

Appendix A

Lake Michigan LaMP Pollutant Identification and Classification

I. Background

The Lake Michigan LaMP in 2000¹ announced its management approach to the Lake Michigan ecosystem would be adaptive. How does one identify Lake Michigan pollutants in an adaptive manner? The Lake Michigan LaMP in 2002 proposed an ongoing biennial review process in its Appendix A². The pollutant identification process for the LaMP was developed in consideration of federal and state regulatory programs, Lake Michigan Lakewide Management Plans drafted before 2000, Great Lakes strategies, and Annex 2 of the *Great Lakes Water Quality Agreement of 1978 As Amended by Protocol Signed November 18, 1987* (GLWQA).

A summary of these influences and previous pollutant identification work provides context for the rest of this LaMP 2006 Appendix.

Annex 2 of the GLWQA (1987) defines “critical pollutants” as substances that persist at levels that, singly or in synergistic or additive combination, are causing, or are likely to cause, impairment of beneficial uses³ despite past application of regulatory controls due to their: presence in open lake waters; ability to cause or contribute to a failure to meet Agreement objectives through their recognized threat to human health and aquatic life; or ability to bioaccumulate. The GLWQA, as incorporated into the Great Lakes Critical Programs Act of 1990⁴ requires the parties to prepare a Lakewide Management Plan to evaluate existing information on concentration, sources, and pathways of critical pollutants, including loading information and estimates, to develop load reduction targets, to track implementation of remedial measures, and to identify a process to recognize the absence of a critical pollutant in open lake waters.

In 1992 and 1993, a list of pollutants was developed by the Federal and State Agencies participating in the Lake Michigan lakewide management planning process. The pollutants were categorized into three groups: critical pollutants, pollutants of concern, and emerging pollutants. This list was incorporated into the chemical stressors section of Chapter 5 in Lake Michigan LaMP 2000⁵. Listed in descending order with regard to the potential level of impairment or importance to the lake, the three categories of LaMP pollutants were: critical pollutants, to be addressed through LaMP reduction targets; pollutants of concern, to be addressed by local actions facilitated by the LaMP, and a Pollutant Watch List to be addressed by monitoring and research encouraged by the LaMP.

In order to adaptively prepare the pollutant list, ambient environmental data is essential. Great Lakes National Program Office grantees have sometimes sampled the open waters of Lake Michigan for pollutants while collecting monitoring samples for its Limnology Program⁶. The Lake Michigan Mass Balance provided a wealth of chemical data for the 1994-1995 period. For a ten year comparison to the Lake Michigan Mass Balance data, states are collecting additional tributary samples in 2005 and 2006. Federal and state agencies monitor fish for public health fish consumption advisories and to assess the condition of water resources.⁷ Finally, the Great Lakes National Program Office also supports a fish monitoring program.⁸

Section 303(d) of the Clean Water Act requires states to prepare lists of waters within the state’s boundaries for which the effluent limitations are not stringent enough to implement any water quality standard applicable to such waters. Section 305(b) of the Clean Water Act requires each State to report, to U.S. EPA, the water quality of all navigable waters biennially. The four

Lake Michigan states satisfied these federal requirements in a variety of formats, complicating comparison. After states followed federal guidance including the 2002 Integrated Water Quality Monitoring and Assessment Report, the Consolidated Assessment and Listing Methodology, Guidance[s] for [the] 2004 [& 2006] Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, the finding, understanding and integration of state water quality information became easier. As state lists of impaired waters change, the LaMP pollutant identification process will reflect those changes. One change consistent with the federal guidance documents and adopted by three Lake Michigan states was the incorporation of hydrologic unit codes, a national system for identifying water bodies and stream segments. This code is reported by Michigan as the NHD code and by Indiana as the 14-digit HUC.

There are multiple Great Lakes-wide strategies. The *Great Lakes Strategy 2002: A Plan for the New Millennium*⁹ is a strategic plan for the Great Lakes Ecosystem developed by the United States Policy Committee for the Great Lakes. It reiterates the goals of the Clean Water Act and the GLWQA, and summarizes water¹⁰, air¹¹ and international¹² programs in the context of Great Lakes goals and objectives. In December 2004, consistent with President Bush's May 18, 2004 Executive Order, a Great Lakes Regional Collaboration formed¹³. In December 2005, a Great Lakes Regional Collaboration Strategy was released. It devoted a chapter to toxic pollutants, one of eight issues addressed.

The State-of-the-Lakes Ecosystem Conference (SOLEC) is another activity established through the 1987 GLWQA. SOLEC focuses on an ecosystem setting (e.g., near shore in 1996) or subject (e.g., chemical integrity in 2006) in its binational conferences in even-numbered calendar years. The desire to use indicators developed by SOLEC is important to the Lake Michigan LaMP pollutant identification process.

The pollutant identification challenge facing the Lake Michigan Lakewide Management plan stakeholders is to be consistent with established policy and promulgated rules. Also, as resources are finite, it is advantageous to rely on existing programs. In that vein, Illinois' draft 303(d) list for 2006 references Superfund sites and Resource Conservation and Recovery Act facilities.¹⁴ The Lake Michigan LaMP 2004 Appendix A had asked whether such sites should be considered during pollutant identification.

II. Lake Michigan LaMP Pollutants Looking Back

1. Criteria to Define Pollutants

The primary goal for pollutant categorization is to identify, at the appropriate geographic scale, problem-causing chemicals that must be addressed regardless of the type of action to be taken. The pollutant categories are heavily dependent on public health fish consumption advisories and state water quality standards because data are available for these programs. In addition, the pollutant watch list includes chemicals without final national water quality criteria, state water quality standards, or fish consumption advisories. Candidates for the watch list therefore include conventional pollutants like nitrogen or ammonia as well as "emerging" pollutants without regulatory thresholds or action levels.

The working definitions of critical pollutant, pollutant of concern, and watch list are the same as in Appendix A of LaMP 2004¹⁵. Any one of these four criteria may be relied upon to define the Lake Michigan LaMP 'critical pollutants':

- Pollutants identified on Illinois, Indiana, Michigan, or Wisconsin Clean Water Act Section 303(d) lists or in Section 305(b) reports as sources of impairment to the open waters of the lake;
- Pollutants that have been found to exceed Great Lakes Water Quality Initiative (GLI) water quality criteria in the open waters of the lake;

- Pollutants that exceed or trigger a relevant Action Level, such as a fish consumption advisory (FCA) or a maximum contaminant level (MCL), in the open waters of the lake; or,
- Pollutants associated with other lakewide designated use impairments (e.g., impairment to aquatic life).

Any one of the following three criteria may be relied upon to define Lake Michigan LaMP 'pollutants of concern':

- Pollutants on State 303(d) lists identified as causing impairments in nearshore waters and Lake Michigan tributary mouths;
- Pollutants exceeding an Agency action level in nearshore waters or tributary mouths, including pollutants identified as a source of impairment in a Great Lakes Area of Concern; or
- Pollutants associated with regional use impairments (e.g., impairment of local fish communities or populations).

The three criteria proposed in 2002 for Lake Michigan LaMP 'watch list' pollutant identification are:

- potential to impact the Lake Michigan ecosystem;
- presence in the Lake Michigan watershed; and,
- bioaccumulation potential, persistence in water or sediment, or toxicity singly or through synergistic effects.

2. Pollutants Proposed in 2004, Finalized in 2006

In Lake Michigan LaMP 2006 Appendix A, we are continuing the adaptive management process of reviewing information not incorporated when the Lake Michigan LaMP 2004 Appendix A was prepared. The new information is used to propose a 2006 pollutant list for finalization in 2008. The pollutant list proposed in 2004 is finalized in 2006 'as is,' unless adverse comments were received or preparatory mistakes were made. In the latter case, corrections are made. The terms "proposed" and "final" are relative and are terms of convenience. There won't be a truly final list of Lake Michigan LaMP pollutants until the LaMP adaptive management process changes or pollutant-caused impairments are remediated. See Table A-1 on the following page for the revised list of LaMP 2006 pollutants (proposed in LaMP 2004). Several corrections were made to the Lake Michigan LaMP 2004 Tables A-6 and A-7:

- including pathogens on the critical pollutant row;
- deleting general category names for pollutants like Salinity/TDS/chlorides;
- deleting "impaired biotic communities (i.e., the possibility of a pollutant causing the impairment has not been eliminated)";
- combining the two tables.
- adding a reference for PFOS; and,
- many of the watch list pollutants proposed in 2004 are not finalized below because peer-reviewed literature or data produced pursuant to a quality assurance plan and satisfying all three watch list criteria were not included in LaMP 2004 or subsequently identified.

The Great Lakes Initiative definition of open waters was used to identify critical pollutants and pollutants of concern in 2004. That approach is rejected later in this document; see scenario 1 in the Lake Michigan LaMP Pollutants 2006 Review, Pollutant Classification into Categories Using Scenarios 1 through 4.

Table A-1. Lake Michigan Pollutants Proposed in 2004 and Revised in LaMP 2006.

Pollutant Classification	Final LaMP 2006 Pollutants Revision of 2004 Proposed Pollutants
Critical Pollutants	PCBs, mercury, DDT and metabolites, chlordane, dioxin, and pathogens (E. coli, Cryptosporidium, Giardia, Salmonella).
Pollutants of Concern	Siltation, sediments, organic enrichment/low dissolved oxygen (DO), nutrients, phosphorus, metals, arsenic, cadmium, copper, chromium, lead, zinc, nitrogen, total (nitrates + total Kjehldal nitrogen), and TDS (conductivity).
Watch List	PBDEs, PCNs, PFOS ¹⁷ , asbestos, PAHs, selenium, radioactive material, toxaphene, sulfur, atrazine & degradation products, metolachlor & degradation products, acetochlor & degradation products, glyphosate & degradation products, 1,4-dichlorobenzene

Between 2004 and 2006, the proposed 2004 LaMP pollutants were compared to National Recommended Water Quality Criteria¹⁸ and three states' water quality standards to determine whether any of the 2004 proposed watch list pollutants have any regulatory thresholds. Watch list pollutants with final federal water quality criteria in 2006 include anthracene, acenaphthene, bis(2-ethylhexyl) phthalate, butylbenzyl phalate, 1,4-dichlorobenzene, di-n-butyl phalate, di-n-octyl phthalate, diethyl phthalate, fluoranthene, fluorene, nonylphenol, phenanthrene, pyrene, selenium, thallium and toxaphene. Water quality criteria for aquatic life remain draft for atrazine¹⁹, nonylphenol²⁰, and selenium²¹. At least one Lake Michigan state has water quality standards for radioactive material (as strontium 90, gross beta, and radium 226), atrazine, butylated hydroxyl toluene, and 4-methyl phenol, in addition to the watch list pollutants identified as having federal water quality criteria.

Please note that water quality criteria are provided in the context of a designated use, like human consumption of organisms and water, human consumption of organisms, and acute (criteria maximum concentration) aquatic life or chronic (criteria continuous concentration) aquatic life. Federal water quality criteria may have been finalized for one designated use and not others. In other words, additional criteria may be proposed for pollutants identified above as having federal water quality criteria.

III. Lake Michigan LaMP Pollutants 2006 Review

1. Pollutant Categorization Scenarios

Given the Great Lakes Water Quality Agreement, federal water quality criteria, state water quality standards, requirements to calculate Total Maximum Daily Loads, and LaMP critical pollutants, how do we go about restoring the contaminant-impaired uses of Lake Michigan? As in LaMP 2004, we rely on data prepared by state and federal programs to identify pollutants, look for monitoring available to help us assess the ambient conditions, and review scientific literature. Once pollutants are identified, the appropriate scale for action should be determined. If one pollutant was primarily in open waters and not in nearshore waters, an open water TMDL could be appropriate. If one pollutant was primarily in nearshore waters and not in open water then, for example, the shoreline approach taken by Indiana for its *E. coli* TMDL might be appropriate for other contaminants. Between LaMP 2004 and LaMP 2006, we intended to examine the metadata from State and Federal monitoring programs in four scenarios with the intention of fine-tuning the criteria used to define the LaMP pollutant categories. Ideally, the categories would suggest the appropriate scale for TMDL development among other purposes.

In the first scenario, we proposed to rely on the Water Quality Guidance for the Great Lakes System (GLI)²² definition of open waters of the Great Lakes and evaluate impairments as Lake Michigan or not Lake Michigan. In this scenario, load reduction targets and total maximum daily loads (TMDLs) would be calculated for the entire Lake. We subsequently learned that when Michigan moved toward a probabilistic assessment of state waters in order to prepare its 305(b) report, it stopped collecting fish in the open waters of the lake.

However, Michigan collection of 'open water fish' continues when the fish are spawning in rivers, and Michigan's Lake Michigan fish consumption advisory applies to the open waters. Similarly, Wisconsin reports fish consumption advisories for Lake Michigan in its 303(d) list. Indiana's draft 2006 303(d) list associates the fish consumption advisory with the waterbody segment name 'Lake Michigan shoreline.'

In the second scenario, we proposed to apply the State of the Lakes Ecosystem Conference 1996 definition of near shore waters (approximated by a depth less than 90 feet), consistent with dividing Lake Michigan into zones for calculating a total maximum daily load. Open waters are deeper than 27 meters. Nearshore waters are from the beach lakeward to a depth of 27 meters. Inland waters are up to the first dam or other state-designated river segment. Pollutant monitoring data specific to open waters and distinct from nearshore waters is not readily available for the lake. The Illinois Lake Michigan monitoring plan identifies stations where lake depths are greater than 90 feet. Pollutant transport from the atmosphere and tributaries to the GLWQA-defined open waters of the Lake was addressed through the Lake Michigan Mass Balance (LMMB) study in 1994-1995, but the sampling points have not been categorized with respect to a depth of 90 feet, and most of the pollutant data collected has not been modeled with a Lake Michigan Mass Balance Level 3 model, the only model level that can distinguish the SOLEC-defined near shore from the SOLEC-defined open waters.

In the third scenario, we proposed to categorize fish consumption advisories by "open water" and "near shore water" fish species, possibly resulting in division of Lake Michigan into zones for TMDL preparation. As in the first scenario, the indicator crosses the geographic boundary. This scenario is further evaluated in this document and is somewhat weakened by inconsistencies in preparation of state advisories and inconsistent knowledge of analytes detected. In other words, a very detailed review of the fish pollutant analyte list for each state has not been completed, and it isn't clear whether a pollutant is only in one state's waters or whether the pollutant was not analyzed by all states.

Finally, we proposed a fourth scenario, to consist of identifying "open water" and "nearshore water" impairments by pollutant. For example, E. coli exceedances have been addressed by Indiana through a TMDL for a geographically discrete nearshore zone. For other pollutants, the presumption that a pollutant moves along the shoreline without affecting the open waters and without significant air deposition is known to be incorrect. Mercury, PCBs, chlordane, and atrazine are known to be air-deposited to Lake Michigan as well as water-transported²³. The International Air Deposition Network (IADN) includes two stations on Lake Michigan, at the Illinois Institute of Technology in Chicago at the south end of the Lake and at Sleeping Bear Dunes National Lakeshore in Michigan, slightly south of the 45th Parallel of Latitude. Gas-phase, particle, and precipitation samples are collected at both stations. Of the final LaMP 2006 pollutants, the IADN chemical list²⁴ includes PCBs, chlordane (trans- and cis-), and DDT (p,p'-, p,p'-DDD, and p,p'-DDE). IADN trace metals are not monitored at the Lake Michigan stations. In addition to Lake Michigan Mass Balance air deposition findings (for mercury, PCBs, chlordane, and atrazine), IADN demonstrates the importance of atmospheric deposition of toxic chemicals like chlordane and DDT to Lake Michigan. IADN Dioxin monitoring was initiated in the summer of 2004 and will continue indefinitely depending on funding availability.

The Lake Michigan states' 303(d) lists were reviewed to identify impaired Lake Michigan waters. In previous LaMPs, only EPA-approved final 303(d) lists were cited. The 303(d) lists due on April 1, 2006 were available as draft Clean Water Act Section 305(b) consolidated reports from three of four Lake Michigan states at the time of document preparation. The draft lists, where available, are referenced in this LaMP because the consolidated reports contained the hydrologic unit code and could be electronically sorted. This significantly expedited preparation of this document.

2. Pollutants from Clean Water Act Section 303(d) Lists of Category 5 Waters for which a TMDL is required

a. Illinois

Illinois' draft 2006 303(d) list groups assessment information as follows: Lake Michigan, Lake Michigan Beaches, and Lake Michigan Bays and Harbors, and Great Lakes/Calumet River Watershed. Based on the Illinois 303(d) list, the fish consumption use of Lake Michigan is impaired by PCBs. Lake Michigan beaches are polluted by E.

Coli and PCBs. Lake Michigan bays and harbors are polluted by Arsenic, Cadmium, Chromium (total), Copper, Lead, PCBs, Zinc, Nitrogen (total), and Phosphorus (total). Listed stream segments adjacent to and discharging to Lake Michigan are polluted by Alpha BHC, Arsenic, Copper, Dieldrin, DDT, Endrin, Lead, Manganese, Mercury, Nickel, PCBs, Silver, Total Dissolved Solids (TDS), and Zinc. Finally, listed Lake Michigan watershed stream segments upstream of the tributary mouth are polluted by Alpha BHC, Aldrin, chromium (total), DDT, Endrin, Heptachlor, Hexachlorobenzene, Nickel, PCBs, Silver, and Nitrogen (total).

b. Indiana

Based on Indiana's draft 2006 303(d) list, deep Lake Michigan open waters are either not impaired or not assessed. The Lake Michigan shoreline is impaired due to PCBs, mercury, and E. coli. Assessed stream segments discharging to Lake Michigan are impaired due to PCBs, mercury, and E. coli. Listed Lake Michigan watershed stream segments upstream of the tributary mouth are polluted by nutrients, PCBs, mercury, E. coli, ammonia, chlorides, cyanide, oil and grease, siltation, and total dissolved solids in Indiana.

c. Michigan

Based on Michigan's draft 2006 303(d) list, Lake Michigan is impaired due to PCBs, mercury, TCDD (dioxins), chlordane, and DDT. The listed Lake Michigan beaches (including beaches on bays) are impaired by pathogens. Listed Lake Michigan bays are impaired due to PCBs, chlordane, TCDD (dioxins), mercury, pathogens, and nuisance oil product pollution. Listed Lake Michigan tributary mouths are polluted by PCBs, mercury, chlordane, nuisance oil product pollution, and pathogens. Listed Lake Michigan watershed stream segments upstream of the tributary mouth are polluted in Michigan by phosphorus, pathogens, mercury, PCBs, TCDD, chlordane, dissolved oxygen, organic enrichment, and bacterial slimes.

d. Wisconsin

Based on Wisconsin's final 2004 303(d) list and a review of counties on Lake Michigan and Green Bay, the Lake Michigan open waters are impaired due to polychlorobiphenyls and mercury. The Lake Michigan beaches are impaired due to E. coli. Bays are impaired due to mercury, polychlorobiphenyls, and phosphorus. Tributary mouths are impaired due to mercury and polychlorobiphenyls. Assuming that stream miles are counted beginning with zero at the mouth, then the stream segments assessed next to Lake Michigan are polluted by sedimentation, creosote, polychlorobiphenyls, polycyclic aromatic hydrocarbon, phosphorus, TBD, nitrate, mercury, metals, and bacteria, so these are pollutants of concern. Listed Lake Michigan watershed stream segments upstream of the tributary mouth in Wisconsin are polluted by phosphorus, sediment, polychlorobiphenyl, metals, mercury, and bacteria.

3. Pollutants Exceeding GLI Criteria

Pollutants have not been found to exceed Great Lakes Water Quality Initiative water quality criteria in the deep open waters of Lake Michigan. Unlike the other Great Lakes, Lake Michigan open waters are not monitored by Canada for chemical pollutants. Lake Michigan open water has been analyzed by researchers and found to be of good quality with respect to PCBs and mercury. Also, atrazine concentrations measured in 1994-1995 did not exceed current federal water quality criteria.

4. Pollutants from Fish Consumption Advisories

State fish consumption advisories are prepared when pollutant concentrations in fish tissue are greater than the action level or regulatory threshold. For LaMP 2004, we listed fish species included in State of Michigan consumption advisories for Lake Michigan and then categorized the species location: normally found in open waters, normally found in nearshore waters, and/or normally found in inland waters up to the first dam. See LaMP 2004 Table A-1²⁵. Between 2004 and 2006, we reviewed fish consumption advisories or guides for all four states and added species to the 2004 Table A-1. It is Table A-2 on the opposite page. We then replaced the x's in the columns above with the contaminant causing the fish consumption advisory. Collapsing the rows by state, we summarized fish contaminants by open waters, nearshore waters, and inland waters in Table A-3.

Table A-2 Fish species in the table are included in the consumption guides or advisories prepared by Illinois, Indiana, Michigan, or Wisconsin. Professional judgment and references available on the Internet were used to categorize the fishes' habitat.

Fish Habitat → Fish Species ↓	Normally found in Open Waters	Normally found in Near-shore Waters	Normally found in Inland Waters
Black Redhorse			X
Bloater	X		
Bluegill		X	X
Brook Trout			
Brown Trout	X	X	X
Burbot	X		
Carp		X	X
Catfish		X	X
Channel Catfish		X	X
Chinook Salmon	X	X	
Chub	X		
Coho Salmon	X		
Crappie		X	X
Flathead Catfish		X	X
Freshwater Drum		X	X
Golden Redhorse			X
Lake Trout	X		
Largemouth Bass		X	X
Longnose Sucker	X	X	
Muskellunge		X	X
Northern Hogsucker			X
Northern Pike		X	X
Pink Salmon		X	
Quillback		X	X
Rainbow Trout			X
Redhorse Sucker	X	X	X
Rock Bass		X	X
Round Goby		X	
Sheepshead		X	X
Shorthead Redhorse	X	X	X
Silver Redhorse			X
Smallmouth Bass		X	X
Smelt	X	X	
Splake		X	X
Steelhead	X	X	
Sturgeon	X	X	X
Suckers		X	X
Sunfish		X	X
Walleye	X	X	X
Whitefish	X		
White Perch		X	
White Sucker		X	X
Yellow Bullhead		X	X
Yellow Perch		X	X

Table A-3 Contaminants causing fish consumption advisories in Lake Michigan. Illinois has a state-wide advisory (SWA) for predator fish for women of childbearing age and children. Indiana has a do not eat advisory for fish from the Grand Calumet River/Indiana Harbor Canal. †Michigan has a mercury advisory for all inland lakes, reservoirs, and impoundments. *Wisconsin's safe eating guidelines (SEG) do not specify the contaminant causing the advisory.

Fish habitat→ CONTAMINANT causing advisory↓	Lake Michigan OPEN WATERS	Lake Michigan NEARSHORE WATERS	Lake Michigan INLAND WATERS
PCBs, number of fish species by state	Illinois 4 Indiana 8 Michigan 11 Wisconsin 9 Total 31	Illinois 5 Indiana 13 Michigan 16 Wisconsin 21 Total 50	Illinois 6 Indiana 16 Michigan 7 Wisconsin 17 Total 40
Mercury, number of fish species by state	Illinois SWA Indiana 1 Michigan 0 Wisconsin * Total 1	Illinois SWA Indiana 3 Michigan 2 Wisconsin * Total 5	Illinois SWA Indiana 4 Michigan 2† Wisconsin 1 and * Total 7
Chlordane, number of fish species by state	Illinois 0 Indiana 0 Michigan 3 Wisconsin * Total 3	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1
DDT, number of fish species by state	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1
Dioxin, number of fish species by state	Illinois 0 Indiana 0 Michigan 3 Wisconsin * Total 3	Illinois 0 Indiana 0 Michigan 2 Wisconsin * Total 2	Illinois 0 Indiana 0 Michigan 1 Wisconsin * Total 1
Safe Eating Guidelines	Wisconsin 3	Wisconsin 16	Wisconsin 20

5. Pollutant Classification into Categories Using Scenarios 1 through 4

Based on a review of pollutants identified from the draft 2006 303(d) lists for Illinois, Indiana, and Michigan, the 2004 final 303(d) list for Wisconsin, and fish consumption advice, the LaMP 2006 critical pollutants and pollutants of concern can be classified using the scenarios described earlier in this document.

Scenario 1. GLI Definition of Open Waters used to categorize pollutants

In this scenario, open waters are all waters lakeward from a line drawn across the mouth of tributaries to the Lake. In this scenario, critical pollutants are found in all depths of the lake, harbors, bays, and beaches. Pollutants causing impairments are taken from 303(d) lists, fish consumption advice, and monitoring data.

Applying the GLI definition of open waters doesn't help the LaMP distinguish between pollutants requiring lakewide action and pollutants to be remediated through regional or local actions. The GLI definition of open waters lumps together AOC and LaMP pollutants. Therefore, the LaMP will not rely on the GLI definition of open waters in order to categorize pollutants.

Table A-4. Proposed LaMP 2006 Pollutants for Finalization in 2008 Using GLI Definition of “Open Water”

Pollutant Classification	Proposed LaMP 2006 Pollutants for Finalization in 2008 Using GLI Definition of “Open Water”
Critical Pollutants (connotation of lakewide TMDL and LaMP action)	Illinois PCBs, E. Coli, arsenic, cadmium, chromium, copper, lead, zinc, nitrogen (total), phosphorous (total) Indiana PCBs, mercury, E. coli Michigan PCBs, mercury, TCDD (dioxins), chlordane, DDT, pathogens, nuisance oil product pollution Wisconsin polychlorobiphenyls, mercury, E. coli, and phosphorus
Pollutants of Concern (connoting AOC action)	Illinois Alpha BHC, Arsenic, Copper, Dieldrin, DDT, Endrin, Lead, Manganese, Mercury, Nickel, PCBs, Silver, Total Dissolved Solids (TDS), and Zinc Indiana PCBs, mercury, and E. coli Michigan PCBs, mercury, chlordane, nuisance oil product pollution, and pathogens Wisconsin mercury and polychlorobiphenyls sedimentation, creosote, polycyclic aromatic hydrocarbon, phosphorus, TBD, nitrate, metals, and bacteria
Watch List (prevent from reaching the Lake)	Illinois Alpha BHC, Aldrin, chromium (total), DDT, Endrin, Heptachlor, Hexachlorobenzene, Nickel, PCBs, Silver, and Nitrogen (total) Indiana nutrients, PCBs, mercury, E. coli, ammonia, chlorides, cyanide, oil and grease, siltation, and total dissolved solids Michigan phosphorus, pathogens, mercury, PCBs, TCDD, chlordane, dissolved oxygen, organic enrichment, and bacterial slimes. Wisconsin phosphorus, sediment, polychlorobiphenyl, metals, mercury, and bacteria

Scenario 2. Use SOLEC definition of open water to categorize pollutants.

Once again, pollutant monitoring data specific to open waters and distinct from nearshore waters is not readily available for Lake Michigan. The Illinois Lake Michigan monitoring plan identifies stations with lake depths greater than 27 meters or 90 feet. Pollutant transport from the atmosphere and tributaries to the deep open waters of the Lake was addressed through the Lake Michigan Mass Balance (LMMB) study in 1994-1995, but the sampling points have not been reviewed with respect to a depth of 27 meters for this document. Most of the LMMB pollutant data collected has not been modeled with a Lake Michigan Mass Balance Level 3 model, the only LMMB model level that can distinguish the SOLEC-defined near shore from the SOLEC-defined open waters. IADN sampling stations qualify as near shore in SOLEC terminology, but there are not air criteria or regulatory thresholds with which to compare ambient analytical results for LaMP pollutants. Therefore, the SOLEC definition of open water is not suitable for LaMP pollutant categorization because there isn't enough data from ambient monitoring programs lakeward of the shoreline, harbors, and bays. The SOLEC definition of open water may be suitable for LaMP pollutant categorization when LMMB level 3 model simulations are available or when EEGLE²⁶ simulations include lake depth information.

Scenario 3. Deduce pollutant categories from fish contaminant advisories.

Table A-3 shows that species-specific consumption advisories with species categorized by habitat (open waters, nearshore waters, and inland waters) can, in some instances, be used to prioritize areas needing contaminant-specific action. For example, more inland species of fish are contaminated with mercury compared to the number of species inhabiting deeper open waters contaminated with mercury. Chlordane impairs more species of open water fish than inland fish in Lake Michigan waters. Some fish consumption advisories are relatively local, and concentration of contaminants would probably be more useful than knowing only the species contaminated and the existence of an advisory. A more robust analysis would

include mapping fish contaminant data and evaluation for spatial trends. Higher fish contaminant concentrations could be associated with sources to be controlled (i.e., distinguish air from water pathways), but this may not shed new light as a source inventory already exists. In conclusion, the summary of fish contaminants causing advisories, lumped by species and tallied by state, do not make the appropriate scale for TMDL development self-evident. The appropriate definition of open water isn't easily derived from fish consumption advisories.

Scenario 4. Use general knowledge of pollutant properties to categorize pollutants.

In chapter 5 of LaMP 2000²⁷, the LaMP pollutants were discussed as chemical, physical, and biological stressors. The loads of these stressors were discussed by source of data, such as monitoring, research, and regulatory programs, and measured or estimated loads to the lake were reported. When information gathered between 2000 and 2006 is added to the LaMP 2000 information, pollutant categorization can be done subjectively (i.e., using professional judgment) as follows.

Pollutant	Critical Pollutant	Pollutant of Concern	Watch List	Reason – typically the pollutant is associated with a category 5 water body on a state's clean water act Section 303 (D) list. Categorization considers long range air transport and known pollutant sources and pathways.
PCBs	X	X	X	PCBs are critical pollutants, pollutants of concern, and on the watch list because of fish consumption advisories in all four states from Lake Michigan to headwaters. Wisconsin reports polychlorobiphenyls. ²⁸
Dioxins/furans	X	X		Dioxins/furans are critical pollutants because Michigan has fish consumption advisories for Lake Michigan and it is on Michigan's list for Lake Michigan, including bays and a near shore inland lake. No impairments due to dioxin are reported by Illinois, Indiana, and Wisconsin.
Mercury	X	X	X	Mercury is a critical pollutant because of fish consumption advisories reported on the Indiana, Michigan, and Wisconsin lists, and air deposition research. Mercury is a pollutant of concern reported in bays, harbors, and tributary mouths on all four states' lists. Stream segments and water bodies throughout the watershed are listed for mercury fish consumption advisories.
DDT and metabolites	X	X	X	DDT and metabolites are a critical pollutant because Michigan has Lake Michigan fish consumption advisories. No impairments due to organic pesticides are reported in Indiana's and Wisconsin's 303(d) lists. DDT was reported on 303 (d) lists for assessed stream segments near to and far from Lake Michigan.
Chlordane	X	X	X	Chlordane is a critical pollutant because Michigan has Lake Michigan fish consumption advisories. No impairments due to organic pesticides are reported on Indiana's and Wisconsin's 303(d) lists. In Michigan, White Lake, Torch Lake, Roscommon, Glen Lake, Galien River, and Lake Macatawa are listed for chlordane.
E. coli		X	X	E. coli impairs Lake Michigan in Illinois (66 beaches). In Indiana, 58 stream segments or water bodies, including 4 segments of shoreline are impaired. E. coli is not monitored offshore, but may be transported with sediment.

Table A-5 (Part 1). Scenario 4 Table

Table A-5 (continued)

Pollutant	Critical Pollutant	Pollutant of Concern	Watch List	Reason – typically the pollutant is associated with a category 5 water body on a state's clean water act Section 303(D) list. Categorization considers long range air transport and known pollutant sources and pathways.
bacteria		X	X	Bacteria impairs 11 Lake Michigan beaches in Wisconsin. In addition, bacteria are reported on Wisconsin's 2004 303(d) list for more than 7 stream segments or water bodies in the counties bordering Lake Michigan. Bacteria are not monitored offshore, but may be carried with sediment ²⁹ . Municipal water intakes are at depths considered near shore.
pathogens		X	X	Pathogens impair Lake Michigan beaches in Michigan. Pathogens are reported on Michigan's list as a problem for 27 stream segments or water bodies. See the endnote for bacteria.
Bacterial slimes			X	Michigan listed Lost Creek and Unnamed Tributary to Platte Lake segments.
Alpha BHC		X	X	Illinois listed the segment closest to the Lake and an upstream portion of Pettibone Creek for Alpha BHC.
Dieldrin		X	X	Illinois listed the tributary segment and an upstream portion of Pettibone Creek for Dieldrin.
Endrin		X	X	Illinois listed the tributary segment and an upstream portion of Pettibone Creek for Endrin.
Nitrogen		X	X	Illinois listed Waukegan harbor and an upstream portion of Waukegan River.
Nitrate			X	Wisconsin listed at least Dutchman Creek.
Cyanide			X	Indiana listed upstream segments of the Grand Calumet and Little Calumet Rivers
Ammonia			X	Indiana listed two upstream segments.
Phosphorus		X	X	Illinois listed Waukegan Harbor. Michigan listed twelve upstream segments or water bodies. Wisconsin listed more than 22 stream segments or water bodies including Green Bay AOC (inner bay).
Nutrients			X	Indiana listed Wisler Ditch and tribs.
Organic enrichment			X	Michigan listed a segment of Unnamed Tributary to Platte Lake.
Dissolved Oxygen			X	Michigan listed Deer Creek and Sycamore Creek segments.
Polycyclic Aromatic Hydrocarbon		X	X	Wisconsin listed at least Lincoln Creek, Lower Menominee AOC, and Manitowoc River.

Table A-5 (continued)

Pollutant	Critical Pollutant	Pollutant of Concern	Watch List	Reason – typically the pollutant is associated with a category 5 water body on a state’s clean water act Section 303(D) list. Categorization considers long range air transport and known pollutant sources and pathways.
Creosote			X	Wisconsin listed at least Little Menomonee River segment.
Nuisance oil product pollution		X		Michigan listed Sawyer Creek.
Oil & grease			X	Indiana listed upstream portions of the Indiana Harbor Canal and Grand Calumet River.
Siltation			X	Indiana listed one upstream segment of Deep River tributary.
Sedimentation		X	X	Wisconsin listed at least 20 stream segments including Mud Creek, Root River, and Two Rivers Harbor.
TDS			X	Indiana listed one upstream segment, Mud Creek.
Chlorides			X	Indiana listed one upstream segment, Mud Creek.
metals		X	X	Wisconsin listed at least Racine Harbor, Milwaukee River estuary AOC, Milwaukee River Estuary AOC - Kinnickinnic River, Milwaukee River Estuary AOC – Menomonee River, Milwaukee River Estuary AOC, Kewaunee Marsh, Kewaunee Harbor, and East River
Arsenic		X		Illinois listed Waukegan Harbor and Pettibone Creek.
Cadmium		X		Illinois listed Waukegan Harbor
Chromium		X	X	Illinois listed Waukegan Harbor and an upstream segment of S. Br. Waukegan River
Copper		X		Illinois listed Waukegan Harbor and Pettibone Creek.
Lead		X		Illinois listed Waukegan Harbor and Pettibone Creek.
Manganese		X		Illinois listed Pettibone Creek.
Nickel		X	X	Illinois listed Pettibone Creek and S. Br. Waukegan River.
Silver		X	X	Illinois listed Pettibone Creek and S. Br. Waukegan River.
Zinc		X		Illinois listed Waukegan Harbor and Pettibone Creek.

The ‘apply professional judgment’ scenario allows classification of E. coli, pathogens (viruses, protozoa, bacteria), and bacteria as pollutants of concern because they have not been demonstrated to cause an impairment in the deep waters of Lake Michigan. At the same time, when biological pollutants impact all states, a classification of E. coli, pathogens, and bacteria as critical pollutants could be appropriate to boost visibility and attract needed resources. Consistent with IADN and LMMB findings, air deposited toxics like PCBs, dioxins/furans, mercury, and organochlorine pesticides have an open water impact and are critical pollutants. Providing the names of the Category 5 waters when only a few are impaired gives some sense of the impairment magnitude. Likewise, providing a number of assessed waters when many are impaired can suggest how widespread the impairment is. Comparison of state lists suggests a discrepancy in number and type of pollutants analyzed. The pollutant specific method and professional judgment also apply to Watch List pollutants identified through literature review.

IV. Lake Michigan LaMP 2006 Pollutants to be Reviewed in 2008

Scenarios 3 and 4 are most helpful when reviewing the critical pollutants and pollutants of concern. The same watch list pollutants proposed in 2004 are proposed again here. Resources to perform a comprehensive literature review were not available.

All actions to virtually eliminate PCBs, dioxin/furan, mercury, DDT, and Chlordane from use and potential release to the environment should be taken in all four Lake Michigan states. Efforts have been underway through a variety of mechanisms, like Hospitals for a Healthy Environment (H2E), Federal Electronics Challenge, PCB Phase Down, and pesticide re-registration and reviews. The Toxic Pollutants chapter of the Great Lakes Regional Collaboration Strategy included the following recommendations.

- 1) Reduce and virtually eliminate the principal sources of mercury, PCBs, dioxins and furans, pesticides and other toxic substances that threaten the health of the Great Lakes basin ecosystem, through coordinated intergovernmental strategies.
- 2) Prevent new toxic chemicals from entering the Great Lakes basin: Target production, use and sound disposal of toxic chemicals across the Great Lakes basin through strategic deployment of pollution prevention and waste minimization programs.
- 3) Institute a comprehensive Great Lakes research, surveillance and forecasting capability to help identify, manage, and regulate 45 chemical threats to the Great Lakes basin ecosystem. A Great Lakes basin-wide coordinated program that incorporates and augments current efforts should be created to better characterize links between PTS sources and exposure. The multiparty program should preferably be housed within an existing program or organization and call upon the combined resources of federal agencies, states, academia, the private sector, and our Canadian neighbors.
- 4) Support efforts to reduce continental and global sources of PTS to the Great Lakes basin.

These recommendations apply to pesticide pollutants of concern, too. The above recommendations are

Table A-6. LaMP Pollutants for Discussion in 2006-2008

Pollutant Classification	LaMP Pollutants for Discussion in 2006-2008
Critical Pollutants	PCBs, mercury, DDT and metabolites, chlordane, and dioxin/furan.
Pollutants of Concern	PCBs, mercury, DDT and metabolites, Chlordane, dioxin/furan, E. coli, bacteria, pathogens, Alpha BHC, Dieldrin, Endrin, Nitrogen, Phosphorus, polycyclic aromatic hydrocarbons, nuisance oil product pollution, sedimentation, metals, arsenic, cadmium, chromium, copper, lead, manganese, nickel, silver, and zinc.
Watch List	Bacterial slimes, Nitrate, cyanide, ammonia, nutrients, organic enrichment, dissolved oxygen, polycyclic aromatic hydrocarbons, creosote, oil and grease, siltation, sedimentation, TDS, chlorides, metals, chromium, manganese, PBDEs, PCNs, PFOS, asbestos, PAHs (acenaphthylene, acenaphthene, fluorene, 1 methyl-fluorene, phenanthrene, anthracene, 2-methylphenanthrene, fluoranthene, pyrene, retene, benzo(a)fluorene, benzo(b)fluorene, benz(a)anthracene, chrysene, benzo(b+k) fluoranthene, benzo(e)pyrene, benzo(a)pyrene, perylene, indeno(c,d)pyrene, diben(ah)anthracene, benzo(ghi)perylene, antanthrene, and coronene), thallium, selenium, phthalates, radioactive material, synthetic musks: six polycyclic musks (AHTN, HHCB, ATII, ADBI, AHMI, & DPMI) and two nitro musks (musk xylene and musk ketone), toxaphene, sulfur, atrazine & degradation products, metolachlor & degradation products, acetochlor & degradation products, glyphosate & degradation products, 1,4-dichlorobenzene, 2,6-di-tert-butylphenol, 2,6-di-tert-p-benzoquinone, butylated hydroxy toluene, tri (2-chloroethyl) phosphate, tri (2-chloroethyl) phosphate, 4-methyl phenol, cimetidine, trimethoprim, lincomycin, cholesterol, coprostanol, 1-naphthol, 2-naphthol

consistent with the Great Lakes Binational Toxics Strategy and other strategy documents.

With respect to the biological pollutants and other pollutants of concern, the Coastal Health, AOC/Sediments, and Nonpoint Source chapters in the Great Lakes Regional Collaboration Strategy identified relevant goals. Chapters 2 and 3 of this LaMP address biological pollutants, too.

V. Concluding Remarks/Next Steps

Additional pollutants, such as those transported by air attached to particles like soot, may be unrecognized pollutants of concern in nearshore urban areas. There is consensus by the Task Force on Hemispheric Transport of Air Pollution that ozone and its precursors, fine particles, acidifying substances, mercury, and persistent organic pollutants have potential for long range air transport. It's not clear that all of these are sampled and analyzed in order to prepare the 303(d) lists or fish consumption advisories. Nonattainment areas could be targeted for investigation after reviewing maps of nonattainment counties for Clean Air Act particulate matter standards. Comparing target analyte lists for fish monitoring and water quality assessment programs was beyond the scope of this document, but would help in evaluating whether dioxin, for example, is below fish consumption advisory risk thresholds or not analyzed in Wisconsin and Indiana. (Dioxin is not part of Illinois' Lake Michigan monitoring.)

This document concluded that looking at fish consumption advisories by species and applying professional judgement to pollutants identified on Clean Water Act Section 303(d) lists are reasonable approaches to defining critical pollutants and pollutants of concern. However, the definitions of critical pollutant, pollutant of concern, and watch list are still open to revision. Questions for reviewers to consider follow. Should pollutants appear only in the lakewide category (critical pollutant) if the pollutant causes impairments throughout the watershed or should the same pollutant also be a pollutant of concern and on the watch list? Do we need rigorous definitions of "open water" and "nearshore water" if the scenario 4 approach is selected? Is there data available to distinguish pollutants in nearshore waters from open waters in other Great Lakes? These questions and more will be the focus of the 2006 SOLEC Lake Michigan workshop on November 2, 2006 in Milwaukee, Wisconsin.

Endnotes

- ¹ Lake Michigan LaMP 2000 is online at www.epa.gov/grtlakes/lakemich/index.html.
- ² Appendix A comprises pages 89 – 95 of the Lake Michigan LaMP 2002, available online at www.epa.gov/grtlakes/lakemich/lm02/index.html.
- ³ The GLWQA (1987) identifies fourteen changes in the chemical, physical or biological integrity of the Great Lakes System sufficient to impair beneficial uses. For lakewide adaptive management, these fourteen changes were rephrased as six endpoint goals such as “We can all eat any fish.”
- ⁴ Lake Michigan Lakewide Management Plan requirements of the Great Lakes Critical Programs Act of 1990 were incorporated in Section 118 of the Federal Water Pollution Control Act (33 U.S.C. §1268(c)(4)).
- ⁵ Chapter 5 may be accessed online at www.epa.gov/grtlakes/lakemich/lmlamp2000/LM%20chapter%205.pdf.
- ⁶ A distinction is made between samples taken for a research project of limited duration and samples routinely taken using an established protocol over many years. The latter type of sampling is called ‘monitoring’ in this Appendix. GLNPO’s Limnology Program is described online at www.epa.gov/glnpo/monitoring/limnology/index.htm.
- ⁷ See, for example, Status and Trends of Prey Fish Populations in Lake Michigan, 2005 and Status of Pelagic Prey Fishes in Lake Michigan, 1992-2005
- ⁸ See GLNPO’s Fish Indicators web page at www.epa.gov/glnpo/glindicators/fish.html.
- ⁹ Available online at www.epa.gov/grtlakes/gls/gls2002.pdf .
- ¹⁰ Great Lakes Water Quality Initiative Guidance, National Pollutant Discharge Elimination System Permits, Total Maximum Daily Load, Great Lakes Binational Toxics Strategy.
- ¹¹ International Atmospheric Deposition Network, Maximum Achievable Control Technology, Great Lakes Regional Air Toxics Emissions Inventory and Regional Air Pollutant Inventory Development System
- ¹² Persistent Organic Pollutants and Heavy Metals Protocols under the United Nations’ Economic Commission for Europe’s Convention (UNECE) on Long Range Transboundary Air Pollution (LRTAP), the Stockholm Convention on Persistent Organic Pollutants, and the North American Commission for Environmental Cooperation (CEC) Sound Management of Chemicals Program which has developed North American Regional Action Plans (NARAPs) for a number of chemicals.
- ¹³ For more information about the Great Lakes Regional Collaboration, see www.epa.gov/greatlakes/collaboration/strategy.html and www.gllrc.us/.
- ¹⁴ The draft Illinois 303(d) list was found at www.epa.state.il.us/water/tmdl/303d-list.html at the time of document preparation.
- ¹⁵ See LaMP 2004 Appendix A online at www.epa.gov/grtlakes/lakemich/2004update/lmlamp04_3a.pdf , pages A-4 through A-6.
- ¹⁶ Tables A-6 and A-7 are on pages A-14 and A-15 of LaMP 2004 online at www.epa.gov/grtlakes/lakemich/2004update/lmlamp04_3a.pdf.

¹⁷ Kannan, K., Tao, L., Sinclair, E., Pastva, S., Jude, D., and Giesy, J. "Perfluorinated Compounds in Aquatic Organisms at Various Trophic Levels in a Great Lakes Food Chain." *Arch. Environ. Contam. Toxicol.* 48, 559-566 (2005).

¹⁸ *National Recommended Water Quality Criteria*, EPA publication number EPA/OW/OST 4304T, 2006 is available online at www.epa.gov/waterscience/criteria/nrwqc-2006.pdf.

¹⁹ For more information, see www.epa.gov/waterscience/criteria/atrazine/index.htm.

²⁰ For more information, see www.epa.gov/waterscience/criteria/nonylphenol/.

²¹ For more information, see www.epa.gov/waterscience/criteria/selenium/index.htm.

²² Title 40 of the Code of Federal Regulations section 132.2: Open waters of the Great Lakes (OWGLs) means all of the waters within Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, Lake Ontario, and Lake Superior lakeward from a line drawn across the mouth of tributaries to the Lakes, including all waters enclosed by constructed breakwaters, but not including the connecting channels. States have adopted this definition.

²³ Lake Michigan Mass Balance results have been reported in this Lake Michigan LaMP, previous LaMPs, and on the Great Lakes National Program Office webpage. See, for example, the LMMB PCB Data Report at www.epa.gov/grtlakes/lmmb/results/pcb/index.html or the LMMB Mercury Data Report at www.epa.gov/grtlakes/lmmb/results/mercury/index.html.

²⁴ From Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results through 2000, available on-line at www.epa.gov/glnpo/monitoring/air/iadn/reports/IADN_1999_2000.pdf. See pages 2 and 3.

²⁵ LaMP 2004 Table A-1 is on page A-3, online at www.epa.gov/grtlakes/lakemich/2004update/lmlamp04_3a.pdf.

²⁶ The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory investigated an annually recurrent winter-spring sediment plume visible on satellite imagery of Lake Michigan, resulting in many Episodic Events: Great Lakes Experiment (EEGLE) publications. Sediment plumes have also been documented in fall. See www.glerl.noaa.gov/eegle/.

²⁷ Chapter 5 of the Lake Michigan LaMP 2000 is online at www.epa.gov/grtlakes/lakemich/lmlamp2000/LM%20chapter%205.pdf.

²⁸ According to www.chemfinder.com, the term polychlorobiphenyls corresponds to Arochlor 1262. Arochlor 1262 is a mixture of PCB congeners containing 62% chlorine by weight.

²⁹ See previous endnote and description of increased bacteria growth with increased P in the plume at www.glerl.noaa.gov/eegle/projects/p09/results.9.2000.html.

³⁰ See Table A-5 in Lake Michigan LaMP 2004 on pages A-10 through A-13, online at www.epa.gov/grtlakes/lakemich/2004update/lmlamp04_3a.pdf.