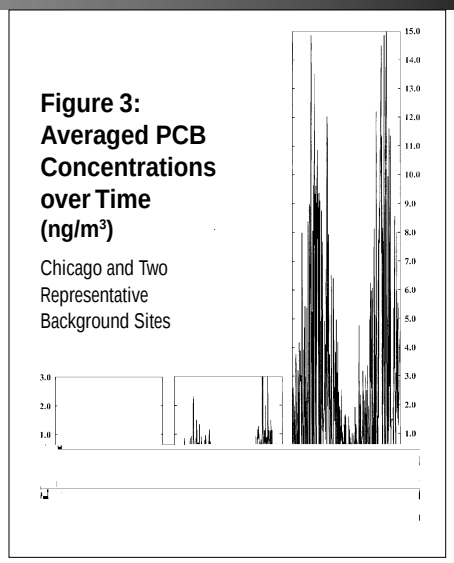

Figure 3: Averaged PCB Concentrations over Time (ng/m³)

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).

F 3 PCB C H B D . A / PCB C . 1997; K 1994; H H 2000). P (H H 2000).

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

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

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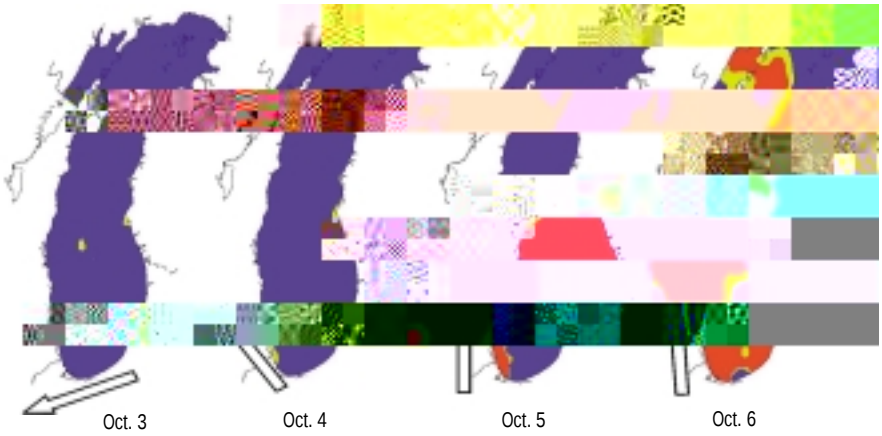
(H H 2000).
PCB

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).

Dioxin

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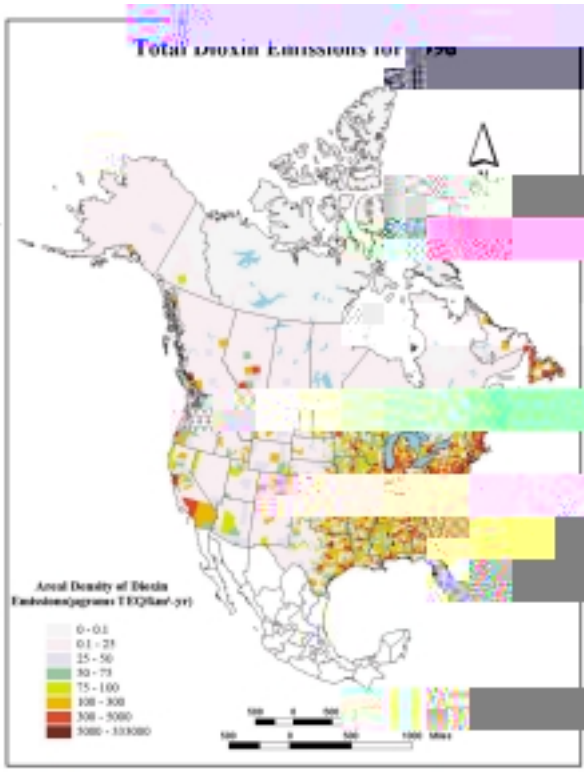
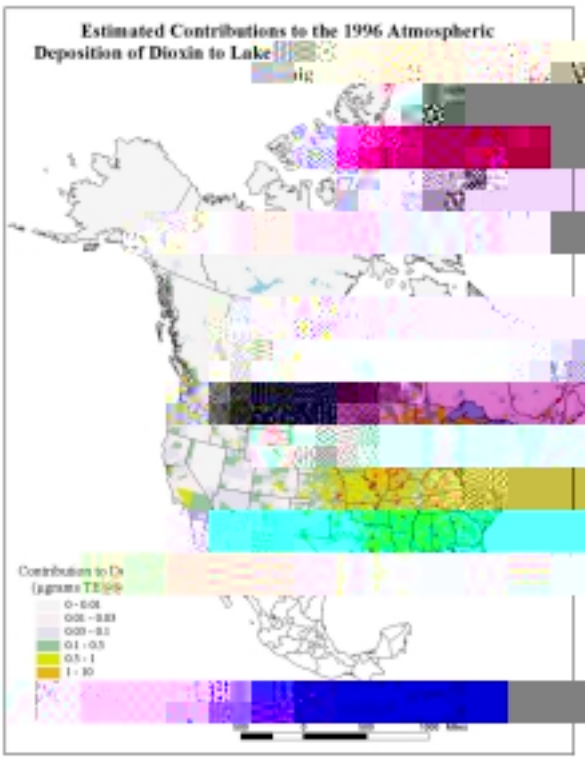
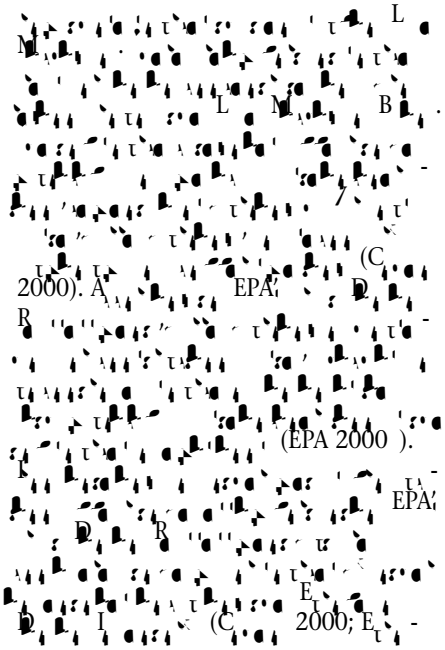
Figure 5: Maps Demonstrating Total Dioxin Emissions and Deposition to Lake Michigan (Cohen 2001)





[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).



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Recommendations:

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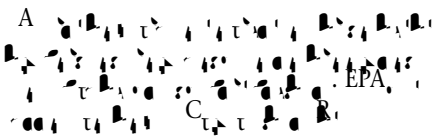
EPA

B. Toxics Monitoring



[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.

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A , E , R , I , E.H. P , & A , . 2000. *S S R a Ha . . / / .*

A , E , R , I , E.H. P , & A , . *S S R a Ha U M* (D.).

A DR. 1993. *T a* . A : . . D H H , P H .

A DR. 1995. *T FAQ C a* . . D H H , P H .

A DR. 1995. *T FAQ DDT, DDE, a DDD.* . . D H H , P H .

A DR. 1999. *T FAQ M* . . D H H , P H .

B , J E. *E a A C a U ba S a Wa : C L - R T* ( ). O .

B . 2000. *T a W P a A T Da a A a E Ba /LADCO C a* . D .

B . 1997. *T G a La B a a T S a* .

B . 1999 . *M R : S a R a* . (D.). N .

B . 1999 . *A -L a : S , R a a O* . (D.). O .

B . 1999 . *B (a) (B(a)P:) S a R a* . N .

B . 1999 . *H a b R : S a R a* . (D.). N .

B . 1999 . *P a B (PCB): S a R a* . (D.). N .

B . 2000. *PCDD(D) a PCDF(F a): S A R a* . (D.). M . (A . A).

B , O.R. 2000. *M A T a a D Pa A - M A E U S a a Ca a a.* E 259.

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C , M., C , B., E , H., B , P., D , A., H , C., Q , J., R , J., 1995. *Q a a a , a , a a - b G a La a b a a b* . C B N . Q C , C M . F , N . M .

C , M. 1997. *T T a a D P T S b a G a La* . *III. M A T a a D P T S b a G a La* . F a R . I J C I Q A B . D .

C , M. 2000. *T T a a D D La M a : A Ca S* (-). NOAA R I . O . - .

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D I . 2000. *A D O T T T G a La : I a S A P* . J .

E , . J.; .M.J. 1992. *E a A D T S b a G a La -A U a* . G L R F E C . 59 P .

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EPA. 1999. *Ha : H A P A V* . O Q P . A .

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EPA. 2000. *La M a Ma Ba a R* . :// / / /

EPA. 2000. *D A P a G a Wa T R T C* . O Q , P & . J .

EPA. 2000. *U A T W b : F a , P a U MACT S a a* . O Q , P & .

EPA. 2000. *Na a A T P a : T I a U ba S a , R C* . J .

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EPA. 2000. *R F a S a /L a /T ba A T R R P a : F a W R* I , O Q P .

EPA. N . *T C a C a R I a* . R :// / 5 / 99/ 8 .

E C . 1997. *E a D I* . O .

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F , G . 2000. *O P S A M b U.S. F a G U P D a* . R A A .

R /, .P.; E , . J.; H , .M. 1998. *D D Pa a P a B a P A a H a b La M a* . E . 32(23): 3681-3688.

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GLC. 2000. *1996 I T A E : A P G a La R a A T E P* .

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LADCO. 2000. *M a A M R a P a O a a A R a Ha* . . / / 2 .

LADCO. 2000. *M a A I a A P S a C* . . / / .

L MP. 2000. *La M a La Ma a P a* (L MP 2000).

L MP CC. 2000. *C a La M a La Ma a P a T a C - a C* . D .

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M , R.P. , K.A. 1997. *M La M a* . E & 31, N 3. P 942-947.

MDEQ. 1998. *I a I S a a a T a D b - DDT a DDE M a , P a 2*. E , 1998/1999. Q D . . . EPA G L N R O .

M , D.M. C , C. 1999. *I S R S P T S b a U S a* . (D) I Q A B I - J C .

M , .M.; , C .; D P , J .; H , K.C. 2000. *A a N P a : R La M a Ma Ba a S* . E . 34(1):55-61.

NADP. 2001. N A - D R (NR P-3)/M D N . R O , I , 2204 G 9 M 0 -

Appendi : E S c P a t C c

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National Toxics Inventory Data

[illegible]	[illegible]	[illegible]	[illegible]
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)			

Great Lakes Toxic Emissions Inventory Data

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Great Lakes Toxic Emissions Inventory Data

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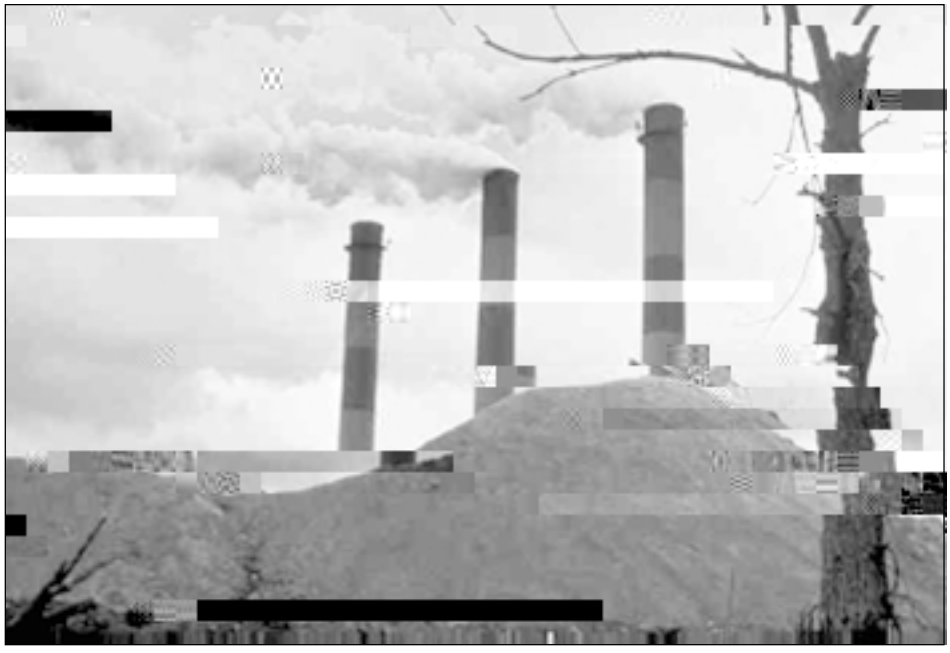
National Toxics Inventory Data

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

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)	

Draft Dioxin Reassessment Data

Backyard barrel burning	23%	U
Municipal waste incineration	23%	B
Landfill fires	22%	U
Medical waste incineration	9%	C
Nonferrous metals	6%	C
Forest fires4% 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

Additional Comments

- (1997).

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%

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

R . (EPA 1998 B 1999)

Sources Accounting for 90% of Lead Emissions in the Lake Michigan States (lbs)							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	0.8%

National Toxics Inventory Data

Hard chromium electroplating	17%
Utility boilers - coal	8%
Petroleum refining	8%
Stainless and non-stainless steel manufacture	4%

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%

1996 Great Lakes Toxic Emissions Inventory Data

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%

National Toxics Inventory Data

[illegible]	[illegible]
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)							
[illegible]							
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)	

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%

[1] 70% 7-PAH EPA 1993 N I

[2] 4% 7-PAH 1993 N I (EPA 2000).

[3] I 74

[redacted]

1996 Great Lakes Toxic Emissions Inventory Data

[redacted]						
[redacted]						