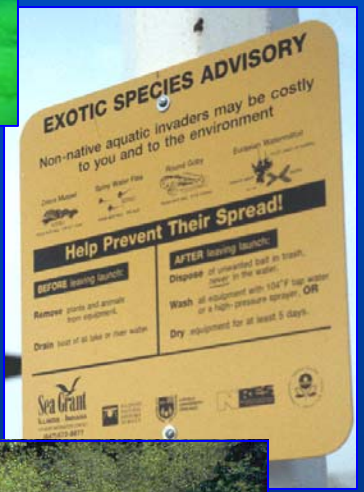
Lake Michigan Lakewide Management Plan (LaMP) 2008



Lake Michigan Lakewide Management Plan (LaMP) 2008 Status Report

Introduction

Organization of the LaMP and this Status Report for 2008

This document is intended to provide a status report on the health of the Lake Michigan ecosystem and a summary of the activities related to the Lake Michigan LaMP that have occurred during the last 2 years. Each chapter provides reports on current status, challenges, indicators, and next steps for a specific sub-goal area.

In addition to providing a status report, this report identifies new information and tools for addressing environmental problems identified within the report. These tools can be used by government and/or watershed groups to build a healthier Lake Michigan environment.

The LaMP is based upon the vision, goal and subgoals developed by a collaborative stakeholder process. The vision and goal were adopted by the Management Committee August 18, 1998.

The LaMP vision is:

The vision is a sustainable Lake Michigan ecosystem that ensures environmental integrity and that supports and is supported by economically viable, healthy human communities.

Lake Michigan beach, Empire, Michigan
Michigan Travel Bureau

The LaMP goal is:

To restore and protect the integrity of the Lake Michigan ecosystem through collaborative, place-based partnerships.

The subgoals are stated as questions and are organized in 11 chapters. The last, 12th chapter, provides information on activities related to these sub-goals in the 33 subwatersheds that make up the Lake Michigan basin. The chapters are as follows:

1. Can we all eat any fish?
2. Can we all drink the water?
3. Can we swim in the water?
4. Are all habitats healthy, naturally diverse, and sufficient to sustain viable biological communities?
5. Does the public have access to abundant open space, shorelines, and natural areas, and does the public have enhanced opportunities for interaction with the Lake Michigan ecosystem?
6. Are land use, recreation, and economic activities sustainable and supportive of a healthy ecosystem?
7. Are sediment, air, land, and water sources or pathways of contamination that affect the integrity of the ecosystem?
8. Are aquatic and terrestrial nuisance species prevented and controlled?
9. Are ecosystem stewardship activities common and undertaken by public and private organizations in communities around the basin?
10. Is collaborative ecosystem management the basis for decision-making in the Lake Michigan basin?
11. Do we have enough information, data, understanding, and indicators to inform the decision-making process?
12. What is the status of the 33 Lake Michigan subwatersheds?

What is the Status of the Lake?

"Lake Michigan is an outstanding natural resource of global significance, under stress and in need of special attention." **LaMP 2000**

The status of the lake is measured against the long-term goals and targets for 2020. It is acknowledged

The Lake Michigan-Mississippi River basin divide: Chicago Avenue west of East Avenue in Oak Park, Illinois. Photograph Courtesy of Jeffrey Edstrom

that much work is needed and that the added stress of climate change may significantly impact meeting our goals.

Since the release of LaMP 2000, several key indicators point to the continuing concern for the health of the ecosystem.

- Beach season still finds many days when beaches are closed due to levels of e. coli above the standard. However, the number of days beaches are closed is decreasing even with increased monitoring of beaches.
- Data reveal that a critical layer of the Lake Michigan aquatic food web continues to disappear.
- The discovery of new aquatic nuisance species – there are now a total of 185 in the Great Lakes ecosystem – threaten the integrity of the food web of Lake Michigan.
- PCBs and mercury in fish, while slowly declining, remain a problem that requires fish consumption advisories.
- Climatic pattern changes, whether temporary or permanent, help focus attention about groundwater levels and lake/groundwater interaction.
- Terrestrial and aquatic animals appear to be rebounding with eagles nesting on the southern shore of Lake Michigan for the first time in 100 years, abundance of wolves lead to delisting it from the endangered list, and a lakewide effort on restocking sturgeon is underway.
- Black Crowned Night Herons are now nesting in lakefront Chicago parks at renovated habitat.
- Following the September 11, 2001 terrorist attacks, the issue of protecting the lake's vast supply of fresh drinking water has become a higher priority.

Since 2006, new and troubling concerns emerged.

- In 2007, an invasive virus, viral hemorrhagic septicemia (VHS), was discovered in Lake Michigan fish.
- In Fall of 2006 and 2007, large bird die offs along the north Michigan coast were attributed to botulism caused as a result of shore birds eating fish that had the toxin.
- These events have pointed out the need to sample and research the nearshore to gain a better understanding of its unique dynamics.

Despite these concerns, Lake Michigan supports many beneficial uses. In addition to providing a drinking water supply for 11 million people; it has internationally significant habitat and natural features; supports food production and processing; supplies fish for food, sport, and culture; has valuable commercial and recreational uses; and is the home of the nation's third-largest population center. Furthermore, significant progress is being made to remediate the legacy of contamination in the basin. Specifically, ongoing actions to restore the Areas of Concern (AOCs) have been successful and have received new resources from the passage of the 2002 Great Lakes Legacy Act. Their status is outlined in Chapter 7. The Lake Michigan Watershed Academy was launched in 2003 and has brought together the regional planning agencies of four states for the first time to align their work with Lake Michigan trends and Phase 3 of this work is beginning.

What was Accomplished?

Accomplishments include the following:

- Selection of Lake Michigan as one of three pilots to test a new national monitoring design (see Chapter 11).
- Reporting on collaborative monitoring of the basin

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

in 2005 (See chapter 7).

- Setting targets for reduction of critical pollutants and stressors (see Chapter 7 and Chapter 4),
- Reviewing the LaMP list of contaminants and stressors based on new monitoring and reports (see Appendix A).
- Identifying data gaps as part of the national monitoring design pilot (see chapter 11).
- Identifying ecologically rich areas and habitats (see Chapter 4 and Chapter 12).
- Adding climate change into the concept of sustainability and stewardship (see Chapter 6 and Chapter 9).
- Convening public conferences and workshops for beach management, monitoring issues, and watershed management (see Chapter 1, Chapter 4, and Chapter 12).
- Holding the 5th State of Lake Michigan conference in October 2007 in Traverse City, Michigan.
- Further developing remedial action plans and developing delisting targets by 2008 for the 10 Lake Michigan AOCs.
- Convening of Ports workshops and project developed.

Progress made on accomplishing these objectives is outlined in this status report.

Adaptive Management

One of the key functions of the LaMP process is to identify pollutants that are or have the potential to adversely affect the Lake Michigan ecosystem. In Appendix A of previous LaMPs the two-year cycle of pollutant identification, an adaptive management process, for three categories of Lake Michigan LaMP pollutants, was outlined.

- Critical pollutants meet any one of four criteria, pollutants needing an open water TMDL, pollutants exceeding a GLI water quality criteria, pollutants causing a fish consumption advisory, or associated with other lakewide lakewide designated uses. Critical pollutants connote the need for a lakewide TMDL.
- Pollutants of Concern meet any one of three criteria, including needing a TMDL in nearshore waters or a tributary mouth, pollutants causing an AOC impairment, or pollutants associated with regional use impairments. Pollutants of concern connote regional or AOC action.
- Watch List pollutants meet all three of these criteria--potential to impact the Lake Michigan ecosystem, presence in the watershed, and bioaccumulation potential, persistence in water or sediment, or toxicity singly or through synergistic effects,. Proposed watch list pollutants must be investigated to confirm that all three criteria are substantiated and should be prevented from reaching the open waters.

The LaMP committed to an adaptive management approach which for the pollutant list, means a data review in order to prepare each LaMP. Subsequently, a five year cycle of an intensive monitoring year for each of the five Great Lakes evolved. It is proposed for discussion that our review of the pollutants follow the five year cycle which will provide the data needed for a review. A Next Step for the LaMP Technical Coordinating Committee is to review Appendix A- the guide for the adaptive management pollutant list review process. There are issues that need clarification and refinement. A few of these include: Do we propose and confirm a watch list pollutant based on potential to impact the lake itself or the lake ecosystem? How should the Clean Water Act section 303(d) process factor into the review? Are we in alignment with other reviews like the Great Lakes Binational Toxic Strategy? Other

state and federal agency lists and reviews? The work will be published in LaMP 2010 and a status report will be presented at The State of Lake Michigan Conference 2009 in Milwaukee, WI.

LaMP 2008 Data and Information

A key to targeting actions is engaging the necessary partners in a common, accessible, and scientifically sound body of knowledge. In 1999, the Lake Michigan LaMP formed a basinwide coordinating and monitoring council to coordinate and promote common protocols and comparability in monitoring. The goal is to facilitate data sharing across agencies as well as among academic and research disciplines. To provide adaptive management, there is a continuing need for monitoring and reporting of the lake's current status as conditions change and targets move (see chapter 11).

Most, but not all of the data we use, has been peer reviewed in its original development. The use in the LaMP is considered secondary data. New data are provided by:

- Researchers who publish and present at conferences.
- Researchers who receive USEPA grants and provide new data and insights.
- Scientists who volunteer and report on Great Lakes indicators every two years at the State of the Lakes Ecosystem Conference.
- Short and long-term monitoring by many different agencies for different aspects of the lake and tributaries (See chapter 11).

Ongoing monitoring is essential to assess the health of coastal ecosystems and detect changes over time. More than any other measure, monitoring provides accountability for management actions. Lake Michigan needs a coordinated, comprehensive monitoring network that can provide the information necessary for managers to make informed decisions, adapt their actions as needed, and assure effective stewardship of Lake Michigan. The proposed National Monitoring Network design sets clear, specific goals and objectives for a coordinated Lake Michigan monitoring network. The proposed network, which would provide critical information about the quality of coastal waters and their tributaries, does not incorporate or replace all ongoing water quality monitoring. Current synoptic monitoring approaches are not effective for determining trends over time due to annual and seasonal rainfall and runoff variability.
A focus on the nearshore monitoring to fill gaps is called for.

A Focus on the Future: Sustainability, Stewardship and Climate Change

While partnerships can leverage resources, they also must be led and supported. Setting shared goals, objectives, and indicators in alignment helps to conserve resources but does not do away with resource needs. The interdependencies inherent in the ecosystem approach require a balance among three fundamental elements: environmental integrity, economic vitality, and sociocultural well-being. The ability of these elements to function in balance over time is one measure of sustainability. Complex ecological processes link organisms and their environment. These processes are often referred to as "ecological services" because they perform functions that combine to sustain life in the ecosystem. The significant natural features of Lake Michigan, such as its encompassing the world's largest collection of freshwater sand dunes, supporting 43 percent of the Great Lakes' large sport fishing industry, and providing drinking water for over 10 million residents, means billions of dollars not only to the economies of the four states that share the lake but also to the nation as a whole (see Chapter 5 and Chapter 6).

A target of reaching sustainability on the way to the ultimate goals of ecosystem integrity is reflected with the nomenclature for the "meter" box at the start of each chapter "not sustainable to sustainable".

A Focus on Climate Change as a Stressor

According to the Center for Science in the Earth System Joint Institute for the Study of the Atmosphere and Oceans (University of Washington ICLEI Local governments of Sustainability), climate change is projected to have important impacts on Midwest water resources. More extreme events will occur, both in terms of droughts and rainfall. Overall, water levels in the Great Lakes are expected to decline significantly through evaporation due to increasing temperatures. These declines are likely to lead to more competition for water within the region and between the U.S. and Canada, decreased

hydropower generation, fewer wetlands, and increased water-based transportation costs. Projected increases in heavy precipitation events are likely to lead to more flooding and non-point source pollution due to runoff.

With respect to human health impacts, the Midwest is likely to benefit from fewer extreme cold outbreaks with the potential for more heat-related illnesses during the summer. Heat-related stress is particularly a concern for urban areas where the concentration of paved surfaces elevates nighttime temperatures. Finally, the projected increase in extreme precipitation events may lead to an increase in insect or tick-borne disease.

Agricultural production is generally expected to increase due to lengthening of the growing season and carbon dioxide fertilization effects, but not in all areas. Increased use of fertilizers for the longer growing season will lead to increased nonpoint source runoff from farm fields. Warmer air temperatures and reduced soil moisture are expected to increase forest fire risk and forest susceptibility to disease and insects, contributing to declines in both coniferous and deciduous trees. Impacts on the forest industry could be significant particularly when combined with the pressure to convert forest land to other land uses.

Goldenrod, Unknown location
National Park Service, Indiana Dunes National Lakeshore

Major changes in freshwater ecosystems are expected. Warmer water temperatures favor warm water fish species over cold water fish species and increase the risk of invasive species. The potential for more nutrient pollution and warmer water temperatures increases the risk for algae growth in freshwater lakes. As noted previously, declining lake levels throughout the region could reduce wetlands habitat. This has implications for the migrating birds and other wildlife dependent on wetland systems for all or part of their life stages.

A Focus on Ecosystems and Watersheds

In 1995, the Federal Interagency Ecosystem Management Task Force defined an ecosystem as "an interconnected community of living things, including humans, and the physical environment with which they interact. As such, ecosystems form the cornerstone of sustainable economies." With regard to ecosystem management, the Task Force explained that "the goal of the ecosystem approach is to restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities. Based on a collaboratively developed vision of desired future conditions, the ecosystem approach integrates ecological, economic, and social factors that affect a management unit defined by ecological–not political–boundaries."

In response to the changing dynamic of environmental management, the Lake Michigan Management Committee adopted the ecosystem approach in 1998. The significance for the Lake Michigan LaMP was in the intent to address not only the 10 areas that had been formally designated AOCs by the 1987 GLWQA amendments, but also other areas that were responsible for impairing the lake's ecosystem. The prime example was the Chicago area. Because of the rerouting of the Chicago River into the Mississippi River system, Chicago's surface water has been diverted out of the basin; however, groundwater from the Chicago

area has not been diverted, and the city's large airshed has been shown to be a source of pollutants that are deposited in and affect the lake. The watershed/diversion connection is currently critical as steps are underway to prevent invasive or aquatic nuisance species from entering the Lake from the Mississippi River system (See chapter 8).

A Focus on Partnerships, Innovation, and Shared Information

Addressing the goals of a broad-based ecosystem approach requires a new management framework. As LaMP 2000 pointed out, the framework is based on "partnerships of organizations brought together to solve problems too large or complex to be dealt with by one agency with a limited mission. This approach also has the potential to leverage and direct local, state and federal, and private resources into a coordinated effort. The challenge is to create the framework for participating organizations to contribute their expertise and resources, often on an uneven basis, but in a manner that allows all partners to participate in the decision making on an even basis" (see chapter 10).

In 2007, a number of public discussions were held in conjunction with new state-issued permits as part of the NPDES system. Questions were raised about the state of knowledge of what is going into the lake. GLNPO monitoring program samples the lake to find what is entering the system from non-point, unpermitted sources like air pollution and storm water runoff. There is also an on-line database for all permits and their limits. USEPA is working to provide data on a watershed basis online and in a user-friendly format (See chapter 11).

Background on the LaMP

Under the Great Lakes Water Quality Agreement (GLWQA), as amended in 1987, the United States and Canada agreed " to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this objective, the parties agreed to develop and implement, in consultation with state and provincial governments, LaMPs for open waters and remedial action plans for contaminated AOCs. In the case of Lake Michigan, the only one of the Great Lakes wholly within the borders of the United States, the Clean Water Act (Section 118c) holds the U.S. Environmental Protection Agency (USEPA) accountable for the LaMP.

In 2000, the Binational Executive Committee determined that an adaptive management approach would guide the LaMP process, making it an iterative approach.

Work on the Lake Michigan LaMP began in the early 1990s with a focus on critical pollutants affecting the lake. At that time, monitoring data showed that point source regulatory controls established in the 1970s and 1980s were reducing the levels of persistent toxic substances such as polychlorinated biphenyls (PCB), DDT, and other pesticides. Monitoring results also indicated that nonpoint sources of pollution such as runoff and air deposition, as well as aquatic nuisance species, were stressing the Lake Michigan ecosystem. LaMP 2000 states that "pathogens, fragmentation and destruction of terrestrial and aquatic habitats, aquatic nuisance species, uncontrolled runoff and erosion are among the stressors contributing to ecosystem impairments."

Increased water quality protection for the Great Lakes watershed is now being implemented with the adoption of more stringent water quality standards for the Great Lakes basin drainage by each Great Lakes state (the Great Lakes Initiative or GLI), with the goal of having the new standards reflected in all permits by 2006 or as new permits are issued.

Lake Michigan presents a set of difficult, persistent, and multifaceted problems. In response, agencies must develop new tools, refocus their strategies and methods, and continually obtain new data. The LaMP recommends using a watershed framework as the most effective scale and structure for working on these problems and provides draft fact sheets for the 33 major Lake Michigan watersheds. Updated versions are provided in Chapter 12.

Linking LaMP Goals to RAPs:

Remedial Action Plans (RAP) for 10 Lake Michigan Areas of Concern

The GLWQA amendments of 1987 also called for the development of RAPs for specific Areas of Concern. The two Federal governments of the U.S. and Canada were directed to cooperate with the state and provincial governments to develop and implement RAPs. The RAPs and LaMPs are similar in that they both use an ecosystem approach to assess and remediate environmental degradation of the 14 beneficial use impairments outlined in GLWQA, Annex 2, and rely on a structured public

involvement process. RAPs, however, encompass a much smaller geographic area, concentrating on an embayment or stretch of a river within a single watershed with contaminated sediments leading to fish advisories.

Forging a strong relationship between the LaMPs and RAPs is important to the success of both efforts. The RAPs serve as point source discharges to the lake as a whole. Improvements in the AOC areas will eventually help improve the entire lake. Much of the expertise and land use control of use impairments, possible remedial efforts and watershed planning reside at the local level. Cooperation between the two efforts is essential in order for LaMPs to remove lakewide impairments and for the RAP watershed to be able to restore integrity. The State of Michigan, with 14 AOCs, has developed, and USEPA has approved, methodologies for setting delisting targets for beneficial use impairments.

Great Lakes Regional Collaboration

In October 2003, the Great Lakes Governors identified nine critical environmental priorities for regional action. These were adopted by the Great Lakes Mayors and the Great Lakes Commission. In May 2004, President Bush signed an Executive Order creating a Cabinet-Level Task Force to bring an unprecedented level of collaboration and coordination among, State, Federal, and local governments, tribes, and other interests in the United States and Canada to accelerate protection and restoration of the Great Lakes. This led to the development and announcement of a series of recommendations from stakeholders in a final Great Lakes Regional Collaboration Report in December 2005 after a year-long process of research and consensus building.

The recommendations, while not official government policy, reflect the consensus of the wide range of stakeholders involved in the collaboration process. GLRC action items and goals key to Lake Michigan are listed at the beginning of each LaMP chapter in next steps. Chapter 10 details the current status of the GLRC.

Great Lakes Water Quality Agreement Review

The governments of Canada and the United States conducted a year long review process involving over 350 stakeholders representing a broad cross section of the Great Lakes community. Upon completion of public comment period, a final Agreement Review Report was presented for consideration to the Binational Executive Committee of Environment Canada and USEPA in Fall 2007. Environment Canada and USEPA are considering the Final Agreement Report and will provide advice, respectively, to Foreign Affairs Canada and the U.S. Department of State. The governments will then determine next steps for the Agreement, including whether it will be revised. The mandated review of the GLWQA every six years, does not obligate the governments to amend or modify the Agreement.

More information is available at www.epa.gov/glnpo/glwqa.

What Do the First Two Pages of Each Chapter Explain?

Page one of each chapter provides the current status of the goal and the 2020 target that we are striving to meet. It also lists the indicators that informs the status statement and the challenges and next steps that are needed with in the next two years.

Why is Some Material Repeated and Some More Detailed than Others?

Material in the LaMP is the most up-to-date that we were able to obtain. There is often a lag time between an activity and its final report, repeated material is left to provide context. Each LaMP has provided more details on a subject of importance or recently released information.

Climate Change—Adaptation and Mitigation

Both mitigation and adaptation actions are required as a balanced response to climate change. Mitigation measures are geared to reduce emissions and increase sinks of greenhouse gases,

while adaptation actions seek to increase resilience by reducing risks and taking advantage of opportunities due to a changing climate."

What are the "Text" Boxes and What Do They Provide?

Throughout the document, "text" boxes are employed to portray examples of work underway in the basin, or, in some cases, a noteworthy event. They are also used to provide details of what is being discussed in the chapter. They often contain a web address where the reader can follow up if interested. The information does not necessarily imply activity done under the auspices of the LaMP, but provides examples of how LaMP goals can be accomplished.

What is a Subgoal and How Does it Relate to the Sustainability Target?

The LaMP goals were developed collaboratively in 1998 and are the end points we hope to achieve working under the GLWQA goal of protecting and restoring the chemical, physical, and biological integrity of the Great Lakes basin. The LaMP committees chose 2020 as the target date where monitoring results should indicate substantial progress toward the goal. The sustainability targets describes the 2020 milestone year id progress is being achieved

What is the "Lake Michigan Toolbox"?

The 2008 Lake Michigan LaMP document has a series of "Lake Michigan Toolboxes" that provide links to resources that can be applied to basin problems and exchange shared experiences. They are targeted to assist local government and watershed groups as they work to better manage their local ecosystems. The tools include example and model ordinances, manuals and resources for local officials, planners, developers, individual citizens, and other interested parties.

Where Can I Find LaMP Reports and Where Do I Send Public Comments?

Lake Michigan LaMP 2000, 2002, 2004, and 2006 are available on line at www.epa.gov/glnpo/michigan.html. For a CD or printed copy of the LaMP or to make a public comment, contact the U.S. Environmental Protection Agency, Mail Code T-17J, 77 West Jackson Boulevard, Chicago, IL 60604. Public comments are factored into LaMP deliberations and will be reflected in LaMP 2010.

How Can I Get Involved and Keep Up-to-Date?

The Lake Michigan Forum is an EPA-sponsored stakeholder group that meets quarterly, undertakes projects that implement the LaMP. In addition, it has a web site and a listserv. For more information, see www.delta-institute.org.

USEPA, the Lake Michigan Forum and others sponsor a State of Lake Michigan conference every two years. The next conference is planned for October 2009 in Milwaukee, Wisconsin. The conference provides opportunities for attending presentations and networking.

Lake Michigan LaMP 2008
Table of Contents

Introduction i-1
Organization of the LaMP and this Status Report for 2008 ..... i-1
What is the Status of the Lake? i-1
What was Accomplished i-2
Adaptive Management i-3
LaMP 2008 Data and Information i-4
A Focus on the Future: Sustainability and Stewardship i-4
A Focus on Climate Change as a Stressor i-4
A Focus on Ecosystems and Watersheds i-5
A Focus on Partnerships and Innovation and Shared Information i-6
Linking LaMP Goals to RAPs i-6
Remedial Action Plans i-6
Great Lakes Regional Collaboration i-7
Great Lakes Water Quality Agreement i-7
What Do the First Two Pages of Each Chapter Explain? i-7
Why is Some Material Repeated and Some More Detailed than Others? i-7
Climate Change—Adaptation and Mitigation i-7
What Are the Text Boxes and What Do They Provide? i-8
What is the 'Lake Michigan Toolbox? i-8
Where Can I Find LaMP reports and Where Do I Send Public Comments? i-8
How Can I Get Involved and Keep Up-to-Date? i-8
Executive Summary ES-1
Subgoal 1: Can we all eat any fish? 1-1
What is our target for sustainability? 1-1
Why is this important? 1-1
What is the current status? 1-1
What are the major challenges? 1-1
What are the next steps? 1-1
What are some tools to assist in the challenges? 1-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 1-2
Fish Consumption Advisories 1-3
Process by which USEPA evaluates Chemicals for Human Risk 1-5
Sources of Exposure of PBDEs 1-5
Fish Contaminant Trends 1-6
Is there a Human Health Risk? 1-8
Collaborative Lake Michigan Strategy to Address Impaired Waters 1-8
Status of Mercury TMDLs in the Basin 1-9
Sources of Mercury 1-10
Sources of Other Pollutants 1-10
Subgoal 2: Can we drink the water? 2-1
What is our target for sustainability? 2-1
Why is this important? 2-1
What is the current status? 2-1
What are the major challenges? 2-1
What are the next steps? 2-1
What are some tools to assist in the challenges? 2-2

What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 2-2
Drinking Water Contaminants 2-3
The Importance of Groundwater 2-4
Drinking Water Monitoring and Reporting 2-4
Water Infrastructure Security 2-4
Drinking Water Security in the Lake Michigan Basin 2-4
Inadvertent Water Contamination 2-6
Water Quality Tracking 2-6
Drinking Water State Revolving Fund 2-7
Drinking Water Quality Reports 2-9
Subgoal 3: Can we swim in the water? 3-1
What is our target for sustainability? 3-1
Why is this important? 3-1
What is the current status? 3-1
What are the major challenges? 3-1
What are the next steps? 3-1
What are some tools to assist in the challenges? 3-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 3-2
Background 3-3
Progress on Developing and Implementing Beach Monitoring and Notification Plans 3-3
Illinois' Beach Program 3-5
Indiana's Beach Program 3-6
Michigan's Beach Program 3-8
Wisconsin's Beach Program 3-8
BEACH Watch 3-13
Annual Great Lakes Beach Association Conference 3-13
BEACH NET 3-13
Beach Cast 3-13
NEEAR Water Study 3-13
Sungoal 4: Are all habitats healthy, naturally diverse, and sufficient to sustain viable biological communities? 4-1
What is our target for sustainability? 4-1
Why is this important? 4-1
What is the current status? 4-1
What are the major challenges? 4-1
What are the next steps? 4-1
What are some tools to assist in the challenges? 4-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 4-2
Background 4-3
Threats to the Food Web Foundation 4-3
Fish Population Decreased in 2007 4-5
Great Lakes Fishery Commission Lake Michigan 2007 Report and Environmental Objectives 4-7
Lake Sturgeon 4-5
Management 4-12
Progress Towards Sustainability and Recommendations for Fish 4-13
Land Use Changes 4-13
Wetland Restoration 4-13
Buffer Strips 4-15

Subgaol 5: Does the public have access to abundant open space, shoreline, and natural areas, and does the public have enhanced opportunities for interaction with the Lake Michigan ecosystem? 5-1
What is our target for sustainability? 5-1
Why is this important? 5-1
What is the current status? 5-1
What are the major challenges? 5-1
What are the next steps? 5-1
What are some tools to assist in the challenges? 5-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 5-2
Interacting with the Ecosystem 5-3
Public Interaction with the Lake Michigan Watershed 5-6
Outdoor recreation Opportunities 5-6
The Many Benefits of Open Space 5-7
Recreational Fishery and Parks Valued 5-7
Subgaol 6: Are land use, recreation, and economic activities sustainable and supportive of a healthy ecosystem? 6-1
What is our target for sustainability? 6-1
Why is this important? 6-1
What is the current status? 6-1
What are the major challenges? 6-1
What are the next steps? 6-1
What are some tools to assist in the challenges? 6-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 6-2
Great Lakes Regional Collaboration Sustainability Vision Statement 6-3
Ecosystem Sustainability 6-3
United Nations 2007 Reports 6-4
Observed and Anticipated Effects on the Great lakes Basin Ecosystem 6-4
New Information on Groundwater Flow 6-2
Water Resource Issues 6-10
Great Lakes Water Availability and Use 6-11
Groundwater Flow Models in the Lake Michigan Basin 6-12
Lake Levels 6-12
Lake Level Monitoring 6-12
Land Use Impacts Water Quality 6-15
Oil and Gas Drilling in the Great Lakes 6-15
Subgoal 7: Are sediments, air, land, and water sources or pathways of contamination that affect the integrity of the ecosystem? 7-1
What is our target for sustainability? 7-1
Why is this important? 7-1
What is the current status? 7-1
What are the major challenges? 7-1
What are the next steps? 7-2
What are some tools to assist in the challenges? 7-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 7-2
Lake Michigan Mass Balance Project 7-3
What It tells Us 7-3
What It Does Not Tell Us 7-3
Pathways of Pollution 7-3

Lake Michigan Mass Balance resampling Results 7-4
Lake Michigan PCBs 7-6
LMMB Major Findings: PCBs 7-6
Lake Michigan Atrazine 7-7
LMMB Major Findings: Atrazine 7-7
Lake Michigan Mercury 7-7
LMMB Major Findings: Mercury 7-7
Nutrients - Eutrophication 7-8
LMMB Major Findings: Eutrophication 7-8
Pollutants and Pathways to Lake Michigan 7-8
Atmospheric Deposition 7-9
Nonpoint Source Pollution 7-9
Phosphorus in the lake Michigan Basin 7-10
What Action is Needed? 7-12
Areas of Concern: Legacy of Contamination and Community Stewardship 7-13
Great Lakes Legacy Act 7-13
The LaMP Pollutant List 7-14
Areas of Concern Overview 7-15
Subgoal 8: Are aquatic and terrestrial nuisance species prevented and controlled? 8-1
What is our target for sustainability? 8-1
Why is this important? 8-1
What is the current status? 8-1
What are the major challenges? 8-1
What are the next steps? 8-1
What are some tools to assist in the challenges? 8-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 8-2
National Developments 8-3
U.S. Department of Transportation: St. Lawrence Seaway Development Corporation 8-3
Great Lakes Ships Initiative 8-3
ANS Task force 8-5
Great Lakes Panel on Aquatic Nuisance Species 8-5
Great Lakes Aquatic Invasions Booklet 8-8
Great Lakes Commission 8-8
Great lakes Regional Collaboration 8-8
Clean Boats Initiative 8-11
State Efforts to Prevent the Spread of ANS 8-12
Illinois 8-12
Indiana 8-15
Michigan 8-18
Wisconsin 8-10
Subgoal 9: Are ecosystem stewardship activities common and undertaken by public and private organizations in communities around the basin? 9-1
What is our target for sustainability? 9-1
Why is this important? 9-1
What is the current status? 9-1
What are the major challenges? 9-1
What are the next steps? 9-1
What are some tools to assist in the challenges? 9-1
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 9-2
The Importance of Partnerships 9-3

Lake Michigan's Watershed Academy 9-3
USEPA Utilizes Watersheds for Regulatory Focus 9-4
Green Ports 9-5
Making Lake Michigan Great 2007 9-6
The Lake Michigan Forum 9-8
State of Lake Michigan Conference 9-9
Lake Michigan Partnership Directory 9-11
Subgoal 10: Is collaborative ecosystem management the basis for decision-making in the Lake Michigan basin? 10-1
What is our target for sustainability? 10-1
Why is this important? 10-1
What is the current status? 10-1
What are the major challenges? 10-1
What are the next steps? 10-1
What are some tools to assist in the challenges? 10-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 10-2
Major New Efforts Build on Lakewide Efforts 10-3
The Great Lakes Regional Collaboration 10-3
Aquatic Invasive Species 10-4
Binational Toxics Strategy Under Review 10-5
Toxic Pollutants 10-7
Habitat/Species 10-8
Coastal Health
Proposed Legislation in the 110th Congress 10-10
The Binational Executive Committee 10-12
Great Lakes Water Quality Agreement 10-13
Great Lakes Human Health Network 10-14
The Great Lakes Fishery Commission 10-14
Great Lakes Legislative Caucus 10-14
Subgoal 11: Do we have enough information, data, understanding, and indicators to inform the decision-making process? **11-1**
What is our target for sustainability? 11-1
Why is this important? 11-1
What is the current status? 11-1
What are the major challenges? 11-1
What are the next steps? 11-1
What are some tools to assist in the challenges? 11-2
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 11-2
What are the next steps for adaptive management review of the LaMP pollutant list? 11-2
Background 11-3
Lake Michigan Serves as National Monitoring Pilot 11-5
Summary and major Conclusions from Pilot Study 11-5
Lake Michigan Monitoring Coordinating Council 11-11
Great Lakes National Parks Monitoring 11-12
State of the Lakes Ecosystem Conferences 11-12
Integrated Atmospheric Deposition Network 11-12
Subgoal 12: What is the status of Lake Michigan's Watersheds? **12-1**
What is our target for sustainability? 12-1
Why is this important? 12-1
What is the current status? 12-1

What are the major challenges? 12-1
What are the next steps? 12-1
What are the State of the Lakes Ecosystem indicators used to help assess the status of the Subgoal? 12-2
Watershed Management 12-3
Actions to Address feedback 12-3
Linking LaMP Goals to Effective Implementation: The Watershed Scale 12-4
Information from the Nature Conservancy 12-4
Lake Michigan Overview 12-4
Excerpt from State of the Great Lakes 2005: Lake Michigan 12-6
Watershed Fact Sheets 12-12
Betsie-Platte
Black-Macatawa
Boardman-Charlevoix
Brevoort-Millecoquins
Brule
Cedar Ford
Chicago Area Waterway System
Door-Kewaunee
Duck-Pensaukee
Ecsanaba
Fishdam-Sturgeon
Lower Fox (AOC)
Upper Fox
Lower Grand
Upper Grand
Kalamazoo (AOC)
Little Calumet-Galien (AOC)
Manistee
Manistique (AOC)
Manitowoc-Sheboygan (AOC)
Maple
Menominee (AOC)
Michigamme
Milwaukee (AOC)
Muskegon (AOC)
Oconto
Pere-Marquette-White (AOC)
Peshtigo
Pike-Root (Waukegan) (AOC
St. Joseph
Tacoosh-Whitefish
Thornapple
Lake Winnebago
Wolf

Appendix A: Lake Michigan LaMP Pollutant Discussion Paper – For Comment.. ..... A-1
I. Background A-1
II. Lake Michigan LaMP Pollutants Looking Back A-2
1. Criteria to Define Pollutants A-2
2. Pollutants Proposed in 2004, Finalized in 2006 ..... A-3
III. Lake Michigan LaMP Pollutants 2006 Review A-4
1. Pollutant Categorization Scenarios A-4

2. Pollutants from Clean Water Act Section 303(d) Lists of Category 5 Waters for which a TMDL is required A-5
a. Illinois A-5
b. Indiana A-6
c. Michigan A-6
d. Wisconsin A-6
3. Pollutants Exceeding GLI Criteria A-6
4. Pollutants from Fish Consumption Advisories A-6
5. Pollutant Classification into Categories Using Scenarios 1 through 4 ..... A-8
IV. Lake Michigan LaMP 2006 Pollutants to be Reviewed in 2008 ..... A-13
V. Concluding Remarks/Next Steps A-14
Appendix B: SOLEC Indicators B-1
Glossary G-1
References R-1

Executive Summary

Details on the Bullets Below are found in the Individual Subgoal Sections for the 2002, 2004, 2006, and 2008 LaMP Reports

Goal: To Restore and protect the integrity of the Lake Michigan ecosystem through collaborative place-based partnerships.

Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2008	Next Steps
Human Health Actions that prevent human exposure to pollutants in the ecosystem and prevent or minimize sources SOLEC Indicator Bundles •Human Health •Coastal Zone •Contamination •Land Use/Land Cover	**Subgoal 1** We can all eat any fish ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020 **Subgoal 2** We can drink the water ***Status*** • Sustainable in 2008 • Sustainable in 2010 • Sustainable in 2020 **Subgoal 3** We can swim in the water ***Status*** • Upgraded to moving toward Mixed/Improving in 2008 • Mixed/Improving by 2010 • Sustainable by 2020	**2002** • Fish advisories for mercury by USFDA and for dioxin by Michigan and Tribes • Grand Cal and Fox River AOC sediment cleanup plans underway • Sokaogon Chippewa Community Bans Burn Barrels • Grand Traverse Band of Ottawa and Chippewa Indians ban burning trash/garbage on tribal lands • TMDL workshops with regulators and stakeholders held • Mercury Phase-Out proposal proposed • Drinking water monitoring and reporting information available on the web • Great Lakes Beach Conference held • Beaches Environmental Assessment and Coastal Health Act of 2000 • EPA and FDA issue joint mercury fish advisory **2004** • Legacy Act 2002 to clean up sediments passed and $10 million appropriated for FY 2004, $46 million proposed for FY 2005 • Fish consumption advisory outreach programs developed for non-English speakers • Impaired waters strategy under development • Source water assessment programs almost completed • Public Health Security and Bioterrorism Preparedness and Response Act of 2002 being implemented • Drinking water education programs developed • Defense Department Developing Rapid Water Quality Testing Technology • Constructed wetland effectiveness researched • Chicago and Milwaukee to control CSOs • Cladophora alga resurges **2006** • Great Lakes Fish Monitoring Program Continues • Illinois Proposes 90 Percent Mercury Emissions Reduction • USEPA Issues New Mercury Rules • Source Water Assessment and Protection Program – States Complete All Assessments • Water Security Plan Required • Pharmaceuticals, Hormones and Other Organic Wastewater Contaminants in U.S. Streams More Identifiable • NEEAR Water Study Helps Set New Beach Alert Standards • Cladophora Alga Continues to Grow • Lake Michigan CSOs Studied • Michigan to Clean up Galien River • Policy on Peak Wet Weather Discharges from Municipal Sewage treatment Facilities Proposed **2008** • **Auto mercury recovery program up and running in all 50 states** • **Fish contaminants trending downward** • **Evidence of pharmaceuticals being found in drinking water increasing** • **States building programs to dispose of medicines** • **All Lake Michigan states' source water assessments completed** • **More water efficiency resources becoming available** • **Number of beaches monitored up, but number of days closed trending downward** • **Cladophora becoming larger problem in Lake Michigan** • **Type E Botulism causes bird die-offs** • **More health departments developing predictive models for determining when to close beaches** • **More sanitary survey resources made available**	▪ Develop an Impaired Waters Strategy ▪ Continue to address sediments and focus more on nearshore contamination ▪ Support a mercury product stewardship phase-down ▪ Hold collection events for e-waste and pharmaceuticals ▪ Work with new WaterSense label and Energy Star program to promote benchmarking energy performance of water utilities ▪ Continue Watershed Academy to ensure land use and planning take account of source water issues protection needs ▪ Seek funding to develop a source water protection GIS system including recharge areas ▪ Enhance local public water supply security awareness ▪ Identify resources for public water suppliers to ensure that by 2011 80% of the community water systems will be substantially implementing source water protection plans ▪ Identify opportunities to work with the Great Lakes and St. Lawrence Cities Initiative conservation framework of 15% reduction from 2000 to 2015 ▪ Continue to implement actions outlined in the Great Lakes Regional Collaboration's Coastal Health Strategy ▪ Continue to improve beach monitoring and public notification. ▪ Develop and disseminate a standardized sanitary survey tool to identify contamination sources at Great Lakes beaches. ▪ Promote measures that will reduce or eliminate pollution sources at Great Lakes beaches. ▪ Continue support of Great Lakes Beach Association conferences. ▪ Disseminate information and training tools on the use of forecast models at Great Lakes beaches.

Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2008	Next Steps
Restoration and Protection Actions that restore, enhance, and sustain the health, biodiversity, and productivity of the ecosystem SOLEC Indicator Bundles •Biotic Communities •Coastal Zone •Aquatic Habitats •Invasive Species •Land use/Land Cover •Resource Utilization •Climate Change	**Subgoal 4** All habitats are healthy, naturally diverse, and sufficient to sustain viable biological communities ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020	**2002** • Perch population still dropping • Northwest Indiana Advanced Identification of Wetlands Study underway • Keystone species (diporeia) in Lake Michigan food web vanishing • Supreme Court Ruling narrows wetland regulation • Wisconsin passes wetlands protection law • Piping Plover critical habitat designated by USFWS • *Antrim County, Michigan Wetland Protection ordinance rescinded* • Wolf populations recovering • Habitat and Land Use Management Tool Box under development • Established a 1994 baseline for land cover • NIPC "Biodiversity Recovery Plan" document produced • Northwest Indian greenway plan unveiled • Sturgeon restoration efforts begin **2004** • Diporeia density continues to decrease • Dam removals in southeastern Wisconsin improve fish habitat • Nature Conservancy develops Biodiversity Blueprint • Chicago signs migratory bird treaty • Bald eagles return to Little Calumet River • Manistee Watershed grant • Wisconsin non-point source regulation promulgated **2006** • Little River Band Release Sturgeon Fingerlings • Boardman River Dams settlement Executed • Perch Young of the Year larger in number • Michigan and Other States Set Wetland Restoration goals • USFWS Awards grant to restore Hegewisch Marsh • Piping Plover agreement in place • Wisconsin DNR works to protect dwarf lake iris • Diporeia density continues to decrease • Wolves thriving, delisting proposed • Chicago Wilderness Report Card released (www.chicagowilderness.org) **2008** • **Fish population decreased in 2007** • **Hersey Dam removed from Muskegon River and Sturgeon River Dam removed and river restored** • **States and federal government develop new plan for Lake Michigan Lake trout** • **GLFC releases 2007 Report and Environmental Objectives for lake Michigan** • **More sturgeon than thought found in Muskegon, Manistee, Grand, and Kalamazoo Rivers** • **Michigan DEQ report outlines impacts of beach maintenance**	• Collaborate with the Great Lakes Fishery Commission on protecting near and offshore spawning reefs • Develop process to refine habitat restoration targets through public discussion and promote work toward targets • Continue to support components of biodiversity plans through the Watershed Academy. • Identify species sensitive to ground and surface water interaction and their current distribution • Provide GIS tools and land use models in workshops to promote knowledge of and protection of key habitat areas • Promote new stream buffers, wetlands, and dam removals using federal, state, local, and private resources and monitor loss and gain trends

Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2008	Next Steps
Sustainable Use Actions that concurrently sustain the health of the environment, the economy, and the communities of the ecosystem SOLEC Indicator Bundles •Contamination •Biotic Communities •Invasive Species •Coastal Zones •Aquatic Habitats •Human Health •Land Use/Land Cover •Resource Utilization •Climate Change	**Subgoal 5** Public access to open space, shoreline, and natural areas is abundant and provides enhanced opportunities for human interaction with the Lake Michigan ecosystem ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020 **Subgoal 6** Land use, recreation, and economic activities are sustainable and support a healthy ecosystem ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020	**2002** • Governors and Premiers sign Great Lakes Charter Annex 2001 • Indiana moves into Coastal Zone Management program • Wisconsin Smart Growth act • Historic Agreement to Manage Fisheries in 1836 Treaty Waters • Economic valuation studies by Northeast-Midwest Institute, Lake Michigan Federation, and University of Wisconsin Sea Grant • Lake Michigan Potential Damages study continues in sixth year • USGS Lake Michigan Trends Project funded • USGS Pollutants of Concern list developed • Upland Michigan Land Use report • Federal two-year ban on drilling under the Great Lakes continued in 2003 • Michigan moratorium on drilling under the Great Lakes • Dams removed in Milwaukee and Muskegon Rivers • Menominee tribe purchases proposed Crandon Mine site • Groundwater studies document unsustainable withdrawal • UIC study shows economic benefits of sediment clean ups 2004 • Crandon Mine site purchased by tribes • Northwest Indiana mayors join to remake Indiana lakeshore. • Lake Michigan water trail proposed • Chicago launches new water agenda. • Michigan governor outlines comprehensive water agenda. • MMSD creates river revitalization program using easement acquisition. • Chicago diversion deficit reduced faster than planned **2006** • Marquette Plan to open Indiana shore • Marquette Plan Phase 1 honored by American Society of Landscape Architects • Lake Michigan Watershed Trail proposed and under development • Sleeping Bear Dunes Developing New General Plan • Great Lakes Governors and Premiers Sign Great Lakes Charter Annex Implementing Agreements • Michigan passes new water withdrawal law • Illinois Governor Orders new water supply study • Lake Michigan diversion "debt" likely repaid in 2004 water year • Michigan court decree on walkable beaches **2008** • **Predicted impacts of climate change on water resources identified** • **Marquette Plan Phase II Visioning Plan launched** • **Chicago area nature centers found rich in public benefit** • **Fishtown, Michigan receives NOAA Preserve America Initiative grant** • **Michigan and five tribes agree on tribal hunting and fishing** • **Chicago Wilderness launches "No Child Left Inside" program** • **International Upper Great Lakes Study preliminary report indicates the armored layer of the St. Clair River is stable and not eroding** • **USEPA issues Green Infrastructure policy that is shared with state, local, and tribal governments and watershed groups** • **Chicago developing comprehensive climate change strategy** • **Brookings Institute releases three studies on Great lakes regional economic leadership and stability**	• Partner with the growing coastal zone management programs in the Lake Michigan basin to ensure that the issue of public access to the lake is balanced with protection of the ecosystem • Support a dialogue on green marinas (see Chapter 9) among states and Sea Grant programs • Determine protection status of world's largest collection of fresh water sand dunes • Promote public involvement in preservation and stewardship of special natural areas and public access: • Broaden the dialogue with state and local government land-use planners and decision-makers to balance environmental and recreational needs through the Lake Michigan Watershed Academy • Provide tools for local communities to understand the value of the resource from a lakewide perspective and develop long-term management programs • Identify open space multi-use opportunities and tools for such things as flood retention parks and open space with commuter bike trails, among others • Assist development of Green: Marina, Highway, and Golf Course programs for the basin to reduce inputs of nutrients, pesticides, and other pollutants into basin waters • Promote studies that investigate the status of groundwater resources and their impact on water quality, aquatic habitat, and levels of Lake Michigan • Support studies to determine sustainable yields for Great Lakes water resources • Continue to promote studies that investigate the economic value of remediating contaminated sites as reported in LaMP 2006 • Promote a basin-wide opportunities for green areas that sequester carbon

Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2008	Next Steps

Remediation and Pollution Prevention
 	
Actions that achieve substantial pollution reduction by remediating sites, controlling pathways, preventing or minimizing sources
 	
SOLEC Indicator Bundles
•Contamination
•Land Use/land Cover
•Invasive Species
	Subgoal 7
	Sediments, air, land, and water are not sources or pathways of contamination that affect the integrity of the ecosystem
	
	Status
	• Mixed in 2008
	• Mixed/Improving by 2010
	• Sustainable by 2020
	
	Subgoal 8
	Aquatic and terrestrial invasive species are prevented and controlled
	
	Status
	• Downgraded to moving toward Mixed/ Deteriorating in 2008, possible deterioration
	• Mixed/Improving by 2010
	• Sustainable by 2020
		2002
		• Lake Michigan Mass Balance (LMMB) findings published
		• PCB levels in lake trout achieving equilibrium
		• U.S. EPA Atrazine Reassessment initiated
		• IADN results consistent with LMMB findings
		• Bush administration announced climate change and "Clear Skies" initiatives
		• 1999 Toxic Air Emissions inventory released
		• U.S. EPA published Air Great Lakes Deposition (GLAD) Strategy
		• PCB/mercury Clean Sweep in Cook County, IL
		• Wisconsin mercury regulations
		• States act to control animal operations
		• New aquatic nuisance species found in Lake Michigan
		• Michigan Ballast Water Bill
		• St. Lawrence Seaway Corporation to incorporate ballast water practices
		• Chicago River invasive species dispersal barrier installed
		• ANS Task Force and Great Lakes Panel on ANS continue work to control ANS
		2004
		• Corps funding secured for building permanent Asian Carp barrier on Chicago River system
		• Wisconsin begins mandatory rural NPS program
		• Michigan and Indiana add animal operation to permits
		• Milwaukee Metropolitan Sewerage District adopts mercury dental program.
		• Michigan proposes new NPDES permit for CAFOs
		• National Aquatic Invasive Species Act of 2003 passed.
		2006
		• Quagga Mussels Increasing in Number to Compete for Food with Native Mussels
		• Sound and Bubble Barrier Could Deter Asian Carp
		• PCB, Mercury and Nutrient findings from LMMB:
		• Forecasted PCB concentrations in lake trout may permit unlimited consumption as early as 2039 at Sturgeon Bay and 2044 at Saugatuck
		  • PCB trends indicate that concentrations are declining in all media
		  • Atmospheric deposition is the major current route of PCBs to the lake (from sources inside and outside the basin)
		  • Chicago urban area is a substantial atmospheric source of PCBs to Lake Michigan
		  • There is a dynamic interaction among water, sediments, and the atmosphere where large masses of PCBs from sediments cycle into and out of the lake via the atmosphere as vapor phase
		  • The current major source of mercury to the lake is from atmospheric deposition.
		  • Modeling results suggest that a significant amount of the existing mercury settling out of water is being recycled back into the system.
		  • Lake Michigan phosphorus loads and concentrations are low and below GLWQA and IJC targets
		  • Tributaries are the major source of phosphorus to Lake Michigan
		  • Highest concentrations can be observed in selected nearshore zones near tributary mouths and in Green Bay
		• Green Bay clean-up agreements announced
		2008
		• **Lake Michigan Mass Balance resampling results released showing reductions in calculated loads of PCBs and mercury**
		• **Draft GLRC mercury Product Stewardship phase-down strategy released**
		• **Great lakes basin program for soil erosion and sediment control reauthorized**
		• **New Grand Calumet River Great Lakes Legacy Act Project Agreement signed.**
		• **Michigan begins to apply AOC delisting document**
		• **St. Lawrence Seaway Corporation require all ships coming to the Great lakes from foreign waters must flush ballast tanks with sea water**
		• **20th anniversary of introduction of zebra mussels into the Great lakes see their numbers declining and invasive quagga mussels numbers increasing at rates higher than zebra mussels at their height**
		• **VHS virus found in all Great lakes**
		• **New ANS Mysidacea found in Lake Michigan**
		• **Chicago Sanitary and Ship Canal Electric Barrier fully funded**
		• **Black carp listed as an injurious species**
			• Impacts of climate change
			• Lack of comprehensive understanding of pollutant movement and remediation makes the goal of reaching sustainability by 2020 difficult
			• Impacts of increased global mercury emissions
			• Increasing monitoring of existing and emerging stressors on the lake
			• Need to set delisting targets for Areas of Concern and resources to implement cleanup actions
			• Conduct education and outreach on aquatic invasive species.
			• Eliminate ship and barge-mediated introductions and spread of AIS in the Great Lakes.
			• Enact federal, state, and/or local governments measures that ensure the region's canals and waterways are not a vector for AIS.
			• Take immediate steps at the federal and state government level to prevent the introduction and spread of AIS through the trade and potential release of live organisms.
			• Establish a Great Lakes Aquatic Invasive Species Integrated Management Program to implement rapid response, control, and management programs and assess the effectiveness of those programs.

Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2008	Next Steps
Information Sharing, Collaboration and Stewardship Actions that provide data access and exchange, facilitate involvement, and build capacity SOLEC Indicator Bundles •Contamination •Biotic Communities •Invasive Species •Coastal Zones •Aquatic Habitats •Human Health •Land Use/Land Cover •Resource Utilization •Climate Change	**Subgoal 9** Ecosystem stewardship activities are common and undertaken by public and private organizations in communities around the basin ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020 **Subgoal 10** Collaborative ecosystem management is the basis for decision-making in the Lake Michigan basin ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020	**2002** • Lake Michigan Forum developing Stewardship trust • State of Lake Michigan Conference held - November 2001 • Forum/Grand Valley State University "Making Lake Michigan Great Tour" continues to educate about Lake Michigan ecosystem during summer cruises • Great Lakes Strategy released in 2002 by U.S. EPA • Great Lakes Human Health Network established • Voluntary monitoring Conference March 2002 • Wingspread Accord signed • Participation by regional councils in watershed planning and water supply conferences **2004** • Watershed Academy training held and 6 regional conferences held or planned • Indiana Coastal Zone program gives out first grants • Illinois Conservation Congress recommends investigation of CZM participation • Great Lakes Cities Initiative launched • Illinois Ecosystem Partnership for Lake Michigan in development • Waukegan recognized as an EPA Environmental Justice community • Great Lakes restoration bill introduced into Congress • EPA utilizes watershed focus • Mona Lake Watershed Stewardship Assessment completed • Illinois-Indiana-Wisconsin planning agencies agree to consistent groundwater planning **2006** • President signs Executive Order organizing Great Lakes Regional Collaboration • Great Lakes Regional Collaboration sees participation by numerous organizations and releases report and recommendation in December 2005 • Regional planning agencies follow-up on Phase II Watershed Academy activities • Lake Michigan Forum performs watershed assessment for Baird Creek • NIRPC releases Water Conservation and Protection Toolkit • NIPC releases 2040 regional framework plan with tools for decisionmakers • Michigan and Indiana Cooperate in Developing the St. Joseph River Watershed Management Plan • Great Lakes governors and Premiers sign Great Lakes Charter Annex Implementation Agreements **2008** • **USEPA using watershed scale for implementation more frequently** • **Michigan builds "Clean Marina" program** • **USEPA and Forest Service sign agreement to restore water quality in national forests** • **Binational toxics Strategy under review** • **Great Lakes and St. Lawrence Mayors develop water conservation goals** • **Great lakes Water Quality Agreement under review**	• Develop projects utilizing the Lake Michigan LaMP watershed fact sheets, land use management tool box and exploration of other tools. • Provide additional education and outreach materials on water conservation and source water protection. • Continue the Lake Michigan Watershed Academy, support GIS and modeling workshops and obtain and provide small implementation grants to local communities. • Continue to build layers for the on-line habitat atlas. • Hold FY 2009 State of Lake Michigan Conference in Milwaukee, Wisconsin. • Continue the research vessel boat tour – Making Lake Michigan Great combined with outreach and teacher workshops. • Continue publication of the Lake Michigan Partnership Directory in each LaMP • Continue development and linkage of local watersheds with basin-wide issues and activities through the Watershed Academy and partnering with state programs • Coordinate LaMP and GLBTS efforts on PCBs and mercury • LMMCC continues leadership role for collaborative monitoring in 2010 • Coordinate with the four Coastal Management programs to explore partnership opportunities • Explore partnerships with key EPA volunteer programs like Climate Change, Clean Ports, Clean Marinas, and Pesticide Environmental Stewardship

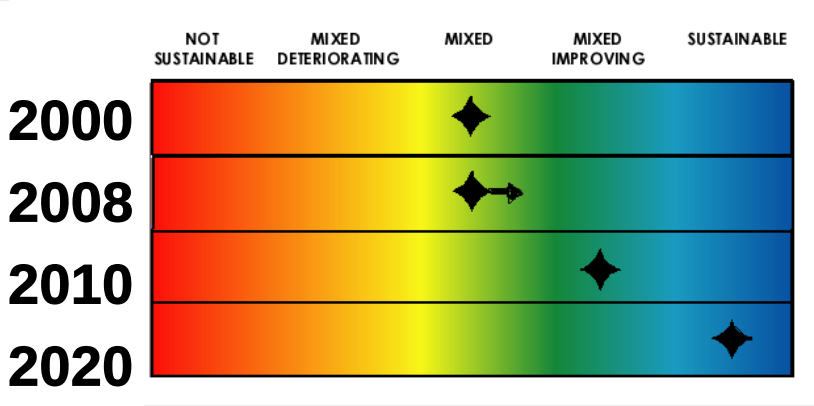
Strategic Action Agenda	Subgoals of the Lake Michigan LaMP	Significant Happenings 2000-2004	Next Steps
Research and Monitoring Actions that monitor the ecosystem, reduce uncertainty, and inform our decisions SOLEC Indicator Bundles ▪ Proposed new "Well-Being" bundle	**Subgoal 11** We have enough information/data/understanding/ indicators to inform the decision-making process ***Status*** • Mixed in 2008 • Mixed/Improving by 2010 • Sustainable by 2020	**2002** • LMMB project findings • Lake Michigan Monitoring Coordinating Council monitoring and assessment inventory • Lake Michigan Monitoring Assessment report released • Beach monitoring program (BEACH) created by U.S. EPA • BEC statement and monitoring conference • IJC/Delta Institute/Lake Michigan Forum Air Deposition Workshop • Great Lakes Wetlands Consortium consolidates wetland information • EPA/ORD wetlands indicators • LaMP pollutant list review • Beach Conference, web site, and manager's group **2004** • National Park Service monitoring begins • Lake Michigan Monitoring Council develops 2005 intensive monitoring year plan • Midwest Spatial Information Partnership formed - Workshop held in conjunction with Lake Michigan Watershed Academy • LMMB data sets available • Ann Arbor Statement on long-range atmospheric transport proposed **2006** • USGS maintains surface water-quality network for streams in the Lake Michigan basin • GLNPO's Aquatic Contaminant Monitoring program completes FY 05 Intensive Year of Monitoring • First collaborative Lake Michigan basin-wide FY 05 Year of Intensive Monitoring completed **2008** • **Lake Michigan serves as national groundwater monitoring pilot** • **EPA using new nearshore monitoring tool, the Traxus** • **GLNPO continues water quality surveys on the newly renamed "Peter L. Wise Lake Guardian"**	• Report on Lake Michigan nearshore and food web issues for Great Lakes Regional Research Information Network • Review monitoring and research to identify LaMP pollutants and trends to determine if LaMP pollutants list needs to be changed • Complete, analyze, and publish coordinated monitoring results for the lake intensive monitoring year 2005 • Ensure Lake Michigan models will be documented further, and additional scenarios simulated with results shared through the LaMP and in other ways • Assist coordination for the intensive year and the national coastal assessment year monitoring programs for 2010 • Use 2008 Lake Michigan Pilot funding, for sampling and analysis, to refine monitoring plans • Utilize FY05 and other monitoring data to aid in adaptive management review of LaMP Pollutant List (See page 11-2 and Appendix A for more information)

Subgoal 1
Can we all eat any fish?

What is our target for sustainability?

No lakewide fish consumption advisories. Possible local condition advisories may exist from time to time.

Lake Michigan Target Dates for Sustainability



Why is this important?

Fish are an important part of everyone's diet. In the 1970s steps were taken to ban, regulate, and clean up sources of toxic substances that had entered the aquatic food web. These actions resulted in marked reductions of toxins in the ambient environment and in fish tissue by the 1990s. Reductions have recently slowed which may be attributed to the impact of aquatic invasives on the food web. In addition, there are new or emerging contaminants such as pesticides, flame retardants, pharmaceuticals, and personal care products now found in our aquatic environment that may impact the food web and require monitoring programs to be developed.

What is the current status?

Overall, the status remains mixed, but FY 2005 monitoring shows a slight, but continued decline, in contaminant levels. While progress has been made, fish advisories for PCBs and mercury are still issued in all four Lake Michigan states. Advisories for chemicals other than PCBs and mercury have decreased over the last several years as the chemicals became less prevalent and their releases more controlled.

What are the major challenges?

- Climate Change: Intense storms may increase high flow runoff events carrying contaminants and sediment that adversely effect water quality.
- Dealing with the impacts of levels of mercury from local, national, and international sources.
- Eliminating use of remaining PCB equipment and remediating legacy PCB contamination in sediment deposits
- Informing people about important health protection information related to fish advisories through widely accessible, user friendly sources.
- Providing resources for action under the Great Lakes Legacy Act (GLLA).

What are the next steps?

- Develop an Impaired Waters Strategy
- Continue to address sediments and focus more on nearshore contamination
- Support a mercury product stewardship phase-down
- Hold collection events for e-waste and pharmaceuticals

What are some tools for addressing the challenges?

- **State Fish Consumption Advisories**
- **National Pretreatment Program**
- **Mercury Programs Database**
- **The Mercury Challenge**

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 114 - Contaminants in Young-of-the-Year Spottail Shiners
Status: Not Assessed, Trend: Not Assessed
Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Status: Mixed, Trend: Improving (for PCBs, banned organochlorine pesticides, dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)
Indicator # 118 - Toxic Chemical Concentrations in Offshore Waters
Status: Fair, Trend: Undetermined
Indicator # 119 - Concentrations of Contaminants in Sediment Cores
Status: Mixed, Trend: Improving/Undetermined
Indicator # 124 - External Anomaly Prevalence Index for Nearshore Fish
Lake Superior, Lake Huron, and Lake Michigan were unstudied for this indicator and were categorized with a not assessed status and an undetermined trend.
Indicator # 4177 - Biological Markers of Human Exposure to Persistent Chemicals
Status: Not Assessed, Trend: Undetermined
Indicator # 4201 - Contaminants in Sport Fish
Status: Mixed, Trend: Improving
Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed, Trend: Improving

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Fish Consumption Advisories

Consumers should know that fish and shellfish can be important parts of a healthy and balanced diet. They are good sources of high quality protein and other essential nutrients.

Women of child-bearing age, fetuses, and children are more susceptible to the effects of contaminants in fish. State fish consumption advisories include advice specifically targeted to these sensitive populations.

Fishing is one of the most popular forms of outdoor recreation in the Midwest, and Americans are eating more fish as diets shift toward more low-fat foods.

Over 43 percent of all Great Lakes fishing in the U.S. is done in Lake Michigan, and both commercial fishing and sport fishing are significant contributors to the economies of the states in the basin. Commercial fish production (both nontribal and tribal) reaches over 14.6 million pounds of fish annually. The commercial fishery is valued at more than $270 million and the recreational fishery at $4 billion.

Fish consumption, however, has been shown to be a major pathway of human as well as wildlife exposure to persistent toxic substances, such as polychlorinated biphenyls (PCBs) and mercury. Contaminants released from many sources are transported through the environment and are carried into streams and lakes. Small organisms absorb these contaminants and are, in turn, eaten by other organisms and small fish. Some of these contaminants bioaccumulate in the fish –and in humans who eat them – to levels that can pose health risks.

Great Lakes Fish Monitoring Program

The Great Lakes Fish Monitoring Program (GLFMP) began in 1980 as a cooperative effort by USEPA, U.S. Food and Drug Administration (no longer participating), U.S. Fish and Wildlife Service (now the Biological Resources Division of U.S. Geological Survey), and the eight Great Lakes States to monitor and better define the fish contaminant problem in the Great Lakes. The program consists of two separate elements to monitor contaminants in whole predator fish and in game fish fillets.

The GLFMP currently collects samples, for both elements of the program, from a set number of sites per lake. Collections alternate on a yearly basis, with even and odd year collections. Element 1 samples consist of 5 whole fish composites for a total of 50 fish collected per site. Element 2 samples consist of 5 skin-on fillets for a total of 15 fish collected per site. All samples are provided to analytical laboratory (currently a university grantee) as approximately 10 grams of frozen homogenate. The GLFMP currently utilizes an established chemical parameter list for analysis, though in recent years emerging contaminants of concern, such as polybrominated diphenyl ethers (PBDEs) and perfluorinated compounds (PFOS, PFOA), have been added.

More information is available at: www.epa.gov/glnpo/glindicators/fish.html

State fish consumption advisories are issued to protect people from potential adverse health effects associated with contaminants found in fish. These advisories recommend amounts and types of fish that are not safe to eat. Fish consumption advisories may also include information to educate the public on how to minimize exposure to certain contaminants through proper fish preparation and cooking. The advisories are viewed as a temporary measure to

The Lake Michigan Toolbox
State Fish Consumption Advisories

Illinois: www.idph.state.il.us/envhealth/factsheets/fishadv.htm
Indiana: www.in.gov/isdh/programs/environmental/fa_links.htm
Michigan: www.michigan.gov/mdch/0,1607,7-132--13110--,00.html
Wisconsin: dhfs.wisconsin.gov/eh/fish/

A consolidated source for Great Lakes fish consumption advisories as well as information on other standards applicable to the lakes is available on a Great Lakes Information Network site:
www.great-lakes.net/envt/flora-fauna/wildlife/fishadv.html

Sport Fish Advisory Example
Illinois Lake Michigan Fish Advisory

Cook and Lake Counties (Illinois)

Species and Meal Frequency

Chinook Salmon

All Waters
Less than 32"
1 meal/month
- or -
Larger than 36"
6 meals/year
Contaminant - **PCBs**

Coho Salmon

All Waters
All Sizes
1 meal/month
Contaminant - **PCBs**

Rainbow Trout

All Waters
Less than 22"
1 meal/week
-or-
Larger than 22"
1 meal/month
Contaminant - **PCBs**

Brown Trout

All Waters
Less than 22"
1 meal/month
- or -
Larger than 25"
6 meals/year
Contaminant - **PCBs**

Channel Catfish

All Waters
All Sizes
Do Not Eat
Contaminant - **PCBs**

Lake Trout

All Waters
Less than 23"
1 meal/month
- or -
23" to 27"
6 meals/year
- or -
Larger than 27"
Do Not Eat
Contaminant - **PCBs**

Yellow Perch

All Waters
All Sizes
1 meal/week
Contaminant - **PCBs**

Carp

All Waters
All Sizes
Do Not Eat
Contaminant - **PCBs**

Figure 1-2. Illinois Lake Michigan Fish Advisory
Source: www.idph.state.il.us/envhealth/factsheets/fishadv.htm

protect the public while control measures and site cleanups reduce contamination to safe levels.

PCBs are the primary contaminant behind the fish consumption advisories published by all four Lake Michigan states. Mercury advisories are also issued by each Lake Michigan state for fish of inland lakes and some select Lake Michigan sites. As a rule, mercury is the dominant contaminant behind fish consumption advice from inland lakes due to atmospheric deposition and the lack of elimination of water through streams and or rivers. Dioxins, chlordane, DDT, and many other contaminants are also present in fish but are not in high enough quantity to warrant advice beyond PCB levels.

States frequently use fish consumption advisories (See opposite page) as indicators of whether their waters are meeting requirements for designated uses. If a fish consumption advisory is issued, this triggers the need for a state to investigate and set a total maximum daily load (TMDL) for contaminants. TMDLs for PCB and mercury are currently required for Lake Michigan. The fish consumption advisories are updated annually and updates are published on state fish consumption advisory web pages. Locations of specific required TMDLs related to fish advisories are listed in the watershed fact sheets (See Chapter 12).

Process by which USEPA evaluates Chemicals for Human Risk

USEPA utilizes the Integrated Risk Information System (IRIS) to evaluate the health effects of individual substances. IRIS provides hazard identification and dose-response assessment information. The information in IRIS can be used in combination with exposure information to characterize the public health risks of a given substance in a given situation. These risk characterizations can form the basis for risk-based decision-making, regulatory activities, and other risk management decisions designed to characterize and protect public health.

EPA's process for developing IRIS assessments consists of: (1) an annual Federal Register announcement of EPA's IRIS agenda and call for scientific information from the public on the selected substances, (2) a search of the current literature, (3) development of a draft Toxicological Review (other support document) and IRIS Summary, (4) internal peer consultation, (5) Agency Review, (6) Interagency Review, (7) external peer review and public comment, (8) final Agency Review, Interagency Review and ORD management approval, and (9) posting on the IRIS database.

For more information on the chemicals currently being evaluated by IRIS go to http://cfpub.epa.gov/ncea/iris/index.cfm.

Sources of Exposure of PBDEs

Although use of flame retardants saves lives and property, there have been unintended consequences. There is growing evidence that Polybrominated Diphenyl Ethers (PBDEs) persist in the environment and accumulate in living organisms, as well as toxicological testing that indicates these chemicals may cause liver toxicity, thyroid toxicity, and neurodevelopmental toxicity. Environmental monitoring programs in Europe, Asia, North America, and the Arctic have found traces of several PBDEs in human breast milk, fish, aquatic birds, and elsewhere in the environment. Particular congeners, tetra- to hexabrominated diphenyl ethers, are the forms most frequently detected in wildlife and humans.

The mechanisms or pathways through which PBDEs get into the environment and humans are not known yet, but could include releases from manufacturing or processing of the chemicals into products like plastics or textiles, aging and wear of the end consumer products, and direct exposure during use (e.g., from furniture). Some research has evaluated PBDE levels

The Lake Michigan Toolbox
Mercury Programs Database

The Mercury Reduction Programs Database was developed and maintained by Region 1 and 2's Northeast Waste Management Officials' Association (NEWMOA) with support and assistance from the Environmental Council of the States (ECOS) and the Pollution Prevention Resource Exchange (P2Rx).

The database can be searched by program, state, and agency to find out what mercury reduction programs are taking place nationally. Programs can also be added by organizations.

More information is available at:
www.p2rx.org/Networking/MercuryDB.cfm

Auto Mercury-Recovery Programs Up and Running in All 50 States

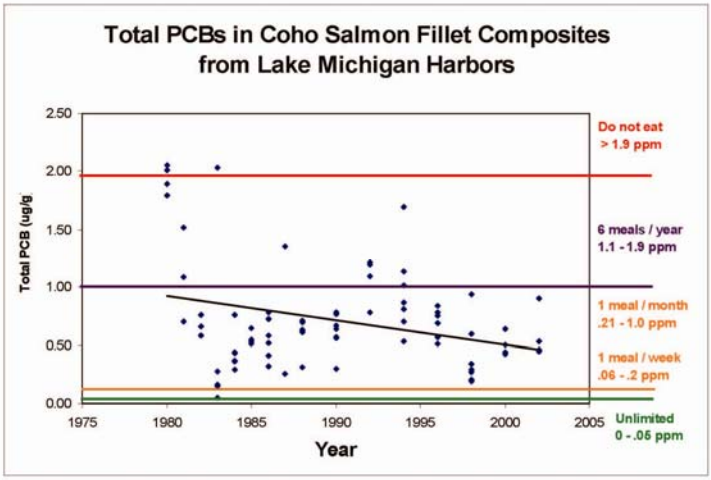
EPA and eight organizations—representing states, nongovernmental organizations, steelmakers, vehicle manufacturers, automobile recyclers, and scrap metal recyclers—launched a program in August 2006 to recover mercury containing light switches from end-of-life vehicles manufactured prior to 2002 before they are dismantled, crushed, shredded, and melted to make new steel.

In its first year where all 50 states are participating in auto mercury-recovery programs, more than 635,000 mercury-based switches were removed from vehicles about to be scrapped. This represents 1,400 pounds of mercury which is more than the average coal-fired power plant emits in a year. The Mercury Switch Removal Program has the potential to recover 80 to 90 percent of available mercury switches, leading to commensurate reductions in air emissions.

A second goal for the first year--developing a way to measure overall progress in the program in future years--has also been achieved. Progress will be measured by determining the percentage of switches that are recovered each year compared to the number of available end-of-life autos from which switches can be recovered.

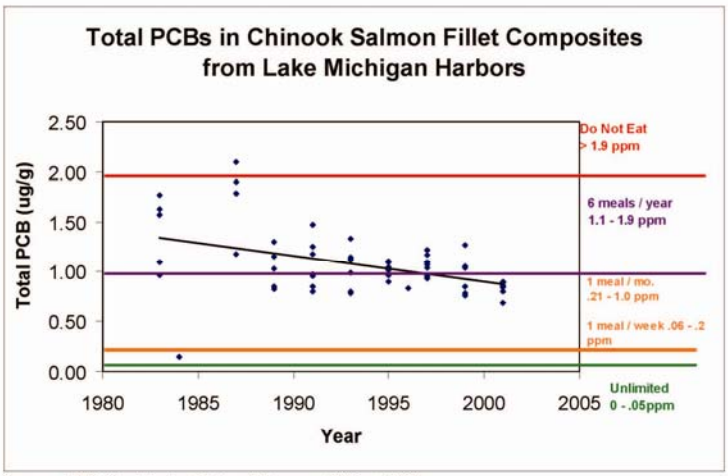
Approximately 5,900 automobile recyclers have already agreed to remove and recover the switches before sending vehicles to scrap recyclers, who in turn send the clean cars to steel mills. The mills can then use the cars to make recycled steel without worrying about releasing toxic mercury emissions.

More information is available at:
www.epa.gov/mercury/switch.htm



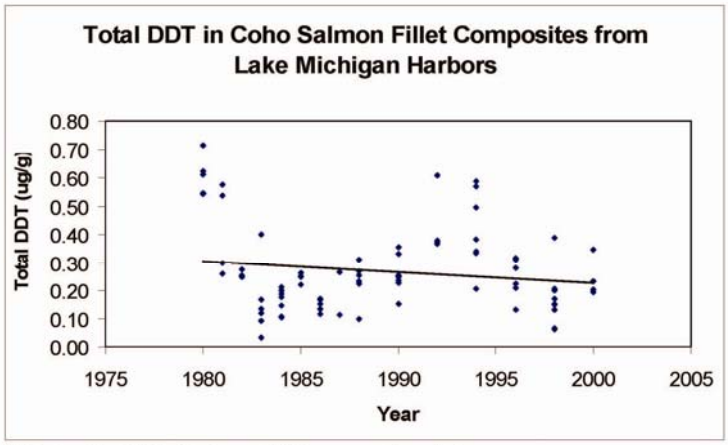
Source: EPA Great Lakes National Program Office, 2008.

Figure 1-1 Total PCBs in Coho Salmon Fillet Composites from Lake Michigan Harbors



Source: EPA Great Lakes National Program Office, 2008.

Figure 1-2 Total PCBs in Chinook Salmon Fillet Composites from Lake Michigan Harbors



No Protocol for DDT exists for sport fish to consumption advice.

Source: EPA Great Lakes National Program Office, 2008.

Figure 1-3 Total DDT in Coho Salmon Fillet Composites from Lake Michigan Harbors

Fish Contaminant Trends

The 6 adjoining diagrams represent general contaminant trends in Great Lake Sport fish. These data were collected by the Great Lakes National Program Office (GLNPO) under the fish monitoring program. This program annually collects and composites 15 salmon filets into three composites in the small, medium, and large size categories from a variety of sites from each of the Great Lakes. Data shown in the graphs above reflect the changing nature of the Sport Fish Fillet Monitoring piece of the fish monitoring program. Sites have been continuously added and removed over the life of the program and samples themselves have varied from year to year according to collection, location, size etc. For that reason, only general trends can be gathered from this data.

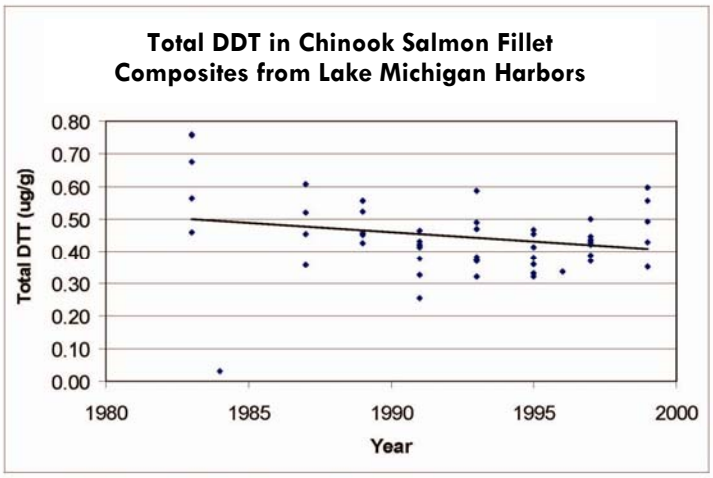
In general, concentrations of select Persistent Bioaccumulative Toxic (PBT) chemicals in Lake Michigan Coho and Chinook Salmon fillets are declining, although very slowly. Without remediation of contaminated sediments or restriction of contaminated atmospheric deposition, tissue concentrations will continue to warrant fish consumption advisories. It is important to note that U.S. EPA does not issue fish consumption advice, the Great Lakes States and Tribes are responsible for this task. However, concentrations of GLFMP sportfish can be compared to the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory categories (see figure 1-7).

Current concentrations of total PCBs in Lake Michigan coho and chinook salmon fillets range between the one meal per week and the one meal per month consumption advice categories (see figures 1-1 & 1-2). Total PCBs are a summation of all PCB congeners analyzed.

No DDT protocols exist to compare Lake Michigan coho and chinook salmon fillets concentrations to consumption advice categories (see figures 1-3 & 1-4).

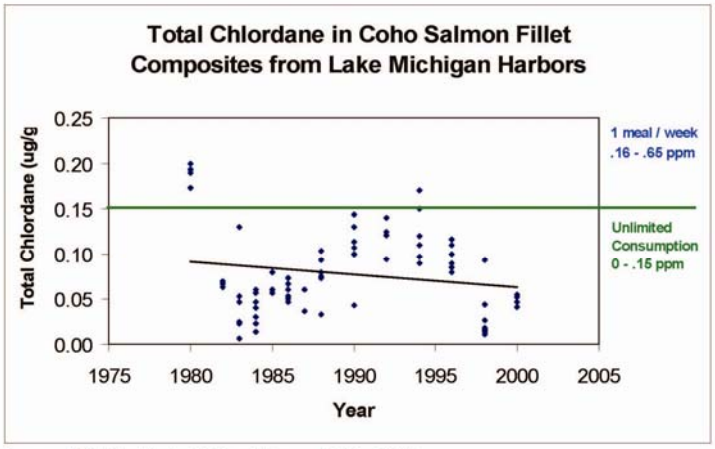
Current concentrations of Total Chlordane in Lake Michigan coho and chinook salmon fillets fall into the unlimited consumption category of the draft chlordane addendum to the protocol (see figures 1-5 & 1-6). Total chlordane is a summation of cis and trans chlordane, cis and trans nonachlor, and oxychlordane.

More information is available at the following:
PCB Protocol - http://fn.cfs.purdue.edu/anglingindiana/HealthRisks/TaskForce.pdf
Hg Protocol - http://dhfs.wisconsin.gov/eh/Fish/FishFS/2007Hg_Add_Final_05_07.pdf



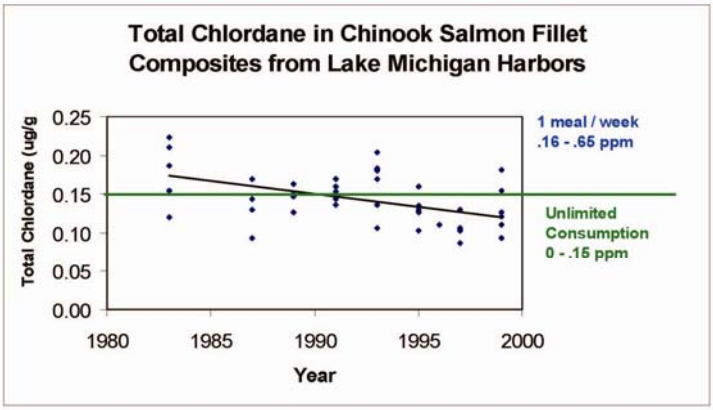
Source: EPA Great Lakes National Program Office, 2008.

Figure 1-4 Total DDT in Chinook Salmon Fillet Composites from Lake Michigan Harbors



Source: EPA Great Lakes National Program Office, 2008.

Figure 1-5 Total Chlrodane in Coho Salmon Fillet Composites from Lake Michigan Harbors



Source: EPA Great Lakes National Program Office, 2008.

Figure 1-6 Total Chlrodane in Chinook Salmon Fillet Composites from Lake Michigan Harbors

Consumption limits for sensitive populations created for the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory**

Consumption Advice Groups*	Concentration of PCBs (ppm)	Concentration of Hg (ppm)*	Concentration of Chlordane (ppm)**
Unrestricted Consumption	0 – 0.05	0 <= 0.05	0 - 0.15
2 meals/ week		> 0.05 <= 0.11	
1 meal/ week	0.06 – 0.2	>0.11 <= 0.22	0.16 - 0.65
1 meal/ month	0.21 – 1.0	>.22 <= 0.95	0.66 - 2.82
6 meals/ year	1.1 – 1.9		2.82 - 5.62
Do not eat	>1.9	>0.95	>5.62

Women of childbearing age and children under 15
**Chlordane protocols is draft
Source: Great Lakes Sport Fish Advisory Task force. http://fn.cfs.purdue.edu/anglingindiana/HealthRisks/TaskForce.pdf

Figure 1-7. Consumption Limits for Sensitive Populations Created for the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory

The Lake Michigan Toolbox
The Mercury Challenge

The National Partnership for Environmental Priorities' (NPEP) Mercury Challenge promotes the voluntary, systematic elimination of mercury-containing equipment from industrial sites. Mercury is a highly toxic chemical designated as one of 31 priority chemicals that USEPA wants to reduce in our nation's products and wastes. Mercury is a documented contaminant of air, land, water, plants, and animals, and exposure to mercury can cause serious health problems.

More information on mercury resources is available at the following sites:

- USEPA's mercury program at: www.epa.gov/mercury/
- The Take the Mercury Challenge program at: www.epa.gov/npep/mercchal/mc_join.htm#take
- "Building a Mercury Reduction Plan" www.epa.gov/epaoswer/hazwaste/minimize/npep/mercchal/mc_redplan.htm
- Mercury-Free Success Stories: www.epa.gov/epaoswer/hazwaste/minimize/npep/mercchal/mc_success.htm
- "Mercury: Serious Problem, Practical Solutions" Brochure at: www.epa.gov/npep/mercchal/mercbrchr.pdf

in market basket foods. This research suggests that dietary exposure does not account for high body burden that have been observed in people. Dust and air from the indoor environment may play a role in PBDE body burden levels in addition to food.

More information is available at: http://www.epa.gov/oppt/pbde/

Source: Schecter A, Päpke O, Harris TR, Tung KC, Musumba A , Olson J, and Birnbaum L. 2006. Polybrominated Diphenyl Ether (PBDE) Levels in an Expanded Market Basket Survey of U.S. Food and Estimated PBDE Dietary Intake by Age and Sex Environmental Health Perspectives Volume 114, Number 10.

Is there a Human Health Risk?

VHS. Viral hemorrhagic septicemia (VHS) virus is a serious fresh and saltwater fish pathogen that is increasingly observed in the Great Lakes region of the United States and Canada. VHS virus is a rhabdovirus that affects fish of all size and age ranges. It does not pose any threat to human health because it is not a human pathogen. Therefore, it cannot infect humans if they eat fish with the pathogen.

More information is available at: http://www.dec.ny.gov/animals/25328.html and http://www.aphis.usda.gov/publications/animal_health/content/printable_version/sa_vhsfo_vs.pdf

Botulism. Type E botulism poisoning of fish and wildlife has recently increased in the Great Lakes with the most recent example in Michigan near the Sleeping Bear Dunes National Lakeshore where shore birds died from eating contaminated fish. Many people are concerned not only of the ecological impacts of this type botulism but also of the human health impacts.

In the past, a few Type E botulism cases have been reported in humans. However, this was due to improperly prepared smoked or cooked fish and these cases were rare. Most media reports of botulism issues in humans are from Type A and B botulism. These types of botulism occur in food as a result improperly canned or jarred food. Cooking food to proper temperatures will destroy bacteria, including botulism.

When fishing or hunting water fowl in the Great Lakes, take steps to choose healthy fish and discard fish or waterfowl that are sick or act abnormally because improper cooking may not destroy the botulism Type E toxin.

Collaborative Lake Michigan Strategy to Address Impaired Waters

The purpose of this strategy is reduce and virtually phase out impairments caused by contaminants such as mercury, PCBs, and certain banned pesticides that have resulted in fish consumption advisories, into the Lake Michigan ecosystem.

The Lake Michigan Toolbox
National Pretreatment Program

USEPA Region 5 developed a pretreatment program for the NPDES Permit Pollutant Minimization Program (PMP) for Mercury.

The new National Pretreatment Program controls and minimizes the loading of pollutants to publicly owned treatment works from industrial, non-domestic sources to protect against operational, water quality, biosolids quality, and worker health and safety problems. The goal is to aid in meeting the Great Lakes Initiative water quality standards the states adopted for mercury in permits. Tools and fact sheets on wastewater pretreatment are also available on the website.

More information is available at the Pretreatment Website at:
www.epa.gov/r5water/npdestek/npdprta.htm.

The states have primary responsibility for preparing Total Maximum Daily Loads (TMDL) for impaired water bodies and USEPA agrees to provide resources, technical assistance, and facilitation to support the states' TMDL development efforts on interstate waters like the Great Lakes. Furthermore, recent changes to USEPA 303(d) list guidance allow the states to address impaired waters that are being remediated by other means in a manner that could delay or possibly eliminate the need for TMDL development.

A strategy to address the impaired waters of Lake Michigan will take time to develop and implement and needs to provide opportunities for the parties to work collaboratively towards air quality reductions in mercury that lead to perceptible reductions in state waters and related fish tissues. This raises the question of what a strategy to address the impaired waters of Lake Michigan should be? Any strategy will take time to develop and implement. It should provide opportunities for the parties to work collaboratively and avoid duplication of effort. Such a strategy would be useful to divide the development and possible products from the discussion into stages aligned with the LaMP publications from 2006 through 2010. The stages could include activities and milestones tracked over time to ensure that progress is being made to remediate Lake Michigan. Any strategy would need to be reviewed and mid-course changes considered at each two year interval. If sufficient progress is not made by 2010, work on standard TMDLs for Lake Michigan would need to begin and be completed by 2013 per the current 303(d) schedule and USEPA regulation.

To implement this approach, the following activities should be conducted over the next two years:

- Continue discussion of the Strategy concept in LaMP 2008.
- Finalize the 2005 Intensive Lake Michigan Monitoring Plan and GLNPO Open Lake Organics monitoring with Lake Michigan Mass Balance models.
- Develop and share matrix of successful state programs.
- If developed, publish the Strategy in LaMP 2010.

The Lake Michigan LaMP 2000, Appendix E, provided an overview of issues and information needs for a full TMDL Strategy for Lake Michigan. LaMP 2002 and 2004 summarized the dialogue and meetings since LaMP 2000 and provided an early draft of a Mercury Phase Out Proposal and also provided data from the Lake Michigan Mass Balance Study and Enhanced Tributary Monitoring Project.

Status of Mercury TMDLs in the Basin

Based on state submittals of the 2004 303(d) impaired waters lists, there are 217 waters in the Lake Michigan basin listed as impaired for mercury. The 217 impaired waters are located in the Lake Michigan states of Illinois (2), Indiana (81), Michigan (88), and Wisconsin (46). With every 303(d) list submittal, states are required to identify waters targeted for TMDLs in the next two years. In 2004, the Lake Michigan states did not include any mercury-impaired waters on their two-year schedule for TMDL development. However, Michigan did submit a long-term TMDL development schedule that included development of mercury TMDLs beginning in 2011.

There are efforts underway by states outside of the Lake Michigan Basin to address waters impaired by atmospheric mercury. Minnesota recently developed a statewide TMDL for mercury-impaired waters. The TMDL addresses 512 TMDLs across the state, excluding Lake Superior.

In 2007, EPA Region 1 approved a regional mercury TMDL for the seven-state Northeast Region. The regional TMDL outlines a strategy for reducing fish

tissue mercury concentrations using smallmouth bass as the target fish. The current 90th percentile mercury concentration in smallmouth bass in the Region is 1.14 ppm. To meet a target fish tissue concentration of 0.3 ppm, the TMDL calls for a mercury load reduction of 2,055 kg/yr in the Region and a reduction of 2,738 from out-of-Region sources for a total load reduction of 98.2%. The reductions will be achieved through a variety of point, nonpoint, and air emission controls.

Sources of Mercury

Air deposition is the dominant mercury pathway for most water bodies. Sources of mercury in the atmosphere are divided roughly at 1/3 natural, 1/3 from past human activity, and 1/3 from current human activity around the world. The current human activity in the U.S. Mercury emissions are shown in Figure 1-8 (See preceding page).

The Great Lakes Regional Collaboration (GLRC) is one potential vehicle for developing a basin-wide mercury product stewardship strategy and basin-wide mercury phase-down program, including a mercury waste management component. The states and the tribes are putting together a workgroup to develop a common strategy.

In February 2008, the Michigan Department of Environmental Quality (MDEQ) released a comprehensive strategy to eliminate the use and release of mercury to Michigan's environment. The DEQ's Mercury Strategy Staff Report contains specific recommendations and a comprehensive approach to controlling mercury, including environmental monitoring, inventory development, collaborations and partnerships, education and outreach, and regulatory controls. It also provides an overview of the mercury problem, identifies current sources that contribute to mercury releases, and identifies various methods for reducing and eliminating the sources. It outlines Michigan's rules, regulations, policies, and monitoring activities for mercury and chronicles various actions undertaken thus far to prevent the use and release of mercury. More information is available at www.michigan.gov/deq/0,1607,7-135--184041--,00.html

Sources of Other Pollutants

See Chapter 7 for a detailed discussion.

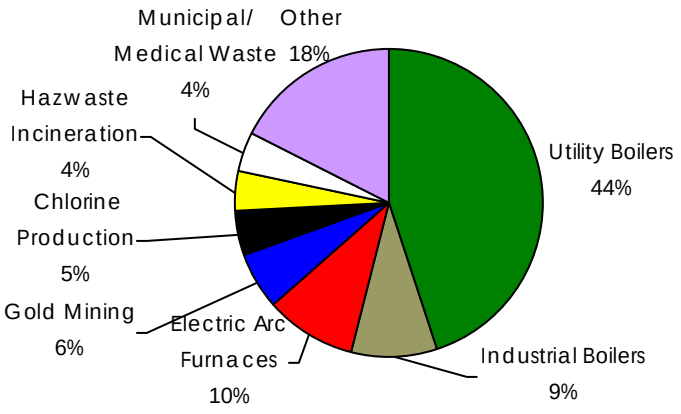


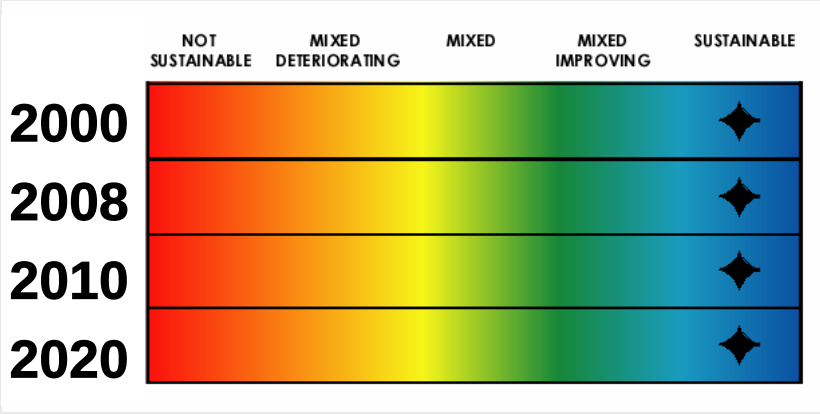
Figure 1-8: USEPA, 2002 National Emissions Inventory

Subgoal 2
Can we drink the water?

What is our target for sustainability?

A treated water supply that meets all Federal drinking water quality standards.

Lake Michigan Target Dates for Sustainability



Why is this important?

The Safe Drinking Water Act provides federal standards and regulations for water supplies. Lake Michigan water quality is overwhelmingly good. Although there have been past local problems that did cause illness, current concerns are the need to monitor for emerging contaminants and depletion of ground water that serves as both a drinking water source and also replenishes Lake Michigan.

What is the current status?

Drinking water quality for municipal systems using Lake Michigan water resources is of good quality. Supplied water is also generally of high quality.

What are the major challenges?

- Climate Change: Energy consumption by water treatment facilities is significant and water quality impacted due to intense storms, runoff, and temperatures promoting pathogen growth as well as emerging water quality concerns
- Aging water treatment infrastructure, operations, and maintenance plans
- Improving public education on protection and conservation of water sources
- Slow pace of implementing of source water protection plans
- Managing impacts of urban and agricultural nonpoint source runoff
- Monitoring for existing and emerging contaminants
- Educating the public on the hydrological cycle and the need for stewardship of both drinking water quantity and quality

What are the next steps?

- Work with new WaterSense label and Energy Star program to promote benchmarking energy performance of water utilities
- Continue Watershed Academy to ensure land use and planning take account of source water issues protection needs
- Seek funding to develop a source water protection GIS system including recharge areas
- Enhance local public water supply security awareness
- Identify resources for public water suppliers to ensure that by 2011 80% of the community water systems will be substantially implementing source water protection plans
- Identify opportunities to work with the Great Lakes and St. Lawrence Cities Initiative conservation framework of 15% reduction from 2000 to 2015

What are some tools for addressing the challenges?

- IL-IN Sea Grant Unwanted Medicine Disposal Community Tool Kit
- Water Security Resources
- USEPA Pollution Prevention Technical Assistance
- Drinking Water Academy
- Water Efficiency Resources

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Great Lakes: Status: Mixed, Trend: Improving (for PCBs, banned organochlorine pesticides, dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)
Indicator # 118 - Toxic Chemical Concentrations in Offshore Waters
Lake Michigan: Status: Fair, Trend: Undetermined
Indicator # 4175 - Drinking Water Quality
Great Lakes: Status: Good, Trend: Unchanging

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

The original 1998 Lake Michigan Lakewide Management Plan goal referred to water quality. Recent concerns about quantity are discussed in Chapter 6. Both quantity and quality factor into "sustainability."

Background

Drinking Water Contaminants

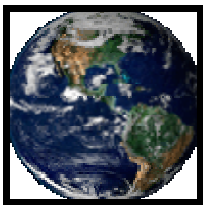
The waters of Lake Michigan and surrounding areas are a primary source of drinking water for 10 million people who live in the basin. The Lake Michigan states currently are delegated to run their own drinking water programs. Since LaMP 2000 the issue of ground water depletion has been growing in importance with implications for drinking water sources and habitat (see Chapter 6 for more information on ground water).

In addition, there is a growing concern over pharmaceuticals in source water. The first national reconnaissance was completed by USGS in 2000. The study found a wide range of contaminants, but at low levels. Many compounds, however, do not have established guidelines thereby demonstrating the need for both monitoring and research.

Various contaminants can adversely impact drinking water, including microorganisms (e.g., bacteria, viruses, and protozoa such as cryptosporidium), chemical contaminants (including naturally occurring compounds and anthropogenic or synthetic chemicals), and radiological contaminants (including naturally occurring inorganic and radioactive materials and metals). Some contaminants in raw (untreated) water supplies, such as aluminum, arsenic, copper, and lead, can be both naturally occurring and the result of human activities. Other contaminants, such as household chemicals, industrial products, urban storm water runoff, fertilizers, human and animal waste, nitrate (from fertilizers and sewage), and pesticides, may also end up in raw water supplies (EPA, 1999a; Health Canada, 1998).

Certain contaminants pose a concern when present in drinking water because of possible health consequences associated with these substances. These contaminants may be in raw water as a result of industrial and agricultural activities or treated wastewater discharges (Minnesota Pollution Control Agency, 1997). Some may also be present in treated water as a result of chemicals used in the drinking water treatment process (Health Canada, 1998). The impact of contaminants is diluted in a large water body like Lake Michigan but could be more serious in a groundwater source.

Great Lakes 2008 Earth Day Challenge



For Earth Day 2008, US EPA challenges residents and communities around the Great Lakes to collect and recycle electronic waste and to properly dispose of unwanted medicines.

e-Waste

Electronic waste includes all those old or broken TVs, cell phones, computer components and similar gadgets that are part of our lives. E-waste contains possibly hazardous materials that can harm human health and the Great Lakes environment if disposed of improperly. In 2005 we discarded an estimated 2 million tons of TVs, computers and other electronic gear. Proper disposal and recycling are necessary to avoid unwanted pollution. When we reuse or recycle e-waste properly, we recover materials for re-use, save energy and reduce the environmental costs of raw material extraction and processing.

Medicines

Traces of medicines have been found in streams and the Great Lakes where we get our drinking water and have also been detected near wastewater treatment outflows. Some of these medicines can lead to reproductive and developmental problems in fish and other animals. We often treat leftover medicine as a common household waste. More than half of people surveyed throw their unused medicines in the trash while a third flush them down the drain. In both cases, the medicines have the potential to be released into our rivers and lakes.

The Challenge

U.S. EPA issued an Earth Day Challenge to residents, businesses and community organizations throughout the Great Lakes basin to plan or participate in collection events of e-waste or unwanted medicines during Earth Week April 19 – 27. Across the Great Lakes region, communities are stepping up, signing on to the challenge and adding their collection and take-back events to the efforts of thousands. This is a chance to see how much we can accomplish together. The Challenge is to collect a million pounds of e-waste for proper management and a million pills of unwanted medicines for responsible disposal during Earth Week.

More information is available at http://www.epa.gov/greatlakes/earthday2008/links.html

In general, drinking water provided by public water suppliers is likely to remain of good quality because of the multiple pollutant barrier approach being implemented across the basin. Not only are treatment systems and operating practices continually improving, but increased monitoring is also providing more information about source water supplies and the need for source water protection. In the past two years, greater emphasis has been placed on protecting raw sources of drinking water. Both the source water assessments that were completed for public water supplies and recent data collected from 22 sites around the Great Lakes are providing more information about raw water supplies.

The Importance of Groundwater

The Lake Michigan basin has had the luxury of sufficient water of good quality. The basin has seen a significant population expansion. However, many communities reliant on groundwater are facing both quality and quantity problems. Further, climate change is likely to add pressure to a system that is already stressed.

Seventy-nine percent of the Lake Michigan annual recharge comes either directly or indirectly from ground water. As such, being stewards of Lake Michigan requires being stewards of the ground water as well.

Drinking Water Monitoring and Reporting

Continuing efforts must be made to inform health professionals and the public of the results of analyses of drinking water. USEPA requires that public water supplies be monitored for bacteriological, inorganic, organic, and radiological contaminants. The analyses of drinking water include tests for the physical and chemical characteristics of the water as well as for contaminants from natural sources or human activities. In addition, the USEPA Office of Groundwater and Drinking Water (OGWDW) web site at www.epa.gov/OGWDW/ provides detailed information on the nation's drinking water, including drinking water and health information, drinking water standards, and local drinking water information. Community water suppliers deliver high-quality drinking water to millions of people every day, and a network of government agencies is in place to ensure the safety of public drinking water supplies.

Water Infrastructure Security

Under both the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA), USEPA works closely with partner organizations -- other government agencies and water utilities and associations (both drinking water and wastewater) -- to ensure clean and safe water. Industry and government are also working cooperatively to improve drinking water and wastewater security. Building on and supporting long-established relationships with its partners, USEPA helps the water sector to: (1) understand and utilize the best scientific information and technologies for water security; (2) support assessment of utility vulnerabilities to possible attack; (3) take action to improve security; and (4) respond effectively and efficiently in the event that an incident occurs. This commitment is outlined in USEPA's Strategic Plan for Homeland Security.

A number of actions are underway to support development of tools, training, and technical assistance for small and medium drinking water and wastewater utilities, and actions are being taken to promote information sharing and research on water security (See the Lake Michigan Toolbox on preceding page).

The Public Health Security and Bioterrorism Preparedness and Response Act of 2002 has drinking water utilities facing new responsibilities. While their mission has always been to deliver a dependable and safe supply of water to their customers, the challenges inherent in achieving that mission have expanded to include security and counter-terrorism. In the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, Congress recognizes the need for drinking water systems to undertake a more comprehensive view of water safety and security.

Drinking Water Security in the Lake Michigan Basin

All Community Water Systems in the Lake Michigan Basin have submitted their Vulnerability Assessments as required by the "Public Health Security and Bioterrorism Preparedness and Response Act of 2002". The current focus of drinking water security efforts is to integrate drinking water security into the everyday culture at all levels – local, state, and federal. The National Drinking Water Advisory Council (NDWAC)

Partnership Investigates Pharmaceuticals and Personal Care Products (PPCP)

Increasing evidence indicates widespread occurrence of PPCP compounds in surface water, sediments, and municipal effluent, but data on the accumulation of PPCP compounds in fish tissue are scarce. US EPA Office of Science and Technology within EPA's Office of Water responded to this agency priority and addressed this data gap through the initiation of a pilot study. The purpose of the study is to investigate the occurrence of PPCP chemicals in fish tissue called the National Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue. It will determine the concentrations of 34 PPCPs in composited fish fillets and liver samples from five effluent dominated stream sites, plus one reference site where waters are not impact dominated by waste water treatment plant effluents. A supplemental study on the North Shore Channel of the Chicago River was added to the Pilot Study through collaboration with GLNPO. Both studies concluded in March 2007.

This comprehensive and exploratory study was created through a collaborative process involving all partners and organized by GLNPO. Because of the collaborative nature of the project, a large amount of work was completed for minimal funding. The collaboration on this project allowed EPA to gain much greater insight into the presence, trends, and ecological significance of PPCPs, hormones, and Alkylphenol. Ethoxylates (APEs) in an effluent-dominated stream. Without the collaboration, EPA would have only been able to estimate concentrations of a small set of PPCPs in fish tissue.

This strong partnership has allowed the project team to leverage resources, gain access to facilities and locations using the resources of all participating organizations, and provide technical support across among federal government, academia, state government, and the local wastewater treatment agency towards a common goal. This partnership is also showing its lasting strength through its use on similar projects in the region.

The supplemental study on the North Shore Channel is a collaborative partnership between GLNPO, Region 5, the Chicago Regional Laboratory (CRL), the Office of Water, the Office of Research and Development (ORD), United States Geological Survey (USGS), United States Department of Agriculture (USDA), Saint Cloud State University, Clarkson University, Baylor University, the Illinois Department of Natural Resources (ILDNR), and the Metropolitan Water Reclamation District of Greater Chicago (District). The four main objectives of the supplemental study support the Agency's strategic Goal 4 to protect healthy ecosytems with the subobjective to improve the health of the Great Lakes ecosystems in addition to addressing Goal 2, clean and safe water. The main objectives of the study are to: (1) determine if there is reproductive impairment to resident fish; (2) estimate whole fish and fillet concentrations of PPCPs, APEs, and hormones; (3) estimate effluent and stream concentrations of PPCPs, APEs, and hormones; and (4) document seasonal differences in concentrations of these compounds in effluent, stream, and fish.

The project's preliminary results indicate mild affects on aquatic life and a need for development of new sampling and analyses by monitoring agencies, additional research by academia, and strengthened relationships between participating partners.

The Lake Michigan Toolbox

Illinois-Indiana Sea Grant Unwanted Medicine Disposal Community Tool Kit

With funding from US EPA GLNPO, Illinois-Indiana Sea Grant created the toolkit Disposal of Unwanted Medicines: A Resource for Action in Your Community http://www.iisgcp.org/unwantedmeds/. This collection of resources is intended for waste management officials and others who are interested in addressing the problem of unwanted medicines in the environment. A panel of expert reviewers, including solid waste managers, pharmaceutical and personal care product researchers, pharmacists, doctors, and communication specialists, reviewed this resource kit and their comments and suggestions were incorporated into the final version.

Illinois-Indiana Sea Grant focuses on collection events for the public as a partial solution to the problem on unwanted medicines on the environment. To assist event organizers, the kit provides a set of case studies and sample educational materials along with the Northeast Recycling Council's step-by-step advice for running a collection. Background information on the science behind the issue and a bibliography of news stories and articles from scientific journals are also featured. Illinois-Indiana Sea Grant continues to post updated materials to the toolkit website in an effort to provide users with the most current content available on this issue.

The Lake Michigan Toolbox
Water Security Resources

Water Security Resources

These resources are available at: cfpub.epa.gov/safewater/watersecurity/waterresources.cfm

- Information on training courses, meetings, and workshops / webcasts for utilities, federal and state governments, and utility security officials.
- Tools and technical assistance to assist utilities in developing and updating vulnerability assessments and emergency response plans.
- Information about recently awarded grants and potential financial assistance programs.
- Information from trade/industry organizations, clearinghouses and information centers, state homeland security web sites, state drinking water protection web sites, and USEPA programs.

Drinking Water Security Education Materials

The USEPA has recently developed a collection of useful education and resource materials on drinking water security. The information includes resources on emergency preparedness, drinking water security, and law enforcement. These materials can be found at: cfpub.epa.gov/safewater/watersecurity/index.cfm.

A compendium of laboratories identifying their capabilities to analyze for contaminants of concern can be found at: www.epa.gov/compendium
The Water Contaminant Information Tool (WCIT) to assist in identifying unknown contaminants in water can be found at: www.epa.gov/wcit.
User registration for these sites is required.

convened a Water Security Work Group (WSWG) that was tasked with identifying the key features of an "active and effective" security program. The NDWAC-WSWG was composed of representatives from water systems, water professional organizations, state drinking water officials, and USEPA. The WSWG identified 14 "key" features of an active and effective security program for water systems. USEPA subsequently met with the Association of State Drinking Water Administrators (ASDWA) Water Security Committee and it was agreed that the 14 "key" features should be integrated into the state and federal drinking programs. USEPA will continue to work with its partners to identify and facilitate integration of water security activities at all levels and is working to identify ways of measuring success in these areas (see the Water Resources Toolbox).

Inadvertent Water Contamination

Contamination of drinking water sources can result inadvertently during the production, use, and disposal of the numerous chemicals used in industry, agriculture, medical treatment, and in the household. Knowledge of the environmental occurrence or toxicological behavior of contaminants has resulted in increased concern over potential adverse environmental and human health effects. For many contaminants, public health experts have incomplete understandings of their toxicological significance (particularly effects of long-term exposures at low-levels). The need to understand the processes controlling contaminant transport and fate in the environment and the lack of knowledge of the significance of long-term exposures has increased the need to study environmental occurrence down to trace levels. Furthermore, the possibility that environmental contaminants may interact synergistically or antagonistically has increased the need to define the complex mixtures of chemicals that are found in our waters (toxics.usgs.gov/regional/emc.html).

Water Quality Tracking

In 2002, USEPA released the Great Lakes Strategy. A key action from this effort was stated: "Beginning in 2002, USEPA, in cooperation with local utilities, will track water quality at the intake points of selected drinking water treatment plants around the Lakes.

Findings will be reported to the public through the biennial State of the Lakes Ecosystem Conference (SOLEC) "State of the Lakes report". More information is available at: www.epa.gov/glnpo/gls/gls04.html.

As of April 2003, USEPA examined data provided by 114 public water systems in the Great Lakes basin and by the U.S. Safe Drinking Water Information System. Specifically, USEPA has evaluated various contaminants, including the following:

- Atrazine, an agricultural pesticide
- Nitrate and nitrite, which are naturally occurring nutrients found at high levels in fertilizers
- Total coliform bacteria, E. coli, protoza, giardia, and cryptosporidium, which may contaminate water supplies after sewage spills

USEPA has also examined the turbidity, taste, odor, and organic carbon content of drinking water supplies to assess any other potential health issues. Of the public water systems evaluated between 1999 and 2001, none exceeded drinking water standards for atrazine, and only one exceeded drinking water standards for nitrate and nitrite after treatment. However, atrazine, nitrate, and nitrite are detected at elevated levels in the Great Lakes, which indicates that advanced treatment technologies prevent the entry of significant concentrations of these contaminants into drinking water supplies. For total coliform and E. coli, only one violation of drinking water standards occurred between 1999 and 2001 in the Great Lakes basin. Finally, public water systems rarely have problems with turbidity, taste, odor, or organic carbon content.

Drinking Water State Revolving Fund

The Nation's water systems must make significant investments to install, upgrade, or replace infrastructure to continue to ensure the provision of safe drinking water to their 240 million customers. Installation of new treatment facilities can improve the quality of drinking water and better protect public health. Improvements are also needed to help those water systems experiencing a threat of contamination due to aging infrastructure systems.

The Safe Drinking Water Act, as amended in 1996, established the Drinking Water State Revolving Fund (DWSRF) to make funds available to drinking water

How the Lake Michigan States are Dealing With Medicine Disposal

There have been numerous new initiatives to deal with the problem of medicine disposal in the Great Lakes. Currently, many people dispose of old medicines by flushing them down the toilet. Existing wastewater treatment strategies cannot effectively treat for these medicines and they end up in water bodies including Lake Michigan.

Illinois EPA has proactively addressed the medicine disposal issue by volunteering to cover incineration costs for collections of household medicines in the state. In response to this, county solid waste managers are accepting medicines at household hazardous waste (HHW) drop-off events. Some HHW sites are single-day collections, while others are ongoing monthly or weekly programs. Other models have been piloted in Chicago, including a single-day multi-site drop-off with the sheriff's department, the police, and retail stores participating.

An ecumenical faith-based environmental group in the Upper Peninsula of Michigan organized collections for various special household wastes-most recently for unwanted medicines on Earth Day 2007.

In Wisconsin, numerous counties and municipalities have run medicine collection events for households, and there is an effort by a state workgroup to create a sustainable mail-back program. By describing and comparing the various disposal methods and funding sources WDNR hopes to provide insight into which methods have been most successful and which will be sustainable in the long term.

The Lake Michigan Toolbox
Drinking Water Academy

Established by the USEPA Office of Ground Water and Drinking Water, the Drinking Water Academy (DWA) is a long-term training initiative whose primary goal is to expand USEPA, State, and Tribal capabilities to implement the 1996 Amendments to the Safe Drinking Water Act (SDWA). In addition to providing classroom and Web-based training, the DWA acts as a resource for training materials pertaining to SDWA implementation. More information is available at: www.epa.gov/safewater/dwa.html.

Source Water Assessment and Protection Program Status

The Safe Drinking Water Act Amendments of 1996 established the Source Water Assessment and Protection Program (SWAP) to help States locate and identify existing and potential threats to the quality of public drinking water for the purpose of fostering local efforts to benefit and protect the resource. States are responsible for assessing the condition of source water for all public water systems within their borders. Each assessment must include a delineation of the source water area for each public water system, an inventory of potential contaminant sources, a determination of the system's susceptibility to contamination from those sources, and must be made available to the public. Assessments are intended to be a useful tool in helping water system develop plans and implement measures to protect their water source.

Wisconsin, Illinois, Indiana, and Michigan have completed all assessments. The focus of this program has now shifted to using the assessments to encourage States and local water utilities to develop source water protection plans and implement protection measures. USEPA and the States will be working to establish partnerships with volunteer and nonprofit organizations and integrate source water protection with other regulatory programs in order to achieve results.

More information on this program is available at the following internet address: cfpub.epa.gov/safewater/sourcewater/ .

The Lake Michigan Toolbox

Sourcewater Protection Tools and Technical Assistance

A variety of tools are available to aid community planners, public water supply operators, and members of local source water protection teams in developing source water assessments. The tools include general information on water quality and surface and ground water hydrology, as well as specific information on watersheds, aquifers, and federally owned public water supplies.

More information is available at: cfpub.epa.gov/safewater/sourcewater/ and cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Tools.

Source USEPA

Source USEPA

Source USEPA

systems to finance infrastructure improvements. The program also emphasizes providing funds to small and disadvantaged communities and to programs that encourage pollution prevention as a tool for ensuring safe drinking water. The funds are passed from USEPA to each state. For more information see: www.epa.gov/safewater/dwsrf.html.

Drinking Water Quality Reports

Information on local water quality is available from several sources, including state public health departments and local water suppliers. To inform the public of the results of analyses of drinking water and to demonstrate a commitment to protecting human health, each community public water supplier is required to generate an annual Consumer Confidence Report that is made available to all residents receiving water from the water system. A Consumer Confidence Report provides information about the source of water used, its susceptibility to contaminants, the levels of contaminants detected in the water, the likely sources of contaminants, and potential health effects of any contaminant detected at a concentration above its maximum contaminant level (MCL). Consumer Confidence Reports can be reviewed to get an indication of the overall quality of treated surface water and groundwater and the condition of the drinking water provided. In addition, the states are distributing information on the status of the source waters used by public water suppliers and the level of susceptibility of those source waters to contamination.

The Lake Michigan Toolbox
Water Efficiency
Climate Change Adaptation and Mitigation

WaterSense

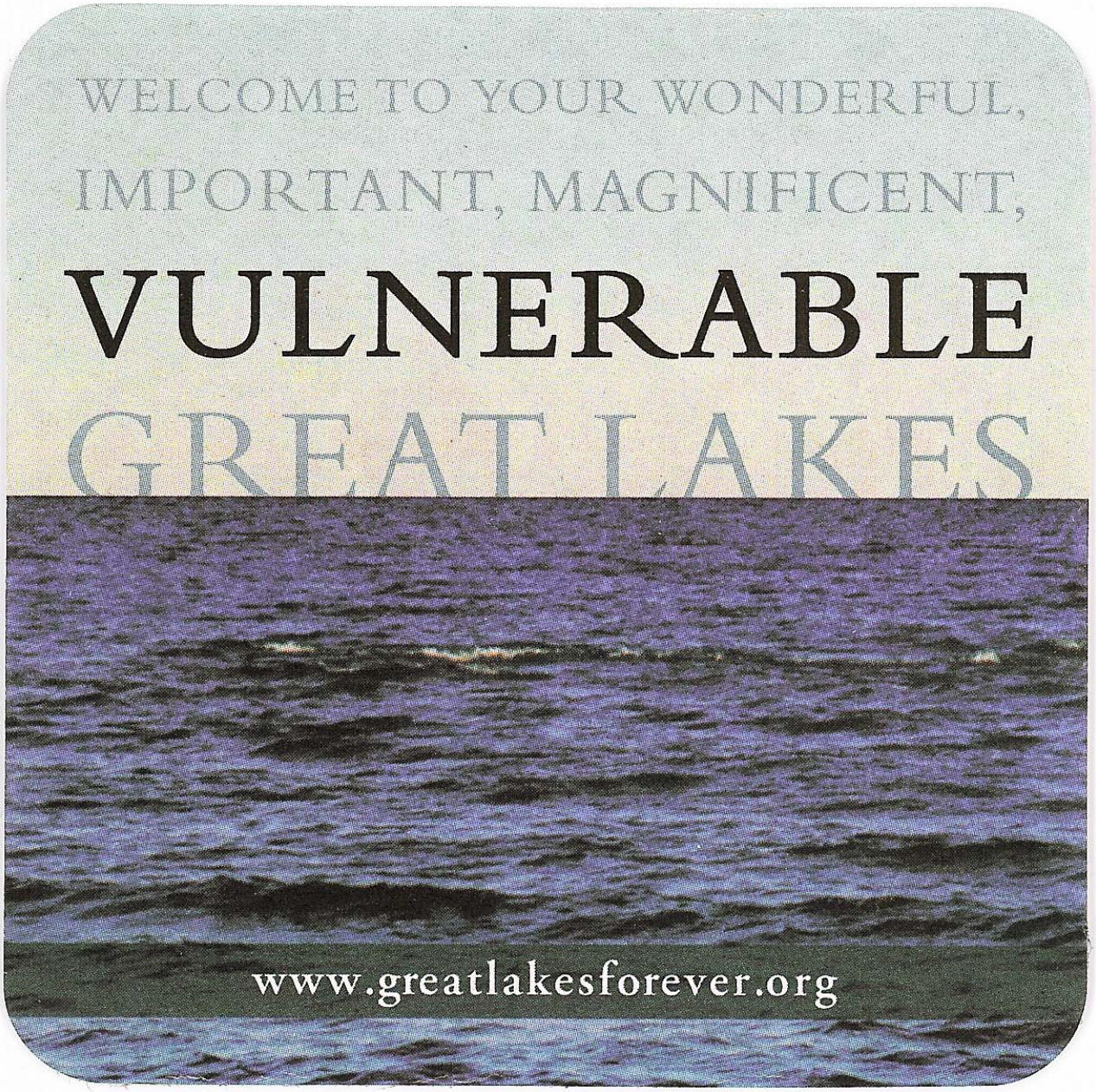
In June 2006, U.S. EPA helped launch the WaterSense label to spread the ethic of water efficiency and promote the tools like the successful energy Star trade marked program for energy-efficient devices. The program features information about water conservation as well as about specific products that meet the WaterSense standards.

The average American could save 30,000 gallons of water annually by adopting water-efficient methods and products that would also translate into money savings on water and sewer rates which are estimated to rise. The current built water systems are aging and EPA estimates the nation's systems need an investment of up to $1.2 trillion over the next 20 years. More information is available at http://www.epa.gov/waterinfrastructure/waterefficiency.html

Alliance For Water Efficiency

A new group is working with stakeholders to help promote the WaterSense standard to the public while also working with the commercial sector. The Alliance for Water Efficiency is a stakeholder-based 501(c)3 non-profit organization dedicated to the efficient and sustainable use of water.

Located in Chicago, the Alliance serves as a North American advocate for water efficient products and programs, provides information and assistance on water conservation efforts. Charter members include Kohler Company and Home Depot. More information is available at www.allianceforwaterefficiency.org.



Great Lakes Forever Coastal Drink Coasters.
Source: www.biodiversityproject.org

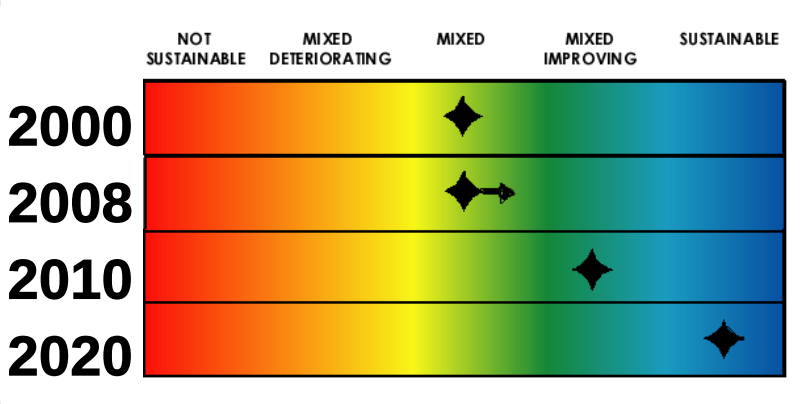
Subgoal 3

Can we swim in the water?

What is our target for sustainability?

Lake Michigan beaches are recognized as a consistently healthy place to visit and enjoy and are open more than 90% of the time.

Lake Michigan Target Dates for Sustainability



Why is this important?

With the passage of the Beach Act in 2000, Lake Michigan states received federal funding to develop monitoring at high use beaches. This increased beach closings as the program commenced, but it also identified gaps in testing and technology for *E.coli* measurement as well as the need for best management practices. Research shows that factors like geography, water depth, weather, beach grooming practices and nearby animal populations also contribute to the beach closing problem in addition to the more obvious stormwater runoff, combined sewer overflows and animal feeding operations up stream.

What is the current status?

Beach closures have decreased slightly in recent years despite the fact that monitoring is increasing. Most closures occurred at the same beaches. New monitoring strategies based on predictive models have allowed beach managers in some areas to make better decisions regarding whether a beach should be closed. Currently, closure decisions are usually based on data from the day before due to limits of testing procedures.

What are the major challenges?

- Climate Change: Possibility of intense storms increase high runoff events promoting pathogen and algae growth with adverse effects on water quality.
- Increasing bacteriological monitoring on beaches.
- Increasing use of predictive beach modeling and document its effectiveness
- Upgrading wastewater treatment systems as well as green infrastructure
- Encouraging increased energy conservation at water facilities

What are the next steps?

- Continue to implement actions outlined in the Great Lakes Regional Collaboration's Coastal Health Strategy
- Continue to improve beach monitoring and public notification.
- Develop and disseminate a standardized sanitary survey tool to identify contamination sources at Great Lakes beaches.
- Promote measures that will reduce or eliminate pollution sources at Great Lakes beaches.
- Continue support of Great Lakes Beach Association conferences.
- Disseminate information and training tools on the use of forecast models at Great Lakes beaches.

What are some tools for addressing the challenges?

- Beach Health Resources
- Lake Michigan States' Beach Program Web Pages
- Great Lakes Beach Association

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 4200 - Beach Advisories, Postings and Closures
Lake Michigan: Status: Fair; Trend: Undetermined (due to vast increase in number of reported beaches)

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

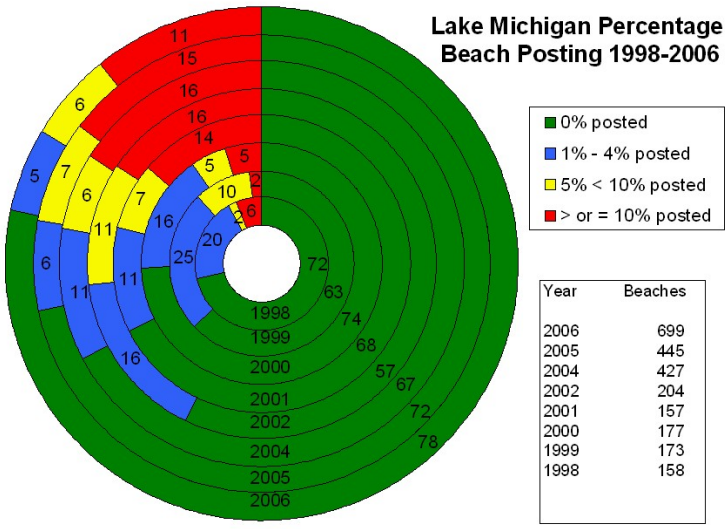
Background

Lake Michigan contains the world's largest collection of freshwater sand dunes and associated beaches, particularly along its eastern shore. Of a total of 3,100 coastal acres, 1,200 acres is publicly owned and available for use, while an additional 1,200 privately owned acres has significant potential for public use. It is important to note that most shoreline areas along Lake Michigan support swimming and secondary contact recreation. However, some areas do experience elevated levels of *E. coli* bacteria. This may be due to wet weather that causes overflows from aging wastewater collection systems or treatment plants, storm water runoff from cities and farms, improperly sited or maintained septic systems, and natural sources such as waterfowl. These sources of contamination may release pathogens into tributaries and the lake. When *E. coli* levels exceed standards, "Beach Advisory or Closure" notices are posted to protect human health. Recent studies show other factors like geography, water depth, weather, beach grooming practices and nearby animal populations also contribute to beach advisories or closures. As a result, the current status of the goal is mixed, but appears to be improving.

Beach advisories or closures resulting from high pathogen loads have a negative effect on the lake's significant tourism industry. To improve water quality testing at the beach and to help beach managers better inform the public when there are water quality problems, Congress passed the Beaches Environmental Assessment and Coastal Health (BEACH) Act on October 10, 2000. The BEACH Act requires adoption of consistent bacterial standards at coastal waters nationwide, research on new pathogens and pathogen indicators, and publication of new or revised water quality criteria for pathogens within five years. The BEACH Act also authorizes EPA to award grants to eligible states, tribes, and territories to develop and implement a program at coastal and Great Lakes beaches, and to notify the public when bacteria levels are exceeded.

Progress on Developing and Implementing Beach Monitoring and Notification Plans

Since passage of the BEACH Act, approximately $11.7 million in BEACH grants have been issued to Great Lakes states to implement beach programs, which has resulted in a significant increase in the number of monitoring and notification programs at Great Lakes beaches. All of the Lake Michigan states



The number of beaches closed every year has decreased despite the increase in the number of beaches tested for *e.coli.*

Cladophora Algae Becoming Larger Problem in Lake Michigan

Cladophora is a branching, green filamentous algae found naturally along the coastline of most of the Great Lakes. Research in the 1960's and 70's linked *Cladophora* blooms to high phosphorus levels in the water, mainly as a result of human activities such as fertilizing lawns, poorly maintained septic systems, inadequate sewage treatment, agricultural runoff and detergents containing phosphorus. Phosphorus levels declined due to tighter regulations and *Cladophora* blooms were largely absent in the 1980's and 90's.

Claphora
Photo courtesy of Brenda Moraska Lafrancois

There has been a resurgence of macroalgae, predominantly *Cladophora*, along the coast of Lake Michigan. These algae blooms lead to unsightly and foul-smelling beaches and have a negative impact on the economy as a result of lowered beach use. *Cladophora* blooms result in reduced quality of drinking water and decreased property values. Possible causes include increased nutrient inputs, increased water clarity, increased water temperature and changing lake level. While there have been some efforts to remove *Cladophora* from beaches, ultimately the solution to the *Cladophora* problem requires the identification of the factors promoting *Cladophora* growth, and mitigating those factors.

It is unknown if there are increased nutrient concentrations entering the lake via streams and rivers or if zebra mussels redistribute existing nutrients from the phytoplankton they consume to the *Cladophora*. Both may be happening. (Source: Great Lakes Water Institute, University of Wisconsin-Milwaukee)

For more information on *Cladophora*, see chapter 8 and www.uwm.edu/Dept/GLWI/cladophora and www.miseagrant.umich.edu/SOLM2007/images/presentations/GLBA/Beach_2207_sadowsky.pdf and www.miseagrant.umich.edu/SOLM2007/images/presentations/GLBA/Kleinheinz-GLBA07.pdf .

Type E Botulism Causes Bird Die-Off at Sleeping Bear Dunes

Sleeping Bear Dunes National Lakeshore experienced extensive waterbird die-offs in 2006 within the waters of Lake Michigan which included nearly 3,000 grebes, gulls, cormorants, loons and mergansers. Poisoning from Type E botulism toxin was identified as the cause of the die-off. Initial indications are that recent increases in native *Cladophora* algae have become common in shoreline locations across the Great Lakes and initial research indicates that these die-offs are related to an upwelling of lake-bottom sediments containing the Type E Botulism. The sediment contain the bacteria are being filtered by non-native Zebra Mussels, concentrating the Botulism in the mussels. The mussels are then eaten by non-native Round Gobies. The Gobies are then eaten by the birds who ingest the virus, become sick, and die. A network of scientists are joining together to address the problem. More information is available at www.epa.gov/glnpo or www.miseagrant.umich.edu.

Photo courtesy of Kenneth Hyde

Combined Sewer Overflows (CSOs): Climate Change and Adaptation a Priority

There are currently 30 CSO communities with 347 CSO outfalls that discharge within the Lake Michigan basin. Eighteen of the Lake Michigan CSO communities are in Indiana, 11 are in Michigan, and one is in Wisconsin.

- In Indiana, all 18 CSO permittees in the Lake Michigan basin discharge in the vicinity of 303(d)-impaired waters. Thirteen of these permittees discharge to waters where pathogens (*E. coli*) and/or siltation were cited as reasons or causes of impairment.
- In Michigan, 10 of the 11 CSO communities discharge to 303(d)-impaired waters. The waters in close proximity to the CSO community of Norway have not been assessed. Three CSO permittees in Michigan (Manistee, Niles, and St. Joseph CSO) discharge to 303(d)-listed waters that specifically cite "CSO pathogen (Rule 100)" as a source of impairment. In addition, three CSO permittees (East Lansing, Lansing, and Crystal Falls CSO) discharge to waterbodies where pathogens or pathogens and dissolved oxygen are cited as reasons or causes of impairment.
- In Wisconsin, the Milwaukee Metropolitan Sewerage District (MMSD) operates the only combined sewer system (CSS) in the Lake Michigan basin. MMSD's CSOs discharge to, or in close proximity to, 303 (d)-impaired waters where pathogens and/or dissolved oxygen have been cited as reasons or causes of impairment.

Lake Michigan CSO communities
Source: USEPA

The proximity of a CSO outfall to an impaired water segment does not in and of itself demonstrate that the CSO is the cause of the impairment. EPA believes the association between CSO location and impaired waters is due to a number of factors in addition to CSO discharges. For example, CSOs are generally located in urban areas where waterbodies also receive relatively high volumes of storm water and other pollutant loads. Nevertheless, the strong correlation between CSO location and impaired waters does suggest that CSOs should be considered as a potential source of pollution when developing a total daily maximum load (TMDL) for an impaired waterbody.

While these CSOs all have long-term plans, climate change could have a major impact as pointed out in the February 2008 USEPA report, "Screening Assessment of Potential Impact of Climate Change on CSOs in the Great Lakes (EPA600R-07/033F). More information is available at: www.epa.gov/ncea.

have beach monitoring and public notification programs in place at most of their coastal beaches and at all of their high priority or frequently used coastal beaches.

During 2006, 83% of Lake Michigan beaches were open more than 95% of the time. Increased monitoring has resulted in approximately twice as many postings since 2000. Several groups are collaborating to identify and remediate sources of beach contamination in Lake Michigan. Following are beach program summaries for Illinois, Indiana, Michigan, and Wisconsin.

Illinois' Beach Program

The Illinois Department of Public Health (IDPH), which licenses bathing beaches in Illinois, has received $1,469,228 in BEACH Act grants since 2001. Illinois' Lake Michigan beaches are monitored five to seven days a week during the swimming season. To augment beach water quality monitoring, IDPH is working with the Lake County Health Department (LCHD) to validate and implement predictive models at several Lake Michigan beaches. Because health warnings are generally based on *E. coli* concentrations from samples taken the previous day, predictive models based on continuously measured hydro-meteorological variables provide an excellent alternative to monitoring. In the summer of 2004,

SwimCast predictive modeling systems were installed by the LCHD to predict whether water quality standards would be exceeded at two Lake Michigan beaches: Illinois Beach State Park-South Beach (IBSP) in Zion, Illinois, and Forest Park Beach (FP) in Lake Forest, Illinois. SwimCast measures air and water temperature, wind speed and direction, precipitation, relative humidity, wave height, lake stage, insolation (light energy), and other water quality parameters. SwimCast accurately predicted whether *E. coli* concentrations were above or below the 235-cfu/100 ml threshold for full body contact 85% of the time during the 2004 swimming season. SwimCast was 89% accurate at IBSP beach and 95% accurate at FP beach when used in 2005. The SwimCast predictive model will be extended to Chicago beaches where a model will be pilot tested during the 2008 beach season. To access the SwimCast Real Time Data Link, go to: www.co.lake.il.us/health/ehs/SwimCastDataAP.asp

IDPH continues to develop and distribute educational resources. An educational beach pamphlet titled, "Why is the beach closed?" was developed and distributed to beach patrons. IDPH also provides beach closure and program information to beachgoers through signs and its website at: www.idph.state.il.us/envhealth/beachhome.htm Please Don't Feed the Waterfowl signs have been posted at several Lake Michigan beaches to discourage visitors from feeding birds, which have the potential to contribute significant fecal loads to beach water. Information on water quality for Lake Michigan beaches in Lake County, Evanston, Winnetka and Wilmette, Illinois, can be found at www.earth911.org/waterquality/default.asp?cluster=0 and information about Chicago's beaches can be found at: www.chicagoparkdistrict.com/index.cfm/fuseaction/swim_report.home.cfm The City of Chicago also has a website and web site links are provided through NBC Channel 5.

In 2007, IDPH developed a DVD for beach managers about predictive models used in the Great Lakes, including SwimCast. The DVD covers data collection, equipment installation, quality assurance, the public's view of the models, and costs. It also discusses innovative beach management measures to reduce beach closures through storm water management and beach grooming techniques.

Source identification work is being conducted by IDPH which received a grant from U.S. EPA to pilot a beach sanitary survey tool in 2007 to identify pollution sources at two Great Lakes beaches: Jackson Park (63rd Street) Beach in Chicago, and Rosewood Beach in Highland Park, Illinois. Preliminary results of the sanitary survey suggest that Jackson Park Beach is influenced by a large land area of rainwater runoff. Also, the beach has a relatively shallow water depth, a shallow beach and lake bottom slope, and has a configuration that may trap water and inhibit entry and mixing of cleaner lake water. Presence of gulls and other birds may contribute to bacterial load especially after rainfall and potentially after high wave events. At Rosewood Beach, a total of 173 pipe structures were mapped, 44 of which were from sanitary sewer sources; the remainder of the pipe structures were storm water or drainage sources. At the time of survey, however, there was little to no flow in the tributaries (only one pipe had measurable flow), so a more thorough investigation is needed.

In 2008, beach managers along Lake Michigan formed a beach management association to standardize beach monitoring protocols and methods by which the public will be notified about beach water quality.

Indiana's Beach Program

The Indiana Department of Environmental Management (IDEM) administers the Beach Monitoring and Notification Program at Indiana's Lake Michigan beaches. IDEM has received $1,235,353 in BEACH Act grants since 2001. The beach program is currently being operated in conjunction with the Lake County Parks and Recreation Department, the Hammond Sanitary District, the City of East Chicago Health Department, the Gary Sanitary District, the Town of Ogden Dunes, and the LaPorte County Health Department.

Indiana has approximately 23 miles of beaches located along the Lake Michigan shoreline, including the Indiana Dunes National Lakeshore, which has 9 nine beaches, and the Indiana Dunes State Park, with 2 two main sections of beaches, along with 14 other county and city beaches. Prior to the BEACH Act, *E. coli* monitoring occurred only one day per week at Indiana's Lake Michigan beaches. Since receiving funding, Indiana beach program managers relying strictly on water quality samples now sample as frequently as three to seven days per week at most of its Lake Michigan beaches.

IDEM has also used BEACH Act grant funds to keep the public informed about beach water quality risks to enable beachgoers to make better informed decisions regarding recreational choices. Beach managers notify the public of elevated bacteria levels by posting beach advisory or closure signs. The public can also access beach open/closure status information on the beach notification project web site (www.in.gov/idem/beaches). IDEM hired a contractor to install 25 kiosks at several coastal beaches which provide beachgoers with up-to-date information regarding the status of beach waters as well as additional information about the possible sources and causes of *E. coli* contamination. Recommendations are also provided as to how beachgoers and watercraft operators can reduce the likelihood of causing an *E. coli* release.

Several organizations have collaborated to identify sources of contamination at beaches near Burns Ditch, Indiana. There are 13 beaches in Porter County and Lake County, Indiana, west of the Burns Ditch outfall (a major point source of pollution), that are subject to beach closures due to high counts of *E. coli*. IDEM participated in a model project collaborating with USGS, NOAA, the City of Gary Sanitary District, the National Park Service, and local health departments, to characterize the movement of *E. coli* from Burns Ditch and to better understand the relative effect of bacteria contamination on beach waters. They studied the relationship between *E. coli* counts in Burns Ditch and beaches to the west, and hydro-meteorological factors, and this information was used to develop a predictive model for high *E. coli* counts at these beaches.

IDEM has used BEACH Act grant dollars to fund the installation of two predictive models at two Lake Michigan beaches with the goal of providing the public with more rapid information about water quality at beaches along Indiana's Lake Michigan shoreline. During the 2006 beach season, IDEM implemented project SAFE at the beaches west of Burns Ditch (Portage Beach, Ogden Dunes, West Beach, Wells Street Beach, Marquette Beaches, and Lake Street Beach). During 2007, IDEM implemented the predictive model, "SAFE" (Swimming Advisory Forecast Estimates) for the Gary and Ogden Dunes beaches. Gary and Ogden Dunes beaches using SAFE model still performed water quality testing at least once per week. A partnership between IDEM and the City of Gary made the above predictive modeling efforts possible.

The Importance of Predictive Modeling and Sanitary Surveys

Public health agencies are starting to use predictive modeling based on statistics to make real-time decisions regarding whether a beach should remain open or not.

Health departments and researchers compile a record of how factors like rainfall, water temperature and the presence of seagulls affect the E. coli count. Some of this data collection can be done by researchers and agencies, but statistics can also be obtained from records kept by other sources, such as local airports and the National Weather Service.

The models use these data to identify when the factors most associated with high levels of *E.coli* occur in combination with each other. In many cases, these models are more accurate for determining the exact days when beaches should be closed as opposed to the current system when beaches may be closed when they are safe, and open when levels of *E.coli* are unsafe.

More communities are using or are investigating the use of predictive modeling for making decisions on closing beaches

While monitoring and predictive modeling are reactive, Beach Sanitary Surveys are a proactive tool that can be employed by local beach managers to help determine probable sources of contamination in recreational water.

More funding was made available to do these surveys over the last two years. In response to the recommended actions of the Great Lakes Regional Collaboration's Coastal Health Strategy, the USEPA released over $500,000, draft tools, and a guidance document to pilot a standardized sanitary survey tool throughout the Great Lakes in 2007.

Advanced Monitoring Initiative is a program coordinated through U.S. EPA's Office of Research and Development. It seeks to model the fate of indicator bacteria as they move downstream of the Valparaiso, Indiana, POTW to the Little Calumet River and eventually Lake Michigan. The study focuses on the relationship of quantitative Polymerase Chain Reaction (qPCR) and cultural counts of indicator

bacteria. The relationship among independent factors such as sunlight, flow, turbidity and fecal indicator bacteria are being investigated. The study will be integrated with IDEM's SAFE, NOAA OHHI and USGS Oceans Research Priority Planning programs.

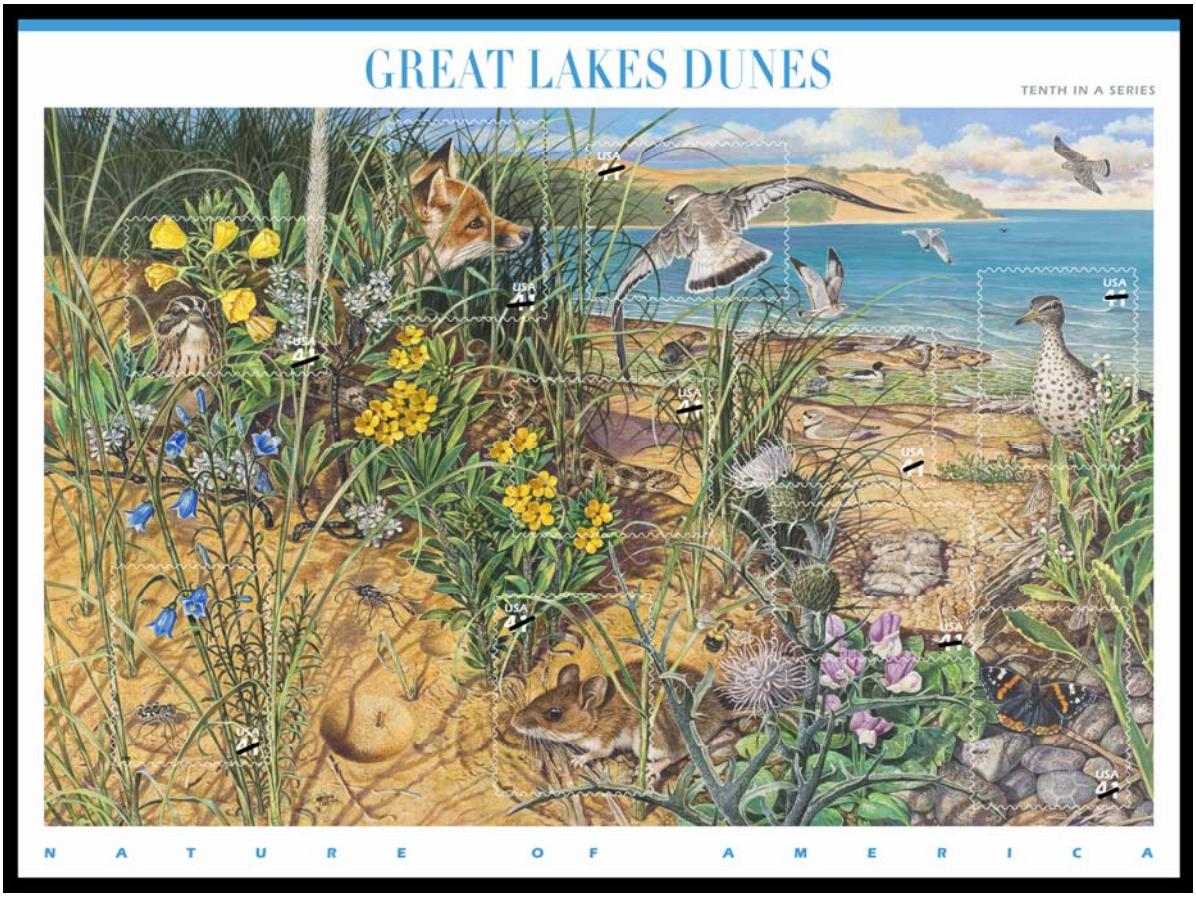
Michigan's Beach Program

The Michigan Department of Environmental Quality (MDEQ) has received a total of $1,708,572 in BEACH Act funding since 2002 to support beach monitoring and notification programs for 440 public beaches in 58 counties along the state's 3,200 miles of Great Lakes shoreline. Along Lake Michigan:

- There are 299 public beaches on Lake Michigan in 18 counties.
- In 2007, of the 110 Lake Michigan beaches that were monitored, 25 beach closures or advisories were reported due to water quality standards being exceeded.

Waters associated with public beaches are considered to not attain water quality standards when *E. coli* monitoring data collected by county health departments during the total body contact recreation season of May 1 to October 31 meet one or more of the following decision elements:

Great Lakes Dunes Stamps Issued in 2008



A series of stamps commemorating Great Lakes dunes will be released this year by the U.S. Postal Service. The series will be offered as a single sheet depicting a dense grouping of plants and animals at Sleeping Bear National Lakeshore on Lake Michigan, with the 10 individual stamps as insets in the scene. All of the 27 different plants and animals depicted on the sheet may be found in the Sleeping Bear Dunes area.

More information is available at: www.usps.com/communications/newsroom/2007/sr07_084.htm.

- *E. coli* concentrations exceed the geometric average water quality standard of 130 *E. coli* per 100 ml based on weekly samples collected over a minimum of 16 weeks.
- Ten percent of the sample results exceed the daily maximum water quality standard of 300 *E. coli* per 100 ml based on weekly samples collected over a minimum of 16 weeks.
- Two or more sample results collected at any time during the total body contact recreation season of May 1 to October 31 exceed the partial body water quality standard of 1,000 *E. coli* per 100 ml.

The monitoring of beaches in Michigan is voluntary and is conducted by the local health departments, which are required to notify various entities of the test results within 36 hours, and may petition the Circuit Court for an injunction ordering the owners of a beach to close the beach. The MDEQ provides Clean Michigan Initiative-Clean Water Fund (CMI-CWF) and BEACH Act grants to the local health departments to aid in the implementation or enhancement of their beach monitoring programs. The CMI-CWF and BEACH Act grants are designed to fund proposals that determine and report levels of *E. coli* in the swimming areas of public beaches. The objectives of MDEQ's beach program are to:

- Assist local health departments to implement and strengthen beach monitoring programs.
- Determine whether waters of the state are safe for total body contact recreation.
- Create and maintain a statewide database.
- Compile data to determine overall water quality.
- Evaluate the effectiveness of MDEQ programs in attaining water quality standards for pathogen indicators.

Local health departments request an average of $380,000 in BEACH Act funds per year from the MDEQ for local beach monitoring programs for 212 high-priority beaches. Since passage of the BEACH Act, there has been a dramatic increase in the number of monitoring and notification programs at coastal beaches in Michigan. The number of Great Lakes beaches in Michigan that were monitored at least once a week has grown from 83 in 2002 to 212 in 2007.

Local health departments provide beach monitoring program information to the public via press releases, brochures, beach signs, beach seminars, and Internet access.

In 2006, monitoring was conducted at 207 Great Lakes public beaches in 37 counties in Michigan. Out of 2,422 daily samples collected, 85 (3.5 percent) exceeded Michigan's water quality standards. The exceedances were reported from 50 beaches (24 percent of monitored Great Lakes beaches), 41 of which reported beach closures or advisories (52 incidents lasting a total of 333 days).

All beach monitoring data are reported to and evaluated by the MDEQ. The MDEQ incorporates beach monitoring data into other water pollution prevention programs to encourage strategic improvements in water quality. Michigan's Beach Monitoring web site immediately provides current and historical test results for *E. coli* and beach closings/ advisories as they are reported from health departments for all public beaches in Michigan. All public beaches are required to post a sign indicating whether the beach is monitored and where the results can be found. More information is available at www.deq.state.mi.us/beach/public/default.aspx.

Source identification work is also being conducted by MDEQ which received a grant from U.S. EPA to pilot a beach sanitary survey tool in 2007 to identify pollution sources at 15 Lake Michigan beaches. Preliminary results of the surveys indicate that numerous sources of pollution have been identified along with potential remediation measures to help reduce beach water contamination. Recommended remediation measures include gull management techniques such as harassment by border collies, installation of wires above the beach to deter gulls from landing, and enacting an ordinance to ban feeding of waterfowl. Other remediation measures may include better beach maintenance, beach grooming, educating beach goers, and implementation of storm water best management practices.

Wisconsin's Beach Program

The Wisconsin Department of Natural Resources (WDNR) operates Wisconsin's Beach Monitoring and Notification Program, the primary goal of which is to reduce beach visitors' risk of exposure to disease-causing microorganisms in water. Since 2001, WDNR has received $1,460,130 in BEACH Act grants to develop and implement monitoring and notification programs at beaches along Lake Michigan and Lake Superior. Passage of the BEACH Act has enabled WDNR to substantially increase the number of coastal beaches it monitors from six to 123.

WDNR issues grants to communities along Lake Michigan and Lake Superior to monitor beach water quality. Fifteen health departments along these lakes sample the water at beaches one to five times per week. An advisory sign is posted warning swimmers that there is an increased risk of illness whenever the water quality criterion of 235 colony-forming units (CFU) of *E. coli*/100 ml of water is exceeded. A red stop sign that closes the beach is posted when *E. coli* levels exceed 1,000 CFU/100 ml, indicating a more serious risk of illness. Advisories and closures may also follow rainfall events or storm water and sewage overflows. Other factors that may influence *E. coli* concentrations include the nuisance algae Cladophora, wind direction, wave height, water temperature, and beach grooming.

Statewide, the summer of 2006 had more closures and advisories than 2005, but less than 2004. In Wisconsin, 17.5% of the samples taken in 2006 exceeded the *E. coli* standard of 235 CFU/100 ml (676 samples out of 3861 total samples). Approximately 5% of the total samples exceeded 1000 CFU/100 ml and resulted in beach closures.

To design its beach program, the WDNR formed a workgroup comprised of state and local environmental and public health officials, academic researchers and community groups. Using GPS technologies, approximately 55 public beach miles and 192 total coastal beaches were identified along Lake Michigan and Lake Superior. Maps of the beaches can be found at www.dnr.wi.gov/org/water/wm/wqs/beaches/state-map.htm Additional GPS data layers were added to include the location of all wastewater treatment plant outfalls along with their proximity to the beaches. Additional information was collected for each beach evaluating the potential for impacts from storm water runoff, bather and waterfowl loads, and the location of outfalls and farms. This information was used to rank and classify beaches as high, medium or low priority. These rankings indicate how often the beaches should be monitored to ensure that water quality conditions are safe for swimming.

Wisconsin's beach program workgroup also developed public notification and risk communication measures so water quality monitoring information is made available to the public in order for beach visitors to make informed choices. These measures included the development and posting of signs at beaches to give notice to the public that the

The Lake Michigan Toolbox
Beach Health Resources

Federal Government Resources

Assessing and Monitoring Floatable Debris.
www.epa.gov/owow/oceans/debris/floatingdebris/

BEACH Watch. www.epa.gov/waterscience/beaches/

BEACON – Beach Advisory On-line Notification
www.epa.gov/waterscience/beacon/

Great Lakes Monitoring – The Swimmability Index
www.epa.gov/glnpo/glindicators/water/beachb.html

National Beach Guidance and Required Performance Criteria for Grants www.epa.gov/waterscience/beaches/grants/guidance/index.html

National Pollutant Discharge Elimination System (NPDES) Combined Sewer Overflow http://cfpub1.epa.gov/npdes/home.cfm?program_id=5

USEPA Report to Congress on Impacts and Control of CSOs and SSOs http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm

USEPA Report to Congress on Implementation and Enforcement of the CSO Control Policy
http://cfpub.epa.gov/npdes/cso/cpolicy_report.cfm?program_id=5

Centers for Disease Control - Healthy Swimming
www.cdc.gov/healthyswimming/

Non-Governmental Resources

Beaches in the Great Lakes Region
www.great-lakes.net/tourism/rec/beach.html#new

Council of Great Lakes Research Managers – Great Lakes-St. Lawrence Research Inventory
http://ri.ijc.org

Great Lakes Beach Association
www.great-lakes.net/glba/

Great Lakes Beach Association Annual Proceedings, Green Bay, WI, November, 2005.
www.great-lakes.net/glba/2005conference.html

Great Lakes BeachCast – Great Lakes Beach Information (many links from this site)
www.great-lakes.net/beachcast/nr_moreinfo.html

The Lake Michigan Toolbox
Lake Michigan States' Beach Program Web Pages

Illinois

- Illinois Beach Monitoring Home page www.idph.state.il.us/envhealth/beachhome.htm
- Chicago Park District's Swim Report www.chicagoparkdistrict.com/index.cfm/fuseaction/swim_report.home.cfm
- Northern Illinois Lake Michigan beach notification Web site (Lake County Health Department, Wilmette Park District, Winnetka beaches and the City of Evanston). www.earth911.org/waterquality/default.asp?cluster=17

Indiana

- Indiana Department of Environmental Management Beach Home page. www.in.gov/idem/beaches
- IDEM beach water quality notification Web site http://www.earth911.org/waterquality/default.asp?cluster=18

Michigan

- Michigan Beach Monitoring home page www.michigan.gov/deq/1,1607,7-135-3313_3686_3730---C1,00.html
- Michigan Department of Environmental Quality – Office of the Great Lakes www.michigan.gov/deq/1,1607,7-135-3313_3677---,00.html
- Michigan Sea Grant: www.miseagrant.umich.edu/

Wisconsin

- Wisconsin Beach Health Web site www.wibeaches.us
- Wisconsin Sea Grant www.seagrant.wisc.edu/
- The Door County Beach Contamination Source Identification Interim Report map.co.door.wi.us/swcd/ and map.co.door.wi.us/swcd/Interim_Beach_report_2005.pdf
- Milwaukee Metropolitan Sewerage District. 2003. Deep Tunnel Fact Sheet www.mmsd.com/wastewatertreatment/deep_tunnel_history_facts.cfm
- Water Quality Research www.cityofracine.org/Depts/health/water_quality.aspx

coastal recreational waters are not meeting, or are not expected to meet, water quality standards. These signs, which are in English, Spanish and Hmong, were designed based on feedback from a beach user survey and public meetings held around the state.

Other public notification and outreach products developed by the workgroup include an automatic e-mail service to which the public can subscribe to receive daily updates on beach conditions; a statewide informational brochure, approximately 100,000 copies of which were distributed at local beaches, parks, and health departments; a Beach Health Web page (www.wibeaches.us) for reporting up-to-date as well as historical conditions at all Wisconsin coastal beaches; and an internal web site for local health departments to report their daily advisory and monitoring data in the format required for EPA reporting at the end of the beach season. Also, the WDNR, in collaboration with the State Lab of Hygiene, released a short "how-to" sample *E. coli* movie to the public.

Water quality awareness has increased in Lake Superior and Lake Michigan Counties as more data become available. Some counties and concerned citizens have taken initiative and are working toward finding sources of *E. coli* contamination and solutions to address them.

In 2007, the WDNR received funding from U.S. EPA to conduct sanitary surveys at 18 Wisconsin Great Lakes beaches, including 11 along Lake Michigan. The project has allowed researchers to identify potential sources of microbial contamination at numerous Great Lakes beaches in Wisconsin. Sources of *E. coli* contamination may include agricultural runoff, urban storm water and sewage overflows. Localized sources from wildlife and waterfowl feces also contribute to high levels of *E. coli* in both beach sand and water. This project has also allowed researchers to initiate the process of planning for mitigation of some of the sources of beach water contamination.

The City of Racine is working closely with partners to identify sources of beach water contamination. Research conducted over the 2006 beach season included:

- Characterization of *E. coli* in beach sands relative to sediment size and hydrologic factors. This grant allowed Racine to do hydrogeological assessments of North Beach in Racine and at

Eichelman and Pennoyer beaches in Kenosha County to determine the relationship between *E. coli* density in beach sands as a function of grain size and uniformity. Results indicated that well-sorted, fine sand has the highest concentration of *E. coli* and this is most pronounced at the berm crest, an area prone to continual wetting. Fine sandy beaches may benefit most from beach sand manipulation tactics. Racine's changes to the beach slope, an increased berm crest, and removing swales at North Beach have resulted in improvements in recreational water quality.

- Sampling of gull feces for the isolation of Campylobacter spp. In 2006, over 100 gull fecal samples were screened for the presence of enteric pathogens. This research will ultimately help determine if *E. coli* from gulls carries the same health risk to humans as from other sources. This may allow Racine to discount the number of advisories in areas where sources have been adequately characterized.
- Evaluation of real-time, quantitative Polymerase Chain Reaction (PCR) as a method to determine pollutant loading. This project will allow Racine to compare the DNA concentration present in treated wastewater effluent, bypasses, storm water, and surface run-off and to assess pollutant loading in real-time. Analyses will be conducted in conjunction with currently approved agar-based and chemical detection techniques for method comparison. The ability to monitor both point source and non-point source contamination in real-time will allow local governments to undertake effective coastal management measures.

For the first time, Racine's North Beach had five or less advisories. This met the 2002 Great Lakes Strategy goal of being open 95% (or more) of the swimming season.

Door County is one of the most popular summer tourist destinations in Wisconsin. Recreational water is an important resource to the economy of this county. In the summer of 2006, BEACH Act grant funds were used to monitor 28 beaches along Lake Michigan; however, funds could not be used for source identification of microbial contamination. The Door County Soil and Water Conservation Department joined forces with University of Wisconsin-Oshkosh to tackle the question, "Where is the beach water contamination coming from, and is it safe to swim at this beach?" The project objectives included:

The Lake Michigan Toolbox
Great Lakes Beach Association

The Great Lakes Beach Association (GLBA) plays an important role in providing a forum for beach managers, researchers, concurrent meeting with the Lake Michigan State of the Lake conference,

More information is available at:
www.great-lakes.net/glba/

- Monitor *E. coli* concentrations at selected beaches after significant rainfall to determine if storm water runoff contributed significantly to microbial contamination of beaches.
- Monitor pathogen concentration (Campylobacter) at five selected beaches.
- Isolate *E. coli* from beach water, sand and avian, bovine and human waste in Door County and conduct DNA fingerprinting of these isolates to further characterize the indicator organism used to monitor beach water quality and help to identify the source of contamination.
- Isolate Bacteriodes from avian waste from Door County beaches to try to identify unique sequences in the bacteria DNA that are specific to waterfowl and will allow another mechanism of source tracking microbial contamination in water. Unique DNA sequences previously have been identified in Bacteriodes from bovine and human feces.

The combined efforts between beach monitoring and microbial source tracking in Door County have resulted in another summer's worth of excellent data to be analyzed. In 2006, approximately 1000 *E. coli* isolates were collected from water and waste and the majority have been DNA fingerprinted. This information has been added to the database from previous years and researchers are beginning to see patterns in isolates. In addition, a large amount of spatial and rain data has been collected for the studied beaches in 2005 and 2006. In all cases *E. coli* concentrations were greater in storm water runoff and appear to have a negative impact on beach water quality for at least 8 hours after a significant rainfall event.

Accomplishments Related to Communication to the Public. Because it has been shown that people who engage in recreational water sports have a higher incidence of symptomatic illnesses, it has become increasingly more important to make the public aware of the potential health hazards that are associated with recreational waters. Recent progress has been made on the national and local levels to provide the public with useful tools that can provide needed information regarding the use of recreational waters. At the national level, the following public communication tools are available:

BEACH Watch

This website contains information about U.S. EPA's BEACH Program, including grants, EPA's reference and technical documents including EPA's *Before You Go to the Beach* brochure, upcoming meetings and events, conference proceedings, links to local beach programs, and provides access to BEACON (Beach Advisory and Closing On-line Notification), U.S. EPA's national beach water quality database. www.epa.gov/OST/beaches

Annual Great Lakes Beach Association (GLBA) Conference

In February 2001, an EPA, LaMP, and City of Chicago-sponsored Great Lakes Beach Conference was held to share information on the science and technology of beach monitoring as well as research on exposure, health effects, and water quality indicators. More than 250 environmental and public health officials, beach managers, and regulators attended the 3-day conference. The conclusions of the conference saw the formation of the Great Lakes Recreation Association whose list serve and annual meetings provide quick sharing of research findings. The GLBA is comprised of members from U.S. states, Environment Canada, local environmental and public health agencies, and several universities and NGOs. The GLBA's mission is the pursuit of healthy beach water conditions in the Great Lakes area. Since 2001, the GLBA has held beach conferences annually to bring together beach managers, scientists, and agency officials to exchange information on improving recreational water quality. The next conference is planned for September, 2008, in northwest Indiana: www.great-lakes.net/glba/

BEACHNET

An email discussion list that seeks to facilitate communication among people interested in the improvement of recreational beach water quality in the Great Lakes basin. The listserv is sponsored by the GLBA and is hosted by the Great Lakes Information Network (GLIN). Both the GLBA and the listserv are open to anyone interested in improving beach water quality, understanding bacterial contamination, developing better ways to detect and monitor pollution, or monitoring and assuring beach visitors' health. There are currently several hundred subscribers to BEACHNET. http://www.great-lakes.net/glba

BeachCast. This website provides Great Lakes beach goers with access to information on Great Lakes beach conditions, including health advisories, water temperature, wave heights, monitoring data, and more. BeachCast is a service of the Great Lakes Commission and its GLIN. http://www.glc.org/announce/03/07beachcast.html

NEEAR Water Study

The National Epidemiological and Environmental Assessment of Recreational (NEEAR) Water Study is a multi-phase research study led by the Centers for Disease Control and EPA's Office of Research & Development and National Health and Environmental Effects Research Laboratory with assistance from USGS and NPS. The study investigates human health effects associated with recreational water use. The objectives of the NEEAR Water Study are to (1) evaluate the water quality at two to three beaches per year for three years concurrently with a health study, (2) obtain and evaluate a new set of health and water quality data for the new rapid, state-of-the-art methods, and (3) develop new federal guidelines and limits for water quality indicators of fecal contamination so that beach managers and public health officials can alert the public about the potential health hazards before exposure to unsafe water can occur. The studies have been conducted at several Great Lakes beaches, including three Lake Michigan beaches: West Beach and Washington Park Beach in Indiana, and Silver Beach in St. Joseph, Michigan. http://www.epa.gov/nheerl/neear/

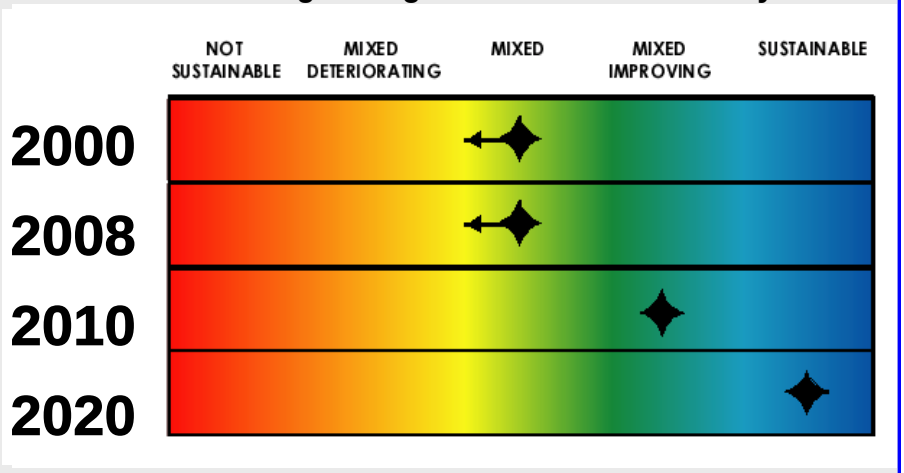
The next State of Lake Michigan Conference and Great Lakes Beach Association meeting will be held in Milwaukee, Wisconsin in October 2009.

Subgoal 4
Are all habitats healthy, naturally diverse, and sufficient to sustain viable biological communities?

What is our target for sustainability?

Healthy and diverse ecosystems are intact, provide residents with wildlife watching and recreation opportunities, and meet tribal needs for cultural, spiritual, and medicinal needs.

Lake Michigan Target Dates for Sustainability



Why is this important?

The Lake Michigan ecosystem continues to experience profound changes due to pollutant loading, development, and impacts of nuisance species. Many species' habitats rank as globally rare or imperiled based on the level of threat, their restricted distribution, and ecological fragility.

What is the current status?

- The overall status is Mixed/deteriorating as habitat destruction is a permanent, irreversible loss.
- **Benthic Aquatic Habitat.** Introduction of invasive species is interrupting the aquatic food web. While aquatic invader zebra mussels are declining in numbers, they are being replaced by the invasive quagga mussel. Native diporeia continue declining significantly, leaving less native food at the base of the food chain.
- **Fish Species.** Invasive species are competing with native species for food. Lake Trout and Lake Sturgeon are making comebacks as their numbers begin to see recovery and increases. Perch year of young are seeing increases as well.
- **Terrestrial Habitat.** Development in coastal counties is taking over habitat and farmland. Some restoration of wetlands, native prairies and other habitat is taking place.
- **Terrestrial Animals.** Wolves are making a comeback in northern Wisconsin and the Upper Peninsula of Michigan. Eagles have been sighted in the Chicago Lake Calumet region. More cities are taking part in decreasing light pollution during bird migration season.

What are the major challenges?

- Climate Change: Temperature rise in tributaries and the lake will promote change to warmer water aquatic species, shrinking of wetlands, and changing of shoreline dunes and coastal ecosystems.
- Restore and protect 125,000 acres of wetlands in the basin
- Changes in climate, lake levels, and groundwater recharge of streams at lake basin and sub-watershed scale impacting native species
- Making habitat information on status and value readily available by 12-digit HUC watersheds
- Increasing stress on habitats based on predicted growth and development of coastal areas of the basin
- Promoting projects to identify, enhance, restore, or protect critical ecosystem features and habitat through purchase, voluntary protection, or improved management
- Lack of connected migration corridors for plants and animals
- Lack of precise tracking tools for reporting gains and losses
- Lack of understanding of the causes, pathways, and needed actions for addressing the deaths of shorebirds from botulism

What are the next steps?

- Collaborate with the Great Lakes Fishery Commission on protecting near and offshore spawning reefs
- Develop process to refine habitat restoration targets through public discussion and promote work toward targets
- Continue to support components of biodiversity plans through the Watershed Academy.
- Identify species sensitive to ground and surface water interaction and their current distribution
- Provide GIS tools and land use models in workshops to promote knowledge of and protection of key habitat areas
- Promote new stream buffers, wetlands, and dam removals using federal, state, local, and private resources and monitor loss and gain trends

What are some tools for addressing the challenges?

- Great Lakes Basin Landscape Ecology Metric Browser
- *WildLink* Program Helps Landowners Keep Space Open for Wildlife
- Great Lakes Basin Landscape Ecology Metric Browser

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Indicator #8 - Salmon and Trout
Lake Michigan Status: Mixed; Trend: Slightly Improving

Indicator #17 - Preyfish Population
Lake Michigan Status: Mixed; Trend: Deteriorating

Indicator #18 - Sea Lamprey
Status: Good/Fair; Trend: Improving

Indicator # 68 - Native Freshwater Mussels
Status: Not Assessed; Trend: Not Assessed

Indicator # 93 - Lake Trout
Lake Michigan Status: Poor; Trend: Declining

Indicator # 104 - Benthos diversity and Abundance - Aquatic Oligochaete Communities
Lake Michigan Status: Mixed; Trend: Unchanging; Deteriorating

Indicator # 109 - Phytoplankton Populations
Status: Mixed; Trend: Undetermined*

Indicator # 111 - Phosphorus Concentrations and Loadings
Lake Michigan Status: Open Lake - Good; Nearshore – Poor; Trend: Open Lake - Improving; Nearshore - Undetermined

Indicator # 116 - Zooplantkton Populations
Lake Michigan Status: Not Assessed; Trend: Undetermined (changing)

Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Status: Mixed; Trend: Improving (for PCBs; banned organochlorine pesticides; dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)

Indicator # 122 - Hexagenia
Lake Michigan Status: Poor; Trend: Undetermined

Indicator # 123 - Abundances of the Benthic Amphipod *Diporeia* spp.
Lake Michigan Status: Poor; Trend: Deteriorating

Indicator # 124 - External Anomaly Prevalence Index for Nearshore Fish
Status: Not Assessed; Trend: Not Assessed

Indicator # 125 - Status of Lake Sturgeon in the Great Lakes
Lake Michigan Status: Mixed; Trend: Improving and Undetermined

Indicator # 4504 - Wetland-Dependent Amphibian Diversity and Abundance
Lake Michigan Status: Poor; Trend: Unchanging

Indicator # 4507 - Wetland-Dependent Bird Diversity and Abundance
Lake Michigan Status: Mixed; Trend: Deteriorating

Indicator # 4510 - Coastal Wetland Area by Type
Status: Mixed; Trend: Deteriorating

Indicator # 4858 - Ice Duration on the Great Lakes
Status: Mixed; Trend: Deteriorating

Indicator # 4861 - Effect of Water Level Fluctuations
Status: Mixed; Trend: Not Assessed

Indicator # 4862 - Coastal Wetland Plant Community Health
Status: Mixed; Trend: Undetermined

Indicator # 4863 - Land Cover Adjacent to Coastal Wetlands
Status: Not Fully Assessed; Trend: Undetermined

Indicator # 7000 - Urban Density
Status: Mixed; Trend: Undetermined

Indicator # 7002 - Land Cover/Land Conversion
Lake Michigan Status: Mixed; Trend: Undetermined

Indicator # 7006 - Brownfields Redevelopment
Status: Mixed; Trend: Improving

Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed

Indicator # 7043 - Economic Prosperity
Status: Mixed; Trend: Not Assessed

Indicator # 7054 - Ground Surface Hardening
Status: Not Assessed; Trend: Not Assessed

Indicator # 7056 - Water Withdrawals
Status: Mixed; Trend: Unchanging

Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed

Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed

Indicator # 7100 - Natural Groundwater Quality and Human-Induced Changes
Status: Not Assessed; Trend: Not Assessed

Indicator # 7101 - Groundwater and Land: Use and Intensity
Status: Not Assessed; Trend: Not Assessed

Indicator # 7102 - Base Flow Due to Groundwater Discharge
Status: Mixed; Trend: Deteriorating

Indicator # 7103 - Groundwater Dependent Plant and Animal Communities
Status: Not Assessed; Trend: Not Assessed

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Alvers
Status: Mixed; Trend: Not Assessed

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Cobble Beaches
Status: Mixed; Trend: Deteriorating

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Islands
Status: Mixed; Trend: Undetermined

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Sand Dunes
Status: Not Assessed; Trend: Not Assessed

Indicator # 8131 - Extent of Hardened Shoreline
Status: Mixed; Trend: Deteriorating

Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving

Indicator # 8147 - Population Monitoring and Contamination Affecting the American Otter
Status: Mixed; Trend: Not Assessed

Indicator # 8164 - Biodiversity Conservation Sites
Status: Not Assessed; Trend: Undetermined

Indicator # 8500 - Forest Lands - Conservation of Biological Diversity
Status: Mixed; Trend: Undetermined

Indicator # 8501 - Forest Lands - Maintenance of Productive Capacity of Forest Ecosystems
Status: Not Assessed; Trend: Undetermined

Indicator # 8503 - Forest Lands - Conservation and Maintenance of Soil and Water Resources
Lake Michigan
Status: Mixed; Trend: Undetermined

Indicator # 9002 - Non-Native Species - Aquatic
Lake Michigan
Status: Poor; Trend: Deteriorating

Indicator # 9002 - Non-Native Species - Terrestrial
Status: **Not Assessed;** Trend: **Undetermined**

Background

Habitats in the Great Lakes basin are many and varied. This chapter discusses the status and challenges of aquatic, terrestrial, and animal habitats. Each faced challenges based on significant changes in land use, invasive species, pollution, and climate change.

Past LaMP Updates have detailed the elements that make up the Lake Michigan basin's many diverse ecosystems- from southern dune and swale to northern forest and the open lake's very significant aquatic food web. For LaMP 2008 we are presenting the lake by its 33 drainage basin watersheds. These watershed fact sheets contain information that resulted from a unique partnership with the Nature Conservancy's Great Lakes Program. They have provided us with the "headlines" of their very detailed work on Great Lakes biodiversity and the Natural Heritage Programs' data and for the first time broken down to the watershed level. Their complete work can be found at www.nature.org/greatlakes or contact them at greatlakes@tnc.org (see Chapter 12).

We are presenting details from the Great Lakes Fishery Commission's 2007 Lake Michigan Report on the aquatic food web and its stressors. We are also presenting an update on the efforts to protect and restore wetlands as called for by the Great Lakes Regional Collaboration. An estimated 65,000 acres of wetlands have been protected, improved and restored across the Great Lakes basin since December 2005 by federal agencies and their partners. This estimate was obtained from a data call to the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Natural Resources Conservation Service, U.S. Forest Service, National Oceanic and Atmospheric Administration and U.S. EPA that adopted reporting conventions of the Council of Environmental Quality's annual, national wetlands report. Agencies were asked to report 2006 and 2007 accomplishments for completed wetlands restoration projects only. The information is intended to provide an estimate of where Federal agencies and their partners are in contributing to the Great Lakes Regional Collaboration's goal of protecting and restoring 200,000 acres of wetlands across the basin.

The LaMP Habitat Committee responded to the GLRC target goals for the Great lakes basin by reviewing habitat losses and proposing to increase net wetlands by 125,000 acres for the Lake Michigan basin. Eighty-nine thousand of these acres would be in Michigan and 30,000 in Wisconsin. Illinois and Indiana have also committed to 1,000 acres each . Additional details are provided in LaMP 2006.

Threats to the Food Web Foundation

The plankton communities (microscopic plant and animals) of Lake Michigan are the foundation of the aquatic food web and therefore are one of the most critical components of the lake's ecosystem.

Monitoring the Benthic Community

The U.S. Environmental Protection Agency's Great Lakes National Program Office (GLNPO) is responsible for monitoring the benthic community health over time to identify any emerging water quality or food chain problems. Benthic organisms inhabit the bottom sediments of the Great Lakes and form an essential part of the food chain. The Research Vessel Peter L. Wise Lake Guardian is used to conduct the surveys. Diporeia, the formerly dominant benthic macroinvertebrate in offshore waters of the Great Lakes, decreased in abundance in southern Lake Michigan by 89%, 91% and 45% at sites at depths of < 30 m, 31-50 m, and 51-90 m between 1993 and 2002.

More information is available at: http://www.epa.gov/glnpo/monitor.html

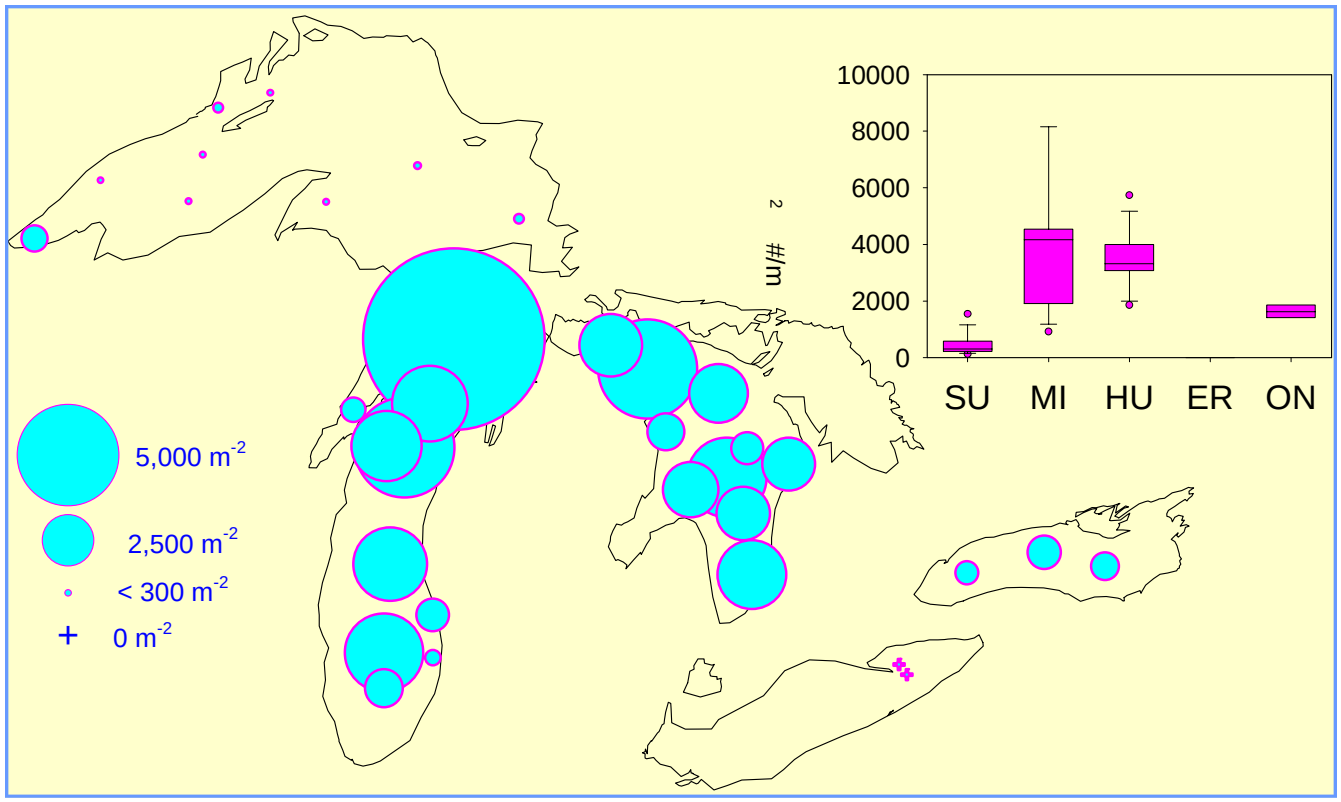


Figure 4-1. Diporeia density in the Great Lakes 1997

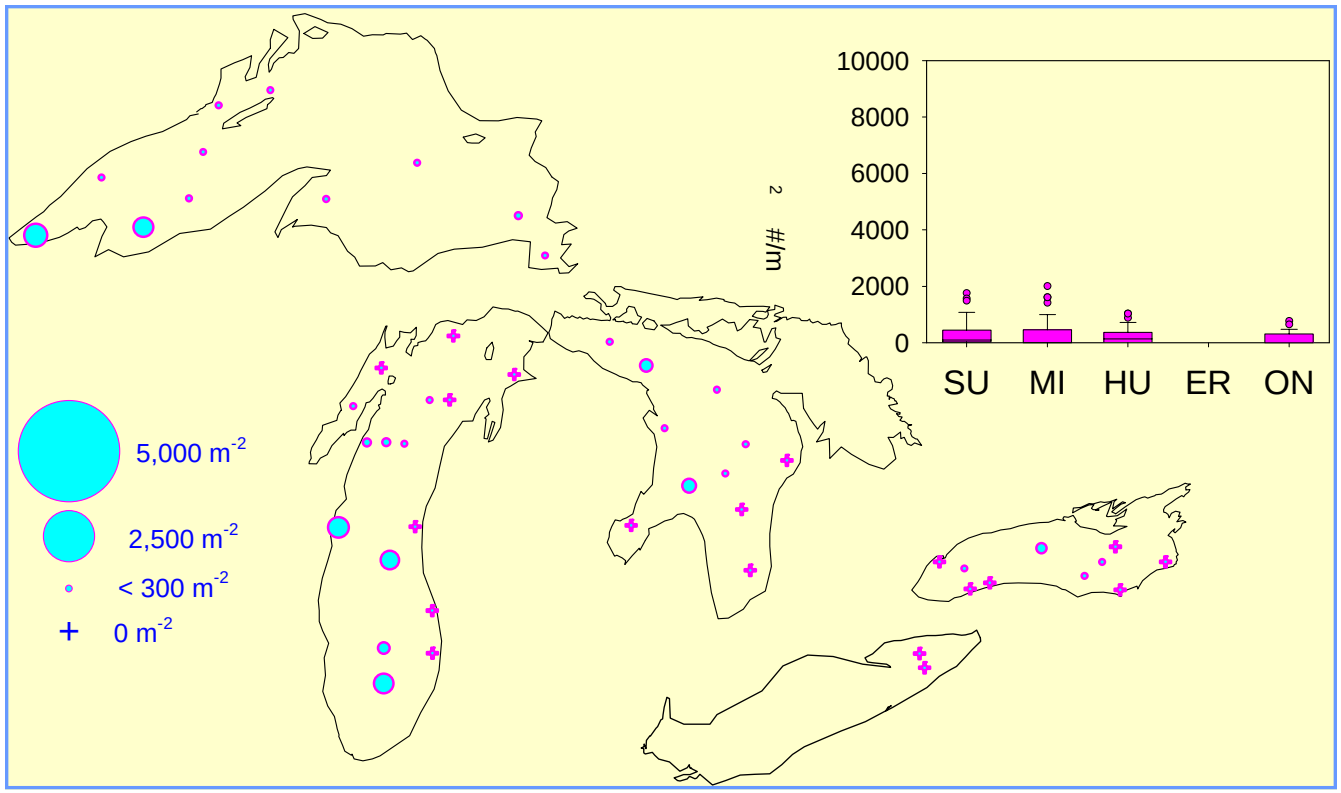


Figure 4-2. Diporeia density in the Great Lakes 2004

Source: David Rockwell, Environmental Scientist, MIRB-GLNPO; Dr. Richard Barbiero, Ph.D., Senior Environmental Scientist, CSC; Thomas Nalepa, Research Biologist, GLERL, NOAA; Dr. Mary D. Balcer, University of Wisconsin-Superior

Changes to these communities may be occurring due to the presence of contaminants and/or nutrients in the water, sediment, and increasing competition from invasive species such as the spiny water flea (*Bythotrephes cederstroemi*) and the zebra mussel (*Dreissena polymorpha*).

The abundance and types of phytoplankton are highly variable within the lake, depending on the time of year, area of the lake, and availability of phosphorus and other nutrients. They are generally found throughout the open lake waters to the depths of light penetration. The amount of phosphorus in the lake is an important man-induced change to phytoplankton communities, especially in nearshore areas. In addition, studies indicate that increased salinity and other (possible climate) environmental changes in Lake Michigan are enabling nonindigenous animals and algae to adapt more readily to the Great Lakes environment.

Zooplankton communities include many different invertebrates and comprise the bulk of the planktivorous fish diet. Because most zooplankton feed on phytoplankton, their abundance and geographic occurrence are similarly dependent upon water temperature, seasonal changes, and food availability. Zooplankton colonize open waters from the surface to the lakebed. Research conducted in the past 15 years indicates that zooplankton populations, such as *Daphnia*, may be experiencing changes induced by *Bythotrephes*, an exotic species.

The *Diporeia spp.*, also known as scuds, sideswimmers, beach hoppers, and sand fleas, belong to the group of invertebrates called amphipods and are about 0.5 inch long. *Diporeia* have inhabited Lake Michigan since the Great Lakes were formed 5,000 to 10,000 years ago, and they are environmentally sensitive, thriving only in clean, cold, well-oxygenated water. *Diporeia* are eaten by a variety of Great Lakes fish and provide an important energy source because they contain high amounts of fat.

***Diporeia spp.*,**
Photo courtesy of GLERL

The numbers and density of these amphipods is decreasing in Lake Michigan. The change between 1997 and 2004 is dramatic (see Figure 4-1 and 4-2). While scientists have not yet determined the exact cause of the disappearance of the amphipods, they suspect it is linked to the introduction of zebra mussels to Lake Michigan in 1989, severely limiting the food available to *Diporeia.*

In addition, zebra mussels appear to be having a significant impact on benthic (bottom-dwelling) community structures and plankton abundance. Zebra mussels, which can attach themselves to any hard surface in the lake, have reached densities higher than 16,000/m^2 in southern Lake Michigan. Negative impacts of their presence include increased food competition (at the expense of fish fry) for nearshore fish species (such as yellow perch), increased biomagnification of contaminants in fish eaters feeding on organisms that eat benthic organisms, and possible zebra mussel-induced mycrocystis blooms, which affect taste and odor in the water.

The Great Lakes National Program Office is supporting sampling activities aboard the Research Vessel Peter Wise Lake Guardian.

Fish Population Decreased in 2007

The quantity of fish food in Lake Michigan hit a record low for the second straight year in 2007. Data collected by the U.S. Geological Survey's Great Lakes Science center indicates that the volume of alewife, bloaters, and other small preyfish eaten by salmon, lake trout, and whitefish fell from 61 kilotons in 2006 to 30 kilotons in 2007. This is 92 percent below the 400 kilotons recorded in 1989.

There is speculation that this may be driven by the explosion of quagga mussels now found in Lake Michigan. Quagga mussels, an invasive species, now make up 98 percent of the mussels in Lake Michigan. Quagga mussels consume the plankton that are at the base of the food chain. Unlike zebra mussels, they can survive and thrive at lower depths. As the quagga mussel population has grown, the zebra mussel population has decreased.

The reduction in preyfish population is leaving less food for salmon and whitefish. The states that surround Lake Michigan stocked fewer salmon. There

Hersey Dam Removed in Muskegon River Watershed

The Hersey Dam, located at the confluence of the Hersey and Muskegon Rivers, was removed in 2007, restoring the natural course of the River. The river, which is a cold-water trout stream, now allows fish and other aquatic life in the lower Hersey and Muskegon rivers to move freely between the two waterways.

The first Hersey Dam was built a mile from where the Hersey flows into Muskegon River in 1858. The dam once powered a sawmill and grain mill, but it disrupted the river's natural flow, blocked fish passage, and increased water temperatures. The river is now a fast-flowing river. Willow trees have been planted on the banks to help provide shade to keep the temperature of the river cooler.

Two dams have been removed from the Muskegon River's main branch since the 1960s: the Newaygo Dam in 1969 and the Big Rapids Dam in 2001. Removal of the Newaygo Dam played a major role in the lower Muskegon River becoming the state's most productive salmon stream.

Sturgeon River Dam Removed

The dam site before removal

The dam site after removal

A Wisconsin Power and Light dam located on the Sturgeon River near Loretto was removed in its entirety in 2006 and the river brought back to its original grade. The penstock, power generating house and all electrical poles, wiring, and other associated items are gone. All of the concrete was removed and more than 80,000 cubic yards of sediment behind the dam and that collected in the slack water below for three years was disposed of in an adjacent upland swale and then topsoiled, seeded and mulched. This is among the largest dams completely removed in the State of Michigan.

is also speculation that the reduction in preyfish has been caused by too many salmon chasing too few preyfish.

Great Lakes Fishery Commission Lake Michigan 2007 Report and Environmental Objectives

Lake Michigan once supported the largest lake trout fishery in the world before lake trout were driven to extinction after the introduction of sea lamprey in the 1940s and 1950s, coupled with overfishing and habitat degradation. In the mid-1980s, two lake trout refuge areas were established in regions where the most productive native lake trout spawning habitats occurred in Lake Michigan. Stocking efforts were concentrated in these areas and regulations prohibited fishing for lake trout within these refuges. Stocking programs have successfully built lake trout spawning stocks to historic levels at which natural reproduction occurred; however, current spawning success has been very limited.

Lake Michigan has a number of offshore reefs which are mainly concentrated in the Northeastern and central regions. The widespread availability of deepwater reef habitats structured the historical fish community, which was predominantly deepwater species such as Lake trout, whitefish, and ciscos. However, with the extinction of native lake trout populations, today these reefs are not being utilized for spawning as much as they could be. The nearshore reefs in Lake Michigan are located along the northern, western and eastern shores as well as in Green Bay, and have been subjected to degradation by sedimentation and the invasion of exotic species. These reefs historically supported reproduction of lake trout, lake whitefish, yellow perch, walleye, and smallmouth bass. Man-made structures such as breakwalls, piers, industrial water intake and discharge structures, and artificial reefs also are utilized as spawning reefs (Fitzsimons 1995).

The 2000 Lake Michigan LaMP adopted the Great Lakes Fishery Commission Lake Michigan Environmental Objectives. For example:

- Benthivore Objective. *Maintain self-sustaining stocks of lake whitefish, round whitefish, sturgeon, suckers, and burbot. The expected annual yield of lake whitefish should be 1.8-2.7 million kg (4 to 6 million lb).* Lake whitefish spawn throughout Lake Michigan. Spawning reefs are located along the northwestern, northeastern and eastern shores with concentrations in Grand Traverse Bay, Beaver Island, Millecoquins Point and the Door County peninsula. Round whitefish spawning reefs are found in the northern half of the lake around the Manitou Islands, Grand Traverse Bay, Ludington, and the Door County peninsula.
- Physical/Chemical Habitat Objective. *Achieve no net loss of the productive capacity of habitat supporting Lake Michigan's fish communities. High priority should be given to the restoration*

States and Federal Government Develop New Plan for Lake Michigan Lake Trout

Michigan DNR, Wisconsin DNR, the Great Lakes Fishery Commission, and the U.S. Fish and Wildlife Service developed a revised plan for the lake trout in Lake Michigan. Over the past 40 years efforts to restore the lake trout populations in Lake Michigan have met with limited success due to inadequate levels of stocking, inappropriate stocking practices, excessive fishing mortality, and interactions between lake trout and native and non-native species. Based on an analysis of these impediments, the Lake Michigan lake trout plan was revised. The goals are to reestablish a diversity of lake trout populations composed predominantly of wild fish and sustain desirable fisheries. By 2035, the states plan to have wild fish comprise 75% or more of the population of age-10 and younger in specific deep and shallow-water habitats.

The plan shifts stocking to priority areas of limited geographic extent that have the best reproductive habitat and where fishing is minimized. In these limited areas, hatchery-reared fish will be concentrated to provide a sufficient density of adults for successful reproduction and to reestablish lake trout as a dominant local predator. Morphotypes introduced from Lake Superior into deep, offshore waters are expected to augment the population of lean lake trout in shallow water.

Continued control of fishing and increased control of sea lamprey populations are needed to achieve the population densities required for sustained natural reproduction. Assessment of progress towards achievement of the goal and the results will be reviewed annually and reported.

More information is available at: http://dnr.wi.gov/fish/lakemich/managementreports.htm.

and enhancement of historic riverine spawning and nursery areas for anadromous species. Nearshore spawning reef habitats are important to the reproductive success of lake trout, lake whitefish, yellow perch and walleye populations and offshore spawning reef habitats for lake trout in Lake Michigan. High quality reef habitats are required for natural reproduction of lake trout.

Degradation of water quality affects the biological productivity of Lake Michigan's ecosystem. Nutrification, sedimentation and contamination are functions of natural as well as human activities and

Lake Trout
Courtesy of the Ontario Department of Fisheries and Oceans

contribute to changes in the food web. Land use changes, point and non-point discharges, and air emission deposition jeopardize the water quality of the lake.

The availability of nutrients in the water column plays an important role in the lower trophic level of the food web. Nutrients are necessary for regulating the planktonic communities and maintaining the lake's production. Increased nutrient levels can result in eutrophication leading to an unbalanced ecosystem. Increases in nutrients lead to an increase in aquatic plant and algae production, a depletion of the water's dissolved oxygen content resulting from plant decay and oxygen uptake during algal blooms. In addition, increased turbidity from algae reduces the amount of light penetrating the water and decreases the growth of submergent vegetation which can result in a loss of habitat for fish and other aquatic organisms.

Phosphorus has the greatest potential to affect the lake's ecosystem by acting as a catalyst for eutrophication. Regulation of phosphorus through decreasing point sources from major water treatment plants, and bans on phosphorus in detergents have been a successful management strategy to control eutrophication . Since 1981, phosphorus loadings in Lake Michigan have been below target loads set by the GLWQA of 5600 metric t/y , while chloride, nitrogen and silica concentrations increased from both increased loadings and biological cycling.

In **nearshore waters**, zebra mussels (and more recently quagga mussels) are thought to have changed the dynamics of phosphorus cycling and increased water clarity, which along with increased tributary loadings of phosphorus from agriculture and urban areas is stimulating blooms of Cladophora, a benthic algae. The consequences of algal blooms for fisheries are potential degradation of nearshore spawning and nursery habitat and harm to social concerns including tourism and angling nearshore.

Sedimentation of nearshore habitats is a water quality issue attributed to natural forces, but exacerbated by human activities. The expansion of urban development around the lake increases surface runoff and magnifies erosion in concentrated patterns. Agricultural practices such as tilling and overgrazing expose large areas of soil to wind and water erosion. Sedimentation can cloud water clarity, which reduces the growth of submerged aquatic vegetation, degrades fish spawning areas and food sources, and acts as a medium to transport and retain pollutants.

Contaminants in the lake basin pose serious threats to the health of the Lake Michigan ecosystem. The various activities occurring in the Lake Michigan basin such as urban, industrial and agricultural land uses have left a legacy of contaminants in the lake. The most severely degraded areas in the lake are identified as Areas of Concern (AOCs). The GLWQA defines AOCs as areas that fail to meet the objectives of the agreement including impaired beneficial use of the area's ability to support aquatic life.

Dams played a major role in the development of the Great lakes for lumber mills, hydroelectric power, navigation, and flood control. While thousands of the dams remain, many of the benefits they originally provided do not. As the original use is lost, so often is the funding source for maintenance. Sixty percent of dams are in private hands, 21 percent belong to local governments, and the rest to federal and state governments and utilities. Concern over aging dams as well as their acting as barriers to fish passage upstream highlighted the need to adapt dam management practices.

In the Great Lakes, the ability to identify linkages between climate, aquatic ecosystems, fish population dynamics and fisheries has improved tremendously

The Lake Michigan Toolbox
WildLink Program Helps Landowners Keep Space Open for Wildlife
Climate Change Adaptation

The WildLink Program is overseen by the Conservation Resource Alliance and assists volunteer land owners in managing private-property corridors used by wildlife for travel between one large parcel of land (such as state-owned wildlife areas) to another. Its aim is to preserve the rural character of northwestern Michigan for outdoor recreation, hunting and wildlife watching in natural surroundings.

Wild Link focuses on parcels which fall within ecological corridors, or pathways of habitat. These privately owned corridors provide the critical connections between larger protected public properties.

The program, funded by the U.S. Fish and Wildlife Service, assists land owners in outlining a five to ten-year voluntary program for developing or modifying land use in order to keep wildlife corridors open for animal movement which may become critical to survival in a future with climate change.

More information available at:
www.rivercare.org/wildlink/wildlink.php

The Lake Michigan Toolbox
Great Lakes Basin Landscape Ecology Metric Browser

USEPA designed a Great Lakes Basin Landscape Ecology Metric Browser. The principal focus of this project is the mapping and interpretation of landscape scale (i.e., broad scale) ecological metrics among hydrologic units and within 1 km, 5 km, and 10 km regions of coastal land in the Great Lakes Basin (GLB). Much is still unknown about the ecological relationships between human activities, surface water quality, and the biological characteristics with the GLB. This browser is an important step toward understanding the distribution of these phenomena and the analyses of their interrelationships.

The browser is designed to present some key ecological metrics to the GLB public and research communities at a landscape scale and will be updated as additional analyses are completed. For additional information regarding the topic of landscape ecology, visit the following web site: www.epa.gov/nerlesd1/land-sci/intro.htm. This is the initial presentation of landscape metrics for the GLB; for current applications of these metrics and results from other related topics in the Great Lakes, visit the following web site: www.epa.gov/nerlesd1/land-sci/wetlands.htm

through collaborative relationships and expertise between state and federal research and management agencies, and universities. The availability of extensive time series data on fish community abundances and harvests now permits characterization of natural variability and prediction of future climate impacts. Hydrodynamic circulation models now available for Lake Michigan permit understanding of how lake circulation patterns may retain or advect fish larvae away from favorable nursery areas, with implications for fish recruitment and movement. Studies of land-use patterns, watershed dynamics and fisheries habitat allow prediction of direct and indirect effects of climate change on tributary habitats and their adfluvial fish populations.

Information and Research Needs include:

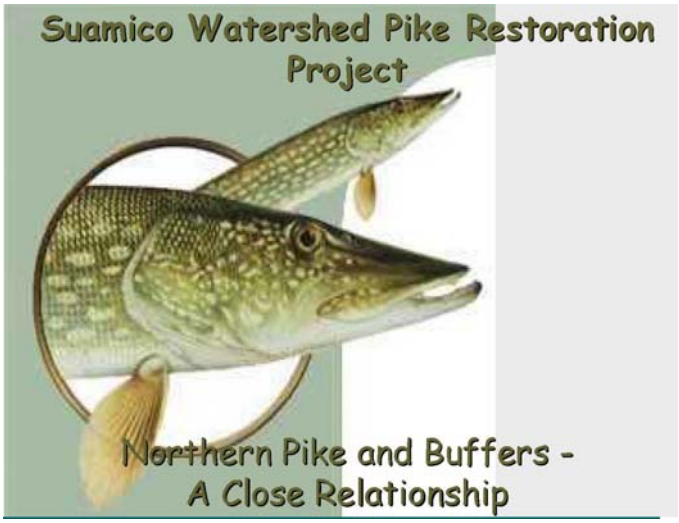
- Understand and predict climate change impacts on fish habitats, fish vital rates, and fisheries harvest over multiple spatial scales, ranging from tributaries to open-lake habitats, and incorporate that knowledge into fisheries management policies.
- Quantify historic natural population variability of young-of-year or yearling fish abundances on annual and decadal time scales, and relating the variability to historic climate patterns.
- Use regression and simulation models to predict climate change impacts on key lake fishes across multiple spatial scales.

Lake Sturgeon

Lake sturgeon, formerly a dominant nearshore species, continues to be the object of increased study and recovery effort. The previous state-of-the-lake report indentified at least eight known remnant populations, the largest spawning runs of several hundred fish and the smallest with few or unknown spawners annually. Several indications suggested lake wide abundance, though low, was increasing. Despite these positive signs, lake sturgeon continues to be considered rare, endangered, threatened, a species of greatest conservation need, or a resource

Suamico Watershed Pike Habitat Restoration Project

The intent of the Suamico Watershed Pike Habitat Restoration Project of the Brown County Land Conservation Department is to create, enhance or restore high quality spawning and rearing habitat for Northern Pike (a predator fish that resides in the Bay of Green Bay as an adult) as well as enhancing and protecting critical wetland habitat in an area where over 70% of such habitat has been lost. To accomplish this, the project will create approximately 12-14 acres of new spawning marshes capable of producing in excess of 20,000 young of the year Northern Pike per acre. The project plans to remove several major stream impediments in order to open access to an additional 3-4 miles of stream to spawning Pike. The project will establish buffers along shallow headwater streams which have been highly degraded by agricultural runoff creating sediment and nutrient related problems. Local and national conservation groups such as Ducks Unlimited, Trout Unlimited and the Nature Conservancy will promote the importance of the project on both a local and national level. The project will work to educate local government and citizens regarding the simplicity and effectiveness of vegetative buffers in protecting streams and will encourage local government to enact local ordinances for their perpetual protection.



conservation priority by one or more of the state, tribal, and/or federal agencies with responsibilities for the lake's fishes.

Recent mark-recapture estimates and direct counts indicate annual spawning runs of 199-577 adults in the lower Peshtigo River, 23-52 adults in the lower Manistee River, 24-49 adults in the lower Fox River, and 15-23 adults in the lower Muskegon River. Though spawning-run size in the lower Menominee River has not been estimated, the resident population during summer was estimated at 457-1,329 fish in 1991, and spawners are thought to number in the hundreds each spring. Gill-net assessments and sightings suggest that annual spawner abundance in the lower Oconto, lower Manistique, lower Grand, and lower Kalamazoo rivers is less than 25 fish per river. Sightings and sampling also suggest that adults may periodically spawn in the lower St. Joseph and Millecoquins rivers, and possibly on some shoals. Populations also persist in two sections upstream of dams on the Menominee River, in Indian Lake upstream of the lower dam on the Manistique River, and possibly upstream of the lower dam on the St. Joseph River. A large, self-sustaining population exists in the Lake Winnebago system upstream of the lower Fox River. Although fish from these systems can move downstream to Lake Michigan, they cannot return upstream beyond the first dam on each river.

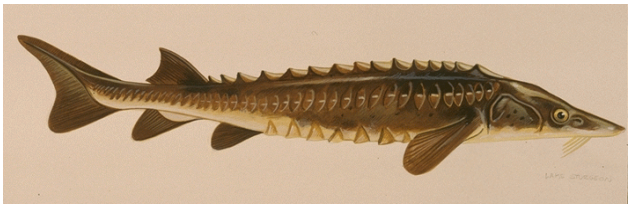
Since 2000, production of sturgeon larvae has been documented in the lower Fox, Oconto, Peshtigo, Menominee, Manistee, Grand, and Muskegon rivers, and fall young-of-year (YOY) have been documented in the Menominee, Manistee, Oconto, and Peshtigo rivers. A single larvae has been collected in each of the St. Joseph and Kalamazoo rivers. The largest catches of drifting larvae and YOY have consistently come from the Peshtigo and Manistee rivers.

Populations of lake sturgeon are genetically structured, with differences occurring geographically. Sturgeon populations in the Menominee, Peshtigo, Oconto, lower Fox, and Wolf rivers, and all of Green Bay were genetically more similar to each other than to populations in the Manistee and Muskegon rivers, which in turn were more similar to each other than to populations in Lake Huron tributaries. Small populations do not lack genetic diversity nor do they exhibit higher levels of genetic drift or inbreeding compared to larger populations. The significant differences in allele frequency at microsatellite loci and in mitochondrial DNA among populations, including those in relatively close proximity, indicate that populations are reproductively isolated and that spawners exhibit a high degree of fidelity to their river of origin. Tag returns also indicate that spawners return to the same river repeatedly to reproduce.

Spawning populations are composed primarily of fish less than 35 years of age and 175-cm total length, although fish exceeding 50 yrs of age and 200 cm have been collected. As expected, sex ratios of

spawning fish are highly skewed toward males, particularly in rivers with younger fish. Open-water assessments targetting all sizes of sturgeon are dominated by fish less than 1,000-mm TL and younger than 12 years, suggesting recruitment to spawning may improve. Observations of increased numbers of spawning fish in some tributaries, and reports of increased encounter rates by commercial and recreational fishers and in agency assessments, suggest recruitment has improved in at least some areas of the lake during the 1980s and 1990s. If true, spawner abundance in some rivers may continue to increase in the near future as juveniles reach maturity.

Recaptures of marked sturgeon from the open waters of central and southern Green Bay indicate a population (fish ≥122 cm) of 920-4,455 (95% CI). In a population of this size a loss of more than 100 adult fish/yr could be excessive. The recreational harvest in the lower Menominee River has increased steadily



Lake Sturgeon
Figure Courtesy of the Ontario Department of Fisheries and Oceans

over the past 20 years, reaching a high of 150 fish (125-cm minimum length) registered during the 2003 season. While increasing harvest could be indicative of increasing abundance, effort also is increasing. Other sources of mortality are from injury of fish released alive by recreational and commercial fishermen and fish struck by boat propellers or killed when passing through or around hydropower facilities. Each summer since 2001, dead lake sturgeon have been reported washed up on beaches from numerous areas around the lake. As many as 21 fish were reported in 2003, primarily from central Green Bay. Other fish have been recovered near Michigan City, Indiana, and Manistee and Petoskey, Michigan. It is uncertain what proportion of this die-off is being observed or reported. At the time of recovery, no obvious cause of death has been apparent, but laboratory examination of fresh specimens recovered from Green Bay found enough *Clostridium botulinum* in ingested prey items to suspect type-E botulism. Similar die-offs in Lake Erie and Lake Ontario since 2000 have been associated with type-E botulism .

More Sturgeon than Thought Found in the Muskegon, Manistee, Grand, and Kalamazoo Rivers

Sturgeon have been in the planet's waters for 100 million years. The fish, which can grow to eight-feet long and weigh 300 pounds, were a dominant Great Lakes fish for thousands of years before the presence of logging, dam construction and excessive fishing eliminated about 99 percent of the fish from Lake Michigan and its tributaries.

Scientists estimate that there are between 1,000 and 3,000 sturgeon in Lake Michigan, down from 11 million thought to live in the lake in 1800. Biologists hope to restore its population by improving fish habitat in large rivers -- such as the Muskegon, Manistee, Grand and Kalamazoo — where sturgeon spawn and once were abundant.

Research by University of Georgia scientists indicated that there are far more juvenile sturgeon in the Muskegon River than previously believed.

Biologists from WDNR, MDNR and the USFWS have conducted regular surveys of the sturgeon population in the Menominee River for years, the largest population in Lake Michigan. WNDR has active management involving the harvest fishery and stocking in that system. Researchers from Purdue University and the University of Alaska working with USFWS and WNDR have conducted annual recruitment surveys of young sturgeon in the Peshtigo River from 2003-2007, indicating recent substantial annual production.

Annual spawner abundance is also monitored in each river where remnant populations persist (Fox, Oconto, Peshtigo, Menominee). The Manistee River, Michigan also has nearly a decade of good assessment data on adults and recruitment of young, and ongoing rehabilitation work.

Though sea lamprey-related mortality has not been quantified for sturgeon, eighty-two of 212 fish collected in 2003 from the open waters of Green Bay bore 128 marks. Type A-IV and B-IV (healed) marks were most common and amounted to 37 per 100 fish, indicating that sea lampreys commonly attached to sturgeon. Marking rates were 6 per 100 fish for AI-AIII marks, which indicate more recent attachments. The relationship between sea lamprey marking and mortality is currently being researched. The sensitivity of young lake sturgeon to the chemical TFM used to treat rivers for larval lamprey has led to the implementation in 1998 of a "sturgeon protocol" that reduces the concentration of TFM and defers

treatments until after July 1 in rivers where YOY sturgeon are known or suspected to occur.

Management

Substantial portions of the sturgeon's historic spawning and rearing habitats are impounded or blocked by dams, and no effective passage exists around these barriers. Passage, however, is being designed into a replacement for the Manistique River dam and for several dams on the Menominee River. Passage for native fish species, including lake sturgeon, will also be provided as a condition of operation of a new barrier to be constructed on the Cedar River. Careful regulation of flow over dams and through hydropower facilities is also necessary to ensure that river segments below dams remain useable by sturgeon.

In 2000, recreational harvest of sturgeon from Lake Michigan waters was banned, except in the Menominee River where harvest from a fall recreational fishery was reduced by increasing the minimum size limit from 50 inches to 70 inches (TL) in even numbered years, creating essentially a catch-and-release fishery.

In 2004, the Little River Band of Ottawa Indians began on the Manistee River a long-term rearing program where wild-caught larvae are transferred into a streamside rearing facility for several months to enhance early survival and then released back, typically in late summer . The goal is to increase early survival while not diminishing imprinting to the river.

In 2003, the Wisconsin DNR initiated reintroduction of lake sturgeon into sections of the Milwaukee and Manitowoc rivers having an unimpeded connection to Lake Michigan. Hatchery-reared larvae from egg-takes in the Wolf River were stocked into the Manitowoc (N = 119,793) and Milwaukee (N = 64,000) rivers in the spring of 2003. In 2004, fingerlings (N = 2,000) and juveniles (N = 200) were stocked into the Milwaukee River, and will be stocked in both rivers in 2005. In addition, 6-8 adults were transferred from the Wolf River into the Milwaukee River in each of these years. Details of these stocking programs spurred significant debate among the agencies and institutions involved with lake sturgeon management and research. Concern focused on the need to maintain and ensure genetic diversity in Lake Michigan populations and on the potential risks posed to remnant populations if stocked fish were to stray and spawn in non-target rivers. In 2003, the LMC formed the Lake Michigan Lake Sturgeon Task Group

The Lake Michigan Toolbox
Milwaukee Pilot Project Offers Wetland Data Tools

In the last few decades, scientists have confirmed the critical role wetlands play in urban as well as rural areas. Not only do they provide habitat to a wide diversity of valuable plants and animals, wetlands reduce flooding, protect surface water quality, and provide scenic beauty and open space. Many of the wetlands in the Milwaukee River Basin have been destroyed, filled in, or drained to create farm fields, cities, and roads. The Milwaukee River Basin Wetlands Assessment Project seeks to understand the consequences of these losses and examine options for future planning. Questions the project will consider include: What wetland resources do we have left and how do they benefit us? Where can former wetlands be restored for the most benefit for people and wildlife in the basin?

The Milwaukee River Basin Wetlands Assessment Project is a pilot project that will develop tools to improve planning wherever wetland resources are a concern. It will provide governments, conservation organizations, and other decision makers tools to better understand where wetland restorations are most likely to improve habitat or water quality. These tools are a way of analyzing the relative level wetlands in small catchments provide wildlife habitat and water quality treatment (through sediment trapping/ nutrient) to protect downstream waters. They relate more to "ecosystem services" than to wetland biological integrity.

The project is spearheaded by the Wisconsin Department of Natural Resources through a grant from the U.S. Environmental Protection Agency. More information is available at: http://search.wi.gov/cs.html?url=http%3A//dnr.wi.gov/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf&charset=iso-8859-1&qt=url%3Adnr.wi.gov+%7C%7C+milwaukee+river+basin+wetlands+assessment+project&col=noquery+query&n=2&la=en

(LSTG) and charged it with reviewing stocking proposals and developing a rehabilitation plan for lake sturgeon. Initial work on this plan resulted in draft *Guidelines for Genetic Conservation, Propagation and Stocking of Lake Sturgeon in Lake Michigan*. The agencies agreed to follow these guidelines when stocking fish in the future and began work to develop streamside facilities as means of rearing lake sturgeon in a manner that all agencies could accept for stocking into the Milwaukee, Manitowoc, Cedar, and Whitefish rivers beginning in 2006.

Michigan DEQ Report Outlines Impacts of Beach Maintenance

A report released in March 2006 by the Michigan Department of Environmental Quality found negative impacts to coastal areas where "beach grooming" had occurred. The report, developed by a team of scientists from Michigan State University and Grand Valley State University, compared groomed beaches with similar, nearby natural beaches, allowing the researchers to measure how fish populations, other animals, and marsh plants are affected.

The study showed that clearing vegetation through a coastal marsh alters the chemical and physical conditions of nearshore waters, reducing or eliminating habitat for Michigan's important game fish including yellow perch, smallmouth bass, and largemouth bass.

According to the Michigan DNR, approximately 90% of the 200 fish species living in the Great Lakes rely on coastal wetlands during some part of their life cycle. The report found negative impacts to several important game fish including yellow perch, smallmouth bass, and largemouth bass. The study also found that beach grooming destroyed stands of important plants and helped invasive species colonize the groomed areas.

In light of this research, MDEQ Director Steven Chester has recommended to the Legislature that the provisions created through 2003 wetlands legislation be allowed to expire according to the sunset dates in the law.

More information is available at: www.michigan.gov/deq/0,1607,7-135-3313_3687-10202--,00.html.

Progress Towards Sustainability Recommendations for Fish

Lakewide abundance and distribution of lake sturgeon in Lake Michigan remains low and restricted compared to historic levels. Although some populations appear to be self sustaining and possibly increasing in abundance, the long-term status of other populations remains questionable. Research and assessment efforts during the last five years represent progress in meeting the fish community objective of maintaining self-sustaining stocks, but the objective of enhancing the lake-wide population will require a larger effort. Existing agency rehabilitation plans and the current draft of the LSTG rehabilitation plan provide additional objectives and strategies for maintaining and enhancing self-sustaining stocks of lake sturgeon. Specific strategies include inventorying populations and habitats so that areas for protection and rehabilitation can be prioritized; augmenting remnant populations and re-establishing others; determining effects of exotic species, contaminants, and diseases on lake sturgeon; and implementing public education. A long-term commitment of additional resources will be required to implement and evaluate these strategies. With the eventual approval of a lake sturgeon rehabilitation plan, it will be appropriate to incorporate more specific objectives and strategies for lake sturgeon into a future revision of the lake's fish community objectives.

Land Use Changes

The Lake Michigan basin is seeing changes in land use over the last several years. According to the National Land Cover database, land is used primarily for agriculture. However, according to the Coastal Change Analysis Program overseen by NOAA, development is encroaching on the farmland. Forest land has decreased by a small amount, but this decrease is being more than offset by an increase in tree farming as evidenced by an increase in shrubland. Wetlands saw a slight increase between 1996 an 2001, indicating that wetland restoration and protection programs have had an effect.

Wetland Restoration

Wetland restoration programs have seen a significant increase in activity. The Great Lakes Regional Collaboration set a goal of increasing the net acreage of wetlands Great Lakes basin-wide by 1.1 million by 2020. Michigan set a target acreage for its

portion of the Lake Michigan basin at 89,750. Wisconsin has set a target statewide of an increase in 30,000 acres. Both states have developed programs that encourage wetlands restoration using state and private programs.

A wetland restoration project tracking database and pilot collection system maintained by NRCS, USFWS, and WDNR is working to help track wetland loss. This project involves collecting a uniform set of data to track wetland restoration projects done by the major organizations responsible for wetlands. The project also involves establishing a geospatial database that contains the tracking data. The objective in this project is to plug a major gap in reporting wetland "gains" achieved through voluntary restoration projects and to resolve the problem of double and triple counting the acres involved when these players

Charter Township of Garfield in Grand Traverse County, Michigan
Riparian Vegetative Buffers

The Garfield Township Planning Commission began examining riparian vegetative buffers based on recommendations in the Mitchell Creek Watershed Study. Vegetated buffers along streams and lakes provide widely recognized environmental benefits. After initial investigations by the Planning Commission the one hundred foot buffer recommendation of the Mitchell Creek Study was determined to be excessive in the context of Garfield Township's suburban landscape.

In March 2006 Garfield Township adopted a thirty five foot vegetative buffer requirement which provides maintenance of ground cover in its natural state, prohibits clear cutting of vegetation, and regulates fertilization of stream bank vegetation.

Existing - Lawns and grading near edges of creeks.

Preferred - natural state vegetative buffers provide full to partial shading, and woody materials contributing to the vegetative "tea" for a healthy fishery.

collaborate on a restoration project. Many wetland losses are not known because we have no way of accounting for illegal losses or loses which do not require a permit. The project will report wetland losses and gains that are captured through the wetland permit tracking and compensatory mitigation databases to generate an overall status report on known wetland activities.

Buffer Strips

Stream bank buffer strips not only provide buffers against nonpoint pollution, they also protect aquatic and stream bank habitat and provide for more natural flow of streams.

Well managed riparian buffers generally support larger populations of wildlife because the buffer provides many habitat requirements. In a stratified forest, different habitat zones exist vertically, including at the soil-air interface, intermediate zones, and at the canopy. Plants in these areas includes herbs and shrubs at lower levels, and intermediate height and taller trees which reach up to the canopy. Included with the leaf litter and rotting logs at the soil-water interface are insects. These organisms are a food source for reptiles, amphibians, small field mammals, and birds. The herbs and shrubs provide habitat for insects, birds, and mammals. The intermediate zone and the canopy serve as habitat for birds, bats, squirrels, opossums, and raccoons. Bird habitat may be highly stratified, and birds generally show a preference for certain layers that differ in habitat characteristics and food sources (See Chapter 7 for information).

The Great Lakes Regional Collaboration set goals for the Great Lakes basin at 1.1 million new acres of buffer strips. The states are beginning to set targets for buffer strips for Lake Michigan streams.

The Lake Michigan Toolbox
Buffer and Shoreline Protection Ordinances in Wisconsin

River Hills Buffers

The River Hills Committee on the Environment is working to restore and protect the riparian buffers which in turn restore and protect the quality of all Village waterways. The Village has had a buffer ordinance since 1973. Because riparian buffers are the single most effective protection for our water resources, it is vital that all residents support the preservation of riparian areas along the Milwaukee River and our other Village waterways.

To be most effective river buffers should include native vegetation and be as wide as possible. Riparian strips of native vegetation, shrubs, and trees filter polluted runoff and provide a transition zone between water and human land use. Buffers are also complex ecosystems that provide habitat and improve the stream communities they shelter. Natural riparian buffers have been lost in many places over the years. Restoring them will be an important step toward improving water quality, riverbank stability, wildlife, and the aesthetics of our waterways in River Hills.

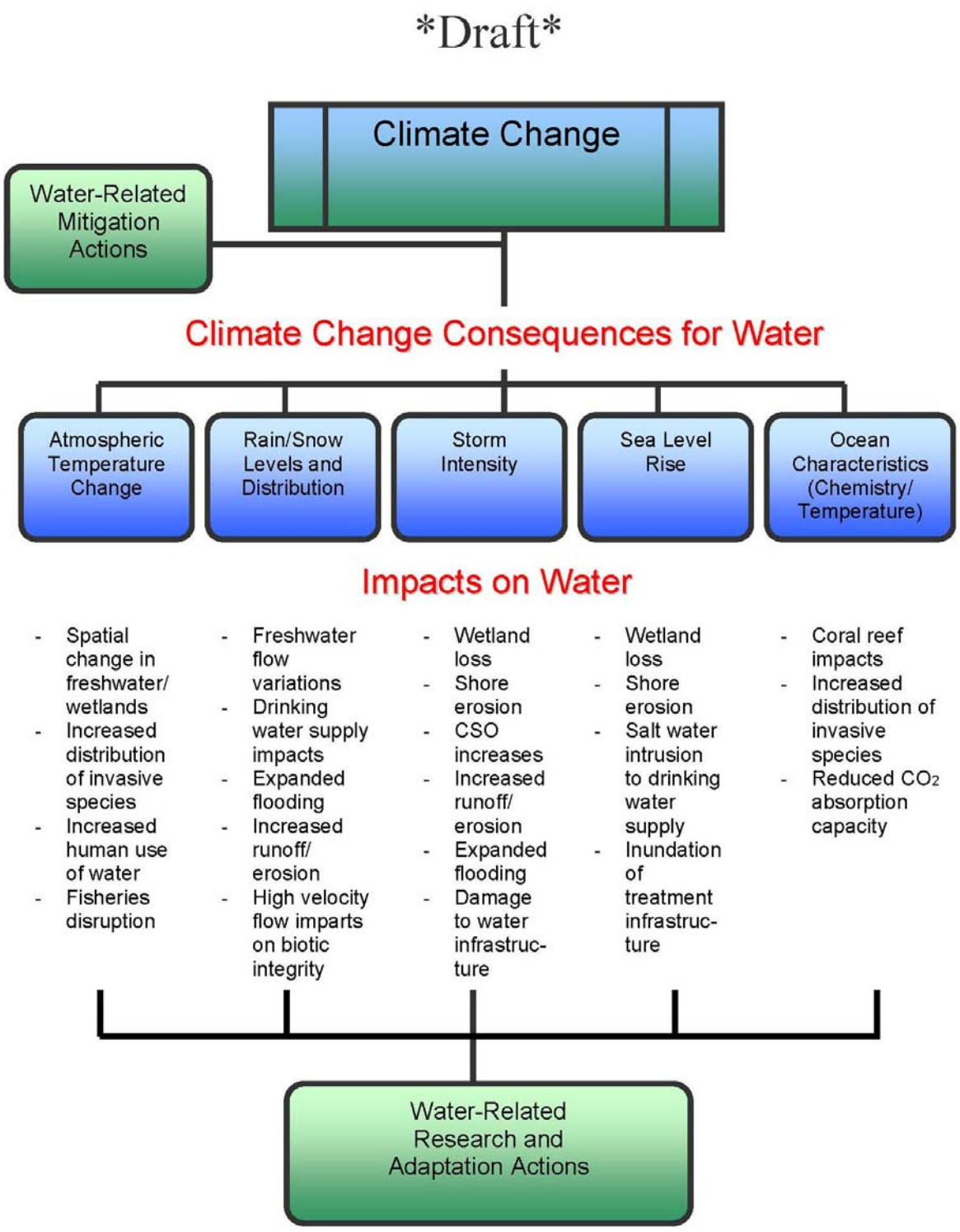
More information is available at www.riverhillswi.com.

Brown County Shorelands Ordinances

Brown County has two County Ordinances that include buffer strip requirements:

- Shorelands and wetlands ordinance (Chapter 22) (regulation can be used under this ordinance without cost share required and
- Agricultural shoreland management ordinance (Chapter 10) (regulation can only be used under this ordinance after cost share has been offered by the landowner)

More information is available at www.co.brown.wi.us/county_clerk/CountyCode/Chapter22.html and www.co.brown.wi.us/county_clerk/CountyCode/Chapter10.html.



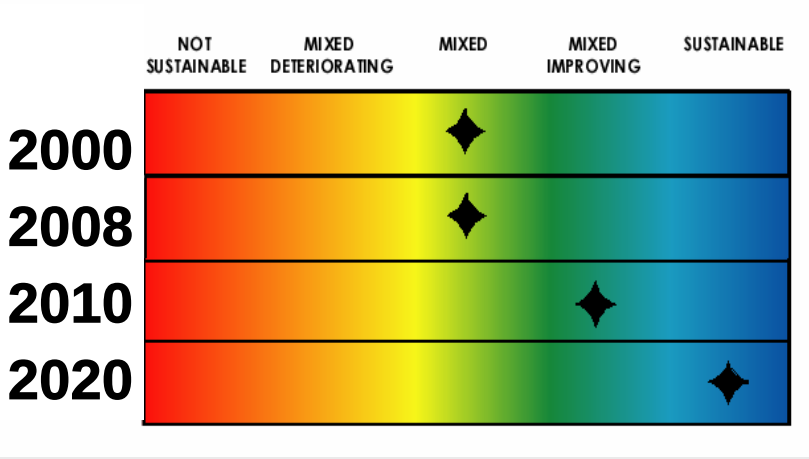
DRAFT Chart: Consequences of Climate Change for Water from "Climate Change and the National Water Program" March 1, 2008 memorandum from USEPA Deputy Administrator Benjamin Grumbles to Office Directors: Office of Water, Water Division Directors: Regions 1 – 10 Great Waterbody Program Office Directors. More information is available at www.epa.gov/water/climatechange/.

Subgoal 5
Does the public have access to abundant open space, shoreline, and natural areas, and does the public have enhanced opportunities for interaction with the Lake Michigan ecosystem?

What is our target for sustainability?

Approximately 50% of the lakeshore area is open and natural with protected areas and abundant opportunities for access and recreation.

Lake Michigan Target Dates for Sustainability



Why is this important?

Outdoor recreation in the Great Lakes basin is an important component of the region's economy and quality of life. The region offers outstanding tourism and recreational opportunities ranging from wilderness activities in pristine national parks to swimming at beaches, fishing, boating, and bird watching. Pressures from development and competing land uses have the potential to limit public access to shoreline and natural areas.

What is the current status?

Currently, the status of the goal is mixed due to the competing needs for the limited lakefront resources.

What are the major challenges?

- Climate Change: Lake level change, emergent vegetation, and storm surges from intensive storms will impact dunes and coastal ecosystems and piers and docks
- Pressure for new development on existing open lands and shorelines
- Increased land costs driven by expanding development
- Fewer government resources available for land use protection and purchase
- Decreasing funding for recreational harbor maintenance
- Lower lake levels leading to closure of some marinas
- Lack of understanding of the economic benefits and value of natural areas

What are the next steps?

- Partner with the growing coastal zone management programs in the Lake Michigan basin to ensure that the issue of public access to the lake is balanced with protection of the ecosystem
- Support a dialogue on green marinas (see Chapter 9) among states and Sea Grant programs
- Determine protection status of world's largest collection of fresh water sand dunes
- Promote public involvement in preservation and stewardship of special natural areas and public access:
  - Broaden the dialogue with state and local government land-use planners and decision-makers to balance environmental and recreational needs through the Lake Michigan Watershed Academy
  - Provide tools for local communities to understand the value of the resource from a lakewide perspective and develop long-term management programs
  - Identify open space multi-use opportunities and tools for such things as flood retention parks and open space with commuter bike trails, among others

What are some tools for addressing the challenges?

- Lake Michigan Water Trails
- Great Lakes Circle Tour Coastal Access Guide: Using Web Mapping to Support Coastal Cultural Tourism

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 7000 - Urban Density
Status: Mixed; Trend: Undetermined
Indicator # 7002 - Land Cover/Land Conversion
Lake Michigan Status: Mixed; Trend: Undetermined
Indicator # 7006 - Brownfields Redevelopment
Status: Mixed; Trend: Improving
Indicator # 7054 - Ground Surface Hardening
Status: Not Assessed; Trend: Not Assessed
Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Alvers
Status: Mixed; Trend: Not Assessed
Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Cobble Beaches
Status: Mixed; Trend: Deteriorating
Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Islands
Status: Mixed; Trend: Undetermined
Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Sand Dunes
Status: Not Assessed; Trend: Not Assessed
Indicator # 8131 - Extent of Hardened Shoreline
Status: Mixed; Trend: Deteriorating
Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Interacting with the Ecosystem

For thousands of years, the abundant natural resources of the Great Lakes system attracted inhabitants to its shores. The fresh water, abundant and diverse fishery, stands of trees, mineral wealth, and fertile soils formed the basis for the quality of life and the economy. The opportunity of using water for drinking, power, and transportation was a key element in the economic equation of the time. The magnitude and diversity of the Great Lakes added a challenging dimension to most endeavors though.

The interaction of Lake Michigan residents with their ecosystem today is still based on natural resources but is less "hands-on." For while the plows still till the soil, the pork belly futures get sold in the Chicago Commodities Exchange pits far removed from the resource. More interaction is now self-selection of activities in which residents are seeking quality of life by being outdoors, often on or near the water. The interaction termed "recreation" is so highly valued by society that special purpose governmental units on the federal, state, tribal, and local levels are charged with protecting natural resources by providing and promoting recreation services utilizing public funds. Recreation takes place on the land, and on, in, and under the water. Scuba diving at old ship wrecks and other natural phenomenon in the lake is a growth sport and opportunities abound to discover other natural and cultural sites.

An entire industry exists to entice visitors to share the region's natural resource-based activities. Studies document that these nature-based tourism activities provide a significant net positive gain for the health of the residents and to the regional and national economy. To sustain this interaction with a positive net gain to the economy, the environment, and society, critical coastal areas must be open and accessible; water must be of high quality and sufficient quantity; sensitive cultural, habitat and biodiversity areas protected; and attention paid to climate change and lake level interaction.

The Green Infrastructure movement is becoming more widespread as a way to educate and inform communities of the important values of open space. Stated simply, green infrastructure is the system of connected parks, trails, and stream corridors that provide conservation and recreation benefits to a community. This connected system is as important as the more traditional infrastructure such as roads and utility corridors for electric power transmission, water and sewer, and public safety.

Areas used for recreation are also important to help adapt to a changing climate. Open space and

The Marquette Plan to Open the Indiana Shoreline

The Marquette Phase II Visioning Plan was launched in 2007. It builds off of the Marquette Phase I project, which set a goal of increasing public access and developing the urbanized area. Marquette Phase II imposes a new set of challenges with a different set of stakeholders and interest groups. It will identify and address the needs of the smaller communities and create a vision that will identify and protect greenways and identify possible water trails in the region.

The Marquette Plan is a regional plan that creates a comprehensive land use vision for the Lake Michigan drainage basin and a strategy for implementation of that vision. Officially the project is an extension, or second phase, of The Marquette Plan: The Lakeshore Reinvestment Strategy (2005).

The initial Marquette Plan: The Lakeshore Reinvestment Strategy was completed in 2005 and addressed pubic access and redevelopment of the lakeshore from the Illinois state line to the Port of Indiana. It was initiated by First District Congressman Peter Visclosky and funded by the cities of Whiting, East Chicago, Hammond, Gary, and Portage. Projects included in the Phase I plan are eligible for funding from the Regional Development Authority. Phase II will focus on the lakeshore from the Port of Indiana to the Michigan - Indiana state line. Funding for planning the second phase is being provided through a grant from the Indiana Department of Natural Resources Lake Michigan Coastal Program with matching funds from the Gaylord and Dorothy Donnelley Foundation, the cities of La Porte and Michigan City, and La Porte County.

The plan received $20 million from the federal government as a result of leadership from Rep. Peter Visclosky.

More information is available at: www.nirpc.org/MP2PCTP/MP2PCTP.htm.

The Lake Michigan Toolbox
Lake Michigan Water Trails

There are many existing water trails in the Lake Michigan basin. Information about them can be found online at the resources listed below.

Illinois
- Northeastern Illinois Watertrails: www.openlands.org/watertrails.asp and gorp.away.com/gorp/location/il/pad_chic.htm
- Chicago Portage Canoe Trail: users.rcn.com/clonk/CCFPD/MINI/#Canoe_trail.htm
- Illinois DNR Canoeing Opportunities: dnr.state.il.us/lands/Landmgt/Programs/Canoe_Kayak.htm

Indiana
- Indiana's Canoe Trails: www.in.gov/dnr/outdoor/canoe/index.htm

Michigan
- Michigan's Canoe Trails: gorp.away.com/gorp/resource/us_river/mi.htm
- Kewaunee Water Trail: www.kayakwisconsin.net/watertrail/countys/kewaunee-wisconsin.html
- Hiawatha Watertrail: www.hiawathawatertrail.org

Wisconsin
- Wisconsin Lake Michigan Watertrail: www.kayakwisconsin.net/watertrail/index.html
- Capitol Water Trails, Inc., Madison, Wisconsin: www.capitolwatertrails.org/

The Lake Michigan Toolbox:
Great Lakes Circle Tour Coastal Access Guide: Using Web Mapping to Support Coastal Cultural Tourism

University of Wisconsin Sea Grant developed an interactive web mapping application to integrate coastal heritage tourism attractions with the Great Lakes Circle Tour route and provide detailed information about public access to the Great Lakes coast. The purpose of the Great Lakes Circle Tour-Coastal Access Guide (http://maps.aqua.wisc.edu/glct/glct_index.htm) is to direct travelers off the heavily-traveled state and federal highways of the primary circle tour route and towards the many coastal access sites and cultural tourism resources located on the downtown streets and rural roads that hug the lakes.

Applications developed in Google Maps, Google Earth, and the open-source Open Layers software provide both a land-side and water-side perspective to the Wisconsin segments of the Lake Michigan and Lake Superior Circle Tour. Map layers include the primary circle tour route, local roads, parks, beaches, lighthouses, shipwrecks, boat launches, historical sites, and oblique photos. Panorama photos that synchronize the field of view with a vicinity map were taken for public access sites to the Great Lakes.

The web mapping applications provide the capability to link to external web content about Great Lakes sites maintained by the custodians of those features. Examples include links to information about shipwrecks, historic markers, lighthouses, museums, and parks from the Wisconsin Maritime Trails web site maintained by the Wisconsin Historical Society and beach information and conditions from the Wisconsin Beach Health site.

INVEST Launches Study to Estimate Dollar Value of Natural Resources

Scientists at Grand Valley State University and Michigan State University developed a computerized tool that estimates the value of natural features in Muskegon, Ottawa, Newaygo, Kent, Ionia, Allegan, and Barry counties. The program is called INVEST, for Integrated Valuation of Ecosystem Services Tool. "We want people to realize that natural features have economic value," said Alan Steinman, director of GVSU's Water Resources Institute and principal investigator on the project. "INVEST is designed to provide citizens with a preliminary look at the value of services that nature provides for free."

Putting a dollar figure on nature, also called green infrastructure, is a difficult job in both a technical and philosophical sense. Officials at the West Michigan Strategic Alliance took on such a challenge though, to help demonstrate that nature is valuable and that damaging it comes at a price. "This is an effort by West Michigan to better understand and measure our quality of life," said Greg Northrup, president of the West Michigan Strategic Alliance. "We hope the monetary values will help residents realize that maintaining our green infrastructure makes good sense in terms of both our environment and our regional economy". Northrup expects the estimated value of the area's natural resources will increase as scientists continue their research especially since current estimates are considered to be conservative.

According to the study performed by the INVEST program, 996,000 acres of forest land in the seven-county West Michigan area were the region's most valuable natural asset, worth an estimated $1.1 billion annually. West Michigan's abundant natural resources — forests, sand dunes, wetlands and water — provide a variety of benefits that are worth at least $1.6 billion annually, according to a new study. Great Lakes beaches and sand dunes, which span 4,762 acres in Muskegon, Ottawa and Allegan counties, ranked second in value, at $139 million. Those were followed by cropland, at $119 million (including the value of crops); wetlands, $81 million; and inland lakes and streams (excluding Lake Michigan), at $62 million. Newaygo County had the largest portfolio of natural features, worth an estimated $899 million. Much of that value is due to the presence of the Manistee National Forest, Steinman said. Muskegon County placed second, with natural features valued at $242 million. Muskegon was followed by Ottawa County, with $134 million, and Kent County, $111 million. By comparison, the value of all goods and services produced by businesses in the seven county area studied is $45 billion annually, according to the West Michigan Strategic Alliance.

The INVEST Web site (www.invest.wri.gvsu.edu) provides a breakdown of the value of natural features in each of the seven counties. Researchers calculated the worth of natural features by measuring the value of ecosystem services that forests, wetlands and lakes provide. Ecosystem services are the direct and indirect benefits that natural features provide humans, including recreation, improved water quality, fish and wildlife habitat, tourism, soil erosion control, food production, scenic beauty, and improved human health.

Environmentalists have some hesitation about putting a dollar figure on nature. Many see natural resources as being invaluable, so having a price tag associated with them makes no sense, because no amount of money could ever fully restore a damaged or destroyed landscape. Members of the INVEST team emphasize that getting accurate costs for natural resources is not as important is their overall goal of influencing people and government officials about the importance of conserving natural resources.

Chicago Area Nature Centers Found Rich in Public Benefit

In many of the fast developing coastal areas around Lake Michigan natural areas are "developed" for economic benefit. A new study funded by Illinois/Indiana Sea Grant shows these preserved places provide benefits for more than flora and fauna. They also provide public benefits that can be measured in dollars, in this case $ 8 million per year.

Daniel McGrath, an economist at the Institute for Environmental Science and Policy at the University of Illinois at Chicago, calculated the worth of two nature centers in Cook County, Illinois to those who use them. Chicago Park District's North Park Village Nature Center and the Forest Preserve District of Cook County 's Sand Ridge Nature Center. He measured the total amount residents of the area were willing to pay in time and travel costs to visit the sites over the course of a season.

The study reflects conservative estimates of the economic values as it did not include the many out of state visitors nor the educational benefits the nature centers provide through school-children visits which can be significant.

More information is available at http://www.iisgcp.org/news/072006.htm.

wetland can also capture storm water and prevent flooding. Walking and biking trails offer alternatives to car transportation that emits greenhouse gasses.

Benefits in communities with well developed green infrastructure include a higher quality of life for residents. Healthy green infrastructure also minimizes non-point source pollution problems, provides transportation alternatives, and improves overall environmental quality and public health.

Development pressures within the Great Lakes basin will continue to increase. Great Lakes communities need to consider growth management planning to ensure that future community expansion, whether residential, commercial, or industrial, does not have negative impacts on the important resources values of the Great Lakes.

Local, state, tribal, and federal government agencies have widely varied natural resource ethics and cannot deliver all that is needed to ensure a sustainable future of protection for the Great Lakes. Ultimately, local stewardship of important resources will cumulatively protect the Great Lakes.

Public Interaction with the Lake Michigan Watershed

According to the Federal Interagency Ecosystem Management Task Force, an ecosystem is defined as: "... an interconnected community of living things, including humans, and the physical environment with which they interact. As such, ecosystems form the cornerstones of sustainable economies. The goal of the ecosystem approach is to restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities" (1995). Based on a collaboratively developed vision of desired future conditions, the ecosystem approach integrates ecological, economic, and social factors that affect a management unit defined by ecological—not political—boundaries. The foundation of the ecosystem approach is relating human beings and their activities to the ecosystems that contain them.

As access to Lake Michigan increases, so does the pressure for development. Growth of summer homes and year-round homes on the shoreline leads to more road construction, pollution from increased use of automobiles, and human use of areas that interrupts the natural web of basin life. In response, Smart Growth policies are being developed and pursued by many communities, and resources such as the "Wisconsin Planning Guide for Smart Growth" (see dnr.wi.gov/org/es/science/landuse/smart/ for more information), the Chicago Metropolitan Agency for Planning's "Environmental Considerations in Comprehensive Planning: A Manual for Local Officials" (see www.cmap.illinois.gov. for more information), and the Northwest Indiana Regional Planning Commission's "Water Resources Protection and Conservation Toolkit" (see www.nirpc.org for more information) are becoming more widely available.

Fishtown Receives NOAA Preserve America Initiative Grant

The Fishtown Preservation Society of Leland, Michigan, Michigan Sea Grant were awarded a "Preserve America Initiative" grant from the National Oceanic & Atmospheric Administration (NOAA) . The $9,000 grant was awarded for "Catching the Fishing History of Lake Michigan, 1871-2006." It was one of eight awards given in a competition which had 34 proposals submitted from across the nation. The money will be added to exisiting funds of $50,000 obtained from fundraising. The project is supported by the NOAA Preserve America Initiative Grant Program, part of Preserve America, a White House initiative aimed at preserving, protecting, and promoting our nation's rich heritage.

Source: Fishtown, Michigan Chamber of Commerce

Outdoor Recreation Opportunities

Outdoor recreation in the Great Lakes basin is an important component of the region's economy. The region offers outstanding tourism and recreational opportunities ranging from wilderness activities in pristine national parks to swimming at beaches in

Michigan and Five Tribes Agree on Tribal Hunting and Fishing

The State of Michigan and five Native American tribes signed a consent decree that would allow the tribes to regulate hunting and gathering as well as inland fishing in tribal areas. Under the agreement, tribes would be allowed, for example, to hunt for longer periods and shoot more deer than under Michigan regulations. The tribes agreed their treaty rights pertain to hunting, fishing, and gathering only for subsistence purposes and not commercial activities.

While writing their own rules and issuing separate licenses, the tribes agreed to observe many of the state's policies for protecting resources from overharvesting and abuse, including limiting use of nets on inland waterways and prohibiting use of gill nets, a type of net that kills virtually any fish it snares.

The tribes also acknowledged their treaty rights do not grant access to private property unless the owner gives permission. However, tribal members can go onto private lands already open to the public, such as forests owned by timber companies, plus 4.5 million acres of federal and state lands.

major cities. A well-defined four-season climate supports many types of recreation ranging from ice fishing, skiing, and snowmobiling in the winter to golf, fishing, boating, and swimming in the summer. There are approximately 40 state parks in or near the Lake Michigan basin as well as national lakeshore parks and fish and wildlife refuges. These can be visited by following the Circle Tour route around Lake Michigan. The Great Lakes Commission, in cooperation with the Great Lakes states and provinces in the 1980s and 1990s, coordinated the creation of the Circle Tours along existing roadways. The Lake Michigan Circle Tour route is marked by signs that feature Lake Michigan and the four surrounding states. In addition, guides prepared by states and localities that highlight enjoyable areas are important tools for promoting public access as well as critical ecosystem protection.

The Many Benefits of Open Space

Open space plays an important role in supporting the economy. According to the National Association of State Park Directors, use of geologically or environmentally sensitive areas as open space or for recreational purposes can reduce potential property damage costs. Hazards that can be mitigated through conservation of open space include flooding, slope instability, and structural fire damage. The combination of habitat protection and recreation is often the highest and best use of lands that are too fragile for development. The cost of not protecting such assets as slopes, aquifers, woodlots, wetlands, fens, alvars, floodways is incredibly high in the long run.

The eight Great Lakes states have about 3.7 million registered recreational boats, or about a third of the nation's total. Michigan is second in the nation in the number of boat registrations and six Great Lakes states rank in the nation's top ten in total registrations.

Recreational Fishery and Parks Value

The Great Lakes recreational fishery is valued at $4.6 billion. The National Park Service (NPS) estimates expenditures related to visits at national and state parks at $22 billion (1993 dollars). The NPS 2004 survey of states estimated demands for recreational facilities and open space acquisition for three-quarters of the states have not met the needs of fifty percent of the population.

Photo courtesy of Susan Beck

Chicago Wilderness Launches "No Child Left Inside" Program

In 2007, more than 200 Chicago Wilderness member organizations formalized their long-standing commitment to forge a connection between children and nature with programs like camping trips, nature scavenger hunts and birding hikes. In 2008, Chicago Wilderness members began offering all-new programs as part of *Leave No Child Inside*, including a Chicago Wilderness Field Book that encourages fun and educational visits to local natural areas. *Leave No Child Inside* comprises hundreds of year-round events in nature that impact millions of children throughout the region.

Leave No Child Inside is built on principles popularized by author Richard Louv in his 2005 book *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*. The book's premise is that social changes within the last thirty years have led to a generation of children disconnected from nature. Increasingly, children's health experts agree that the lack of unstructured outdoor playtime for children may be linked to childhood obesity, attention deficit disorder, depression and other children's health problems.

The U.S. Forest Service is taking the lead on the program for Chicago Wilderness.

Chicago Wilderness' 200 members form a natural network spanning more than 300,000 acres of forests, prairies, savannas, wetlands, lakes and other protected open spaces across southeastern Wisconsin, through northeastern Illinois, in northwestern Indiana, and into southwestern Michigan.

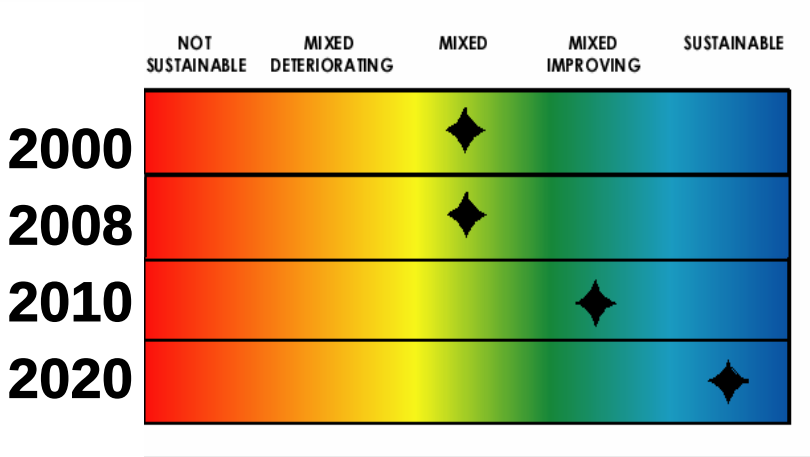
More information is available at www.KidsOutside.info.

Subgoal 6
Are land use, recreation, and economic activities sustainable and supportive of a healthy ecosystem?

What is our target for sustainability?

A healthy ecosystem that benefits and supports a strong economy valued, enjoyed, and maintained by society.

Lake Michigan Target Dates for Sustainability



Why is this important?

Land use, recreation, and economic activities are more sustainable, healthy, and supportive of a healthy ecosystem, but there is significant work that needs to be done. There is more information available on critical ecosystems, significant activity in better managing water resources, and more interest in determining the true value of a healthy ecosystem. There is danger, however, that the ecosystem could deteriorate if the knowledge is not shared widely and translated into actions especially in light of climate change.

What is the current status?

The status remains mixed due to both positive and negative changes outlined in the LaMP.

What are the major challenges?

- Climate Change: national goal of 18% reduction of greenhouse gases by 2012
- Aging infrastructure and diminishing replacement resources
- Lack of confidence in green infrastructure as replacement foraging infrastructure
- Defining the climate change stressors likely to occur in the basin
- Educating people on the watershed approach to ensure more effective environmental management
- Conservation land being converted back to crops for biofuel

What are the next steps?

- Assist development of Green: Marina, Highway, and Golf Course programs for the basin to reduce inputs of nutrients, pesticides, and other pollutants into basin waters
- Promote studies that investigate the status of groundwater resources and their impact on water quality, aquatic habitat, and levels of Lake Michigan
- Support studies to determine sustainable yields for Great Lakes water resources
- Continue to promote studies that investigate the economic value of remediating contaminated sites as reported in LaMP 2006
- Promote a basin-wide opportunities for green areas that sequester carbon

What are some tools for addressing the challenges?

- Smart Growth Information Sources
- Milwaukee Metropolitan Sewerage District Protects Land to Store Stormwater
- Green Infrastructure Overview Resources
- Wisconsin Sea Grant Online Planning Guide for Coastal Communities
- Index of Sustainability Web Pages
- Managing Stormwater for Sustainability
- LEED Certification of Green Buildings
- Chicago Climate Exchange Trading System
- The Sustainable Sites Initiative

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Indicator # 4862 - Coastal Wetland Plant Community Health
Status: Mixed; Trend: Undetermined

Indicator # 4863 - Land Cover Adjacent to Coastal Wetlands
Status: Not Fully Assessed; Trend: Undetermined

Indicator # 7000 - Urban Density
Status: Mixed; Trend: Undetermined

Indicator # 7002 - Land Cover/ Land Conversion
Lake Michigan Status: Mixed; Trend: Undetermined

Indicator # 7006 - Brownfields Redevelopment
Status: Mixed; Trend: Improving

Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed

Indicator # 7043 - Economic Prosperity
Status: Mixed; Trend: Not Assessed

Indicator # 7054 - Ground Surface Hardening
Status: Not Assessed; Trend: Not Assessed

Indicator # 7056 - Water Withdrawals
Status: Mixed; Trend: Unchanging

Indicator # 7057 - Energy Consumption
Status: Mixed; Trend: Not Assessed

Indicator # 7060 - Solid Waste Disposal
Status: Not Assessed; Trend: Undetermined

Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed

Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed

Indicator # 7064 - Vehicle Use
Status: Poor; Trend: Deteriorating

Indicator # 7065 - Wastewater Treatment and Pollution
Status: Not Assessed; Trend: Undetermined

Indicator # 7100 - Natural Groundwater Quality and Human-Induced Changes
Status: Not Assessed; Trend: Not Assessed

Indicator # 7101 - Groundwater and Land: Use and Intensity
Status: Not Assessed; Trend: Not Assessed

Indicator # 7102 - Base Flow Due to G groundwater Discharge
Status: Mixed; Trend: Deteriorating

Indicator # 7103 - Groundwater Dependent Plant and Animal Communities
Status: Not Assessed; Trend: Not Assessed

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Alvers
Status: Mixed; Trend: Not Assessed

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Cobble Beaches
Status: Mixed; Trend: Deteriorating

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Islands
Status: Mixed; Trend: Undetermined

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Sand Dunes
Status: Not Assessed; Trend: Not Assessed

Indicator # 8131 - Extent of Hardened Shoreline
Status: Mixed; Trend: Deteriorating

Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving

Indicator # 8147 - Population Monitoring and Contamination Affecting the American Otter
Status: Mixed; Trend: Not Assessed

Indicator # 8164 - Biodiversity Conservation Sites
Status: Not Assessed; Trend: Undetermined

Indicator # 8500 - Forest Lands - Conservation of Biological Diversity
Status: Mixed; Trend: Undetermined

Indicator # 8501 - Forest Lands - Maintenance of Productive Capacity of Forest Ecosystems
Status: Not Assessed; Trend: Undetermined

Indicator # 8503 - Forest Lands - Conservation and Maintenance of Soil and Water Resources
Lake Michigan Status: Mixed; Trend: Undetermined

Great Lakes Regional Collaboration Sustainability Vision Statement

The Great Lakes Regional Collaboration states that:

> Sustainability is not one government program or a spectator activity, it is a balancing act that requires full involvement of all Lake Michigan basin citizens. Until recently there were many published materials on" what is" sustainability and "how to" but we have now reached the point where we can begin to measure our progress or lack there of. It is essential we track the use of our resources: climate, water, energy, land, industrial and municipal waste, water run off, and flora and fauna.

GLRC's vision is:

> A sustainable Great Lakes ecosystem that ensures environmental integrity and that supports, and is supported by, economically viable, healthy communities.

This is built upon the United Nations' 1987 Bruntland Commission report that defined sustainability as: development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In alignment with this sentiment is the Anishinaabeg Seventh Generation Principle that each generation considers the impact of its decisions on the next seven generations.

Ecosystem Sustainability

The interdependencies inherent in the ecosystem perspective require a balance between three fundamental elements: environmental integrity, economic vitality, and sociocultural well-being. The ability of these elements to function in balance over time is a measure of sustainability. The ecosystem perspective requires a shift of focus from resource programs to resource systems and in some cases their interaction. It places human activities and communities within an ecosystem and consequently, within ecosystem management.

The LaMP helps to identify the activities, partnerships, and locations where ecosystem management needs adjustment in order to attain a sustainable Lake

International Upper Great Lakes Study Releases Progress Report on St. Clair River

The International Upper Great Lakes Study (IUGLS) released its semiannual Progress Report. The main objectives of this study are to review the regulations related to Lake Superior outflows and to examine the physical processes and possible ongoing St Clair River changes and their impacts on the water levels of Lake Michigan and Huron. The International Joint Comission (IJC) directed the Study Board to complete the St Clair River portion of the Study by early 2010.

As part of this effort, a binational team of researchers has been investigating why water levels in the Upper Great Lakes are so low and whether possible physical changes in the St. Clair River might be responsible. The goal of the study is to determine whether altering regulations dealing with outflows from Lake Superior to take into account changing interests and climate would positively impact other connected waterways.

A recent estimate by the Georgian Bay Association (GBA) indicated that the volume of the river outflow may have increased by as much as 2.5 billion gallons per day, or about 2 percent of the flow of the St Clair River, as a result of dredging. These impacts are greater than those previously reported by the IJC. The GBA is requesting that action be taken immediately to address this issue. IUGLS will be assessing all the potential contributing factors to the changes in water level in order to ensure that informed decisions can be made. Studies have been initiated, hydrographic surveys are being conducted, and hydrometric stations are currently being installed in order to provide the information needed to address this issue.

Included in the report were initial results of a video analysis of more than 50 kilometers (30 miles) of the St. Clair river bed on videotape. The preliminary analysis noted that the river bed in the upper reach of the river is fully armored and that the armor layer is made up of coarse gravels, pebbles, and cobbles with sediment size ranging from about 4 mm to 250 mm (1/6 inch to nearly 10 inches). Based on the capacity of the flow to transport sediment, the armor layer in the upper part of the St. Clair River is considered to be stable and is not eroding.

More work involving sediment transport measurements and sediment models are planned to test this hypothesis. Additional video observations in the river are planned.

The next semiannual IUGLS Progress Report is scheduled to be released in April of 2008. More information is available at www.iugls.org.

Michigan basin. Sustainable landscapes are local ecosystems that are healthy enough to provide a range of valuable benefits and services, both now and in the future. Such benefits and services to humans include the following:

- Moderating natural events and human activities. Healthy landscapes can make communities safer and more livable by tempering the effects of natural events and human activities. For example, wetland systems can absorb and store storm waters, thereby aiding in flood control and ensuring more predictable stream flows and water levels as well as often providing for recharging local ground water.
- Enhancing social well-being. Healthy landscapes provide services that make communities more enjoyable and rewarding. For example, they provide opportunities for outdoor recreation, while also providing habitat for diverse plant and animal species. Plantings along stream banks can also provide buffers to filter pollutant runoff.
- Supporting local economies through tourism and sustainable natural resource use

United Nations 2007 Reports

Sustainability Report. In 2007, 20 years after the Brundtland Report, the United Nations weighed in on both climate change and sustainability in different reports. In its fourth Global Environment Outlook report published in October, 2007 the UN reported that in the two decades since the 1987 Brundtland Commission findings on Sustainability that warned the survival of humanity was at stake from unsustainable development, not much has changed for the better. The fourth report cites climate change, the rate of extinction of species, and the challenge of feeding a growing population among the threats putting humanity at risk.

Climate Change Report. The United Nations in 2007 released the Intergovernmental Panel on Climate Change (IPCC) *Fourth Assessment Report Climate Change 2007*. The Synthesis Report summarizes the most important findings, some of which are:

1. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

2. Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

In terrestrial ecosystems, earlier timing of spring events and poleward and upward shifts in plant and animal ranges are with *very high confidence* linked to recent warming. In some marine and freshwater systems, shifts in ranges and changes in algal, plankton and fish abundance are with *high confidence* associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation.

3. Global greenhouse gas (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70 percent between 1970 and 2004.

Changes in atmospheric concentrations of GHGs and aerosols, land-cover and solar radiation alter the energy balance of the climate system.

4. Global atmospheric concentrations of CO2, methane (CH4) and nitrous oxide (N2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years.

5. Most of the observed increase in globally-averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations. It is *likely* there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).

In North America, one projected regional impact is that coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. The report also discussed adaptation and mitigation options, albeit not from a regional perspective.

Observed And Anticipated Effects On The Great Lakes Basin Ecosystem

In 2003, the International Joint Commission's (IJC) Water Quality Board issued a report to the IJC on the projected effects of climate change on the Great Lakes Basin and recommended management strategies. Climate Change and Water Quality in the Great Lakes Basin; Report of the Water Quality Board

The Lake Michigan Toolbox
Milwaukee Metropolitan Sewerage District Protects Land to Store Stormwater
Climate Change Mitigation

The Milwaukee Metropolitan Sewerage District is purchasing and protecting land to reduce the impact of development on stormwater overflows. The program, Greenseams, formerly known as the Conservation Plan, is a, flood management program that permanently protects key lands containing water absorbing soils. The program also aims to preserve land along stream corridors that connects the region's supply of public properties. Greenseams provides added support and protection for MMSD's structural flood management projects - infrastructure investments worth hundreds of millions of dollars. Greenseams identifies and purchases undeveloped, privately owned properties in areas that are expected to have major growth in the next 20 years and parcels of open space along streams, shorelines and wetlands. Sales are completely voluntary.

MMSD hired The Conservation Fund (TCF) to run Greenseams. TCF is a national non-profit conservation organization that forges partnerships to protect America's legacy of land and water resources. TCF performs high volume real estate transactions for local land trusts and government agencies throughout the country.
All land acquired will remain as open space, protecting water and providing the ability to naturally store rain and melting snow in critical areas. Wetlands maintenance and restoration at these sites will provide further water storage.

In addition, preserving the properties also saves wildlife habitat and creates recreational opportunities for people living in the region. Where applicable, the properties can be used by the public for hiking trails, bird watching, and other passive recreation.

More information is available at: www.mmsd.com/floodmanagement/greenseams.cfm.

The Lake Michigan Toolbox
Smart Growth Information Sources
Climate Change Mitigation

Smart growth is development that serves the economy, the community, and the environment. It changes the terms of the development debate away from the traditional growth/no growth question to "how and where new development should be accommodated."

Smart Growth answers these questions by simultaneously achieving:

- Healthy communities -- that provide families with a clean environment. Smart growth balances development and environmental protection -- accommodating growth while preserving open space and critical habitat, reusing land, and protecting water supplies and air quality.
- Economic development and jobs -- that create business opportunities and improve local tax base; that provide neighborhood services and amenities; and that create economically competitive communities.
- Strong neighborhoods -- which provide a range of housing options giving people the opportunity to choose housing that best suits them. It maintains and enhances the value of existing neighborhoods and creates a sense of community.Transportation choices -- that give people the option to walk, ride a bike, take transit, or drive.
- A sample of smart growth information sources include:
    - www.epa.gov/smartgrowth/
    - www.cwp.org/index.html
    - www.lowimpactdevelopment.org/

to the Great Lakes International Joint Commission, ISBN 1-894280-42-3. 2003. It is available at http://www.ijc.org/php/publications/html/climate/index.html. The report said," A change in climate could lead to alterations and impacts on environmental quality. The climate changes for a number of reasons- natural and anthropogenic- and studies are being carried out to detect changes in climate and identify associated impacts. Natural climate variability is influenced by changes in solar radiation, wobbles in the earth's orbit, and volcanic activity. Humans influence the climate by urban development, changes in land use patterns and practices and increased emissions of greenhouse gases.

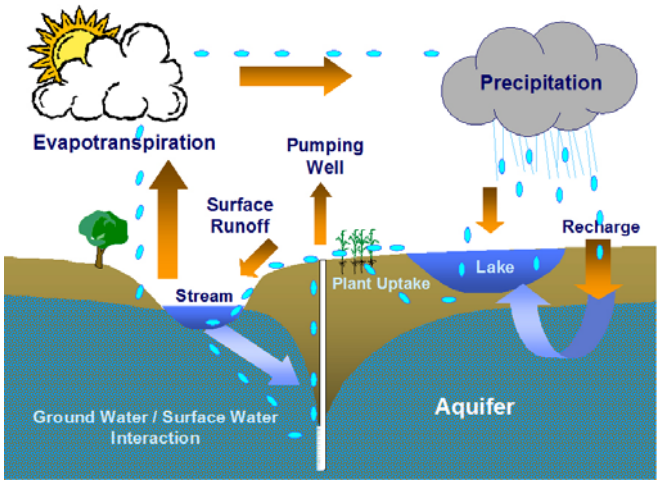
Both mitigation and adaptation actions are required as a balanced response to climate change. Mitigation measures are geared to reduce emissions and increase sinks of greenhouse gases, while adaptation actions seek to increase resilience by reducing risks and taking advantage of opportunities due to a changing climate."

The effects of a changing climate will be experienced in the Great Lakes and the Lake Michigan basin over the next century. The Union of Concerned Scientists Executive Summary Report, *Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems,* has documented the following expected changes:

- Winters are getting shorter;
- Annual average temperatures(air and water) are growing warmer;
- Extreme heat events are occurring more frequently;
- The duration of lake ice cover is decreasing as air and water temperatures rise; and
- Heavy precipitation events, both rain and snow, are becoming more common.

In addition, anticipated changes might include the following:

- Future lake levels are expected to decline as winter ice coverage decreases;
- Declines in the duration of winter ice are expected to continue;
- The distributions of fish and other organisms in lakes and streams will change. Coldwater species such as lake trout, brook trout, and white fish are likely to decline in the southern parts of the Great Lakes region, while warm water species are likely to expand northward;
- Invasions by non-native species will likely be more common, increasing the stress on native plant and animal populations;
- Lower water levels coupled with warmer water temperatures may accelerate the accumulation of mercury in the aquatic food chain as it is more likely to convert into a more bio-available form;
- Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows, and increases in heavy rainstorms may cause more frequent flooding;
- More forest fires due to hotter and drier conditions;
- Increased incidence of extreme events such as severe storms and floods carrying sediment, nutrients and other contaminates into tributaries and the lake; and
- Increases in the number and severity of summertime pollution episodes.



The Water Cycle
Source: USEPA

In the Lake Michigan watershed, a number of mitigation measures are already underway. The Chicago Climate Exchange and the LEED guidelines for buildings are two examples of these measures. As climate change adds stress to many of the current Lake Michigan problems, green infrastructure tools become a high priority that must move from "examples" to the way to sustain communities.

As an example of moving from planning to reality, Wisconsin Governor Jim Doyle signed Executive Order

The Lake Michigan Toolbox
Green Infrastructure Overview Resources (Climate Change Adaptation)

Green infrastructure is an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations. The following are a series of resources for further protecting and developing green infrastructure.

- USEPA Low Impact Development page: www.epa.gov/owow/nps/lid
- Low Impact Development Center: www.lowimpactdevelopment.org
- Conservation Design Resource Manual: Language and Guidelines for Updating Local Ordinances, www.chicagowilderness.org/pubprod/miscpdf/CD_Resource_Manual.pdf
- Nonpoint Education for Municipal Organizations Network, http://nemo.uconn.edu/
- Center for Watershed Protection, An Introduction to Better Site Design www.cwp.org/better_site_design.htm
- Town of Franklin, Massachusetts, The Franklin Best Development Practices Guidebook www.franklin.ma.us/town/planning/HANDBOOK.PDF
- U.S. Department of Housing and Urban Development, The Practice of Low Impact Development, www.huduser.org/Publications/PDF/practLowImpctDevel.pdf.
- Prince George's County Low Impact Design Strategies, www.epa.gov/owow/nps/lid/lidnatl.pdf
- Planning with Power, Purdue University, www.planningwithpower.org
  - The Relationship Between Land Use Decisions and the Impacts on Our Water and Natural Resources, www.planningwithpower.org/pubs/id_260.pdf
  - Impacts of Development on Waterways, www.planningwithpower.org/pubs/id-257.htm

The Lake Michigan Toolbox
Wisconsin Sea Grant Develops Online Planning Guide for Coastal Communities (Climate Change Adaptation)

The University of Wisconsin Sea Grant program developed an online planning guide for communities located on the Great Lakes. Communities situated on the Great Lakes in Wisconsin face a variety of challenges in developing comprehensive plans to guide future growth and development. In addition to all the elements of a comprehensive plan that inland communities must address (e.g., housing, transportation, infrastructure, land use, etc.), coastal communities also must tackle the preservation and sustainable use of coastal amenities, and the reduction of coastal hazards.

The Great Lakes Coastal Communities section of the Community Planning Resource Website provides a toolkit to support comprehensive planning and sustainable development along the Lake Michigan and Lake Superior coasts of Wisconsin. The website includes:

- A Planning Guide
- Information on Hazards Planning
- Plan Examples
- Laws and Regulations
- Training Materials
- Additional Links
- Maps and Data
- News and Events

More information is available at: http://www.aqua.wisc.edu/cpr/

The Lake Michigan Toolbox
Index of Sustainability Web Pages

The USEPA Sustainability web site examines sustainability and provides links to USEPA programs and tools in four key areas: the Built or Human-created Environment; Water, Ecosystems and Agriculture; Energy and the Environment; and Materials and Toxics. Links to the programs and tools are organized in three categories: Policies and Programs; Research, Tools and Technologies; and Assessments and Performance Measures.

More information is available at: www.epa.gov/sustainability/index.htm and www.epa.gov/sustainability/links.htm

The Lake Michigan Toolbox
Chicago Climate Exchange Trading System for Climate Change Mitigation

The Chicago Climate Exchange (CCX) has developed an integrated greenhouse gas (GHG) reduction and trading system includes a full portfolio of offset projects. CCX issues tradable Carbon Financial Instrument® (CFI™) contracts to owners or aggregators of eligible projects on the basis of sequestration, destruction or reduction of GHG emissions.

All CCX offsets are issued on a retrospective basis, with the CFI vintage applying to the program year in which the GHG reduction took place. Projects must undergo third party verification by a CCX approved verifier. All verification reports are then inspected for completeness by the Financial Industry Regulatory Authority (FINRA, formerly NASD).

Offset projects can be registered by Members, Offset Providers and Offset Aggregators. Offset Providers and Offset Aggregators do not have significant GHG emissions. Entities that have significant GHG emissions are eligible to submit offset project proposals only if they have committed to commit their own emissions to the CCX Emission Reduction Schedule as Members. Offset projects involving less than 10,000 metric of CO2 equivalent per year should be registered and sold through an Offset Aggregator. The terms of the business and legal relationships between aggregators and offset project owners are left to the discretion of those parties.

CCX has developed standardized rules for issuing CFI contracts for the following types of projects:

- Agricultural methane
- Coal mine methane
- Landfill methane
- Agricultural soil carbon
- Rangeland soil carbon management
- Forestry
- Renewable energy

Traders moved 100,496 carbon contracts in February 2008 which equaled half of the total 2007 volume of 224,375.

More information is available at: www.chicagoclimateexchange.com.

145 that requires that new state buildings be constructed with "green" design".

The following are activities related to climate change that support mitigation and adaptation in the basin.

- The *National Summit on Coping with Climate Change* took place on May 8-10, 2007, in Ann Arbor, Michigan. The summit brought together leading scientists and scholars with key decision makers in a structured discussion that addressed the options available to institutions, firms, and societies in the U.S. for adapting and responding to climate change. The summit focused on four specific sectors that represent illustrative examples of the social, economic, environmental, and natural resource issues that need to be addressed. The chosen areas of focus were Public Health, the Energy Industry, Water Quality, and Fisheries. The summit then turned its attention to general models for how different kinds of organizations, within these sectors and more generally, can put into place structures or processes that help them to anticipate and adapt to near- and long-term change. Background papers and other information about the summit are available on the internet at http://www.snre.umich.edu/climate_change/sector_papers.
- US EPA Region 5 recently released its climate change strategy, entitled *USEPA Region 5 Framework for Addressing Climate Change and Clean Energy*. (available at http://www.epa.gov/region5/aboutr5/climatechange.htm). The framework focuses on:
  - Changing how our energy is produced;
  - Changing how our energy is used;
  - Changing how materials, products, and waste are managed; and
  - Integrating climate change considerations into US EPA operations and core programs.
- The Pileus Project is coordinated by Michigan State University (MSU) and US EPA's Office of Research and Development. This project provides useful climate information to assist decision makers. The current focus is on two leading industries in the Great Lakes region: agriculture and tourism. Through the use of climate models and participatory workshops, Pileus seeks to: provide a better understanding of historical climate trends, variability, and their past impacts on people and industry; evaluate how future climate trends and variability may impact people and industry, using newly developed,

Green Infrastructure Policy

Ben Grumbles, USEPA Assistant Administrator for Water outlined a Green Infrastructure policy in 2007 that is not just for USEPA but is a shared effort with states, tribes, local governments and watershed groups.

Green infrastructure can be both a cost effective and an environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions. EPA Water Programs are in a pivotal position to exert leadership in the consistent and reliable implementation of green infrastructure approaches.

Several cities, searching for alternatives to traditional hardscape solutions to wet weather discharge problems, have initiated some green infrastructure approaches. The Natural Resources Defense Council (NRDC)has recently published a document with information and case studies on these efforts. EPA urges the use of green infrastructure approaches described in the NRDC report. Rooftops to Rivers: Green strategies for controlling stormwater and combined sewer overflows (NRDC, June 2006) is available at: www.nrdc.org/ water/pollution/rooftops/contents.asp

Green infrastructure approaches essentially infiltrate, evapotranspirate or reuse stormwater, with significant utilization of soils and vegetation rather than traditional hardscape collection, conveyance and storage structures. Common green infrastructure approaches include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used where soil and vegetation can be worked into the landscape. It is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement, and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets. These approaches can be used to keep rainwater out of the sewer system to reduce sewer overflows and to reduce the amount of untreated stormwater discharging to surface waters.

Green infrastructure facilitates or mimics natural processes that also recharge groundwater, preserve base flows, moderate temperature impacts, and protect hydrologic and hydraulic stability.

Green infrastructure has a number of benefits:

- Cleaner Water -Vegetation and green space reduce the amount of stormwater runoff and, in combined systems, the volume of combined sewer overflows.
- Enhanced Water Supplies -Most green infiltration approaches result in stormwater percolation through the soil to recharge the groundwater and the base flow for streams.
- Cleaner Air-Trees and vegetation improve air quality by filtering many airborne pollutants and can help reduce the amount of respiratory illness.
- Reduced Urban Temperatures -Summer city temperatures can average 10°F higher than nearby suburban temperatures. High temperatures are linked to higher ground level ozone concentrations. Vegetation creates shade, reduces the amount of heat absorbing materials and emits water vapor -all of which cool hot air.
- " Increased Energy Efficiency -Greenspace helps lower ambient temperatures and helps shade and insulate buildings, decreasing energy needed for heating and cooling.
- Community Benefits -Trees and plants improve urban aesthetics and community livability by providing recreational and wildlife areas and can raise property values.
- Cost Savings -Green infrastructure may save capital costs on digging big tunnels and stormwater ponds, operations and maintenance expenses for treatment plants, pipes, and other hard infrastructure; energy costs for pumping water; and costs of wet weather treatment and of repairing stormwater and sewage pollution impacts, such as streambank restoration.

The Office of Water is working with a coalition of organizations, including the Natural Resources Defense Council, the National Association of Clean Water Agencies, and the Low Impact Development Center, to develop additional strategies for green infrastructure approaches to water quality challenges.
More information is available at: http://www.epa.gov/npdes/greeninfrastructure.

The Lake Michigan Toolbox
LEED Certification of Green Buildings
Mitigating Climate Change

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. LEED standards include:

- New commercial construction and major renovations
- Existing building operations
- Commercial interiors projects
- Core and shell projects
- Homes
- Neighborhood development

LEED was created to:

- define "green building" by establishing a common standard of measurement
- promote integrated, whole-building design practices
- recognize environmental leadership in the building industry
- stimulate green competition
- raise consumer awareness of green building benefits
- transform the building market

LEED provides a complete framework for assessing building performance and meeting sustainability goals. LEED emphasizes state of the art strategies for sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

The U.S. Green Building Council is currently working with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE); and the Illuminating Engineering Society of North America (IESNA) to develop proposed Standard 189, Standard for the Design of High-Performance Green commercial Buildings.

The proposed standard will apply to new commercial buildings and major renovation projects, addressing sustainable sites, water use efficiency, energy efficiency, a building's impact on the atmosphere, materials and resources, and indoor environmental quality.

Standard 189P will be an ANSI-accredited standard that can be incorporated into a building code. It is intended that the standard will eventually become a prerequisite under LEED.

More information is available at: www.usgbc.org/

climate-related models; and create an economic framework which explicitly incorporates climate into the decision-making process. Stakeholders and researchers from the Pileus Project are building on each other's experiences, pooling expertise, and expanding knowledge about climate impacts on industry. The core research team is located at MSU and consists of scientists from diverse disciplines. For more information about the Pileus Project, see http://pileus.msu.edu.

- Teaming-up to create a resource on adaptive management are King County, Washington, the University of Washington, and ICLEI - Local Governments for Sustainability, who have recently produced *Preparing for Climate Change: a Guidebook for Local, Regional and State Governments.* The guidebook is one of the first major local government resources on planning for the impacts of climate change. It is available online and can be downloaded for free. http://cses.washington.edu/db/pdf/snoveretalgb574.pdf.
- The Midwest Governors signed an agreement leading the way toward increasing energy efficiency, expanding community-based energy development, and establishing a statewide goal to reduce GHG emissions.
- The National Governor's Association (NGA), chaired by Governor Tim Pawlenty of Minnesota, has developed a publication entitled *Securing a Clean Energy Future: A Call to Action*, which outlines a strategy for reducing dependence on oil and reducing emissions of GHGs. Securing a Clean Energy Future: A Call to Action. 2008. Available at http://www.subnet.nga.org/ci/scef/.

Water-Resources Issues

The Great Lakes basin contains 95 percent of the fresh surface water in North America and 18 percent of the fresh surface water in the world. Ground water underlying the basin constitutes another large volume of freshwater. Humans, animals, and plants have adapted to this abundance in water resources. Yet, even in this water-rich area, water withdrawals, diversions, and use sometimes conflict with the needs of other users and ecosystems in the basin. For example, pumping of large water-supply wells in Wisconsin and Illinois has lowered ground-water levels in the area, increasing pumping costs and levels of such contaminants as radium. Because the Great

The Lake Michigan Toolbox
Managing Stormwater for Sustainability
Climate Change Adaptation

Overviews

- Catching the Rain: a Great Lakes Resource Guide for Natural Stormwater Management, American Rivers www.americanrivers.org/site/PageServer?pagename=AR7_CatchingtheRain.
- An Eight-Step Approach to Stormwater Retrofitting: How to Get Them Implemented, Center for Watershed Protection, www.cwp.org/retrofit_article.htm.
- Watershed-Based National Pollutant Discharge Elimination System Permitting Implementation Guidance, USEPA www.epa.gov/npdes/pubs/watershedpermitting_finalguidance.pdf.
- Stormwater BMP Design Supplement for Cold Climates, Center for Watershed Protection, www.cwp.org/cold-climates.htm.
- Lake County Stormwater Management Commission Technical Reference Manual, Lake County, Illinois, www.co.lake.il.us/smc/regulatory/tac/refmanual.asp.

Example Stormwater Ordinances

- Stormwater Ordinances, www.stormwatercenter.net.
- Stormwater Manual Builder, www.stormwatercenter.net.
- Watershed Development Ordinance, Lake County Illinois, www.co.lake.il.us/smc/regulatory/wdo/default.asp
- Post-Construction Stormwater Management Ordinances, USEPA www.epa.gov/owow/nps/ordinance/postcons.htm.
- Post-Construction Stormwater Management Ordinances, Stormwater Center, www.stormwatercenter.net/Model%20Ordinances/Post%20Construction%20Stormwater%20Management/post_construction_runoff_control.htm.
- Operation and Maintenance Criteria for Stormwater Practices, www.stormwatercenter.net/Model%20Ordinances/Operation%20&%20Maintenance.htm.
- Grand Traverse County, Michigan Soil Erosion and Stormwater Runoff Control Ordinance, including construction and post-construction runoff control. www.stormwatercenter.net/Model%20Ordinances/Post%20Construction%20Stormwater%20Management/grand_traverse_county_soil_erosi.htm.

Lakes basin contains so many communities, industries, and ecosystems that depend on quantities of water and because competition for available water is intensifying, there is a need to quantify the region's water resources and the trends affecting them so that the potential for possible future water-use conflicts can be reduced or avoided.

In recent years, numerous government agencies, commerce, industry, and the general public all have expressed concern about potential large withdrawals of water within the Great Lakes basin. In response, the Great Lakes States and Canadian Provinces signed the Great Lakes Charter Annex Implementing Agreements in December 2005. Illinois, Indiana, Minnesota, and New York have approved the agreement. These multi-state and binational agreements commit the States and Provinces to more effective water-resources management. This commitment requires a more detailed understanding of the region's water resources and a synthesis of available data and information.

Great Lakes Water Availability and Use

At the request of Congress, the U.S. Geological Survey (USGS) is assessing the availability and use of the Nation's water resources to gain a clearer understanding of the status of our water resources and the land-use, water-use, and natural climatic trends that affect them. The goal of the National Assessment of Water Availability and Use Program is to improve our ability to forecast water availability for future economic and environmental uses. Simply put, the assessment will help characterize how much water we have now, how water availability is changing, and how much water we can expect to have in the future.

Currently, the assessment is focused on the Great Lakes basin (See Figure 6-1) to determine the best methods to evaluate water resources, both surface and ground water and to develop strategies for delivering information about water availability and use. Planned activities for the pilot study include estimation of: (1) recent monthly streamflows; (2) spatial and temporal trends in streamflow characteristics, ground-water recharge, groundwater flow, and ground-water storage; (3) basin ground-water divides; and (4) consumptive water use. Other water-resources regions will be added to the assessment as evaluation methods improve and as funding permits. More information is available at: http://water.usgs.gov/ogw/gwrp/activities/wateravail_pilot.html.

Ground-Water-Flow Models in the Lake Michigan Basin

Application of ground-water-flow models is one of the most comprehensive ways to synthesize ground-water data and to analyze the response of a ground-water system to changes in the system, such as increased pumping rates, changes in pumping locations, changes in recharge, and climate variations. Regional models that simulate ground-water flow will greatly improve the overall understanding of ground-water conditions in the Great Lakes basin and provide a quantitative framework to help manage water resources in ways consistent with the Great Lakes Charter Annex agreements. Comprehensive ground-water-flow models are complex and time consuming to develop; therefore, the entire Great Lakes basin could not be modeled for this study. Instead, a ground-water-flow model of the Lake Michigan subbasin is being developed because (1) the entire watershed is in the United States, and many datasets already are available within the USGS; (2) ground water is withdrawn from bedrock and glacial-deposit aquifers, both of which are important aquifer systems throughout the Great Lakes basin; (3) important issues related to ground-water and surface-water interaction can be simulated with the model; (4) ground-water withdrawals in the Lake Michigan subbasin may affect the locations of ground-water

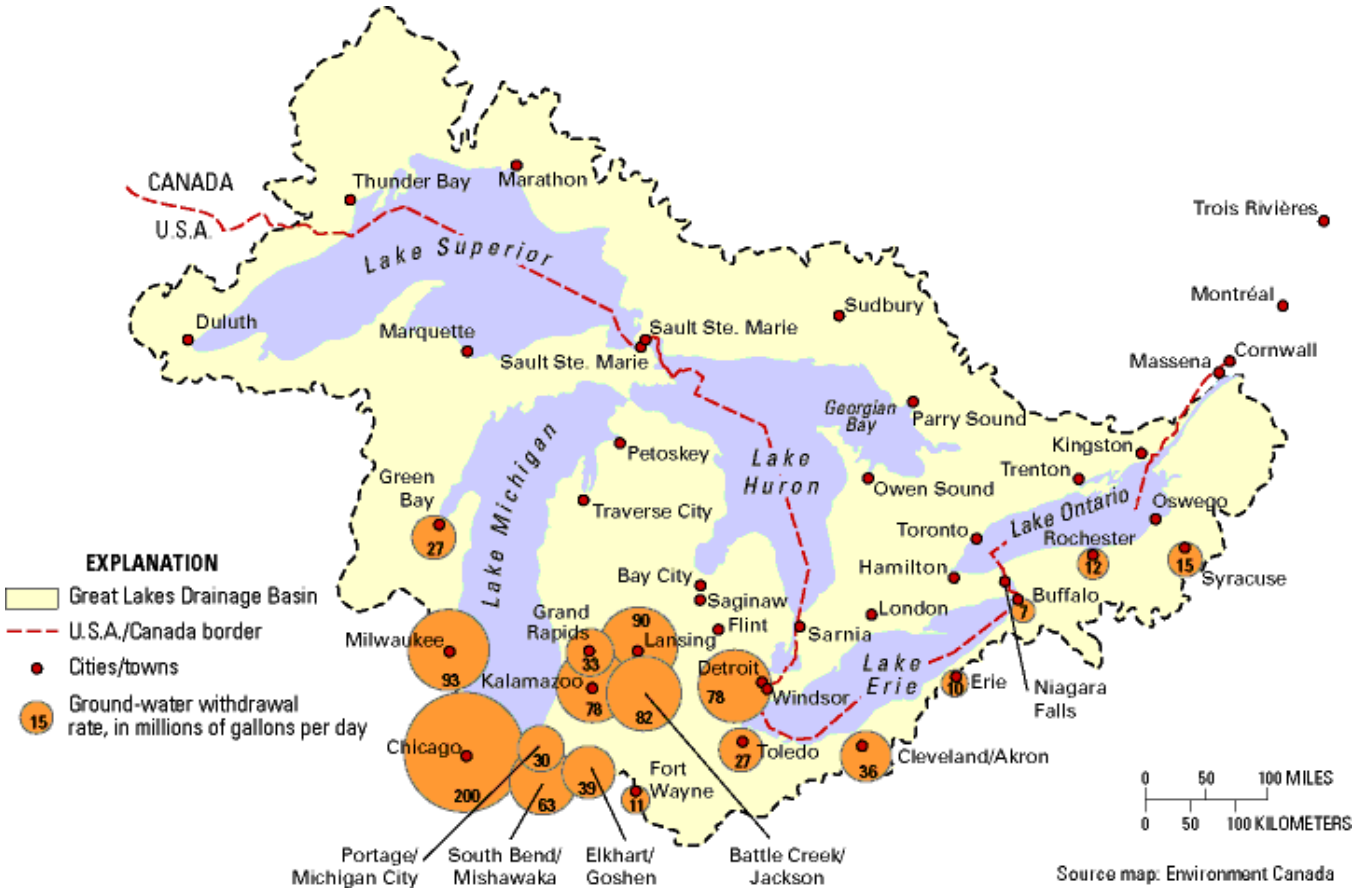


Figure 6-1 Groundwater Withdrawals in the Great Lakes Region

divides with Lakes Superior, Huron, and Erie; and (5) problems caused by large-scale ground-water withdrawals have been documented in the subbasin. In addition, one or more separate models within the Lake Michigan subbasin will be developed specifically to simulate ground-water and surface-water interaction in smaller watersheds because this is an important component of the water balance not only here but elsewhere in the Great Lakes basin. These models will be used to test new techniques for simulating the interactions of ground water and surface water at the appropriate scale. More information is available at http://pubs.usgs.gov/fs/2005/3113.

Lake Levels

The water-level elevations of Lakes Michigan, Huron, Erie, and Ontario have varied about 6 feet since 1860, when accurate records of lake levels were first recorded. Water levels in Lake Superior varied about 3 feet during the same interval. Prehistoric variations were much greater and were strongly correlated with climate change. Changes in water levels of the Great Lakes constitute the largest changes in the amount of water in the region. The Great Lakes basin study will summarize what is known about lake levels over the past 4,700 years. This analysis of lake levels will help put recent low lake levels into perspective, especially given the prospect of future global warming.

Lake Michigan was measured at 2 feet below the long-term average in 2001, having dropped more than 40 inches since 1997 when it was at near record highs. Levels increased for the 2002, but were still below average. The decrease in precipitation over the last five years resulted in Lake Michigan hitting its lowest point since 1966. Lake levels rose between the mid 1960s and the late 1990s.

The lower lake levels cause problems for the shipping and boating industry. Cargo ships are forced to lighten their loads, and many boat ramps become inaccessible. According to the U.S. Great Lakes Shipping Association, for every inch of water that Lake Michigan loses, a cargo ship must reduce its load by 90 to 115 metric tons, leading to losses of between $22,000 and $28,000 per trip.

Early reports for 2008 indicate that the lake remains below average even after a cold, wet winter. The fluctuation may be part of a 30 year cycle but deserves closer monitoring. Levels have remained lower for longer than they have in recorded history. The 1964 low level was 576.1 feet.

There are other potential factors affecting the levels. The International Joint Commission has proposed a study to investigate possible physical changes in the upper St. Clair River that may be causing water level changes in Lakes Michigan and Huron. this work would revise its upper Great Lakes Plan of study.

Climate Change Mitigation Strategies

Illinois Green Neighborhood Award Act

The Illinois Green Neighborhood Award Act is intended to provide support for sustainably designed neighborhoods which are known to reduce energy consumption, encourage strong local economies, and improve public health. The Act provides incentives for development projects in Illinois that are consistent with LEED_ND standards of the U.S. Green Building Council, Congress for the New Urbanism, and Natural Resources Defense Council. Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) is an extention of LEED certification, the nationally accepted benchmark for the design, construction and operation of high-performance green buildings. Grants are available for up to 1.5% of the total project development costs through the department of Commerce and Economic Opportunity. the result will reduce energy consumption equal to $554 per household annually and reduce dependence on cars and gasoline that leads to $2,594 annual savings per household.

Chicago Climate Change Comprehensive Strategy

Chicago, under the direction of Mayor Richard M. Daley, is developing a comprehensive strategy to address climate change. Work began in December 2006 and the full research findings, strategy and a measureable plan will be released in 2008 . Key to the extensive nature of the research and detailed plans was a base of foundation support (The Joyce, Grand Victoria, Lloyd A. Fry, and William J. Clinton Foundations). A large group of stakeholders make up a task force, advisory and communication committees to helped guide the work.

Lake Level Monitoring

Current Lake Michigan levels can be monitored online through a new National Oceanographic and Atmospheric Administration website, http://glakesonline.nos.noaa.gov. The site provides

Long-term Average and Current Lake Michigan-Huron Water Levels

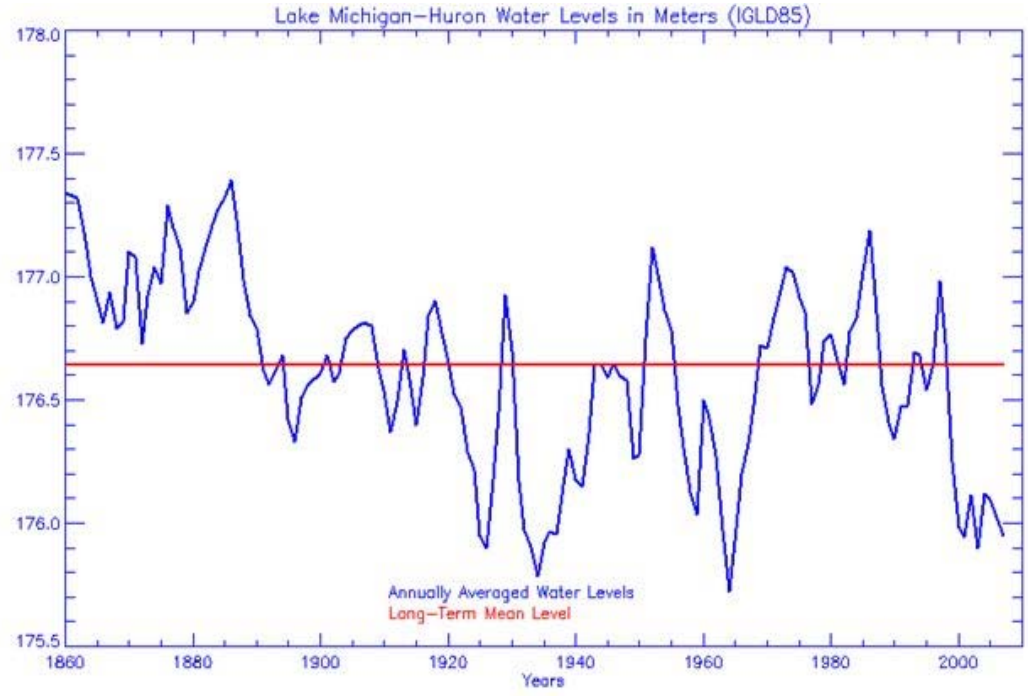


Figure 6-1 Long-term average water levels in Lakes Michigan-Huron
Source: National Oceanic and Atmospheric Administration

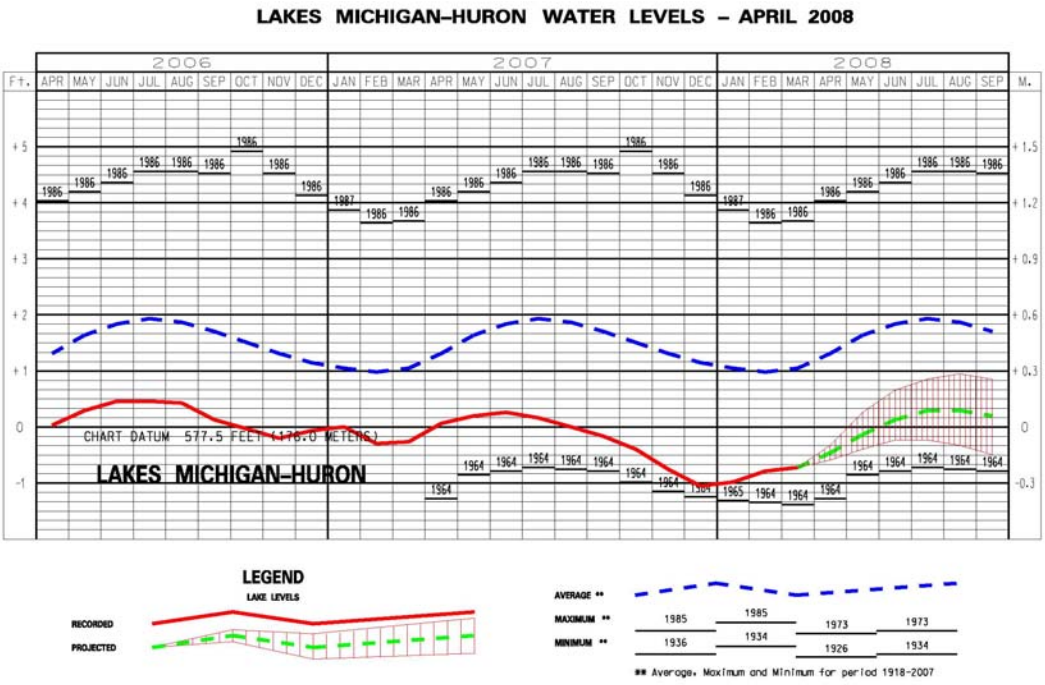


Figure 6-2 Lakes Michigan-Huron Water Levels, April 2006 - April 2008
Source: U.S. Army Corps of Engineers

Lake Michigan Toolbox
Climate Change and Water Quality
Climate Change Adaptation

A May 2007 National Summit at the University of Michigan: Coping with Climate Change highlighted the potential economic impacts of climate change on the Great Lakes region. Many of the speakers referenced the conclusions and recommendations of a 2003 IJC Water Quality Board report entitled "Climate Change and Water Quality in the Great Lakes Basin" (http://www.ijc.org/php/publications/html/climate/index.html).

The report focuses on the need to adapt to changes in climate in order to ensure effective protection of the environment and maintain the region's economic strength.

The Lake Michigan Toolbox:
The Sustainable Sites Initiative
Climate Change Mitigation

The Sustainable Sites Initiative is an interdisciplinary partnership between the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, the United States Botanic Garden and a diverse group of stakeholder organizations to develop guidelines and standards for landscape sustainability. The motivation behind this initiative stems from the desire to protect and enhance the ability of landscapes to provide services such as climate regulation, clean air and water, and improved quality of life. Sustainable Sites™ is a cooperative effort with the intention of supplementing existing green building and landscape guidelines as well as becoming a stand-alone tool for site sustainability.

More information is available at: www.sustainablesites.org/

immediate water level and meteorological data from water level stations. There is a six minute interval between data readings, and NOAA plans for real time wind speed and direction data, in addition to barometric pressure and air temperature data. This augments the U.S. Army Corps of Engineers website that provides water level information http://huron.lre.usace.army.mil/levels/hmpglv.html.

Land Use Impacts Water Quality

The urbanized land area in the United States has quadrupled since 1954. To compound the problem, populations in coastal areas, which contain some of the most sensitive ecosystems, have been increasing even faster than in the rest of the country. From 1982 to 1996, the population in the Chicago-Northwest Indiana area grew by 10.9 percent but consumed 44.2 percent of the land. (Urban Roadway Congestion: Annual Report 1998) Wetlands, which naturally help control runoff from urban areas by storing flood and surface water and slowly releasing and filtering it, have been destroyed in the Lake Michigan basin to a greater degree than elsewhere in the country.

USEPA's Office of Environmental Information states that "the construction of impervious surfaces such as roads and rooftops leads to the degradation of water quality by increasing runoff volume, altering regular stream flow and watershed hydrology, reducing groundwater recharge, and increasing stream sedimentation and water acidity." A 1-acre parking lot produces a runoff volume 16 times as large as that produced by an undeveloped meadow. Many impervious construction materials have higher surface temperatures that may cause ambient air temperatures to rise. When combined with a decrease in natural vegetation, areas are subject to what is called the urban heat island phenomenon, which may increase utility bills, cause health problems associated with heat stress, and accelerate formation of harmful smog. Clearly the effect of urban development on our communities and environment is a cross-cutting issue.

Oil and Gas Drilling in the Great Lakes

Due to the high cost of fuel, there has been renewed interest in tapping oil and natural gas reserves below the Great Lakes. In the Great Lakes basin, much of these resources lie under the lakes themselves. Drilling under the lakes raises concerns because a spill would lead to harm of the world's single largest source of freshwater providing drinking water to 33 million people.

Due to this concern, an amendment to the Energy and Water Development Appropriations Act of 2002 prohibited all federal and state governments from issuing leases or permits for new oil and gas directional or offshore drilling in or under the Great Lakes for two years. This moratorium was made permanent in the Energy Policy Act of 2005.

Michigan's legislature passed legislation that would ban all direct and directional drilling in its portion of the Great Lakes basin. Furthermore, a proposed natural gas pipeline for lake bed of Lake Michigan from Wisconsin to Indiana was withdrawn in 2001.

Currently in the Lake Michigan basin, only Illinois has never issued an oil or gas mineral lease for Lake Michigan bottomlands. Indiana has permitted limited exploratory drilling, but no oil or gas has been produced. Wisconsin allows drilling for oil and gas in certain circumstances and, in the past, Michigan has allowed drilling that begins on land with the pipes "slanting" under the lake.

Brookings Institute Studies: Building Leadership for North America's Fresh Coast

Over the last two years, the Great Lakes Economic Initiative for the Metropolitan Policy Program at the Brookings Institute has produced three studies aimed at the economic leadership and stability for the binational Great Lakes region.

The recommendations offered by the Institute are organized around a limited set of ambition goals, goals that would serve to prioritize and unify efforts.

- By 2010, develop a binational innovation fund and strategy
- By 2010, redevelop North America's freshwater coast
- By 2015, define and implement the U.S.-Canada "Border of the Future"
- By 2025, realize binational Great Lakes carbon goals and renewable energy standards
- By 2030, create a common market for commerce and human capital

More information is available at www.brookings.edu/metro.

In July 2008, 460 sailboats and more than 4,500 sailors will flood the Straits area during the 100th sailing of Chicago Yacht Club's Race to Mackinac, filling the Mackinac Island marina and spilling over into St. Ignace and Mackinaw City, MI. This is the world's longest freshwater sailing race at 333 miles.

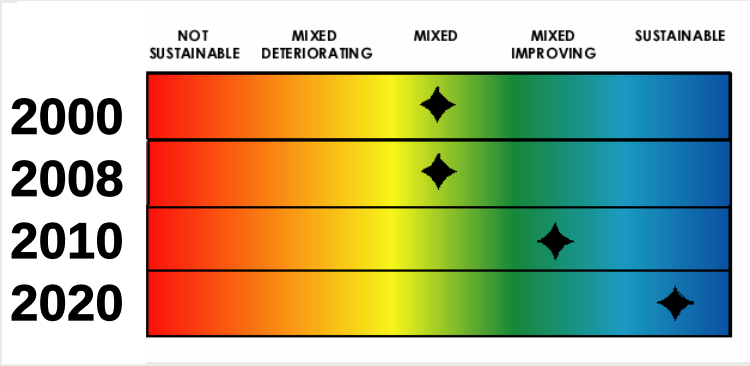
Photo courtesy of Darren Beck

Subgoal 7
Are sediments, air, land, and water sources or pathways of contamination that affect the integrity of the ecosystem?

What is our target for sustainability?

A basin where remedial action needs have been accomplished and materials in use are the least harmful to the environment and are used and disposed of in an environmentally sensitive manner in the basin and around the world.

Lake Michigan Target Dates for Sustainability



Why is this important?

Pollutants are transported via different pathways leading to multiple approaches needed to address pollutant sources. The Lake Michigan Mass Balance Study has made a detailed examination of four categories of pollutants and their impacts on pollutant loading on the lake. The findings of the study allow decision-makers to better understand pollution pathways and adopt policies to address pollutant sources.

What is the current status?

- **PCBs.** PCB concentrations in fish over the past 30 years show a downward trend from peak levels in the 1970s for all media. Atmospheric deposition is the major current route of PCBs to the lake (from sources inside and outside the basin) with the Chicago area being a significant source of atmospheric PCBs. The most recent data also exhibit a decline, however, this indicates that the rate of decline is slowing and concentrations in lake trout remain above desired levels.
- **Mercury.** The current major source of mercury to the lake is from atmospheric deposition. Modeling results suggest that a significant amount of the existing mercury settling out of water is being recycled back into the system. Most Lake Michigan lake trout and coho salmon exceed the USEPA guidelines for unrestricted consumption.
- **Atrazine.** Observed and forecasted lake-averaged concentrations of atrazine are well below USEPA biological effects thresholds with tributaries serving as the major transporter of atrazine runoff from agricultural fields to the lake. Atrazine is very persistent in Lake Michigan with decay estimated at less than 1% per year and concentrations forecasted to increase in the lake under present loads (1994-1995 constant load).
- **Phosphorus.** Tributaries are the major source of phosphorus to Lake Michigan, but Lake Michigan open lake phosphorus loads and concentrations are low and below GLWQA and IJC targets. Highest concentrations can be observed in selected nearshore zones near tributary mouths and in Green Bay.
- **Urban Runoff.** An increase in urbanization is leading to an increase in nonpoint source runoff in the basin. Many cities, however, are working to reduce the impacts of runoff through pollution prevention programs and stormwater retrofits and implementation of Phase II of the Stormwater regulations.
- **Agricultural Runoff.** The Lake Michigan basin has a high concentration of agricultural enterprises where animals are kept and raised in confined environments. Polluted runoff from animal feeding operations is a leading source of water pollution in some watersheds.
- **Areas of Concern.** Areas of Concern have seen significant strides in remediation, although none of the lake Michigan basin AOCs have been delisted. Work is currently focused on a BUI by BUI approach with Manistique the first to delist a BUI.
- **Climate Change.** Temperatures impact on pollutants and their interaction with the aquatic environment

What are the major challenges?

- Impacts of climate change
- Lack of comprehensive understanding of pollutant movement and remediation makes the goal of reaching sustainability by 2020 difficult
- Impacts of increased global mercury emissions
- Increasing monitoring of existing and emerging stressors on the lake
- Need to set delisting targets for Areas of Concern and resources to implement cleanup actions

What are the next steps?

- Develop a better understanding of the natural dynamics that affect pollutant distribution in the Lake Michigan ecosystem and why near shore and open lake can have wide variances.
- Reduce pollutant loads with effective pollution control measures with a focus on nutrients and mercury.
- Build on the coordinated monitoring of 2005 and develop a 10-year trend analysis based on the 1994-95 mass balance project.
- Review contaminated sediment sites and their status and update the status of the Legacy Act funding or delisting opportunities.
- Research nutrient contributions from the agricultural sector and nonpoint sources during wet weather and determine if nutrient levels are linked to *Cladophora* blooms.
- Develop Impaired Waters Strategy.
- Promote phase-out of grandfathered in PCB use in equipment, and phosphorus in detergents, and fertilizers.

What are some tools for addressing the challenges?

- Nitrogen Removal
- Catalog of Federal Funding Sources for Watershed Protection and Nonpoint Source Control

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 111 - Phosphorus Concentrations and Loadings
Lake Michigan Status: Open Lake - Good; Nearshore – Poor; Trend: Open Lake - Improving; Nearshore - Undetermined

Indicator # 114 - Contaminants in Young-of-the-Year Spottail Shiners
Lake Michigan Status: Not Assessed; Trend: Not Assessed

Indicator # 115 - Contaminants in Colonial Nesting Waterbirds
Lake Michigan Status: Mixed; Trend: Improving

Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Status: Mixed; Trend: Improving (for PCBs, banned organochlorine pesticides, dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)

Indicator # 118 - Toxic Chemical Concentrations in Offshore Waters
Lake Michigan Status: Fair; Trend: Undetermined

Indicator # 119 - Concentrations of Contaminants in Sediment Cores
Status: Mixed Trend: Improving/Undetermined

Indicator # 121 - Contaminants in Whole Fish
Lake Michigan Status: Fair; Trend: Improving

Indicator # 124 - External Anomaly Prevalence Index for Nearshore Fish

Indicator # 4177 - Biological Markers of Human Exposure to Persistent Chemicals
Lake Michigan Status: Not Assessed; Trend: Undetermined

Indicator # 4201 - Contaminants in Sport Fish
Lake Michigan Status: Mixed; Trend: Improving

Indicator # 4202 - Air Quality
Status: Mixed; Trend: Improving

Indicator # 4501 - Coastal Wetland Invertebrate Community Health
Status: Not Assessed; Trend: Not Assessed

Indicator # 4502 - Coastal Wetland Fish Community Health
Status: Mixed; Trend: Improving

Indicator # 4506 - Contaminants in Snapping Turtle Eggs
Status: Mixed; Trend: Undetermined

Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed

Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed

Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed

Indicator # 7064 - Vehicle Use
Status: Poor; Trend: Deteriorating

Indicator # 7065 - Wastewater Treatment and Pollution
Status: Not Assessed; Trend: Undetermined

Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving

Indicator # 9000 - Acid Rain
Status: Mixed; Trend: Improving

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Lake Michigan Mass Balance Project

What It Tells Us

The Lake Michigan Mass Balance (LMMB) Project is an enhanced monitoring and modeling project that is working to develop a scientific base of information to inform LaMP policy decisions and better understand the science of pollutants within an ecosystem (USEPA 1995; 1997a; 1997b; 1997c; 1997d; 1997e; Richardson et al. 1999; USEPA 2001d) . The LMMB Project's specific objectives are:

- To identify relative loading rates of four categories of pollutants (PCBs, mercury, trans-nonachlor, and atrazine) entering Lake Michigan from major media (air, tributaries, and sediments);
- To establish baseline loading estimates in 1994-95 against which to gauge future information;
- To develop the predictive ability through the use of models to determine the environmental benefits of specific load reduction scenarios for toxic substances and the time required to realize those benefits;
- To improve our understanding of key environmental processes governing the movement of pollutants through and out of the lake (cycling) and fish and plant life (bioavailability) within this large freshwater ecosystem; and
- In addition, 11 tributary mouths were sampled for nutrients.

The LMMB Project focused on sampling and constructing mass balance models for a limited group of pollutants. Polychlorinated biphenyls (PCBs), atrazine, phosphorus, trans-nonachlor, and mercury were selected for inclusion in the LMMB Project because these pollutants currently or potentially pose a risk to aquatic and terrestrial organisms (including humans) in the Lake Michigan ecosystem and on the LaMP pollutant lists. These pollutants were also selected to cover a wide range of chemical and physical properties and represent other classes of compounds which pose current or potential problems. Once a mass budget for selected pollutants is established and a mass balance model calibrated, additional contaminants can be modeled with sufficient data. For the LMMB Study, models were calibrated using samples collected and analyzed for such purposes by numerous partners and collaborators (Hornbuckle et al 1995; Hall and Robertson 1998; Hall et al 1998; Hawley 1999; Robbins et al 1999; Green et al 2000; Van Hoff 2000; Miller et al. 2001; USEPA 2001a; 2001b; 2001c; 2001e, 2002a, 2002b).

What It Does Not Tell Us

The data and models provide insights to the whole lake ecosystem which may not represent data in any given specific near shore area. The relationship of the near shore to the open waters remains a topic needing additional research.

Pathways of Pollution

Sediments, air, land, and water continue to be sources or pathways of contamination that affect the integrity of the Lake Michigan ecosystem. In the Lake Michigan system, pollutant inputs may come from atmospheric deposition, tributary loads, or sediments. Pollutants may leave the system through volatilization to the atmosphere, or discharge through the Straits of Mackinac. Pollutants within the system may be transformed through degradation or stored in ecosystem compartments such as the sediments, water column, or biota, including humans.

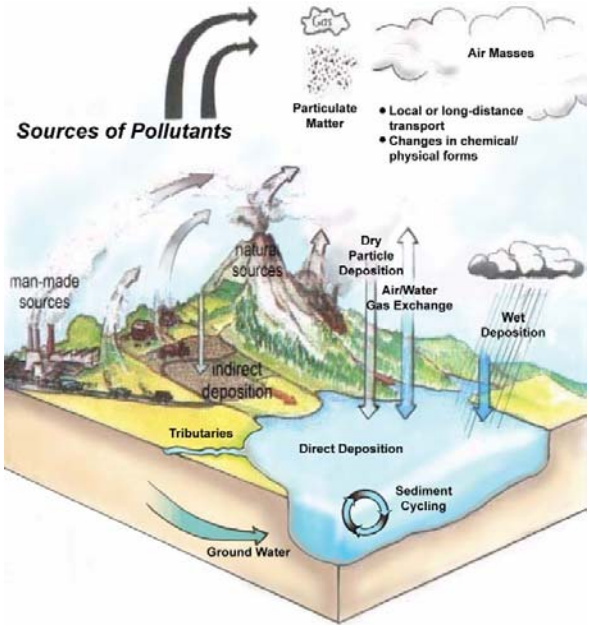


Figure 7-1 Pollutants enter and leave Lake Michigan through several pathways
Source: www.epa.gov/owow/oceans/airdep
Augmented by Joseph F. Abboreno, LaMP 2002

Lake Michigan Mass Balance Resampling Results

Five of the original eleven Lake Michigan Mass Balance tributary sampling sites were resampled in 2005-2006. The resampled sites were selected based on previously calculated loads of PCB and mercury to Lake Michigan; the resampled sites included the Lower Fox in Wisconsin, the Grand Calumet Ship Canal in Indiana, and the Kalamazoo, Grand, and St. Joseph Rivers in Michigan. Twelve (12) rounds of sampling were conducted at each of the five resampled tributary monitoring sites.

Total Mercury Loads

Reductions in calculated total mercury loads relative to the loads calculated as part of the Lake Michigan Mass Balance were observed in all five of the resampled sites (table 7-1).

Table 7-1. Calculated total mercury loads for the resampled sampling sites.

Site	Load (Kg) 1994-1995	Load (Kg) 2005-2006	Min and Max Load (Kg) Previous Years
Grand	26	10	13.5 (2002); 24.8 (1999)
Kalamazoo	17	8	7.6 (2002); 13.3 (1999)
St. Joseph	21	7	13.1 (2004); 32.1 (2001)
Grand Calumet Ship Canal	6	4.5	N/A
Fox	108	53	N/A

The Michigan Department of Environmental Quality (MDEQ) and the Michigan District office of the U.S. Geological Survey Michigan Water Science Center have been sampling the Grand, Kalamazoo, and St. Joseph Rivers for a variety of constituents, including total mercury, since about 1999. Considering the loads calculated from the available data shows how variable these numbers may be from year to year. The 1994-1995 load was nearly reached in 1999 on the Grand River. In 2001 the load from the St. Joseph river exceeded that calculated during the 1994-1995 period.

Total PCB Loads

Reductions in total PCB loads relative to those calculated as part of the Lake Michigan Mass Balance were observed at all five of the resampled sites (table 7-2).

Table 7-2. Calculated total PCB loads for the resampled sampling sites.

Site	Load (Kg) 1994-1995	Load (Kg) 2005-2006
Grand	10	6.2
Kalamazoo	39	20
St. Joseph	9.3	6.7
Grand Calumet Ship Canal	31	16
Fox	210	130

Year to year variations in flow and temperature make assessing changes in PCB loading rates a difficult proposition. Considering the dissolved fraction of PCB during winter conditions minimized the effects of the confounding factors and should offer a glimpse of the true trend in loading rates.

At the Lower Fox River, dissolved wintertime PCB concentrations have dropped from a median of about 3.5 ng/L to 1.5 ng/L. This change suggests that natural recovery and active remediation on the Lower Fox River have resulted in a reduction in wintertime PCB concentrations on the order of a factor of two in the 10 years since the completion of LMMB Project sampling.

Confounding Factors

The calculated load reductions observed for both total PCB and total mercury may indeed be genuine; however several factors suggest that the reduced loads might not be part of a larger trend, but are related to a number of confounding factors. These factors include differences between flow regimes and sampling plans. Median flows for the 2005-2006 period were lower at all sites relative to the 1994-1995 median flow values; total annual flow volumes were less than 75% of the total annual flow volumes observed during the LMMB for the Grand and Fox Rivers (table 7-3). The most dramatic difference in flow regimes was observed at the Fox River site, where the May through September monthly median flow values in 2005-2006 were up to several thousand cubic feet per second lower than the corresponding monthly median values in 1994-1995.

Table 3. Median flows and comparison of total flow volumes for the resampled LMMB tributary monitoring sites.

Site	1994-1995 (cfs)	2005-2006 (cfs)	% of 1994-1995 Flow Volume
Grand	4360	2838	72.4 %
Kalamazoo	1990	1510	99.5 %
St. Joseph	4100	3006	106 %
Grand Calumet Ship Canal	459	407	89.0 %
Fox	3500	3360	74.1 %

Although the median flow values are consistently lower for the 2005-2006 period relative to the 1994-1995 period, the extreme high flows were larger for the 2005-2006 period at the Kalamazoo, St. Joseph, and Grand Calumet sites (table 7-4). Since an appreciable portion of the total mercury and total PCB load is driven by resuspension of contaminated sediment, the higher ten percent exceedance flows might offset the effect of the lower median flow values for these sites.

Table 7-4. Ten percent exceedance flows for the resampled tributary monitoring sites.

Site	1994-1995 (cfs)	2005-2006 (cfs)
Grand	8640	8131
Kalamazoo	**2900**	**3620**
St. Joseph	**5900**	**8255**
Grand Calumet Ship Canal	**486**	**525**
Fox	6970	5350

Budgetary constraints limited each of the five resampled sites to twelve (12) rounds of sampling. Numerical experiments using suspended sediment data from the Lake Michigan Mass Balance confirm that calculating loads using a smaller pool of observations decrease both the accuracy and precision of the load estimate (table 7-5). This makes detection of trends much more difficult.

Table 7-5. Example of reduction in accuracy and precision of load estimate given a reduced level of sampling effort.

Sampling Scheme	Computed Load and 95% Confidence Interval
ALL DATA (n=222):	*128,700 MT ± 7,300*
MONTHLY DATA (n=12), 1st of month:	118,500 MT ± 34,800
MONTHLY DATA (n=12), mid-month:	85,800 MT ± 13,800
MONTHLY DATA (n=12), high-flow events:	141,100 MT ± 43,900

Conclusions

Reductions in calculated loads of both total mercury and total PCB relative to the loads calculated as part of the Lake Michigan Mass Balance were observed in all five of the resampled sites. Hydrologic conditions at the Kalamazoo, St. Joseph, and Grand Calumet sites suggest that the observed reductions in load are partly due to real changes in watershed loading rates. It has been suggested that the half-life for PCB in the Lower Fox River is between 7 and 14 years. Unfortunately, in order to detect even such a change as this given the confounding factors will require more sampling, or the passage of more time in order that the effect size increases.

The LMMB Study used an integrated, multimedia mass balance modeling approach (USEPA 1995; 1997a; Richardson et al. 1999) to evaluate the sources, transport, and fate of contaminants in the Lake Michigan ecosystem. The modeling framework is a series of coupled and/or linked models which integrates the physical, chemical, and biological components of the system and accounts for the dynamic interactions and processes in the system. The mass balance approach is based upon the principle of conservation of mass, which states that the mass of a chemical contained in the lake is equal to the amount entering the system, less the amount leaving and chemically changed in the system. In the Lake Michigan system, pollutant inputs may come from atmospheric deposition, tributary loads, and from sediments within the system. Pollutants may leave the system through discharge through the Straits of Mackinac, permanent burial in bottom sediments, and volatilization to the atmosphere. Pollutants within the system may be transformed through degradation or stored in the ecosystem compartments such as the sediment, water column, or biota, including humans.

The mass balance models rely on data and output from multiple sources and were compiled into a LMMB Study database (USEPA 2001e). Computational transport includes a hydrodynamic model for advective/dispersive transport and temperature and a surface wave model for wave direction, height, and period; both use meteorological data for input. The mass balance components include sediment transport, eutrophication, and contaminant transport and fate. These models integrate atmospheric deposition and tributary mass loadings. The food web models receive chemical exposure concentrations and bioavailability (chemical concentration in phytoplankton) from the mass balance models and are used to simulate and forecast contaminant concentrations in the food web.

The modeling construct was applied to the study contaminants, where appropriate, and used three different spatial resolutions. Modeling results will be provided for each of the contaminants at the highest resolution that is presently available. The mass balance was primarily designed to provide a lakewide perspective of contaminant sources, fate, transport and effects. However, with the present spatial resolution design, selected aspects of the contaminants can be addressed on a finer scale. Information regarding Lake Michigan tributaries will be provided from samples collected only from tributary mouths.

Lake Michigan PCBs

Polychlorinated biphenyls (PCBs) are a class of manmade, chlorinated, organic chemicals that include 209 congeners, or specific PCB compounds. The highly stable, nonflammable, non-conductive properties of these compounds made them useful in a variety of products including electrical transformers and capacitors, plastics, rubber, paints, adhesives, and sealants. PCBs were produced for such industrial uses in the form of complex mixtures under the trade name “Arochlor” and were commercially available form 1930 through 1977, when the USEPA banned their production due to environmental and public health concerns (2001b).

PCB concentrations in fish over the past 30 years (USEPA 2002a) show a downward trend from peak levels in the 1970s. The most recent data also exhibit a decline, however, this indicates that the rate of decline is slowing and concentrations in lake trout remain above desired levels. Similar trends are occurring for other species. Declining concentrations (IADN 2000; USEPA 2001b; 2001e; 2002a) are also observed for other media. Although PCB concentrations have been dramatically reduced in all media since the 1970s, PCBs continue to bioaccumulate above desired levels in fish as well as other species. The LMMB Study was undertaken, in part, to investigate this problem in detail and to develop mathematical models that could be used to project future concentrations in water, sediment, and biota, with and without future remedial and/or regulatory efforts (USEPA 1995; 1997a; Richardson et al. 1999; USEPA 2001d).

LMMB Major Findings: PCBs

- Forecasted PCB concentrations in lake trout may permit unlimited consumption as early as 2039 at Sturgeon Bay and 2044 at Saugatuck.
- PCB trends indicate that concentrations are declining in all media.
- Atmospheric deposition is the major current route of PCBs to the lake (from sources inside and outside the basin).

- Chicago urban area is a substantial atmospheric source of PCBs to Lake Michigan.
- There is a dynamic interaction among water, sediments, and the atmosphere where large masses of PCBs from sediments cycle into and out of the lake via the atmosphere as vapor phase.

Lake Michigan Atrazine

Atrazine is one of the chloro-triazines, which also include simazine and cyanazine. Atrazine is a widely used herbicide for control of broadleaf and grassy weeds in corn, sorghum, rangeland, sugarcane, macadamia orchards, pineapple, turf grass sod, forestry, grasslands, grass crops, and roses. In the Lake Michigan basin, atrazine is used primarily on corn crops and is usually applied in the spring before or after emergence of the crop. Trade names for atrazine include Aatrex, Alazine, Crisazina, Malermais, Primatol, and Zeapos. Atrazine has been widely used in the agricultural regions of the Great Lakes basin since 1959 when it was registered for commercial use in the United States. Atrazine was estimated to be the most heavily used herbicide in the United States in 1987 to 1989 with heavy use in Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Nebraska, Ohio, Texas, and Wisconsin. Peak total annual U.S. usage of atrazine occurred in 1984 at 39.9 million kilograms. Usage has been dropping since then and was estimated at 33.8 million kilograms in 1995.

Unlike PCBs, the herbicide atrazine does not bioaccumulate in organisms but does remain in the water column. The two single-most important atrazine loads to Lake Michigan are tributaries and wet deposition (rain and snow). Decreases in loadings from the tributaries are evident starting in 1985. A decreasing trend of loadings from the atmosphere in the form of wet deposition is not as evident. All of the estimates of tributary loadings assumed that 0.6% of the applied active ingredient (atrazine) reached Lake Michigan. This 0.6% is often referred to as the Watershed Export Percentage (WEP). Tributary loadings for 1989, 1992, 1993, 1994, 1995, and 1998 were based on actual records of amounts applied per each county in the basin, and calculating what portions of the amount applied in those counties falls within a Lake Michigan Hydrologic Unit Code area that eventually drains into the lake. Tributary loading estimates for other years depicted were based on total annual U.S. usage for those years. For 1991, 1994, and 1995 wet deposition load estimates were based on actual precipitation data collect in the basin. Wet deposition loading estimates for other years were based on total annual U.S. usage for those years. Atmospheric loadings to the lake are higher in the southern portions than in the northern areas. The higher loadings in the south are likely due to the close proximity of this area to corn growing regions in the southern basin (Rygwelski et al. 1999).

LMMB Major Findings: Atrazine

- Observed and forecasted lake-averaged concentrations of atrazine are well below USEPA biological effects thresholds.
- Tributaries are the major source of atrazine to the lake.
- Atrazine is very persistent in Lake Michigan – decay is estimated at less than 1% per year.
- Atrazine concentrations are forecasted to increase in the lake under present loads (1994-1995 constant load).

Lake Michigan Mercury

Mercury is a naturally-occurring metal in the environment. Mercury is used in products such as battery cells, barometers, thermometers, switches, fluorescent lamps, and as a catalyst in the oxidation of organic compounds. Global releases of mercury to the environment are both natural and anthropogenic (caused by human activity). Sources of mercury releases include: combustion of various fuels such as coal; mining, smelting and manufacturing activities; wastewater; agricultural, animal and food wastes. As an elemental metal, mercury is extremely persistent in all media. Mercury also bioaccummulates in fish tissue. Mercury is also a possible human carcinogen and causes the following human health effects: stomach, large intestine, brain, lung, and kidney damage; blood pressure and heart rate increase, and fetus damage (USEPA 2001c). Because of the possible human and ecological effects of mercury, mercury was selected for study in the Lake Michigan Mass Balance Study as a bioaccumulative metal. The objective of the mercury investigation was to provide a mass balance for total mercury (USEPA 1995; 1997a; 1997b; 1997c; 1997d; 1997e; Richardson et al. 1999; USEPA 2001d). Methylmercury was not directly measured for the LMMB Study, however, some information on this parameter will be discussed.

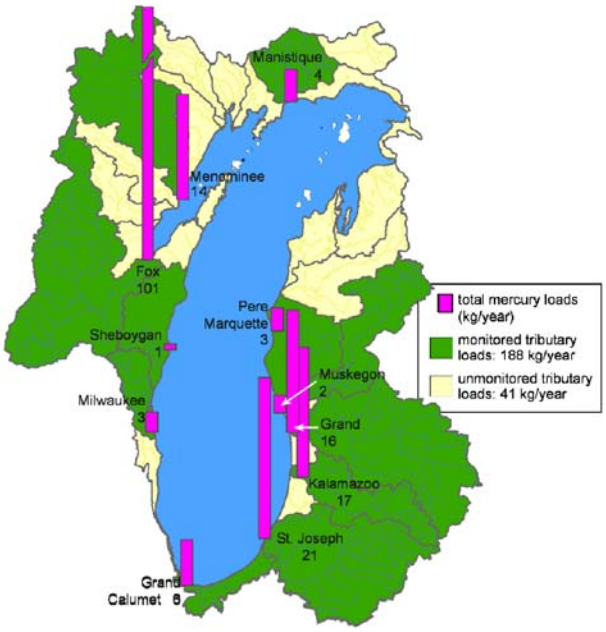


Figure 7-2. Total mercury loads (kg/year) to Lake Michigan from major monitored and unmonitored tributaries.
Source:USEPA Office of Research and Development

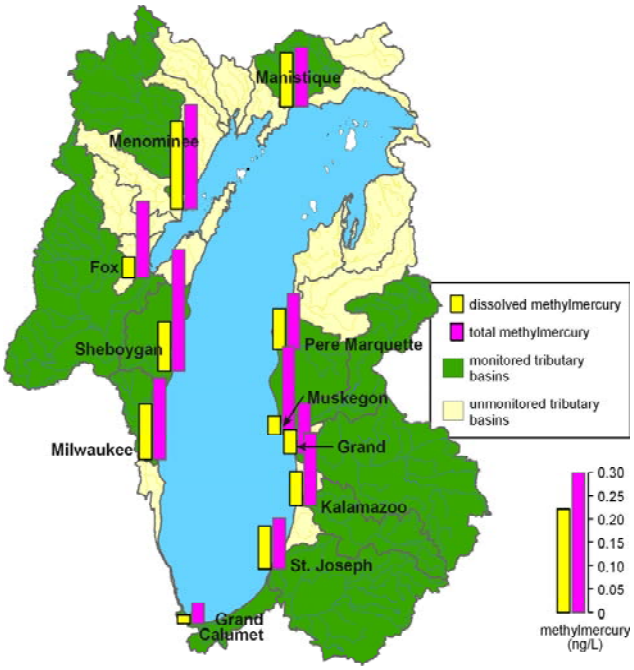


Figure 7-3. Dissolved and Total Average Methylmercury Concentrations in Monitored Tributaries.
Source:USEPA Office of Research and Development

Results of a dated sediment core provide a historical perspective of mercury in Lake Michigan. Results from a depositional basin indicate that concentrations of mercury peaked in the mid 1940s and have been declining since that time.

LMMB Major Findings: Mercury

- The current major source of mercury to the lake is from atmospheric deposition.
- Most Lake Michigan lake trout and coho salmon exceed the USEPA guidelines for unrestricted consumption.
- Modeling results suggest that a significant amount of the existing mercury settling out of water is being recycled back into the system.

Nutrients - Eutrophication

Eutrophication from excessive nutrient loads and nutrient concentrations has been under investigation and has received control strategies in the Great Lakes for the past 30 years.

LMMB Major Findings: Eutrophication

- Lake Michigan phosphorus loads and concentrations are low and below GLWQA and IJC targets.
- Tributaries are the major source of phosphorus to Lake Michigan.
- Highest concentrations can be observed in selected nearshore zones near tributary mouths and in Green Bay.
- There is no evidence of increasing loads or increasing concentrations in the open-water through 2002; forecasts indicate relatively stable phosphorus and chlorophyll-a concentrations into the future.

Pollutants and Pathways to Lake Michigan

While the LMMB study focused on four pollutants to develop a better understanding of pollutant fate and transport within the Lake Michigan ecosystem, many other pollutants are entering the ecosystem through a variety of pathways. The following discussion addresses recent investigations of four of these pathways:

- Atmospheric deposition,
- Nonpoint source runoff, including combined sewer overflows (CSO)
- Sediment, and
- Groundwater.

Atmospheric Deposition

The role of air pollution as an important contributor to water pollution has long been recognized and has been the subject of growing scientific study and concern in recent years. Over the past three decades, scientists have collected a large and convincing body of evidence showing that toxic chemicals released into the air can travel great distances before they are deposited on land or water. Most notably, PCBs and some persistent pollutants (including several pesticides that have not been used in significant amounts in the United States since the 1970s) have been widely distributed in the environment and are now part of the global atmospheric background. Section 112 of the Clean Air Act required congressional reports of the effect of air deposition on the "Great Waters" of the United States, including the Great Lakes where this pathway was documented.

Loadings of pesticides whose use has been canceled or restricted in the United States to Lake Michigan are primarily from atmospheric sources that is impossible to regulate or control. Although there are no current commercial sources of banned pesticides in the United States, loadings continue from use of remaining consumer stocks, evaporation from soils, resuspension of contaminated sediments, and atmospheric transport from other countries that continue to apply these substances. Further pesticide reductions can only be achieved through cleanup of contaminated sites, collection and disposal of existing stockpiles ("clean sweeps"), and use reduction in other countries. Between 1988 and 2001, USEPA Region 5 estimates that agricultural clean sweeps have removed 1.9 million pounds of pesticides from the Great Lakes basin.

While long-range atmospheric transport is an important pollutant source for Lake Michigan, recent studies also point to the influences of local sources, particularly from urban areas. For example, air sampling over Lake Michigan when the wind is blowing from the southwest shows contributions of PCBs, PAHs, and mercury from the Chicago area to the lake. The relative importance of each pollutant source to the overall loadings is variable depending on the season and local weather conditions.

Nonpoint Source Pollution

According to the USEPA National Water Quality Inventory Reports to Congress, states, tribes, and other jurisdictions consider siltation and the over enrichment of nutrients two of the three most significant causes of impairment in many of the streams throughout the Nation. Siltation alters aquatic habitat and suffocates fish eggs and affects other bottom dwelling organisms. Excessive nutrients have not only been linked to hypoxia in the Gulf of Mexico, but also to eutrophication and *Cladophora* blooms in many of the bays and beaches around Lake Michigan. Research in the 1960's and 70's linked *Cladophora* blooms to high phosphorus levels in the water, mainly as a result of agricultural runoff, detergents containing phosphorus, inadequate sewage treatment, and other human activities such as fertilizing lawns and poorly maintained septic systems (More information is available at *www.uwm.edu/Dept/GLWI/cladophora*). Due to tighter restrictions, phosphorus levels declined during the 1970's and *Cladophora* blooms were largely absent in the 1980's and 90's. Recently *Cladophora* blooms are again a common occurrence along the coast of Lake Michigan; however, the cause of these blooms is unknown.

USEPA identifies polluted runoff as the most important remaining uncontrolled source of water pollution and provides for a coordinated effort to reduce polluted runoff from a variety of sources. Previous technology-based controls, such as secondary treatment of sewage, effluent limitation guidelines for industrial sources, point sources and management practices for some nonpoint sources, have dramatically reduced water pollution and laid the foundation for further progress. However, nonpoint source loads continue to turn rivers and streams into pollutant pathways to the lake. Total maximum daily load (TMDL) studies are needed for impaired tributaries to identify the management measures needed to bring them back into compliance with water quality standards. Over the next several years, states will be developing many TMDLs for pollutants entering into water bodies from both point and nonpoint sources. TMDLs will provide data to help manage water quality on a watershed scale. See the watershed fact sheets in Chapter 12.

Major sources of nonpoint pollution include urban stormwater runoff, discharges from animal feeding operations, cropland runoff, and episodic combined sewer overflows. In addition, pollution can arrive via air from outside a watershed.

Urban nonpoint source stormwater is water from rain or snow that runs off city streets, parking lots, construction sites, and residential yards. It can carry sediment, oil, grease, toxicants, pesticides, pathogens, and other pollutants into nearby storm drains. Once this polluted runoff enters the storm sewer system, it is discharged, usually untreated, into local streams and waterways. It can contaminate drinking and recreational waters and remains a major source of beach closures.

In late 1999, USEPA promulgated rules to reduce stormwater runoff from construction sites between 1 and 5 acres and municipal storm sewer systems in urbanized areas serving populations of less than 100,000 through the issuance of permits. Generally, these controls were required to be in place by 2008 and build on the existing program to control stormwater runoff from municipalities with populations greater than 100,000 and 11 industrial categories, including construction disturbing over 5 acres. Under the expanded program, sediment discharges from approximately 97.5 percent of the acreage under development across the country will be controlled through permits. Many communities have passed ordinances to address the regulation with more being added every month.

The Lake Michigan basin has a high concentration of agricultural enterprises where animals are kept and raised in confined environments. Polluted runoff from animal feeding operations is a leading source of water pollution in some watersheds. Potential impacts include the absence or low levels of dissolved oxygen in surface water, harmful algae blooms, fish kills, and contamination of drinking water from nitrates and pathogens and beach closures.

For the vast majority of animal feeding operations (AFO), voluntary efforts will be the principal approach to assist owners and operators in developing and implementing site-specific management plans. Impacts from higher risk, concentrated animal feeding operations (CAFO), such as sites with the equivalent of 300 beef cows, will be addressed through National Pollutant Discharge Elimination System (NPDES) permits under the authority of the Clean Water Act. Wisconsin and Michigan developed state programs for control. About 5 percent of all animal feeding operations are expected to need permits.

The Lake Michigan Toolbox
Nitrogen Removal

A recent U.S. EPA report "Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations", provides a synthesis of existing scientific literature on the effectiveness of riparian buffers to improve water quality through their inherent ability to process and remove excess anthropogenic nitrogen from surface and ground waters. The following URL will access a pdf of the report.

http://www.epa.gov/ada/download/reports/600R05118/600R05118.pdf

The Lake Michigan Toolbox
Catalog of Federal Funding Sources for Watershed Protection and Nonpoint Source Control

U.S. EPA has compiled a Catalog of Federal Funding Sources for watershed protection and nonpoint source control at http://cfpub.epa.gov/fedfund/. The web site is a searchable database of financial assistance sources (grants, loans, cost-sharing) available to fund a variety of watershed protection projects. Examples of funding sources include the U.S. EPA administered Section 319 Nonpoint Source grant program under the Clean Water Act and the Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Easement Program (CREP) administered by the U.S. Department of Agriculture.

Phosphorus in the Lake Michigan Basin

Phosphorus has been shown to be the nutrient limiting production in Lake Michigan. To estimate where phosphorus originates in the watershed, results from

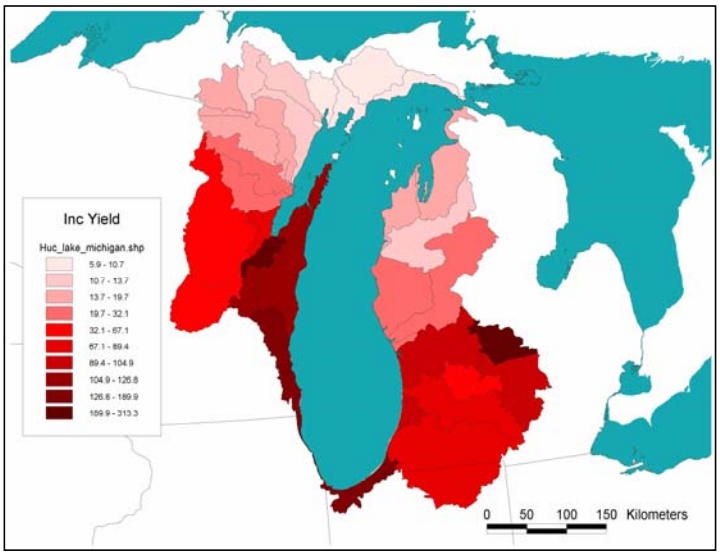


Figure 7-4. Phosphorus yields from Lake Michigan watersheds as estimated from the SPARROW model for conditions similar to 1992 (Alexander and others, 2008).

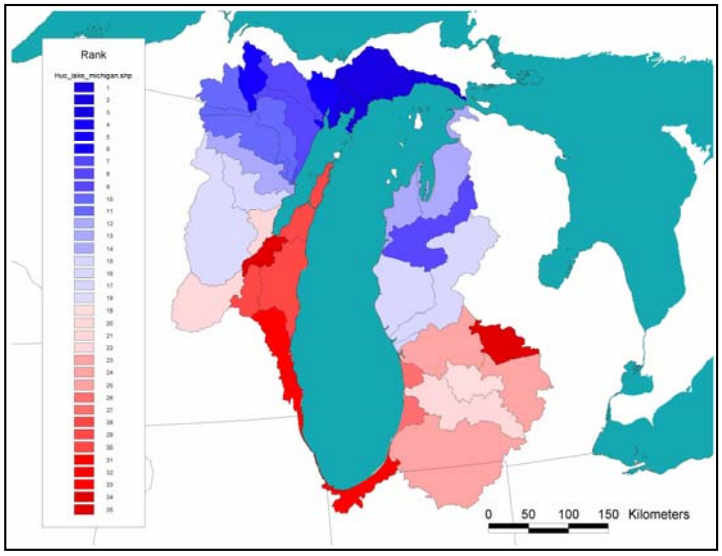


Figure 7-5. Ranking of phosphorus yields by watershed, based on the yields from Figure 7-4 (Alexander and others, 2008).

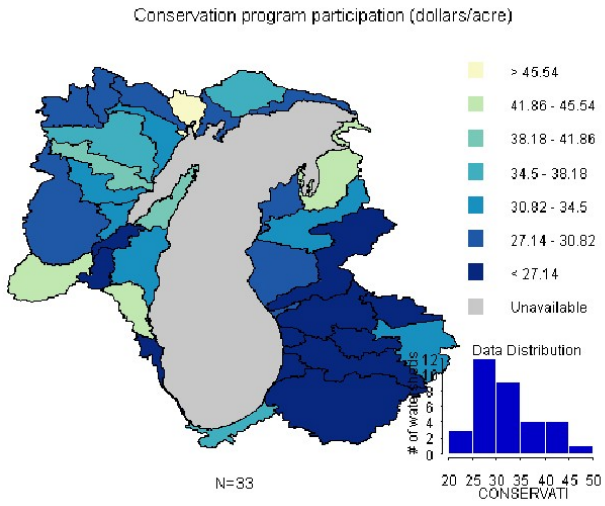


Figure 7-6. Conservation program participation (dollars/acre).
Source: USEPA

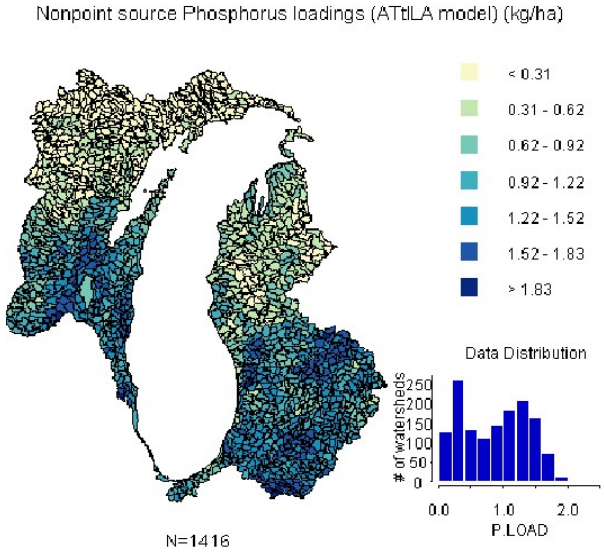


Figure 7-7. Nonpoint source phosphorus loadings.
Source: USEPA

the SPAtially Referenced Regressions on Watershed Attributes (SPARROW) model were examined for the Lake Michigan Basin (Figure 7-4). SPARROW is a hybrid statistical/deterministic model that relates water-quality monitoring data to watershed sources and characteristics. Results from SPARROW model demonstrate that the majority of the phosphorus load originates from the southern half of the drainage basin. The highest yields were estimated to be from West of the Fox River in Wisconsin, Northwest Indiana, and the Maple River watershed in Michigan. These areas have either intense agriculture or are highly populated. Relatively low yields were estimated from the forested areas in the Upper Peninsula of Michigan. This information can be used to rank the basins in terms of their relative yields to the lake (Figure 7-5).

The Lake Michigan Mass Balance project and the annual GLNPO open water sampling concentrate sampling for the open water of the lake for the targets set in the Great Lakes Water Quality Agreement.

While the open water targets were being met, there was a nearshore problem developing that resembled the problems of the 1960s-1980s, cladophora blooms. Research has linked these blooms to high phosphorus

levels in the water, mainly as a result of human activity such as fertilizing lawns, poorly maintained septic systems, inadequate sewage treatment, agriculture and urban runoff and detergents containing phosphorus. Due to past restrictions on some sources of nutrients, open water phosphorus levels declined during the 1980s and 90s, but recent research suggests that the invasion of zebra and quagga mussels in the Great Lakes are responsible for the increase in algae by increasing the availability of phosphorus for Cladophora and increasing water clarity as they feed on the plankton in the lake. Since we do not have management options to control the invasive mussel population, the nutrient control management options are again key to addressing the problem. Additional research on the dynamics of the nearshore is also needed.

What Action is Needed?

EPA is encouraging all states, territories and authorized tribes to accelerate their efforts and give priority to adopting numeric nutrient standards or numeric translators for narrative standards for all waters in states and territories that contribute nutrient loadings to our waterways. Incremental progress can be an effective way to accelerate progress. If a state needs to implement numeric nutrient criteria incrementally, EPA strongly recommends that states adopt numeric nutrient standards for their priority waters—i.e., waters at greatest risk of nutrient pollution (such as those identified through the EPA-USGS SPARROW modeling effort) or of greatest consequence (such as drinking water sources)—first. States may also choose to prioritize their actions for waters where sufficient information is available to move quickly to adopt numeric criteria in the near-term. The state's nutrient criteria plan should reflect the state's approach to setting standards for its waters, and include schedules for adopting those standards.

To be effective, nutrient criteria should address causal (both nitrogen and phosphorus) and response (chlorophyll-a and transparency) variables for all waters that contribute nutrient loadings to our waterways. EPA encourages the adoption of standards for all four parameters because of the interrelationships between these parameters and its experience showing that controlling both nitrogen and phosphorus is important to successfully combating nutrient pollution in all waters. As always, states, territories and authorized tribes have the flexibility to address nutrient pollution using a subset of or alternatives to these parameters if they are shown to be scientifically defensible and protective of designated uses.

With the establishment of numeric nutrient standards, state governments and local communities can set goals, establish controls, agree on risk management approaches, measure performance, demonstrate progress, and learn from each other. In a time of scarce resources and competing priorities, we cannot afford delayed or ineffective responses to this major source of environmental degradation.

Bans on the use of phosphorus-containing products are become more common. In 2003 Minnesota adopted a ban on application of phosphorus in lawn fertilizer and the amount of phosphorus applied via lawn fertilizer dropped from 292 tons to 151 tons. Both

Five-Year Review Report Completed, Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site, Kalamazoo, Michigan

On October 19, 2007, the Region 5 Superfund Division issued the first Five-Year Review Report for the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund site, located in Kalamazoo, Michigan.

The site consists of six operable units (OUs). Record of Decisions (RODs) were issued for OU3 (February 1998), OU4 (September 2001), and OU2 (September 2006); the remaining OUs (OU1, OU5, and OU7) are in different stages in the Superfund cleanup process. The remedies selected for OU3, OU4, and OU2 include: consolidation and containment of polychlorinated biphenyl (PCB)-contaminated material; landfill cap over waste material; long-term monitoring; and deed restrictions limiting development of the property. The remedy has been constructed at OU3; is under construction at OU4; and has not yet been constructed at OU2.

The five-year review concluded that the remedy at OU3 is protective of human health and the environment in the short term. However, in order for the remedy to be protective in the long term, effective institutional controls need to be implemented and methane gas that has migrated off-site needs to be mitigated. The remedy at OU4 is not protective of human health and the environment because exposure pathways that could result in unacceptable risks are not controlled.

For more information, contact: Shari Kolak at 312-886-6151.

Draft Great Lakes Regional Collaboration Mercury Product Stewardship Phase-down

The Great Lakes Regional Collaboration (GLRC) held a sixty day (60) public comment period for a Draft Great Lakes Mercury Product Stewardship Strategy (http://www.glrc.us/initiatives/toxicsdrafthgphasedownstrategy.html) that ended at the end of October 2007. This Mercury in Products Phase-Down Strategy was developed in response to the Great GLRC Strategy to Restore and Protect the Great Lakes. The GLRC Strategy calls for the development of a basin-wide mercury product stewardship strategy designed to phase out the use of mercury and provide for mercury waste management. The GLRC document identifies full phase-outs of mercury-added products by 2015, as possible, as an interim milestone for toxics reduction.

Some states, tribes and cities in the Great Lakes basin have passed laws or have implemented programs to prevent pollution from mercury-containing products. This strategy seeks to build on those foundations to accomplish the 2015 phase-down goal. The strategy recommends a wide range of product-targeted policies for states to adopt, including sale bans and phase-outs, disposal regulations, public awareness and education programs, collection/end-of-life management for products, purchasing preferences, and labeling requirements. Some would require legislative action; others can be implemented by state, municipal or tribal agencies.

Wisconsin and Michigan have put limits on the large Confined Animal Feeding Operations which also contribute to the nutrient load. Indiana banned laundry detergents containing phosphorus in the 1970s and just passed a ban on eliminating phosphorus in dishwashing detergents for home use. The ban takes effect in July of 2010, giving industry time to distribute the new, reformulated product. In Michigan, bans on application of phosphorus containing fertilizers for residential use have been passed at both the county and local community level. Public education is also needed as many products are used without the soil tests to determine if they are needed since there is the recognition that some situations call for phosphorus like the establishment of a new lawn.

Areas of Concern: Legacy of Contamination and Community Stewardship

LaMP 2000 explained: In 1987 the Great Lakes Water Quality Agreement (GLWQA) between the US and Canada was expanded to address critical stressors affecting the basin's ecosystem. The intersections of major tributaries and the Lakes are areas where human activity by-products and collected river deposits concentrate. " The Parties recognize that there are areas in the boundary waters of the Great Lakes system where, due to human activity, one or more of the general or specific objectives of the Agreement are not being met. Pending virtual elimination of the persistent toxic substances in the Great Lakes system, the Parties, in cooperation with the State and Provincial Governments and the Commission, shall identify and work toward restoring and protecting beneficial uses in Areas of Concern or in open waters." (GLWQA)

For each AOC a stakeholder group was convened to work with federal and state agencies to develop remedial action plans that defined the problem and suggested remedial actions. This program has been very successful in capturing the energy and creativity of the communities. Unfortunately, agency funding and resources have been uneven and have never approached the scale needed for remediation of large-scale legacy sites. Federal authorities like Superfund, Resource Conservation and Recovery Act Corrective Action Program and the Clean Water Act have provided USEPA the tools to address some of the large-scale actions needed. The U.S. Army Corps of Engineers has been given specific program authority for AOCs.

Federal and State agencies and the AOC communities want to move ahead, remediate and restore impairments and delist their AOC. Matching authorities to specific impairment sources and the recovery time needed for the remediation actions to "take" in the environment are lengthy procedures. A number of new tools are now available:

- Delisting guidance finalized by Michigan and approved by USEPA GLNPO in January 2006.
- Delisting Principles and Guidelines- adopted by the U.S. Policy Committee in December 2001
- The Legacy Act of 2002- providing funding and new authorities for putting remediation partnerships together

Great Lakes Legacy Act

The Great Lakes Legacy Act (GLLA) is aimed at accelerating the pace of contaminated sediment

Great Lakes Basin Program for Soil Erosion and Sediment Control in Proposed Farm Bill

Congress included the Great Lakes Basin Program for Soil Erosion and Sediment Control as one of the conservation programs in the proposed 2007 Farm Bill. The legislation identifies the Basin Program as a means of achieving one of the top priorities of the Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes – reducing nonpoint source runoff from rural and urban areas.

The Great Lakes Basin Program for Soil Erosion and Sediment Control provides grants to local projects that help reduce soil erosion and sedimentation and otherwise control nonpoint source pollution on Great Lakes tributaries. By helping to keep excess sediment and land-based pollutants such as phosphorous and nitrogen out of the water, the program helps maintain clean sources of drinking water, protect fish and wildlife, and reduce the costs of dredging sediment from navigation channels and harbors. The program is administered by the Great Lakes Commission. Since 1991, the program has helped prevent more than 1 million tons of soil erosion and kept more than 5 million pounds of phosphorous out of Great Lakes tributaries.

Sediment Remediation New Grand Calumet River Great Lakes Legacy Act Project Agreement Signed

In April 26, 2007, a Project Agreement was signed by the U.S. EPA, the Indiana Department of Environmental Management (IDEM), and the remediation and develop the final design plans and specifications, general provisions, and special requirements necessary for sediment remediation at the West Branch Grand Calumet River (WBGCR) between Columbia and Hohman Avenues. This AOC represents one of the most heavily industrialized areas in the United States, contains steel mills and heavy manufacturing sites associated with the steel industry, petroleum-related land uses, packaging operations, chemical processing plants, and other industrial land uses. The WBGCR has received inputs of contaminants from various sources over the past century. In general, sediments in the river have elevated concentrations of heavy metals, PCBs, Semi-volatile organics (primarily PAHs), and pesticides (e.g., DDT and degradation products). This phase of the project is scheduled to be completed in early 2008 with the possibility that the project may eventually evolve into a remediation project. This will occur if the project successfully meets U.S. EPA's selection criteria identified in the Great Lakes Legacy Act Implementation Rule, and is agreed to by U.S. EPA, IDEM and IDNR.

remediation in Great Lakes' Areas of Concern (AOCs). The Act authorizes up to $50 million for projects that remediate contaminated sediments or lead to remediation. The goal of the U.S. Environmental Protection Agency's Great Lakes National Program Office is to identify and potentially remediate all eligible contaminated sediment sites within the 31 U.S. Areas of Concern.

As of July 2007, 3 remediation projects have been completed (Black Lagoon, Trenton, MI; Hog Island Inlet and Newton Creek, Superior, WI; and Ruddiman Creek and Pond, Muskegon, MI). Two remediation projects are underway (Ashtabula River, Ashtabula, OH and Tannery Bay St. Marys River, Sault Ste. Marie, MI), several assessment/feasibility/design projects, and follow up restoration projects are underway. The three completed projects have been highly successful from a technical point of view, attaining and/or exceeding the remediation goals established for the project.

The projects have also been highly successful in terms of attaining and/or exceeding the goals of the stakeholders, their communities and the municipal, county and state partners. The impacts of the remediation will be highlighted, as well as the roles and responsibilities from project submittal to completion, and the key factors that made the projects successful.

Under the GLLA a project is to be carried out in an AOC located wholly or partially in the United States, and the project:

1. monitors or evaluates contaminated sediment;
2. implements a plan to remediate contaminated sediment; or
3. prevents further or renewed contamination of sediment.

More information is available at http://www.epa.gov/glnpo/sediment/legacy/ .

The LaMP Pollutant List

There are a number of pollutants that could be placed on the LaMP pollutant list. These were identified in LaMP 2004. The process for identifying LaMP pollutants, the 2004 pollutants list, potential pollutants to be added in 2006, and information on pollutant management activities completed since 2002 are presented in Appendix A.

Areas of Concern Overview

There is an increasingly strong focus on remediating the problems of areas of concern (AOCs). The ultimate goal is to ensure the effective clean-up of these contaminated areas and protect them by utilizing watershed stewardship activities as a means of ensuring their on-going protection.

The following matrix provides summary information for the Lake Michigan AOCs. It provides information regarding:

- AOC Name and Beneficial Use Impairments (BUIs)
- Primary Contaminants
- Geographic Area
- Stressors
- Programs
- Clean-Up Actions
- Key Activities Needed
- Challenges
- Next Steps

The Great Lakes Water Quality Agreement calls for Remedial Action Plans (RAPs) to restore and protect 14 beneficial uses in Areas of Concern. An impaired beneficial use means a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause any of the impairments listed below (BUIs are listed in the AOC name column using the following numeration).

I. **Restrictions on fish and wildlife consumption** - When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish and wildlife.

II. **Tainting of fish and wildlife flavor** - When ambient water quality standards, objectives, or guidelines for the anthropogenic substance(s) known to cause tainting are being exceeded or survey results have identified tainting of fish and wildlife flavor.

III. **Degraded fish and wildlife populations** - When fish or wildlife management programs have identified degraded fish or wildlife populations. In addition, this use will be considered impaired when relevant, field-validated, fish and wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.

Michigan Begins to Apply AOC Delisting Document

The Michigan Department of Environmental Quality's Water Bureau recently published its Guidance for Delisting Michigan's Great Lakes Areas of Concern. The Guidance includes specific, measurable criteria for restoration and removal of Beneficial Use Impairments identified in Annex 2 of the 1987 Amendments to the Great Lakes Water Quality Agreement. The delisting criteria have been applied in most of Michigan's Lake Michigan AOCs, including the removal of the Degradation of Benthos Beneficial Use Impairment in Manistique River. This presentation will provide an overview of Michigan's delisting criteria and focus on application of specific criteria, using Manistique River, Muskegon Lake, White Lake, and Kalamazoo River as case studies for Michigan's Areas of Concern.

IV. **Fish tumors or other deformities** - When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bullheads or suckers.

V. **Bird or animal deformities or reproductive problems** - When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species.

VI. **Degradation of benthos** - When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field-validated bioassays with appropriate quality assurance/quality controls) of sediment-associated contaminants at a site is significantly higher than controls.

VII. **Restrictions on dredging activities** - When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.

VIII. **Eutrophication or undesirable algae** - When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.

IX. **Restrictions on drinking water consumption or taste and odor problems** - When treated drinking water supplies are impacted to the extent that: 1) densities of disease- causing organisms or concentrations of hazardous or toxic chemi-

cals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).

X. **Beach closings** - When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use.

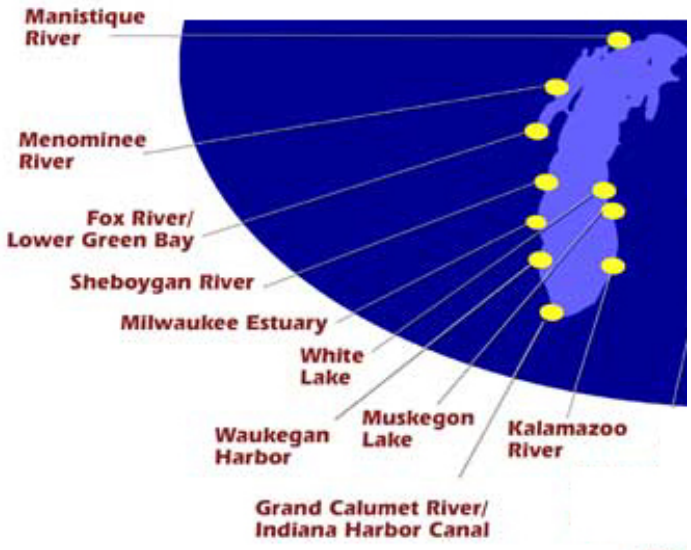
XI. **Degradation of aesthetics** - When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).

XII. **Added costs to agriculture and industry** - When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) or industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).

XIII. **Degradation of phytoplankton and zooplankton** - When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton bioassays (e.g. Ceriodaphnia; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.

XIV. **Loss of fish and wildlife habitat** - When fish or wildlife management goals have not been met as a result of loss of fish or wildlife habitat due to a perturbation in the physical, chemical or biological integrity of the Boundary Waters, including wetlands.

Lake Michigan Areas of Concern



Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Grand Calumet River **Indiana** Grand Calumet River: Lagoon, East Branch and West Branch Indiana Harbor and Ship Canal, The Lake George Branch of the Canal, Wolf Lake, George Lake and Nearshore Lake Michigan. Listed BUIs I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII, XIII, XIV Delisted BUIs	• PCB and mercury Contaminated Sediments • Pathogens from Combined Sewer Overflows • Contaminated groundwater • Contaminated land sites • Habitat Fragmentation • Fire Suppression • Aquatic nuisance species • PAHs • Biochemical oxygen demand • Suspended solids • Oil and grease • PCB • Mercury • Metals	• Superfund • RCRA • Clean Water Act • WRDA • Navigational Dredging • Natural Resource Trustee's Damage Assessment • Great Lakes Legacy Act	• West Branch Remediation – a sediment dredging and habitat restoration demonstration project at the East Chicago Sanitary District Canal has been designed by the USACE and ECSD • U. S. Steel Gary Works dredging of 5 river miles on the East Branch complete including 824,00 cubic yards of sediment removed from the river and placed in the Corrective Action Management Unit (CAMU). • GSD Sediment Remediation-selected remedial option is currently being considered by EPA • Navigational dredging • U.S. Lead - 19,000 cubic yards of sediment have been remediated • A total of 700,000 cubic yards of sediment have been remediated • IDEM and EPA are currently working on the amendment to currently existing federal consent decrees to address CSO long term control plan issues.	• Delisitng targets for all 14 listed BUIs will be in place by December 31, 2008.	• Sediment remediation • CSO Long Term Control Plans • Issue NPDES Permits • BUI Indicator Monitoring • West Branch assessment completed in 2002 • Remedial Alternatives Development Report completed in 2006 • Coordination with RAP program for AOC delisting purposes	• Public concern regarding location of contaminated material disposal • Local funding and match for federal projects • Legal concerns • Permitting • Monitoring resources • The draft Water Quality Component of Stage Two includes some provisions being implemented through indirect methods; direct resources for implementation have been limited	• EPA GLNPO - IDEM - IDNR are working in partnership with the Great Lakes Legacy Act to remediate the West Branch of the Grand Calumet River. • Dredging at U. S. Steel complete • NRDA-Consent decree has been entered and restoration planning is underway • ACOE- WRDA Diagnostic Feasibility Study • GSD-Site Characterization • Monitor BUI Indicators • CDF construction is currently underway • The RAP process has developed and obtained funds for a Toxic Pollution Prevention (TPP) Program

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Kalamazoo River **Michigan** I, III, V, VI, VII, X, XI, XIV From Morrow Dam, which forms Morrow Pond and extends about 80 miles downstream to Lake Michigan. Also includes about three miles of Portage Creek.	• PCBs in Sediments • Failing dams forming onstream impoundments that house PCB contaminated sediments • PCB/Sediment source areas such as riverside former mill properties, disposal areas, and landfills, and river banks, and floodplains. • Nonpoint pollution • Phosphorus • Sediments • Nitrates • Salt • Mercury • Dioxin (2008 draft IA) • E.coli • Antiquated land use policies/ ordinances	• Superfund • Clean Water Act • Brownfields • Natural Resource Trustee's Damage Assessment	• Superfund removal of 150,000 cubic yards of PCB-contaminated sediments from Bryant Mill Pond • Contaminated material removal from former Georgia Pacific and Hawhthorne Mill properties • Post Record of Decision landfill closure occurring at Willow Blvd./A-Site and 12th Street • Contained material removal and offsite disposal year 1 of 2 completed in river, bank, and floodplain near Plainwell (Plainwell Dam removal integrated into the cleanup effort) • Additional progress at other Superfund Operable Units • Sub-basin Watershed Management/nonpoint pollution projects Erosion control programs, and stormwater management projects • A phosphorus TMDL for Lake Allegan and the river upstream has been established; measures are being implemented to reduce phosphorus pollution from point and nonpoint source partners	• Yes; working on finalizing targets for Loss of Fish and Wildlife Habitat and Degradation of Populations	• Dredging/ Excavation/Safe Disposal • Superfund site cleanup decision action • Stream buffers/river corridor habitat connections and preservation • Dam removal • Coordination between Superfund, NRDA, stormwater, TMDL, and RAP programs necessary for AOC delisting purposes	• Local funding match for federal projects • Sustainable funding for public advisory councils and other watershed project implementers • Decisions and actions on the remediation of this Superfund Site have recently accelerated and this momentum should be fostered with community participation and departmental collaboration from federal, state, and local program partners	• Continue NRDA tracking • Continue remedial investigation/ remedial action at operable units and newly defined river reaches in Operable Unit 5 • RAP to be revised as Community Action Plan n 2008 • Kalamazoo River/Lake Allegan TMDL (Total Maximum Daily Load) continues • Fish and Wildlife Habitat Restoration tasks to be identified and pursued • Work to Remove Beach Closing BUI and Aesthetics BUI • Formalize PAC operations as a watershed umbrella organization • Formalize a draft watershed partnership agreement • Write watershed nonpoint source plan

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Lower Fox River/ Southern Green Bay **Wisconsin** The lower 40 miles of the Fox River and Green Bay I, III, V, VI, VII, VIII, IX, X, XI, XIII	• PCBs • Phosphorus • Suspended solids • Mercury • Urban and rural runoff • Sediments • Aquatic exotic species • Wetland loss • Habitat alteration	• Clean Water Act – Integrated TMDL for the Lower Fox • Superfund • Natural Resource Trustee's Damage Assessment	• Watershed NPS abatement • Remedial investigation completed remedial action nearly ongoing. Dredging and PCB removal (Deposit in 11,000 cubic yards of sediment removed,, Deposit 56/57: 80,000 cubic yards of sediment removed OU1 335,000 cubic yards of sediment removed, and Phase I, 132,000 cubic yards of sediment removed) • Dissolved oxygen wasteload • Deposit N, 56, 57 • Cumulative sediments remediated from 1998-2007 – 558,000 cubic yards • Consent Decree for Phase I Fox River clean-up announced 4/12/06, Unilateral Administrative Order issued November 2007 for remainder of river contamination (from OU2 to OU5)	• No, will be started in 2008	• Dredging • Pollution Prevention • Stream buffers • Habitat protection and restoration • Coordination with RAP program for AOC delisting purposes • Coordination with integrated TMDL	• Rapid land development • Contaminated material disposal • Seeing through completion of cleanup for OUs 2-5	• Implement 4/12//06 Consent Decree for detailed engineering for the final cleanup plan. • Compliance with the Unilateral Administrative Order issued November 13, 2007 • Remediation (using dredging/disposal, capping and sand covers) l of an additional 7.5 million cubic yards of sediment. • Final cleanup expected to be complete approximately 2020. River monitoring will continue indefinitely. • Implement integrated TMDL
Manistique River **Michigan** The last 1.7 miles of the river to the mouth of the harbor at Lake Michigan I, VII, X, XIV BUI VI delisted	• PCBs • Combined sewer overflow • PCB-contaminated sediments • Superfund	• Superfund • USACE	• Dredging of contaminated sediments completed in 2000 (190,000 cubic yards) • Manistique Wastewater Treatment Plant made improvements to its system toward elimination of CSOs • Degradation of benthic community beneficial use impairment delisted.	• Yes, all delisting targets were set in 2006	• Sampling and monitoring follow-up to confirm downward trends of contamination • Coordination with RAP program for AOC delisting purposes	• Navigational dredging • Fish consumption advisories • CSO to be closed by 2020	• Sampling and monitoring continuing as part of delisting process

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	**Stressors and Primary Contaminants**	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Step
Menominee River **Michigan/ Wisconsin** Lower 4.8 km of river to the mouth and 5 km north and south of the mouth along the Green Bay shore I, III, VI, VII, X, XIV	• Lloyd/Flanders Paint Sludge Site-high level of lead and other heavy metals coated sediments where deposited • Arsenic • Mercury • PCBs • PAHs • Oil and grease • Pathogens • Sediments • Coastal wetlands habitat loss • Nonpoint pollution • Historic shoreline developments to support harbor activities	• MDNR-Administrative Order • RCRA Corrective Action • Superfund • Menominee Watershed Intiaative	• Paint sludge cleanup completed in 1995 (10 million pounds of hazardous waste from Bay and 20 million pounds of contaminated sediments. • Development of cleanup plans for the Ansul site and river.	• In progress.	• Arsenic source control • Dredging of arsenic and coal tar contaminated sediments • Protect riparian and coastal habitat • Manufactured Gas Plant PAH site remediation and dredging.	• Funding for dredging the Menekaunee Harbor. • Funding needed for monitoring for BUI evaluation and delisting targets.	• Ansul site barrier wall installation. • Complete Arsenic dredging • Manufactured Gas Plant site remediation and dredging for coal tar (PAHs). • Identify sources for fish consumption advisories (mercury, PCBs, dioxin) to ensure that sources are controlled
Milwaukee Estuary **Wisconsin** The lower 5 km of the Milwaukee River ; the lower 4.8 km of the Menominee River; the lower 4 km of the Kinnickinnic River; the inner and outer Harbor and the nearshore waters I, III, IV, VI, VII, VIII, X, XI, XIII, XIV	• Phosphorus • Pathogens • PCBs • Metals • PAHs • Urban and rural runoff • Wastewater discharges • Sediments • Habitat loss • Dams	• Clean Water Act • Clean Air Act • Superfund • Brownfields • Navigational dredging	• Milwaukee Estuary Fish spawning habitat improvement project • Kinnickinnic River Remediation planned for 2008-09	• In progress	• Dredging • Nonpoint source pollution control • Stream buffers • Pathogen source research • Coordination with RAP program for AOC delisting purposes	• High urban density and rapid development • Historic developed sites which could be restored to improve floodplain functions and wetland function	• Estabrook Impoundment remediation needed (assessment in progress) • Watershed analysis to assess water quality impacts and options for restoration (funding needed)

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Muskegon Lake **Michigan** The entire 4149 acre lake and several tributaries within the immediate watershed. I, V, VI, VII, VIII, IX, XIV	• PCBs • Mercury • Unstable hydrologic flow • Contaminated Sediments • Nonpoint pollution • Coastal wetlands and habitat loss, isolation and fragmentation	• Shoreline Brownfield Redevelopment Authority • Navigational dredging • Great Lakes Legacy Act and Clean Michigan Initiative • Superfund • Non-point Source • USACE • US Fish and Wildlife Service - Coastal Program	• Wastewater treatment upgraded • Some tributary remedial actions underway • Removal of about 90,000 cubic yards of contaminated sediment in Ruddiman Creek	• Yes targets are set and approved by the Muskegon Lake Watershed Partnership and MDEQ for six (6) of the nine(9) BUIs: 1) Fish consumption advisories; 2) Beach Closings; 3) Degraded Benthos; 4) Restrictions on Dredging; 5) Degradation of Aesthetics; 6) Eutrophication/ Undesireable Algae; ; Working on finalizing targets for Loss of Fish and Wildlife Habitat, Degradation of Populations, and Restrictions on Drinking Water	• Contaminated Sediment Remediation • Stream buffers for improved habitat and water quality • More assessment for progress on attaining BUI targets • TMDL Assessments for Muskegon Lake; Ruddiman Creek; Ryerson Creek; Bear Lake • Habitat restoration along Muskegon Lake's south shoreline and adjacent mouths of tributaries and lower river mouth • Coordination with RAP program for AOC delisting purposes	• PCB disposal • Local funding match for federal projects • Base support for local coordination of AOC/PAC process	• Remediation of brownfields and sediments • Sediment remediation in Muskegon Lake at the Division Street Outfall. • Fish and Wildlife Habitat Restoration
Sheboygan River **Wisconsin** The lower Sheboygan River downstream from the Sheboygan Falls Dam, including the entire harbor and nearshore waters I, III, V, VI, VII, VIII, XIII	• Suspended Solids • PCBs • PAHs • Heavy Metals • Pathogens • Phosphorus • Nonpoint source pollution • Habitat restoration on streambanks and wetland areas	• Superfund • RCRA Corrective Action • Clean Water Act #319	• The former Tecumseh plant site PCB hot spot removal and cut-off trench installed along the Sheboygan River removing any preferential pathways for contaminants to move to the river from the site. • Removal of 20,700 cubic yards of PCB-contaminated sediments from Sheboygan Falls downstream to the Waelderhaus Dam – 4.5 miles of river. • Brownfield remediation on the C. Reiss Coal site.	• In progress.	• Completion of PCB remediation • Completion of PAH remediation at Camp Marina coal gasification site • Control buffers • Habitat protection • NPS controls for urban and rural pollution • Development of Delisting Targets for AOC.	• Funding needed for monitoring for BUI evaluation and delisting targets. •	• Conduct sediment recharacterization for the Middle River, Lower River and Inner Harbor reaches. • Complete dredging. • Dredge PAH contaminated sediment at the manufactured Gas Plant. • Conduct post-remedial monitoring at the site and in the Upper River section.

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

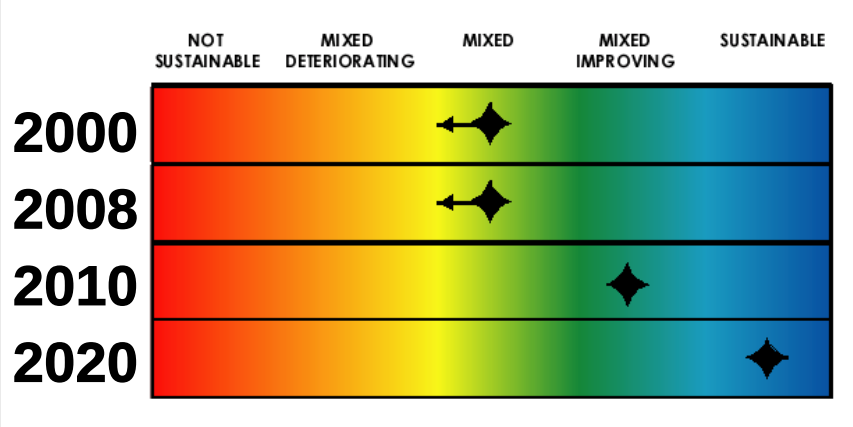
AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Waukegan Harbor **Illinois** 1.2 square kilometers of industrial, commercial, municipal and open lands. VI, VII, X, XIII, XIV	• PCB contaminated sediments	• Superfund • Clean Water Act #319	• Approximately 1 million pounds of PCBs dredged from the harbor • Soil removal activities completed at Waukegan Manufactured Gas and Coke site in 2005; extraction and treatment of contaminated groundwater to continue at the site for several years • Removal and disposal of large amounts of acids, bases, paints, solvents, hydraulic oil, machining oil, compressed gases, metals, sludge and PCB-containing transformer fluid from the Waukegan lakefront site	• In progress	• Dredging • Brownfield development • Habitat restoration • Coordination with RAP program for AOC delisting purposes	• Dredging for navigation and contaminated sediment removal • Contaminated sediment disposal • Funding to fulfill local match for dredging and remediation projects	• Pursuit of a dredging plan for the removal of PCB contaminated sediments from Waukegan Harbor • Final dredging and disposal of Waukegan Harbor sediments • Outboard Marine Corporation building, soil and groundwater remediation • Implementation of best management practices to reduce nonpoint source pollution and improve water quality in the Waukegan River watershed, as per the watershed plan
White Lake **Michigan** Includes White Lake and a one-quarter mile wide zone around the lake. I, III, VI, VII, VIII, IX, XI, XIV	• Heavy metals • Stormwater nonpoint pollution • Arsenic • Chromium • Sediments • Industrial contamination • Groundwater contamination	• Superfund • RCRA	• Dredging in ATannery Bay@ (2002) – 73,000 cubic yards of waste (hides, chromium, and arsenic) • Cleanup of Occidental Chemical site in 2002 • Potential sources of groundwater contamination to White Lake and its tributaries have been identified and remediation efforts are underway • Some eutrophication has been alleviated by improvements to the sewage collection and treatment systems • Contaminated groundwater venting to the lake is being intercepted by purge wells and treated prior to	• Yes; Targets are pending MDEQ approval	• Assessment and further study of contaminated sites • Coordination with RAP program for AOC delisting purposes	• Monitoring achievement of delisting targets	• Further study of the extent of contamination from the Whitehall Leather Company is needed, in addition to possible remediation funds. • Assessment is needed of sediments at discharge points for other contaminated sites • Fish and Wildlife Habitat Preservation

Subgoal 8
Are aquatic and terrestrial nuisance species prevented and controlled?

What is our target for sustainability?

The major pathways for invasive species have been identified and controlled and research has yielded some effective control actions.

Lake Michigan Target Dates for Sustainability



Why is this important?

The Lake Michigan ecosystem is in a state of flux due to changing populations of aquatic nuisance species and their resulting interactions with native species. Once established, aquatic nuisance species (ANS) are very difficult and nearly impossible to control. The best example of control is the case of sea lamprey. The Great Lakes Fishery Commission, with participation by State, Tribal and Federal agencies, has a mandate to assess and control sea lamprey populations in the Lake Michigan basin.

What is the current status?

- The 20th anniversary of the zebra mussel's introduction and spread is overshadowed by the more than 180 invasives that have followed.
- While the number of zebra mussels are declining they are being replaced by the more recent invasive quagga mussel in numbers not seen by zebra mussels at their height. The native diporeia are declining in numbers significantly, leaving less native food at the base of the food chain. The quagga mussels are also consuming larger amounts of food eaten by the diporeia and other native Lake Michigan species.
- Although Asian carp have not been seen in Lake Michigan, they remain a threat and are held back by an electric barrier in the Illinois Waterway Sanitary and Ship Canal. Funding for replacing the electronic barrier in the Sanitary and Ship Canal was approved in November 2007.

What are the major challenges?

- Preventing new aquatic invasive species from entering the Great Lakes through ballast water
- Preventing invasive species from entering through canals and waterways
- Establishing a program for rapid response and management
- Determining the role of invasives in the nutrient problems and shorebird deaths due to botulism

What are the next steps?

- Conduct education and outreach on aquatic invasive species.
- Eliminate ship and barge-mediated introductions and spread of AIS in the Great Lakes.
- Enact federal, state, and/or local governments measures that ensure the region's canals and waterways are not a vector for AIS.
- Take immediate steps at the federal and state government level to prevent the introduction and spread of AIS through the trade and potential release of live organisms.
- Establish a Great Lakes Aquatic Invasive Species Integrated Management Program to implement rapid response, control, and management programs and assess the effectiveness of those programs.

What are some tools for addressing the challenges?

- Keeping Exotics out of the Water Through Public Awareness Campaigns
- ANS Task Force Experts Directory
- Sea Grant Programs
- Controlling Invasive Species
- Great Lakes Aquatic Nonindigenous Species Information System(GLANSIS) Database of Aquatic Invasive Species on the Great Lakes.
- Control and Management of Invasive Phragmites

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator #18 - Sea Lamprey
Status: Good/Fair; Trend: Improving
Indicator # 68 - Native Freshwater Mussels
Status: Not Assessed; Trend: Not Assessed
Indicator # 104 - Benthos diversity and Abundance - Aquatic Oligochaete Communities
Lake Michigan Status: Mixed; Trend: Unchanging, Deteriorating
Indicator # 109 - Phytoplankton Populations
Status: Mixed; Trend: Undetermined
Indicator # 123 - Abundances of the Benthic Amphipod *Diporeia* spp.
Lake Michigan Status: Poor; Trend: Deteriorating
Indicator # 9002 - Non-Native Species - Aquatic
Lake Michigan Status: Poor; Trend: Deteriorating
Indicator # 9002 - Non-Native Species - Terrestrial
Status: Not Assessed; Trend: Undetermined

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

*** The terms "Aquatic Invasive Species" and "Aquatic Nuisance Species" are used interchangeably throughout this chapter. They both refer to species that are non-indigenous to Great Lakes waters.**

National Developments

The National Invasives Species Act (NISA) is the primary legislation for the prevention and control of aquatic nuisance species in the United States. NISA was slated for review by the U.S. Congress and eligible for re-authorization in 2002, however, despite new introductions of ANS in the Great Lakes and pressure from the Great Lakes States to take action at a national level, Congress has failed to pass a comprehensive reauthorization of NISA at the time of this report. Several bills have been introduced in the House and Senate including bills that would, specifically, regulate ballast water discharges, however, these bills are still pending.

U.S. Department of Transportation: Saint Lawrence Seaway Development Corporation

The Saint Lawrence Seaway Development Corporation, in conjunction with the St. Lawrence Seaway Management Corporation of Canada, have updated their rules and regulations to require that all ships coming into the Great Lakes and Saint Lawrence River from foreign waters and that are reporting no ballast on board (NOBOB) will be required to flush their ballast tanks with sea water in order to reduce the risk of the introduction of exotic species. Ships that enter the Saint Lawrence Seaway from foreign waters [outside of the Exclusive Economic Zone (EEZ)] and are reporting to the U.S. Coast Guard that they have ballast water in their tanks are required to exchange that water with sea water before entering however, until the recent rule change, ships reporting no ballast on board were under no such requirements.

Specifically, ships coming from outside waters under Canadian jurisdiction, declaring no ballast on board, must ensure that the residual ballast water in tanks has been exposed to salinity conditions equivalent to ballast water exchange by complying with one of the following options:

- The residual ballast water came from ballast water that was properly exchanged at sea;
- The residual ballast water meets the international standard for treated ballast water;
- The ship complies with sections 1, 2, 6 and 7 of the Code of Best Practices for Ballast Water Management of the Shipping Federation of Canada dated September 28, 2000, or;
- The ship conducted a saltwater flushing at least 200 nautical miles from shore.

It has been recognized that NOBOB ships often contain residual ballast water and sediments in their ballast tanks that can harbor exotic species and pathogens. When these ships enter the Great Lakes, they may visit more than one port and take on ballast water from the Great Lakes in one place and then release that water in another place allowing the foreign organisms to be released.

This development has been hailed by many participants of the Great Lakes Collaboration as a positive step towards the prevention of aquatic nuisance species in the Great Lakes. The requirement for all NOBOB ships to flush their ballast tanks with sea water or "swish and spit" as it has come to be known, was one of action items recommended by the Aquatic Invasive Species Strategy Team in the Great Lakes Collaboration report.

Great Lakes Ships Initiative

The Great Ships Initiative (GSI) is a collaborative effort managed by the Northeast-Midwest Institute to end the problem of ship-mediated invasive species in the Great Lakes-St. Lawrence Seaway System through independent research and demonstration of environmental technology, financial incentives and consistent basin-wide harbor monitoring. The overarching goal of the GSI is to resolve the problem of ship-mediated invasive species in the Great Lakes as quickly, effectively and economically as possible, and in coordination/ cooperation with prevailing regulatory regimes.

The specific objective of the GSI is to accelerate research, development and implementation of effective ballast treatment systems for ships that visit the Great Lakes from abroad. To achieve its research and development objective, the GSI has established research capabilities at three scales--bench, land-based, and shipboard scales. The GSI activates these capabilities to provide intensive testing services to developers of ballast treatment prospects suitable to Seaway-sized vessels. Meritorious systems can thereby progress as rapidly as possible to an approval-ready and market-ready condition. The GSI also provides financial incentives for early installation and technical assistance for effective operation of treatment equipment.

The Lake Michigan Toolbox
Keeping Exotics out of the Water Through Public Awareness Campaigns

Habitattitude

Federal agencies and the pet industry are teaming up to help consumers prevent the release and escape of nonnative plants and animals through Habitattitude, a new public education and outreach effort launched in September 2004. This government-industry coalition is formed from the Pet Industry Joint Advisory Council, the U.S. Fish and Wildlife Service and the Great Lakes Sea Grant Network. The campaign encourages aquarium owners and water gardeners to avoid unwanted introductions of nonnative species by adopting simple prevention steps when faced with an unwanted aquatic plant or fish. Habitattitude campaign materials will be displayed in aquarium stores, aquatic retail outlets, hobby magazines and nursery and landscape businesses across the country, as well as on packaging of related products.

More information is available at: www.habitattitude.net.

Stop Aquatic Hitchhikers!

Stop Aquatic Hitchhikers! is the first national public awareness campaign developed by the ANS Task Force. It brings public, private and nonprofit organizations together from the local, State, regional, and national levels to promote a single, straight forward, empowering message via a compelling brand that focuses on preventing the continued spread of aquatic nuisance species. The campaign targets all recreational water users to raise their awareness about aquatic invasive species and empowers them to adopt prevention procedures that limit the spread of aquatic invasive species to unaffected waters of the U.S.
More information is available at: www.protectyourwaters.net.

Lake Michigan Toolbox
Sea Grant Programs

Sea Grant is a nationwide network (administered through the National Oceanic and Atmospheric Administration [NOAA]), of 30 university-based programs that work with coastal communities. The National Sea Grant College Program engages this network of the nation's top universities in conducting scientific research, education, training, and extension projects designed to foster science-based decisions about the use and conservation of aquatic resources.

Michigan Sea Grant, Illinois Indiana Sea Grant and Wisconsin Sea Grant programs have ANS educational and outreach programs relevant to Lake Michigan.

These resources can accessed at the Sea Grant websites:

- National Sea Grant: www.seagrant.noaa.gov/colleges/colleges.html
- Michigan: www.miseagrant.umich.edu/
- Illinois and Indiana: www.iisgcp.org/
- Wisconsin: www.seagrant.wisc.edu/

Lake Michigan Toolbox
ANS Task Force Experts Directory

The Aquatic Nuisance Species Task Force created a database of invasive species experts who can be contacted to help identify species to determine if they are a new or existing invasive species. The database has been set up as a 2-tier system with the first tier accessible to the public. The public portion of the database will guide you to a state contact who acts as a filter for information and identifications. If they can't answer your question, these state contacts have the ability to log in to the second tier experts. This allows better tracking of the movement of invasives in the Great Lakes.

More information is available at:
www.anstaskforce.gov/experts/search.php

The GSI is also working collaboratively with federal, academic and state entities to establish consistent and credible harbor monitoring for newly established invasive species in harbors throughout the Great Lakes-St. Lawrence Seaway system.

ANS Task Force

The Aquatic Nuisance Species (ANS) Task Force is an inter-governmental body created by the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990. The Task Force is co-chaired by the US Fish and Wildlife Service and National Oceanic and Atmospheric Administration. Via regional panels and issue specific committees, the Task Force coordinates governmental efforts dealing with ANS in the United States with those of the private sector and other North American interests.

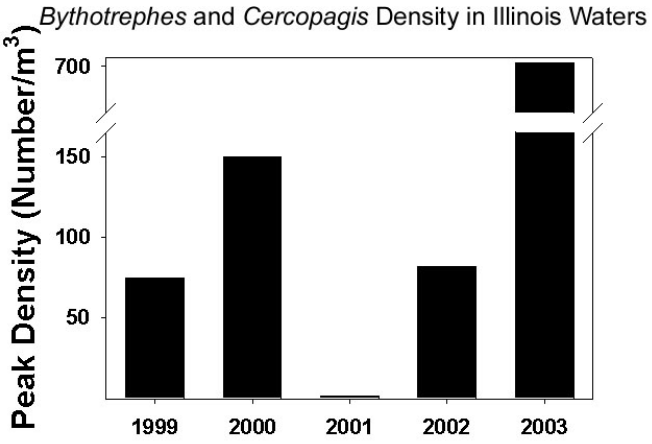
The following Task Force programs are very relevant to preventing introductions of ANS to Lake Michigan:

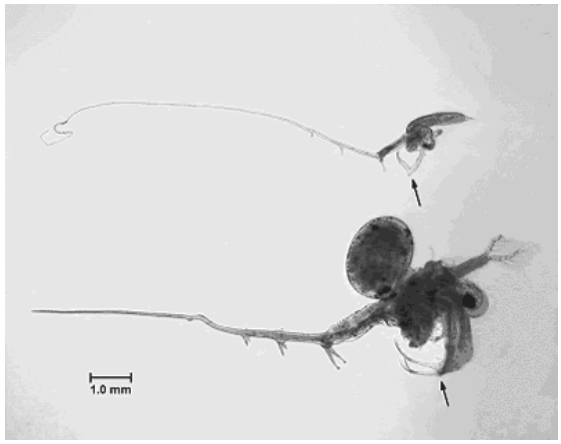
Great Lakes Panel on Aquatic Nuisance Species

The Great Lakes Panel on Aquatic Nuisance Species was officially convened in late 1991 by the Great Lakes Commission in response to section 1203 of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646). The Panel is directed to perform the following tasks:

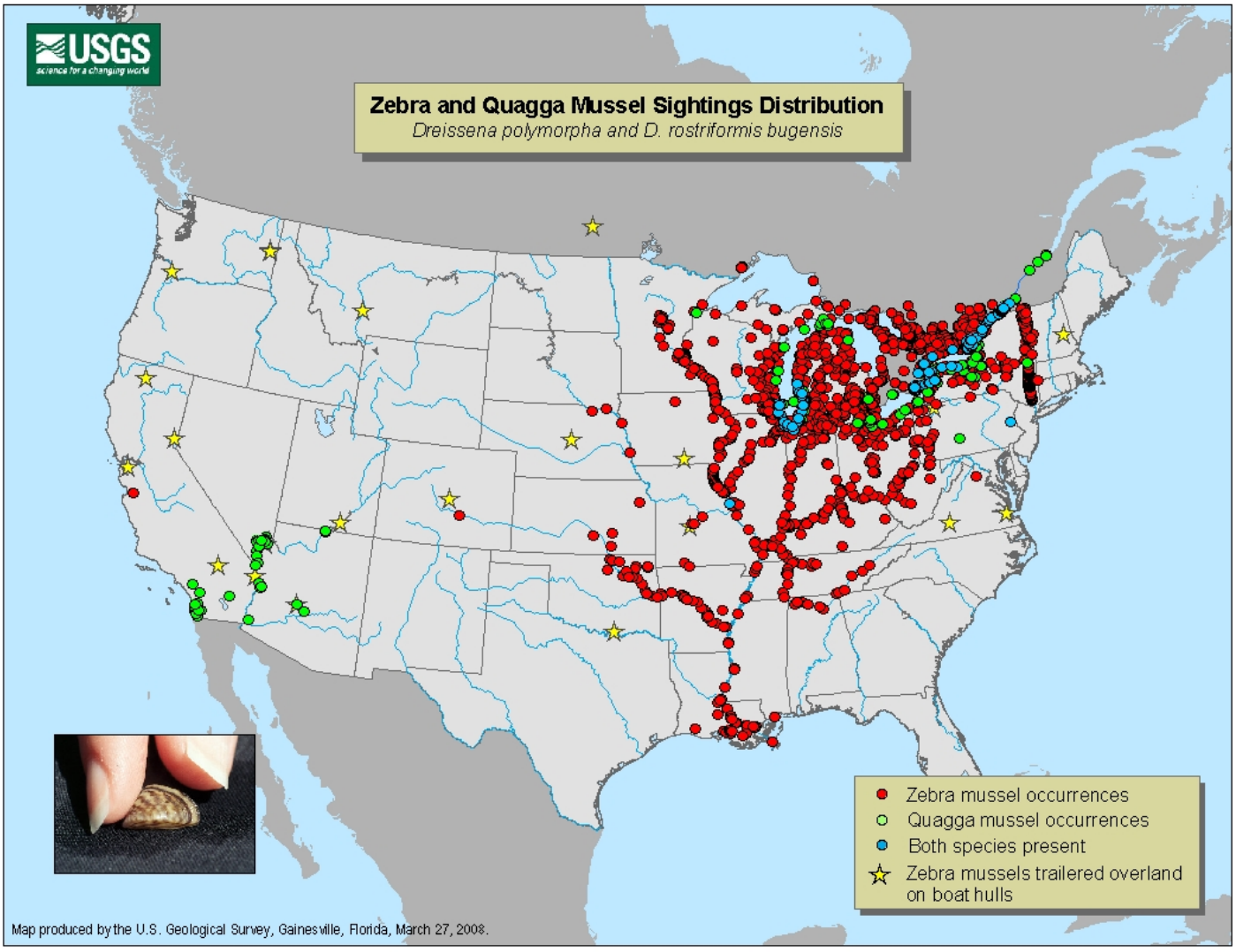
- Identify Great Lakes priorities
- Assist/make recommendations to a national Task Force on Aquatic Nuisance Species (also established via P.L. 101-646)
- Coordinate exotic species program activities in the region
- Advise public and private interests on control efforts
- Submit an annual report to the task force describing prevention, research and control activities in the Great Lakes Basin

The panel membership is drawn from U.S. and Canadian federal agencies, the eight Great Lakes states and the province of Ontario, regional agencies, user groups, local communities, tribal authorities, commercial interests, and the university/research community.





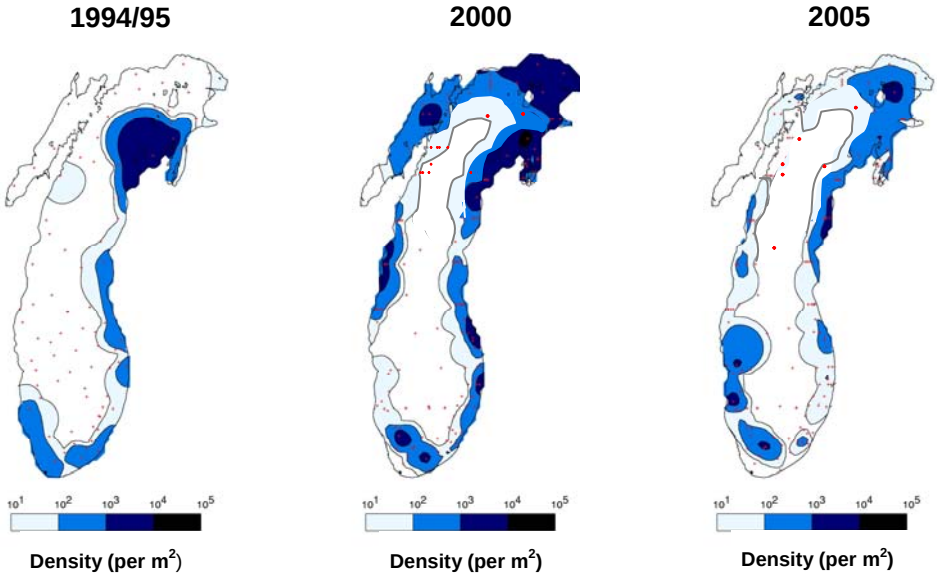
Spiny Water Flea (*Bythotrephes*) and Fishhook Water Flea (*Cercopagis*) Density in Illinois Waters of Lake Michigan
Source: INHS Sampling, Witt et al. (in review)



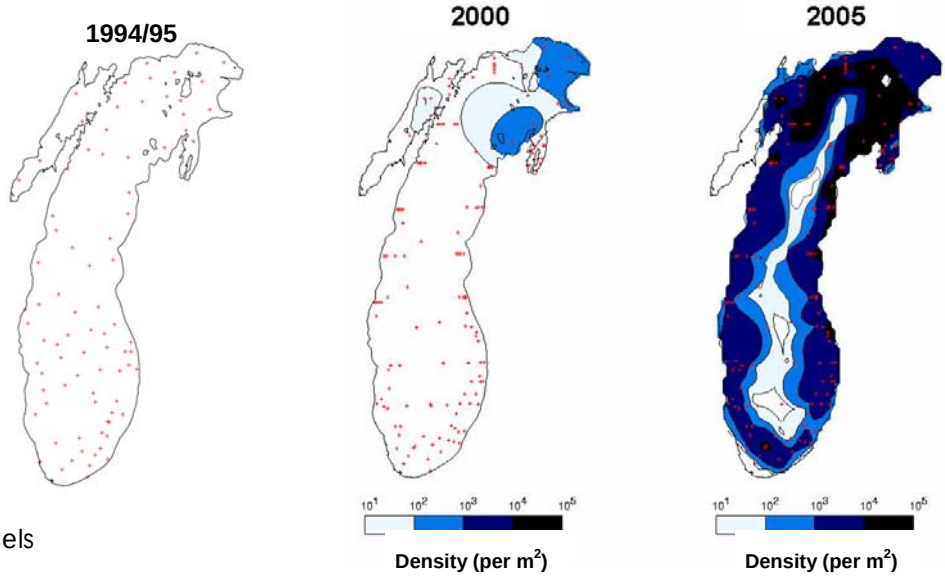
Spread of zebra and quagga mussels 20 years after the zebra mussel was first introduced to the Great Lakes.
Source: USGA

Quagga Mussel Overtakes Zebra Mussel as Dominant Invasive Mussel

The quagga mussel (*Dreissena rostriformis bugensis*) was first found in Lake Michigan in 1997 and has now replaced the zebra mussel (*Dreissena polymorpha*) as the dominant dreissenid in the lake. A whole-lake survey (160 sites) in 2000 showed that zebra mussels comprised 98.1% of the total dreissenid population, but a similar survey in 2005 indicated quagga mussels comprised 97.7% of the population. Quagga mussels are replacing zebra mussels at depths <50 m, but are also increasing at depths (>50 m) where zebra mussels were not previously found. Further sampling at 40 sites in the southern basin in 2006 indicated that quagga mussels continue to increase. Densities in 2005 at the 0-30 m, 31-50 m, 51-90 m, and > 90 m intervals were 1,585, 6,810, 658, and 24 per m2, respectively, but densities in 2006 had increased to 11,622, 13,410, 4,754 and 180 per m2, respectively. Quagga mussel densities in 2006 were 8.5 times greater than peak densities observed for zebra mussels in 1999. The dreissenid phenotype found exclusively throughout each depth interval is quagga mussel "profunda", which is well suited to conditions found in deeper regions. As the quagga mussel has increased and spread to deeper water, the benthic amphipod *Diporeia* has continued to decline. The population of this fish food resource has declined 94% between 1995 and 2005.



Zebra Mussels



Quagga Mussels

VHS Virus

Concerns over aquatic invasive species (AIS) have been growing since the sea lamprey invasion of the Great Lakes in the early to mid-twentieth century.

Recently, a growing concern has emerged for aquatic invaders that cannot be seen with the naked eye, such as viruses, bacteria, and parasites. Although pathogens and parasites have received less attention to date, they are formally recognized as aquatic invasive species in the most recent amendment of the Nonindigenous Aquatic Nuisance Prevention and Control Act (16 USC 4702), and are clearly addressed in the mandate of the intergovernmental Aquatic Nuisance Species Task Force (ANS Task Force, Strategic Plan 2007 – 2012).

The Viral Hemorrhagic Septicemia virus (VHSv) has been identified in all of the Great Lakes, except Lake Superior, with a significant number of large-scale fish mortality events. The pathogenic effects of this microbe are clearly evidenced by massive die-offs among VHSv-infected Great Lakes fish, including muskellunge, freshwater drum, yellow perch, gizzard shad, white bass, and round gobies.

VHSv, a viral fish disease, caused mortality in rainbow trout and turbot aquaculture operations in Europe, and in Pacific herring and pilchard populations along the Pacific Coast of North America. This virus has a number of identified isolates (unique genetic types) grouped in four types: three from Europe and one from North America. The isolate recently found in Great Lakes fish is most similar to the VHS strain previously isolated from the Atlantic Coast in eastern North America.

Great Lakes Commission

Great Lakes Aquatic Invasions Booklet. Great Lake Commission staff, on behalf of the Great Lakes Panel on Aquatic Nuisance Species, completed work on the development of a comprehensive publication: Great Lakes Aquatic Invasions. The publication was printed at the end of February 2007 and unveiled with initial distribution in March at the Commission sponsored Great Lakes Day 2007 events in Washington, DC. Copies were also provided to members of the national ANS Task Force, the Panel and other interested parties at the Joint Meeting of the ANS Task Force and Great Lakes Panel in May 2007. Staff have distributed over 2,000 of the 10,000 copies to agencies, legislators and others at a variety of regional events. Further distribution of this educational tool will continue to be targeted toward state and federal legislators, as well as other prime user groups from the recreational and commercial sector. The Panel I/E Committee will also be asked to aid in the development a feedback survey to track the distribution and perceived value of the booklet. An electronic version and associated references is available online at http://glc.org/ans/aquatic-invasions .

Further information about the Panel, its activities, and its membership can be found at: www.glc.org/ans/

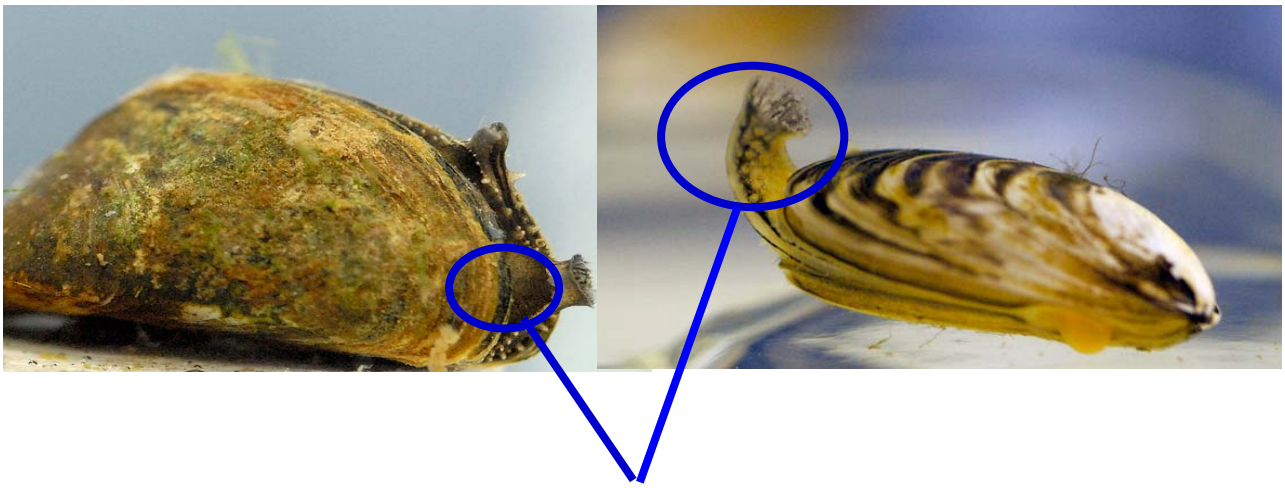
Organisms in Trade The Great Lakes Commission is currently conducting a collaborative planning exercise with the goal of identifying and detailing the primary components of a robust, outcome-oriented project to advance management of the organisms in trade vector for the Great Lakes region. Of growing concern in the Great Lakes region are the invasion risks posed by the organisms in trade vector and associated pathways such as the aquarium and pet trade, nursery and water garden outlets, aquaculture, and bait, among others. This project, funded through the Great Lakes Protection Fund, will allow public and private sectors to work together to address fundamental questions and identify information resources regarding high-risk pathways and associated species, business practices and consumer behavior, and management approaches (e.g., regulatory, voluntary and outreach).

Great Lakes Regional Collaboration

Aquatic Invasive Species Rapid Response Initiative

The first line of defense against aquatic invasive species (AIS) introductions is prevention; however,

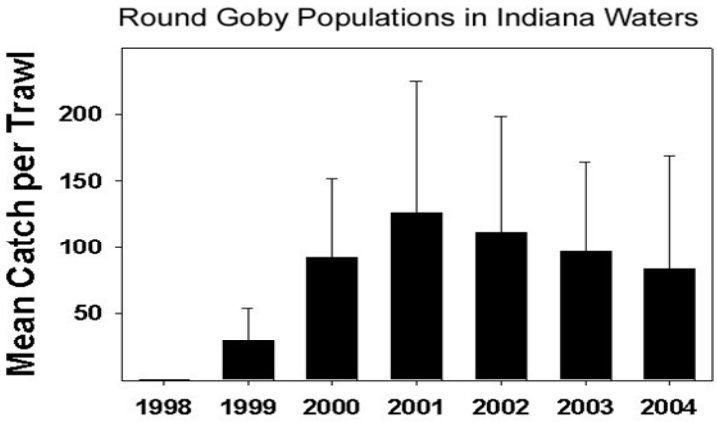
Zebra Mussel ***Quagga Mussel "profunda"***



Intake Siphon

Source: Great Lakes Environmental Research Laboratory

The Round Goby



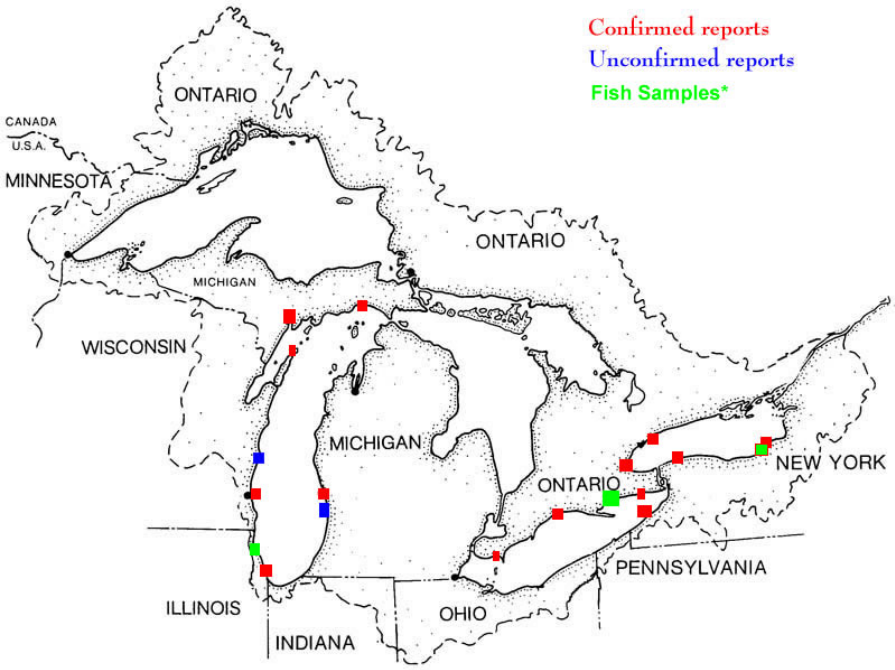
Round Goby Populations in Indiana Waters of Lake Michigan
Source: Ball State University (Lauer et Al., 2004)

even the best prevention efforts may not stop all introductions. Early detection and rapid response efforts increase the likelihood that invasions will be addressed successfully while populations are still localized and can be contained and eradicated. There are a variety of species-specific and location-specific contingency plans that have been completed by natural resource, environmental protection, and land management agencies. However, current organizational and fiscal resources do not allow for planning for all possible events. As an interim step toward improving AIS response capability in situations where specific contingency planning does not exist, a Rapid Response Communication Protocol has been developed to insure that agencies can efficiently coordinate and pool resources as soon as a new invader is detected.

In December 2005, the federal agencies endorsed forty-eight Federal Near Term Actions in support of the Great Lakes Regional Collaboration (GLRC) Strategy, including "The Federal Interagency Task Force will explore creating a Rapid Response Subcommittee under the Regional Working Group to serve as a central point of contact for information and activities related to invasive species rapid response efforts."

New ANS Mysidacea found in Lake Michigan

H. anomala, or Mysidacea, was reported for the first time in 2006 from two regions in the Great Lakes: southeastern Lake Ontario at Nine Mile Point near Oswego, New York, in May 2006. The species, native to the Ponto-Caspian region, was discovered during fall 2006 in the Lake Michigan basin. Large numbers of individuals formed aggregations in a shallow docking basin connected to the channel linking Lake Michigan and Muskegon Lake. It has since been confirmed in a growing number of locations around Lake Michigan and the Great Lakes. *H. anomala* was observed in the docking basin through April 2007, but disappeared thereafter. A few individuals were subsequently collected in the channel, and large numbers (>130) were found in a white perch stomach collected from Muskegon Lake in July 2007. Sampling in Lake Michigan off Muskegon (tucker trawls, benthic sleds, vertical tows, fish diets) did not reveal any *H. anomala* during fall 2006 through summer 2007. Additional isolated reports of *H. anomala* scattered around the nearshore areas of southern Lake Michigan from Muskegon to Cheboygan may indicate that the species is now widespread in the basin. This is aquatic nuisance species number 183 for the Great Lakes.



Reports of Mysidacea in the Great Lakes
Source: National Center for Research on Aquatic Invasive Species

For more information, or to report new findings of Mysidacea**, see:**
http://www.glerl.noaa.gov/res/Programs/ncrais/hemimysis/index.html.

Mysidacea
Source: NOAA GLERL

The Lake Michigan Toolbox
Controlling Invasive Species

Controlling the numbers and distribution of existing nonindigenous species in the Great Lakes is still extremely important in the ongoing battle against invasive species. There are a variety of methods of controlling existing populations. Some examples include:

- **Biocides:** Chemicals, such as the lampricide TMF (used to control sea lamprey populations) and herbicides on aquatic plants, are sometimes used to reduce or eradicate local populations of exotic species.
- **Barrier construction:** Barriers use a variety of methods, including sound waves, electrical impulses, and visual and physical deterrents. These barriers can help prevent the spread of exotics in smaller waterways like canals and streams.
- **Physical removal:** Harvesting small populations of aquatic plants, for instance, can act as a temporary control in smaller inland lakes and waterways.
- **Biological control:** Very carefully selected non-native species, usually predators, are introduced to control population growth of another invasive species. A good example of this is work done with insects that specialize in eating purple loosestrife.
- **Public education**

More information is available at: www.great-lakes.net/teach/pollution/ans/ans_5.html

Over the year 2006, the Regional Working Group established the Federal Aquatic Invasive Species Rapid Response (FAISRR or "phaser") Subcommittee. The subcommittee developed a Communication Protocol with formal points of contact to help insure that Federal agencies can efficiently coordinate and pool resources.

Recognizing that this effort would only be successful if non-federal partners were included, the Regional Workgroup began discussions with GLRC Executive Committee. In the Spring of 2007, the GLRC Executive Committee endorsed the formation of an Aquatic Invasive Species Rapid Response Initiative which would expand the Communication Protocol to include points of contact within State, Tribal, and City agencies. A letter signed August 3, 2007 has been transmitted to GLRC agencies, requesting the identification of formal points of contact by September 15, 2007.

Pennsylvania has offered to host a Mock Exercise which will test the Communication Protocol. They are able to bring additional resources to the effort from an existing grant and will provide the meeting facilities at Presque Isle, PA. (This location/event may also occur in conjunction with Pennsylvania's Clean Boats Day.)

The next step is to form a small steering committee to guide the Mock Exercise. Membership will be on a volunteer basis, solicited from the Communication Protocol membership list.

Clean Boats Initiative

The Great Lakes are one of the top recreational boating destinations in the nation. Nearly 4.3 million boats are registered in the eight Great Lakes states. These boaters spend nearly $16 billion on boats and boating activities in a single year, directly supporting 107,000 jobs. Outreach efforts to this user group can help ensure a healthy Great Lakes ecosystem, as well as help support a strong and sustainable recreational economy. The proposed "Great Lakes Clean Boat Initiative" would promote these goals.

- The Great Lakes Regional Collaboration Executive Committee Sub-committee has proposed that U.S. Sea Grant representatives lead regional efforts on the Clean Boats Initiative. An initial conference call with GLRC partners, Sea Grant staff and other interested parties will be held in coming weeks to clarify the workplan and timeline moving forward.
- An informal steering group will be established that will coordinate efforts to establish a compendium of existing boater education and outreach materials. It is possible that the steering group will coordinate with the existing database hosted by Portland State University (http://www.clr.pdx.edu/projects/edoutreach/content/browse.php)
- Steering group members will also select a date or dates for Clean Boat Day to be held during the 2008 boating season. It is possible that Clean Boat Day will be held in conjunction with, or promoted along with, the GLRC Rapid Response mock

exercise.

State Efforts to Prevent the Spread of ANS

The states which share Lake Michigan's resources, (Illinois, Indiana, Michigan and Wisconsin) know all too well the negative effects that ANS have had on their industries, tourism and lifestyles. The states, collectively, are sharing the burden of controlling the ANS already established in Lake Michigan but they also share the desire to prevent further introductions. The following efforts are being conducted to prevent and control ANS on a state by state basis:

Illinois

Ilinois pet stores get a Habitattitude

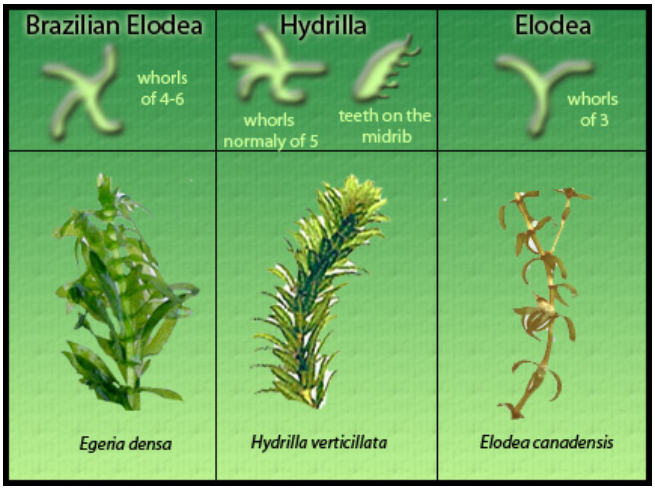
(TM)Habitattiude posters are now in nearly every pet store in Chicago. These posters, which were created through a partnership between Illinois-Indiana Sea Grant (IISG) and the City of Chicago Department of Environment, encourage aquarium owners to use alternatives to dumping aquatic pets and plants. Soon, the posters will be distributed throughout the state. The Illinois DNR,Äôs fishery biologists will be personally distributing the posters to pet stores in their districts. This means that aquarium hobbyists and backyard water gardeners statewide will have the information they need to prevent the introduction and spread of invasive species via their activities.

For more information, contact Kristin TePas (ktepas@uiuc.edu).

Chicagoland's "New Invaders Watch List" to add aquatics

The New Invaders Watch is a partnership of government, nonprofit, and volunteer organizations dedicated to the early detection and control of new exotic invasive plant and insect species in the Chicago Wilderness (CW) region, an area of globally threatened natural communities. They work to 1) increase understanding of invasive species impacts, their modes of invasion, and control measures to limit their spread, 2) provide mechanisms to collect and share information on plant and insect target species to improve management strategies and predict future distributions, and 3) facilitate the prevention and control of new exotic invasives. To do this, they rely on trained volunteers to locate and voucher target species. With newly-secured funding, they will

Exotic Species Advisory Sign



Indiana is working to prevent the spread of Brazilian elodea which has been found in the southern part of the state. This diagram shows how to identify Brazilian elodea from other nuisance aquatic plants.

More information is available at:
http://explorebiodiversity.com

be able to add aquatic plant species to their current list of mostly terrestrial target species.

More information is available at http://ewrr.inhs.uiuc.edu/newinvader/about_us.aspx.

AIS messages in 2007 fishing guide

Pages 48 and 49 of the 2007 Illinois Fishing Guide feature AIS messages including the ,"Stop Aquatic Hitchhikers" campaign and ,"Don't Dump Bait" logo. It also includes full-color photos of adult Asian carp to help anglers know these fishes. Side-by-side, full-color photos of Asian carp juveniles and shad are also featured, to show how similar the species appear. Because they are difficult to tell apart, anglers should not collect bait from Asian-carp infested waters for use on uninfested waters.

To view an on-line version of the fishing guide, visit http://dnr.state.il.us/fish/digest.

Chicago marinas get new AIS signs

The marinas along Lake Michigan in Chicago are decked out with new Exotic Species Advisory signs. The Chicago Park District posted the signs at their boat ramps so that recreational boaters see them as they pull in and out of Lake Michigan. The sign contains simple steps boaters can take to prevent spreading AIS. To view the sign, visit http://www.iisgcp.org/products/sign.gif.

Indiana

Brazilian Elodea Update

2007 marked the second consecutive year of Brazilian elodea eradication efforts at 109 acre Griffy Lake. Prior to eradication it was easy to fill sampling rakes with Brazilian elodea. In the spring of 2007 only two small sprigs of the plant were found; a hint that continued vigilance was required. During an August 2007 intensive plant survey no Brazilian elodea was found. While it is still too early to claim victory over the species in Griffy Lake, at least the plant is at a non-detectable level and may have been eradicated. Plant surveys will continue in the coming years to determine if there is any re-growth which will force additional treatments.

Hydrilla Update

Hydrilla was discovered in 735 acre Lake Manitou in August 2006. A multi-year eradication plan was developed between DNR and SePRO Corporation.

Purple Loosestrife

Purple loosestrife is a plant of European origin, that has spread and degraded temperate North American wetlands since the early nineteenth century. The plant was introduced both as a contaminant European ship ballast and as a medicinal herb for treatment of diarrhea, dysentery, bleeding, wounds, ulcers and sores.

The continued expansion of *the plant* coincided with increased development and use of road systems, commercial distribution of the plant for horticultural purposes, and regional propagation of seed for bee forage. It is found in all contiguous states (except Florida) and all Canadian provinces.

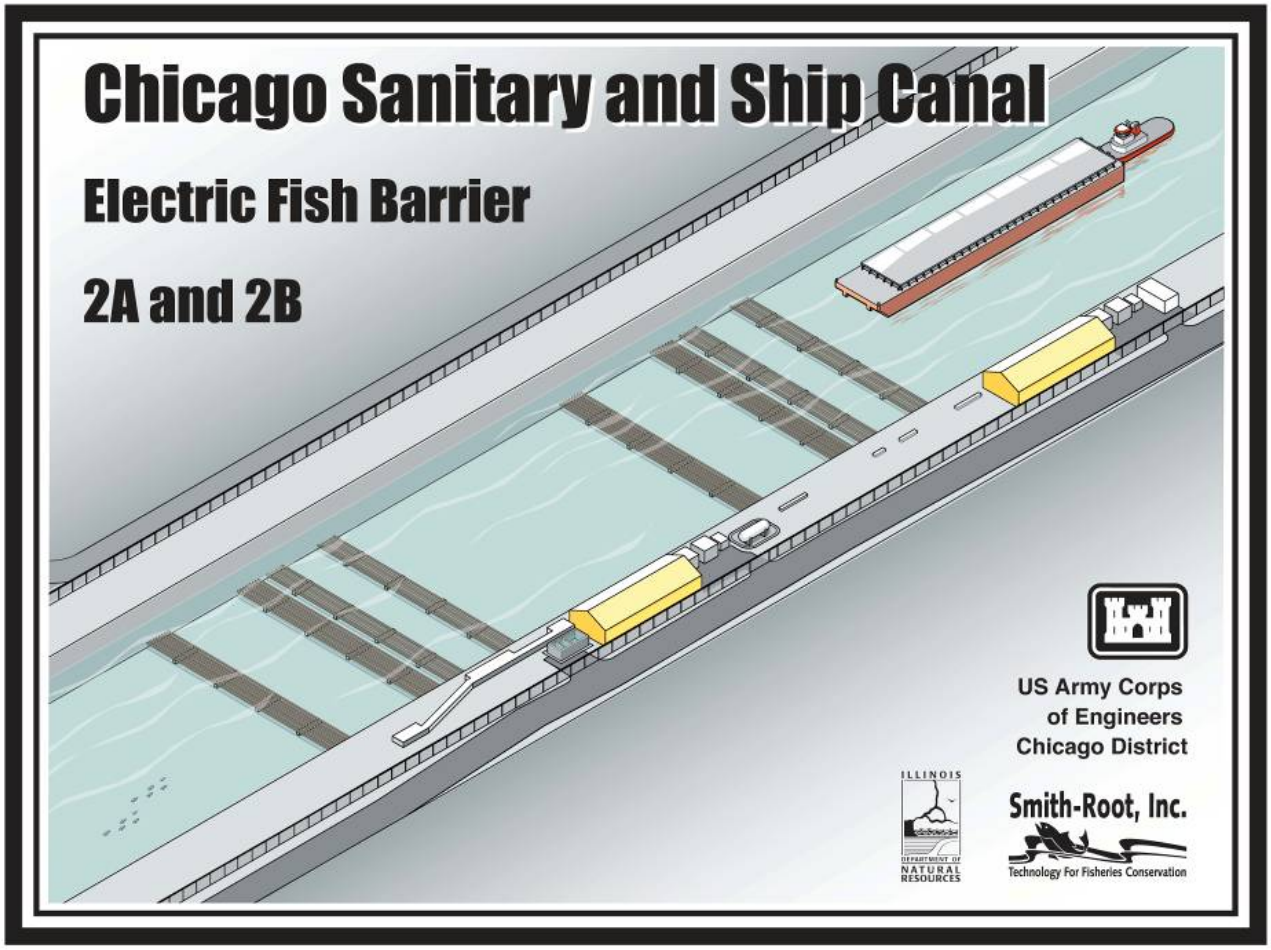
Once established in wetlands and along stream banks it crowds out native species. One plant may produce 2.5 million seeds. It is estimated that 200,000 ha of US wetlands are lost annually through invasion of this species. The loss of wetlands and native habitat impacts both flora and fauna with birds and migratory birds being especially impacted.

Purple Lossestrife
Source: Lake Koshkonong Wetland Association

Chicago Sanitary and Ship Canal Electric Fish Barrier Gets Funding

The Chicago Sanitary and Ship Canal provides an artificial link between the Great Lakes and Mississippi River basins. To prevent the trans-migration of invasive species between the two basins—and largely motivated by the spread of Asian carp toward the Great Lakes—the U.S. Army Corps of Engineers constructed and operates an experimental electrical barrier on the canal. This barrier is failing and is in need of retrofitting. In addition, a second, permanent barrier is being constructed near the experimental barrier to provide an extra layer of protection.

The second barrier consists of two arrays 350 feet long, which is 10 times the larger than the first. Unlike the first experimental barrier that has a 3-5 year service life, this barrier has a 20 year service life. $8.6 million in construction, $500,000 in operations and maintenance, and $665,000 in carry over funding was approved as part of the Water Resources Development Act for the second barrier. Funding already provided by the Great Lakes states for construction will be credited by the ACOE for other projects in the states.



The Lake Michigan Toolbox
Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) Database of Aquatic Invasive Species on the Great Lakes.

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) is a database of Aquatic Invasive Species on the Great Lakes. The Great Lakes have a long history of aquatic nonindigenous species (ANS) introductions – both intentional and unintentional. As of 2007, over 180 nonindigenous species have been reported to have reproducing populations in the Great Lakes basin, i.e. lakes Superior, Michigan, Huron, St. Clair, Erie, Ontario, and their connecting channels and water bodies within their respective drainages.

The present database targets ANS that are not considered to have been native to any part of the Great Lakes basin. Species that are documented as native to part of the basin, but invaded other parts of the basin due to human-expedited mechanisms or range expansions are not included in this database at the present time, except for the **sea lamprey**.

More information is available at:
www.glerl.noaa.gov/res/Programs/ncrais/glansis.html

Implementation of that plan began in the spring of 2007. Sonar was immediately applied after hydrilla growth was observed in the spring. The last hydrilla vegetative material observed in Manitou was in the middle of June; just one month after treatment began. Lethal fluridone levels were maintained through at least October. The telling sign in determining whether the battle with hydrilla is being won is to watch the tuber bank in the sediment. Pre-treatment versus late summer 2007 tuber densities were compared. It appears as though the tuber bank has been reduced by more than 80% in the first year. While Indiana DNR has made great strides at reducing hydrilla at Lake Manitou in the first year, we still have a long way to go to achieve our goal of zero tubers and complete elimination of hydrilla. At least two more years of whole-lake treatments are anticipated.

Contact: Doug Keller, 317-234-3883, dkeller@dnr.in.gov

Michigan

Michigan Passes Ballast Water Reporting Law

Michigan passed a ballast water reporting law that requires the Michigan Department of Environmental Quality (MDEQ) to determine whether ballast water management practices are being complied with by all vessels operating on the Great Lakes and the St. Lawrence waterway.

The State of Michigan wants to take action to protect the Great Lakes from aquatic invasive species. Law supporters believe that If actions are not taken to stop the spread of aquatic invasive species, additional species will be transported into the Great Lakes (and from the Great Lakes to other parts of the world) through ballast water. Additional major impacts such as elimination of native species may be seen on the Great Lakes ecosystem.

Under the law, owners/operators of vessels must register with The Michigan Department of Environmental Quality's Ballast Water Reporting List and fill out a Ballast Water Management Practices Report Form. Information required on the form includes:

For oceangoing vessels:

- Indicate whether during the last 12 months, the vessel maintained compliance with the Code of Best Management Practices for Ballast Water Management provided by the Shipping Federation of Canada.
- Indicate whether the vessel is currently complying with the ballast water management practices

For nonoceangoing vessels:

- Indicate whether during the last 12 months, the vessel maintained compliance with the Voluntary Management Practices to Reduce the Transfer of Aquatic Nuisance Species within the Great Lakes by the United States and Canadian Domestic Shipping, provided by the Lake Carriers' Association and the Canadian Shipowners' Association
- Indicate whether the vessel is currently complying with the ballast water management practices.

More information is found at: http://www.michigan.gov/deq/0,1607,7-135-3313_3677_8278---,00.html

As a result of Public Act 33 of 2005, Michigan's Ballast Water Control General Permit became effective January 1, 2007. As of October 2007, MDEQ has issued 83 permits to 28 international shipping companies to conduct port operations in Michigan. A lawsuit was filed in federal court in Detroit by a group of shipping interests, who sought to nullify Public Act 33 of 2005; however, a federal judge dismissed the suit determining the statute was clearly rational and valid due to the fact that Michigan is facing a serious threat to its environment caused by AIS, has determined the likely avenues by which those species are being introduced, and has taken measures to stop this introduction.

The Michigan DNR has also developed a process for listing or delisting a species from Michigan's current list of prohibited and restricted species. Under the process, anyone can submit a request to the MDNR proposing to list or delist a species provided they complete the required request form including reasons for the proposal and documentation (scientific studies, expert opinion, etc.) that supports the proposal. The MDNR will then review the information for completeness and then charge a technical review committee with assessing the species. An opportunity for public input will be offered. The Technical Committee will then provide findings to the MDNR who will then prepare a "Final Species Recommendation" for the MDNR Director. Once a decision has been made by the Director, legislative action will be sought.

Wisconsin

Ballast Water

The WDNR has a draft rule completed on invasive species control. The rule classifies existing and new invasive species based on established criteria. The rule places restrictions on the purchase, sale, possession, transportation, and cultivation of invasive species that are classified as prohibited or restricted. It allows for the conditional possession of some invasive species when authorized by a permit from the WDNR. The WDNR will be taking the rule out to public meetings in January to obtain input from stakeholders and interested parties.

A Port of Milwaukee onshore ballast water treatment feasibility study report was completed by Brown and Caldwell via a contract with the WDNR. The ballast water would be treated using filtering screens and ultraviolet light to kill

Black Carp Listed as an Injurious Species

The U.S. Fish and Wildlife Service (FWS) on October 18, 2007 added black carp (Mylopharyngodon piceus) to the list of injurious fish under the Lacey Act. This action prohibits live black carp, gametes, viable eggs and hybrids from being imported into or transported between the states of the continental U.S., the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any territory or possession of the U.S.

Black carp originally entered the U.S. in 1973 as a "contaminant" in imported shipments of grass carp or other Chinese carp stocks. The second introduction of black carp took place in the early 1980s when it was used in fish production ponds in the southeastern U.S. for biological control of a parasite, and as a potential food fish. Since that time black carp have become more commonly used and transported, particularly during the late 1990s to control another species of snail-borne parasite at primarily catfish and hybrid striped bass farms.

Lake Michigan Toolbox
Control and Management of Invasive Phragmites

Phragmites australis (frag-MY-teez), also known as common reed, is a perennial, wetland grass that can grow to 15 feet in height. While *Phragmites australis* is native to MIchigan, an invasive, non-native, variety of phragmites is becoming widespread and is threatening the ecological health of wetlands and the Great Lakes coastal shoreline. Invasive phragmites creates tall, dense stands which degrade wetlands and coastal areas by crowding out native plants and animals, blocking shoreline views, reducing access for swimming, fishing, and hunting and can create fire hazards from dry plant material.

Phragmites
Source: Michigan Sea Grant
ww.miseagrant.umich.edu

Phragmites can be controlled using an integrated pest management approach which includes an initial herbicide treatment followed by mechanical removal (e.g., cutting, mowing) and annual maintenance. For large areas with dense stands of phragmites, prescribed burning used after herbicide treatment can provide additional control and ecological benefits over mechanical removal. Early detection is key to preventing large dense stands and is also more cost efficient.

What You Can Do

1. Identify plants to confirm if it is invasive phragmites
2. Read the Landowners Guide to Phragmites Control to understand the management issues
3. (In Michigan) Determine the location of the plants relative to the Ordinary High Water Mark (OHWM) by contacting MDEQ's Land and Water Management Division (LWMD) for assistance
4. If necessary, apply and obtain permit(s):
   - If chemical treatment below OHWM or in standing water, submit application for single-season Aquatic Nuisance Control permit before August 15 in the year of the proposed chemical treatment
   - If regulated mechanical activity below OHWM, submit application for 5-year LWMD permit

If necessary, submit application for permit from Army Corps of Engineers

5. Conduct treatment
6. Monitor impacts of the treatment(s)
7. Fulfill any permit reporting requirements
8. Repeat the process in future years

What You Should Know

- To Identify Phragmites, visit www.invasiveplants.net/phragmites/phrag/morph.htm or http://plants.usda.gov/java/profile?symbol=PHAU7
- Frequently Asked Questions about Control of Phragmites using Herbicides
- Required Criteria to Qualify for the General Permit for Limited Great Lakes Shoreline Management Activities - "Control of Phragmites on Great Lakes Shorelines"

Searchable Database for Licensed Herbicide Applicator Businesses (search under category "Aquatics")

More information is available at http://www.michigan.gov/deq/0,1607,7-135-3313_3681_3710-178183--,00.html

organisms. Study results focused on the Port of Milwaukee, but the approach would work in other Great Lakes at a cost of $1 to $2 million per port. The onshore treatment offers a less expensive alternative to smaller ships that may find on-board treatment technologies prohibitive.

Hydrilla

Hydrilla was discovered in August in a small pond in northeast Wisconsin. The WDNR, the Department of Ag, Trade, and Consumer, local county officials and the landowner developed a plan to eradicate the invasive plant. The pond was chemically treated with an aquatic herbicide and other area waters were surveyed to assure that the plant hadn't spread to nearby waters. The pond has been recently dewatered in preparation for the colder weather with the goal being to hopefully freeze the hydrilla tubers and propagules this winter.

Subgoal 9

Are ecosystem stewardship activities common and undertaken by public and private organizations in communities around the basin?

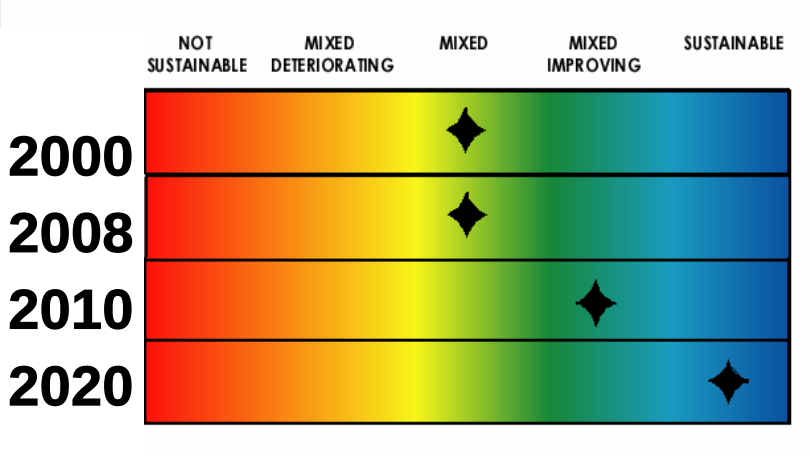
What is our target for sustainability?

There has been a paradigm shift from a few actions on a large scale to many additional actions by educated and trained basin stewards

Why is this important?

Each government, institution, organization, and individual within the Lake Michigan basin has a potential role in ecosystem stewardship; however, no single government, institution, organization, or individual has the ability to implement stewardship activities and achieve sustainability in the basin unilaterally. The watershed fact sheets in Chapter 12 are tools created to encourage the recognition of the linkage between local watershed actions and Lake Michigan. The current status of stewardship is mixed but will improve as more Lake Michigan watershed partnerships are formed and linked.

Lake Michigan Target Dates for Sustainability



What is the current status?

There has been major progress in development of tools to help guide those interested in environmental action from Leadership in Energy and Environmental Design (LEED), EnergyStar, and WaterSense, although there is not enough awareness about these programs.

What are the major challenges?

- Creating a framework of tools and activities tailored to the watershed and community level while promoting Lake Michigan basin-wide interaction and partnerships.

What are the next steps?

- Develop projects utilizing the Lake Michigan LaMP watershed fact sheets, land use management tool box and exploration of other tools.
- Provide additional education and outreach materials on water conservation and source water protection.
- Continue the Lake Michigan Watershed Academy, support GIS and modeling workshops and obtain and provide small implementation grants to local communities.
- Continue to build layers for the on-line habitat atlas.
- Hold FY 2009 State of Lake Michigan Conference in Milwaukee, Wisconsin.
- Continue the research vessel boat tour – Making Lake Michigan Great combined with outreach and teacher workshops.

What are some tools for addressing the challenges?

- Watershed Management On-line Tools
- USEPA Watershed Academy On-Line
- Draft Handbook for Developing Watershed Plans
- Michigan Environmental Council Tips on Reducing Phosphorus Pollution
- Ecosystem-based Environmental Management System (Eco-EMS) Assessment Tool
- EPA Calculator Puts Greenhouse Gas Savings in Everyday Terms
- West Michigan Sustainable Purchasing Consortium

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 3514 - Commercial/ Industrial Eco_Efficiency Measures
Status: Not Assessed; Trend: Not Assessed

Indicator # 4507 - Wetland-Dependent Bird Diversity and Abundance
Lake Michigan Status: Mixed; Trend: Deteriorating

Indicator # 4510 - Coastal Wetland Area by Type
Status: Mixed; Trend: Deteriorating

Indicator # 4858 - Ice Duration on the Great Lakes
Status: Mixed; Trend: Deteriorating (with respect to climate change)

Indicator # 4861 - Effect of Water Level Fluctuations
Status: Mixed; Trend: Not Assessed

Indicator # 4862 - Coastal Wetland Plant Community Health
Status: Mixed; Trend: Undetermined

Indicator # 4863 - Land Cover Adjacent to Coastal Wetlands
Status: Not Fully Assessed; Trend: Undetermined

Indicator # 7000 - Urban Density
Status: Mixed; Trend: Undetermined

Indicator # 7002 - Land Cover/ Land Conversion
Lake Michigan Status: Mixed; Trend: Undetermined

Indicator # 7006 - Brownfields Redevelopment
Status: Mixed; Trend: Improving

Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed

Indicator # 7043 - Economic Prosperity
Status: Mixed; Trend: Not Assessed

Indicator # 7060 - Solid Waste Disposal
Status: Not Assessed; Trend: Undetermined

Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed

Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed

Indicator # 7064 - Vehicle Use
Status: Poor; Trend: Deteriorating

Indicator # 7065 - Wastewater Treatment and Pollution
Status: Not Assessed; Trend: Undetermined

Indicator # 7100 - Natural Groundwater Quality and Human-Induced Changes
Status: Not Assessed; Trend: Not Assessed

Indicator # 7101 - Groundwater and Land: Use and Intensity
Status: Not Assessed; Trend: Not Assessed

Indicator # 7102 - Base Flow Due to Groundwater Discharge
Status: Mixed; Trend: Deteriorating

Indicator # 7103 - Groundwater Dependent Plant and Animal Communities
Status: Not Assessed; Trend: Not Assessed

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Alvers
Status: Mixed; Trend: Not Assessed

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Cobble Beaches
Status: Mixed; Trend: Deteriorating

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Islands
Status: Mixed; Trend: Undetermined

Indicator # 8129 - Area, Quality and Protection of Special Lakeshore Communities - Sand Dunes
Status: Not Assessed; Trend: Not Assessed

Indicator # 8131 - Extent of Hardened Shoreline
Status: Mixed; Trend: Deteriorating

Indicator # 8164 - Biodiversity Conservation Sites
Status: Not Assessed; Trend: Undetermined

Indicator # 8500 - Forest Lands - Conservation of Biological Diversity
Status: Mixed; Trend: Undetermined

Indicator # 8501 - Forest Lands - Maintenance of Productive Capacity of Forest Ecosystems
Status: Not Assessed; Trend: Undetermined

Indicator # 8503 - Forest Lands - Conservation and Maintenance of Soil and Water Resources
Lake Michigan Status: Mixed; Trend: Undetermined

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

The Importance of Partnerships

The past decade of ecosystem management in the basin has seen a profound shift from a top-down, command and control, government-dominated approach to a bottom-up, partnership-based, inclusive approach. This evolution is the manifestation of a number of developments, including changes in federal, state, tribal and local relationships; local community empowerment; increased focus on local partners; and watershed-based institution building. If a sustainable Lake Michigan ecosystem is to be achieved, it falls to us to rearrange ourselves, our interest groups, and our governments into a new institutional framework—a framework that consists of existing organizations and governments "rafted" together as full partners in the pursuit of the LaMP goals.

Effective place-based partnerships are the result of the rafting of "full partners." Full partnership implies moving beyond the stakeholder model, wherein citizen committees (stakeholder groups) are briefed about agency plans and projects, to a model based on full collaboration in the definition of basin-wide goals and the sharing of resources to achieve these goals. The Lake Michigan LaMP helped start and supports a number of partnerships including the Lake Michigan Forum and the Lake Michigan Watershed Academy. The Lake Michigan LaMP helped start and supports a number of partnerships including the Lake Michigan Forum and Watershed Academy.

Lake Michigan's Watershed Academy

The challenge of translating Lake Michigan scale watershed data and planning to local governments divided by political boundaries is being undertaken through the development of the Lake Michigan Watershed Academy. In 2000 and 2002, the Lake Michigan Lakewide Management Plan highlighted the need to promote a series of dialogues with local decision makers about the status of their watersheds and their impact on Lake Michigan. Monitoring data and Geographic Information System presentations clearly show the interconnected aspects of the basin and the need to plan and cooperate across political boundaries in order to conserve habitat and sustain biodiversity.

The Lake Michigan Watershed Academy was launched in March 2003 when the Academy hosted a three-day event for staff, commissioners, and local officials from six regional planning commissions that operate on the shores of Lake Michigan. The purpose of the sessions was to introduce many of them to the watershed planning concept and provide an overview on how the approach can be implemented on the local level. The meeting was co-sponsored by Western Michigan University's Institute for Water Sciences. The participating regional planning commissions from the four Lake Michigan states include the Bay Lakes Regional Planning Commission, the Southeastern Wisconsin Regional Planning Commission, the Chicago Metropolitan Agency for Planning, the Northwest Indiana Regional Planning Commission, West Michigan Regional Shoreline Development Commission, and the Northwest Michigan Regional Planning Commission.

The Academy meeting provided an opportunity to present perspectives from USEPA Region 5, USEPA

Lake Michigan Toolbox
Watershed Management On-line Tools

The Midwest Partnership for Watershed Management was launched in 2002 by the Wisconsin DNR and USEPA Region 5 Water Division to provide access to free, coherently organized, scientifically-based watershed–based information for local officials and planners, natural resource managers, and the general public. The partnership aims to provide the maximum information and analytic tools to those levels of government closest to the actual problems. It offers both direct access to its own free web-based decision support tools and road maps to other sites where additional tools can be found. The effort has been working closely with the Lake Michigan Watershed Academy.

Many communities do not have access to computer models, or initial screening of, their environmental problem and need cost effective, user friendly tools to assist them. Existing information and analytic tools, properly presented and freely accessible, and can help meet this challenge. Watershed management data and decision support tools can allow informed screening and preliminary selection of alternatives, eliminating large amounts of preliminary "leg work" needed for watershed plan development.

More information is available at www.epa.gov/waterspace.

headquarters, other federal agencies, tribal, state, and environmental perspectives on clean water issues and their relationship to watershed planning. The regional planning commissions then followed up with conferences in their respective areas tailored for their communities. In addition to two pilot conferences in South Bend, Indiana, and Kalamazoo, Michigan, conferences were held in Green Bay, Wisconsin, Traverse City, Michigan, Muskegon, Michigan, and Milwaukee, Wisconsin. Additional conferences in Phase II of the Academy.

The concept of a Lake Michigan Watershed Academy is to provide a "packaging and delivery system" that brings together the tools, data, and expertise of many federal, state, local, and tribal agencies as well as NGOs and environmental organizations to explore opportunities for new partnerships, thereby impacting the quality of the land use plans and partners in the Lake Michigan watershed.

The Lake Michigan Watershed Academy Phase III will convene in May 2008 with a training conference and will provide start-up funding for efforts to implement projects resulting from the regional conference discussions. See page 10-4 for a summary of Phase II activities. For more information contact www.chicagoareaplanning.org/lakemichigan/

USEPA Utilizes Watersheds for Program Implementation

In December 2002 USEPA's Assistant Administrator for Water issued a policy memorandum entitled: "Committing EPA's Water Program to Advancing the Watershed Approach." The memorandum not only reaffirmed USEPA's commitment to the watershed approach, but also reenergized efforts to ensure that USEPA as a whole fully integrates the watershed approach into program implementation. The memorandum established a USEPA Watershed Management Council (WMC) to accelerate efforts to develop and issue National Pollutant Discharge Elimination System (NPDES) permits on a watershed basis. The USEPA issued final guidance on watershed permitting in December 2003 (EPA 833-B-03-004).

Watershed-based NPDES permitting is an approach to developing NPDES permits for multiple point sources within a defined geographic area. The

Lake Michigan Toolbox
USEPA Watershed Academy On-Line

The Watershed Academy is a focal point for providing training and information on implementing watershed approaches. Training materials and tools have been developed including USEPA's Watershed Academy Web-Based Training, Drinking Water Academy, American Water Works Association Source Water Training, Land Trust Alliance training materials, other existing videos and state and local training materials such as Michigan's Department of Environmental Quality's "Developing a Watershed Management Plan for Water Quality."

These and others are available at: Many can be accessed at www.epa.gov/OWOW/watershed/wacademy

The Lake Michigan Toolbox
Draft Handbook for Developing Watershed Plans

This draft handbook is intended to help communities, watershed organizations, and state, local, tribal and federal environmental agencies develop and implement watershed plans to meet water quality standards and protect water resources. It was designed to help any organization undertaking a watershed planning effort, and it should be particularly useful to persons working with impaired or threatened waters. USEPA intends for this handbook to supplement existing watershed planning guides that have already been developed by agencies, universities, and other nonprofit organizations. The handbook is generally more specific than other guides with respect to guidance on quantifying existing pollutant loads, developing estimates of the load reductions required to meet water quality standards, developing effective management measures, and tracking progress once the plan is implemented.

USEPA is making this draft document widely available with the purpose of having it used and tested by a variety of watershed partnerships. USEPA will be seeking advice from such organizations in developing the final version. More information is available at:

http://epa.gov/nps/watershed_handbook/pdf/handbook.pdf.

primary difference between this approach and the current approach to permitting is the consideration of watershed goals and the impact of multiple pollutant sources and stressors, including nonpoint source contributions. Watershed-based permitting may encompass a variety of activities ranging from synchronizing permits within a basin to developing water-quality based effluent limits using a multiple discharger modeling analysis. The type of permitting activity will vary from watershed to watershed, depending on the unique circumstances in the watershed and the sources affecting watershed conditions. The ultimate goal of watershed-based NPDES permitting, however, is to develop and issue NPDES permits that consider the entire watershed, not just an individual point source discharger.

Although significant water quality improvements have been made during the past three decades, water quality problems remain. Many of the remaining problems involve complex mixtures of sources and impacts that require integrated, holistic solutions. Over the past decade, the number of sources subject to the NPDES program has increased almost tenfold. There is a pressing need for innovative and efficient solutions to permitting these point sources that will result in further water quality gains. As a mechanism to help integrate other water program activities and to target the most pressing environmental issues within a watershed, a watershed-based approach to NPDES permitting can serve as one innovative tool for achieving new efficiencies and environmental progress.

Lake Michigan Toolbox
Michigan Environmental Council Tips on Reducing Phosphorus Pollution

(Excerpted from "Something's Amuck: Algae blooms return to Michigan shores,"]

Most American homeowners use fertilizers to assure green and healthy lawns, but soil testing programs in Michigan and other states have found that up to 99% of samples provided by homeowners already have enough naturally occurring phosphorus without any additional contributions from fertilizers. Adding phosphorus fertilizers means much of this ingredient will run off into lakes and streams, stimulating algae blooms. Even homeowners who don't live near lakes and streams can send excess phosphorus into Michigan waters through storm drains.

Some things that people can do to reduce phosphorus in the environment include:

- Have your lawn soil tested. Many lawn care and nursery stores now provide soil testing services.
- Use phosphorus-free fertilizer. Any bag of fertilizer has a series of three numbers. The middle number indicates phosphate content and should read "0." If your store doesn't offer a phosphorus-free fertilizer, demand to know why.

Other ways to reduce phosphorus include:

- Expand the use of buffer strips and other incentives to reduce animal waste runoff.
- Control phosphorus content in dishwashing detergents.
- Reduce the leakage of human wastes into groundwater, streams and lakes from failing septic systems and municipal sewers.

More information is available at: http://www.mecprotects.org/algae062006.pdf.

Green Ports

USEPA has unveiled a new plan of action for working with public port authorities and other interested groups to reduce the environmental impacts of moving goods through ports. The "Vision, Mission, and Strategy for Sustainable Ports" recognizes the steady growth in global maritime commerce and the critical role American ports and related transportation and supply chain partners play in managing the environmental impacts of moving goods across the country.

Ports are vital to the United States economy. Ocean-going ships move more than 99 percent of U.S. overseas trade (by weight). The top ten U.S. ports moved a combined total of 23 million cargo containers in 2006. The environmental challenges for ports and their transportation network include reducing air emissions, improving water quality, and protecting the health of communities near port facilities.

EPA's Strategy focuses on six themes: Clean Air and Affordable Energy, Clean and Safe Water, Healthy Communities and Eco-systems, Global

Environment, Ports Communications, and Enforcement. There are more than 70 possible actions, including working with port authorities, their business partners and other sectors of the transportation industry to quantify and reduce air emissions from all sources along the shipping supply chain; setting up state innovative financing funds to help small owner-operators of diesel equipment finance the upgrading or replacement of older, dirtier engines; and collaborating with the international port community on innovative technologies and development of international standards.

EPA's strategy complements the recent resolution and guiding principles on port sustainability issued by the American Association of Port Authorities (AAPA). EPA programs will work with AAPA, individual port authorities, private port operators, transportation supply and logistics companies, government agencies, states, communities, and other interested groups to promote and implement sustainable practices at ports and their related operations. EPA regions will work collaboratively with individual ports to select (from among the full menu of possible actions in the EPA Strategy) a specific set of activities to work on together. These shared action plans will address the unique environmental impacts and opportunities for ports in different parts of the country. More information is available at www.epa.gov/sector/ports.

Making Lake Michigan Great 2007

Since 1998, the *W.G. Jackson* research and education vessel has been spreading the word about the Lake Michigan Lakewide Management Plan through the Making Lake Michigan Great tours. Throughout the years, 30 ports of call have been visited reaching four states, with local hosts coordinating groups for hands-on water quality sampling cruises. Participants in tour activities learn about Lake Michigan and have the opportunity to discuss lakewide concerns. Tour funding has come mainly from the U.S. Environmental Protection Agency's Great Lakes National Program Office.

The *Jackson* kicked off its 2007 season with 3 days in Milwaukee, The first stop was at the Great Lakes Water Institute, a University of Wisconsin Research Facility. The *Jackson* then moved to the Pier Wisconsin Dock, where it hosted five tours for local

Mona Lake Update

Industrial contamination has had a significant impact on the Mona Lake watershed. A recent study by Matthew Cooper at Grand Valley State University looks at the impacts of the extensive history of industrial contamination on all levels of life in the watershed. The purpose of this study was to relate sediment contamination to faunal community structure in Little Black Creek.

Little Black Creek, a tributary of Mona Lake, was heavily industrialized with refineries, plating companies, and metal finishing operations. Cress Creek, an uncontaminated tributary of Mona Lake, was used as a reference. Sediment toxicants, water chemical/physical variables, benthic invertebrates, and fish were sampled at multiple stream and wetland sites throughout each watershed seasonally. The two streams had similar chemical/physical characteristics though Little Black Creek sediments contained higher levels of heavy metals and PAH compounds.

Richness and densities of pollution sensitive *Trichoptera* and *Plecoptera* taxa were higher in Cress Creek. Indirect gradient analyses indicated that differences between the two streams outweighed differences due to relative watershed position or season, suggesting that anthropogenic disturbance in Little Black Creek altered macroinvertebrate communities and these alterations overshadowed temporal and site-specific variability. Turbidity, sediment grain size, and toxicant levels were greater in the wetlands of Little Black Creek though macroinvertebrate communities appeared to respond more to substrate characteristics and turbidity than toxicant concentration.

Fish communities were substantially different between Little Black and Cress Creek wetlands. Nineteen fish species were collected from the Cress Creek wetlands while only three species were collected from the Little Black Creek wetland.

More information is available at http://www.monalakewatershed.org/

Mona Lake Watershed Project Muskegon, MI

Lake Michigan Toolbox

Ecosystem-based Environmental Management System (Eco-EMS) Assessment Tool

Over the past few months, the Lake Michigan Forum has been developing an Ecosystem-based Environmental Management System (Eco-EMS) assessment for the Muskegon Lake watershed. The goal of the Eco-EMS is to identify opportunities to improve the environmental performance of Muskegon Harbor relative to local watershed issues as part of the work of the LaMP Nearshore Focus Area.

The first task was the completion of an Ecosystem Impairment Profile and Matrix. The Delta Institute, which supports the Forum, uses the Profile and Matrix to identify local ecosystem impairments and community issues surrounding the Muskegon Harbor. By using various public databases, the Forum was able to compile a comprehensive list of chemical and physical discharges in the Muskegon Lake watershed.

The next task is to compare the environmental impacts of Muskegon Harbor with those identified in the Profile and Matrix. The purpose of this comparison is to evaluate the potential effects (positive or negative) of the Harbor's operations on the local ecosystem.

To begin this process, the Forum convened a small group of Muskegon Lake stakeholders in November 2007. The project is expected to be completed at the end of the year.

If you are interested in attending, please contact Todd Parker at the Delta Institute, 517.482.8810.

Source: www.AmericanSteamship.com/unload_ports_big.html

and state government officials, community groups, youth, engineering and environmental professionals. The Jackson wrapped up its Milwaukee visit with a special cruise for the Friends of the Milwaukee River Water Monitors, a group that seeks to establish a watershed-wide network of trained citizens, who collect data and monitor streams. In early July, the *Jackson* steamed into Waukegan for seven tours. At this stop, the *Jackson* hosted a river clean-up group, recreational boaters, a neighborhood group and various youth and senior citizen groups. In addition, the *D.J. Angus,* a second Grand Valley State University research vessel, hosted three cruises for the public in Grand Haven in late July. These cruises were funded by the Grand Haven Community Foundation.

Plans are underway for the *Making Lake Michigan Great* 2008 tour with stops in Michigan City, Indiana and perhaps Racine, Wisconsin. If you are interested in hosting a port or if you would like more information, contract Janet Vail at vailj@gvsu.edu.

The Lake Michigan Toolbox
EPA Calculator Puts Greenhouse Gas Savings in Everyday Terms

The calculator converts greenhouse gas-related savings estimates, typically presented in "million metric tons of carbon dioxide equivalents," into familiar terms such as the greenhouse gas emissions that would result from:

- Driving a particular number of cars for a year,
- Using a particular amount of gasoline or barrels of oil,
- Using a particular number of tanker trucks' worth of gasoline,
- Providing energy to a particular number of homes for a year,
- Growing trees across a particular number of acres for a year,
- Recycling a particular quantity of waste instead of sending it to the landfill, or
- Generating electricity from a particular number of coal fired power plants for a year.

Users can enter savings in emissions, electricity consumption, gallons of gasoline, or number of vehicles into the calculator and determine up to 13 different ways to express the magnitude of the savings. The calculator uses the latest emission factors, approaches and statistics available through 2007.

As an example, if a typical household switched all its incandescent light bulbs to Energy Star qualified compact fluorescent light bulbs, it would save about 75 percent of the lighting electricity use, or about 1,463 kWh a year. After five years, these energy savings are equivalent to:

- Saving about 10,289 pounds of CO2 emissions,
- Conserving 530 gallons of gasoline,
- Saving 11 barrels of oil,
- Planting 120 tree seedlings, or
- Recycling 1.6 tons of waste.

More information is available at www.epa.gov/cleanenergy/energy-resources/calculator.html

The Lake Michigan Forum

The Lake Michigan Forum provides input on the LaMP to USEPA from representative stakeholders of the Lake Michigan basin. In recognition of the LaMP statement that every basin resident is a "Lake Michigan Manager," the forum seeks opportunities to foster ecosystem stewardship through multi-organizational initiatives and partnerships, looking for LaMP implementation opportunities beyond what can be achieved by government efforts.

The Lake Michigan Toolbox
Eco-Logical

Infrastructure consists of the basic facilities - such as transportation and communications systems, utilities, and public institutions - needed for the functioning of a community or society. Sometimes the development of these facilities can negatively impact water quality, habitat and ecosystems. Techniques have been developed to better avoid, minimize, and mitigate these impacts, as well as the impacts of past infrastructure projects. However, the avoidance, minimization, and mitigation efforts used may not always provide the greatest environmental benefit, or may do very little to promote ecosystem sustainability. This concern, along with a 1995 Memorandum of Understanding to foster an ecosystem approach, mobilized a federal interagency team to collaborate to write Eco-Logical: An Ecosystem Approach to Developing Infrastructure Project. This approach has been captured in a publication and in June of 2007 Federal Highways made its first grant solicitation for projects integrating transportation and resource planning to develop ecosystem based infrastructure projects.

More information is available at: www.environment.fhwa.dot.gov/ecological.

As the nongovernmental component of the Lake Michigan LaMP, the Forum has a number of responsibilities, including:

- Representing the diverse interests and geography of the Lake Michigan basin and creating a communication link between the forum members' constituents and the LaMP process
- Providing input to and review of LaMP updates and assisting in their completion and implementation
- Identifying targets of opportunities for demonstration projects relating to LaMP goals and recommendations
- Promoting the LaMP to the public and building a constituency for its implementation
- Serving as a forum for regional and watershed approaches to accomplish LaMP goals;
- Serving as a forum for identifying, discussing, and conveying critical/priority issues
- Serving as a conduit for public concerns and input to the LaMP process

The forum's membership consists of representatives of local governments, industry, environmental groups, sport fishing interests, academia, agriculture, Native American tribes, sewerage districts, and AOCs. Interested parties should go to www.lkmichiganforum.org.

The forum holds public meetings quarterly at different locations around the Lake Michigan basin and, in partnership with USEPA and Grand Valley State University, sponsors an education and outreach tour. Each summer since 1998, the ship *W.G. Jackson* has made its way around Lake Michigan on the Making Lake Michigan Great Tour, spreading the word about the Lake Michigan LaMP. The tour provides hands-on experience in water issues for the public aboard a research vessel operated by the Robert B. Annis Water Resources Institute of Grand Valley State University in Muskegon, Michigan. The event includes cruises for students and the public, open houses, and community activities. Since it began, thousands of people have participated in the tour at 26 ports of call around Lake Michigan.

The Forum publishes a monthly newsletter with up-to-date information on its activities and information on activities in the Lake Michigan watershed.

For more information, visit the forum web site at www.lkmichiganforum.org.

State of Lake Michigan Conference

In October 2007, USEPA, the Lake Michigan Forum, Michigan Sea Grant, and the Great Lakes Beach Association hosted the biennial State of Lake Michigan conference in Traverse City, Michigan. The Conference brought together over 300 attendees and presenters to discuss the status of the lake. Presentations from the conference inform and are often incorporated into the next LaMP publication.

The next conference is planned for October 2009 in Milwaukee, Wisconsin.

Michigan's Clean Marina Program

Boating is one of Michigan's most popular pastimes, with 1 million registered boats and 750 marinas. However, common boating practices often release hazardous substances into Michigan's waters.

In partnership with the Michigan Boating Industries Association and the Michigan Sea Grant, the Michigan Department of Environmental Quality developed this program with the goal of protecting water resources and wildlife habitat through environmentally sound marina and boating practices.

The Clean Marina Program encourages marinas to develop technically sound and economically achievable approaches to prevent the release of hazardous substances and reduce the generation of waste. A simple process helps marinas achieve a clean marina designation.

- Contact MBIA, Sea Grant or MDEQ
- Sign pledge card
- Enroll & attend workshop—receive guide book and checklist
- Perform marina self-evaluation
- Schedule site visit
- Site visit and evaluation by Clean Marina representatives
- Marina incorporates recommendations
- Final site visit
- Clean Marina designation

This voluntary stewardship program is open to all public and private marinas in the state.

More information is available at www.michigan.gov/deq and www.miseagrant.umich.edu.

Shedd Builds Great Lakes Awareness Campaign: Listen to your Lakes

Shedd Aquarium launched a new Great Lakes awareness campaign. The campaign consists of newspaper, magazine, television, radio, online advertising, festival and expo appearances and banners displayed at Chicago's Venetian Night. The ads run in Chicago, Michigan and Wisconsin.

Shedd also created a new Great Lakes web site, www.listentoyourlakes.org, which includes a blog with up to date Great Lakes stories from around the basin and updates on the Great Lakes efforts.

Lake Michigan Toolbox
West Michigan Sustainable Purchasing Consortium

A unique partnership between industry, business, academia, local governments and non-profits has led to the formation of the West Michigan Sustainable Purchasing Consortium (WMSPC). Sustainable purchasing involves the purchase of products and services that have a lesser or reduced effect on human health and the environment when compared with competing products that serve the same purpose.

The objectives of the WMSPC are to 1) consolidate the purchasing volume of the consortium, 2) leverage favorable pricing on commonly used, high volume supplies, equipment, and services that have a low impact on the environment, and 3) promote economic development in West Michigan.

If successful, the consortium could reduce waste, conserve natural resources, materials, and energy, maximize recyclability of purchased products and prevent persistent, toxics from entering the Lake Michigan watershed. Initial WMSPC members include Cascade Engineering, City of Grand Rapids, DEQ, Delta Institute, GVSU, MetroHealth, Steelcase, Sustainable Research Group and Van Andel Institute

More information is available at www.delta-institute.org.

Source: Association of Zoos and Aquariums, www.yearofthefrog.org/

The Zoo and Aquarium Parnership for the Great Lakes was launched in January of 2007. Zoos and aquariums reach a broad audience and are a trusted resource for information as well as an inspiration for taking conservation action in general and specifically on the Great Lakes. 38 institutions initially signed on to formally join the partnership. For more information on the partnership, see www.aljargal.brookfieldzoo.org.

LAKE MICHIGAN PARTNERSHIP DIRECTORY

United States Environmental Protection Agency
Great Lakes National Program Office
Lake Michigan Lakewide Management Plan
77 West Jackson Boulevard
Chicago, Illinois 60604

Overview

The desire to protect and restore the Great Lakes has created a number of governmental programs at the international, national, state, tribal and local levels. The intent of this directory is to present some of the international, federal, state, and tribal government partners involved in Lake Michigan issues, provide brief descriptions of their roles, and list contacts for further information. Partners at the local level are key to any successful effort. Unfortunately, all of the possible partners are too numerous to list. Links to local watershed groups are listed in the watershed fact sheets found in the 2004 Lake Michigan Lakewide Management Plan update report.

There has been renewed efforts in fostering greater coordination to better protect, conserve, and restore the Great Lakes. A 2004 Presidential Executive Order calls for collaboration among regional, state, local, tribal, and other interests to develop an overall strategy for protecting the Great Lakes. This work was conducted between December 2004 and December 2005, providing both short and long term recommendations. The final strategy will be found at www.epa.gov/glnpo. In addition, the Great Lakes Water Quality Agreement (GLWQA) of 1978 is up for review triggered by the International Joint Commission's 12th Biennial Report on the GLWQA. To participate, visit the IJC's website bulletin board at www.ijc.org.

Lake Michigan–Lakewide Management Program: Meetings and Reports

- Lakewide Management Plans are updated every two years. The next update will be completed in April 2010.
- The State of Lake Michigan conference is held every two years. The next meeting will be held in Milwaukee in Fall 2009.
- The Lake Michigan Forum, an EPA sponsored stakeholder group holds quarterly meetings around the basin.
- The Lake Michigan Monitoring Council meets twice per year around the basin.
- The International Joint Commission (www.ijc.org) holds a Great Lakes public conference every two years. The next meeting will be held in 2007.
- The State of the Lakes Ecosystem Conference (SOLEC) (www.epa.gov/glnpo/solec) is held every two years.

More Information on Federal Resources and Grants

There are many federal resources listed in this document. A website, www.grants.gov, contains information for finding and applying for all federal grant programs. It creates a centralized process to find and apply for over 900 federal grant programs. This site provides information in a standardized format across agencies and includes:

A "Find Grant Opportunities" feature to help applicants find potential funding opportunities.
An "Apply for Grants" feature that allows applicants to download, complete, and submit applications for specific grant opportunities from any federal grant-making agency. A "Receive Grants Opportunity Notification" feature that allows you to subscribe to receive announcements of both new grants and modifications of existing grant announcements.

International and Regional Partners

International Joint Commission — www.ijc.org

The International Joint Commission (IJC) prevents and resolves disputes between the United States of America and Canada under the *1909 Boundary Waters Treaty*. It rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; assists the two countries in the protection of the transboundary environment, including the implementation of the *Great Lakes Water Quality Agreement* and the improvement of transboundary air quality; and alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes. The IJC operates a Great Lakes Office in Windsor, Ontario.

Great Lakes Commission — www.glc.org

The Great Lakes Commission is an interstate Compact Commission that promotes the orderly, integrated, and comprehensive development, use, and conservation of the water and related natural resources of the Great Lakes basin and St. Lawrence River. Its members include the eight Great Lakes states and associate members from the Canadian provinces of Ontario and Québec.

Great Lakes Fishery Commission — www.glfc.org

The Great Lakes Fishery Commission (GLFC) was established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries. The GLFC coordinates fisheries research, control measures for the invasive sea lamprey, and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies. On the basis of its research findings, the commission recommends measures that will permit the maximum sustained productivity of stocks of fish of common concern.

Council of Great Lakes Governors — www.cglg.org

The Council of Great Lakes Governors is a private, non-profit corporation established in 1982 and charged by its member governors and associate member premiers to encourage and facilitate environmentally responsible economic growth in the Great Lakes region. This is done through public-private efforts among the ten jurisdictions to address common environmental and economic challenges.

Great Lakes and St. Lawrence Cities Initiative — www.glslcities.org/

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) is a binational coalition of mayors and other local officials that works actively with federal, state, and provincial governments to advance protection and restoration of the Great Lakes. The GLSLCI helps mayors and other local officials develop and advocate programs to improve the resource.

Great Lakes Protection Fund — www.glpf.org

The Great Lakes Protection Fund is a private, nonprofit corporation formed in 1989 by the Governors of the Great Lakes States as a permanent environmental endowment that supports actions to improve the health of the Great Lakes ecosystem. The Fund seeks projects that lead to tangible improvements in the Great Lakes ecosystem; promote the interdependence of healthy ecological and economic systems, and are innovative, creative, and venturesome.

Great Lakes Fishery Trust — www.glft.org

The Great Lakes Fishery Trust (GLFT) provides funding to enhance, protect and rehabilitate Great Lakes fishery resources. The GLFT manages its resources to compensate for lost use and enjoyment of the Lake Michigan fishery resulting from the operation of the Ludington Pumped Storage Plant.

Lake Michigan Forum — www.lkmichiganforum.org

The Lake Michigan Forum provides public input to U.S. EPA on the Lake Michigan Lakewide Management Plan (LaMP) and is a medium for direct involvement in the LaMP process from representative stakeholders of the Lake Michigan basin. The Forum also identifies and implements non-governmental activities that can help meet the LaMP goals.

Lake Michigan Monitoring Coordination Council — http://wi.water.usgs.gov/lmmcc

The Lake Michigan Monitoring Coordination Council fosters cooperation and coordination among groups involved in all types of Lake Michigan Lakewide Management Plan monitoring activities. It works toward developing a systematic and comparable approach to the collection, management, interpretation, and dissemination of environmental data related to environmental monitoring in the Lake Michigan Drainage Basin.

Great Lakes Beach Association — www.great-lakes.net/glba

The Great Lakes Beach Association's (GLBA) mission is to pursue healthy beach water conditions in the Great Lakes through communication and coordination of Great Lakes beach managers and researchers. It is made up of members from state and local governments in Ohio, Michigan, Indiana, Illinois, and Wisconsin, Environment Canada as well as several mid-west universities, non-government, regulatory and coordinating agencies, and environmental groups. It oversees BEACHNET, a communication network/listserv, and holds an annual beach conference.

United States Federal Partners

United States Environmental Protection Agency (EPA) — www.epa.gov

EPA administers educational and regulatory programs designed to protect the environment. EPA works mainly with state, federal, regional, tribal, and local agencies on pollution control and prevention efforts. EPA oversees the revolving loan fund program and brownfield grants. It conducts environmental assessments, water quality monitoring, regulations and regulatory oversight, education, planning, technical, assistance, and grants. The agency may provide staff, information, and data; laboratories and research facilities; grants and loans for pollution control; educational materials; and monitoring equipment.

Office of Research and Development - www.epa.gov/ord/

The Office of Research and Development (ORD) is the scientific research arm of EPA. ORD's leading-edge research helps provide the solid underpinning of science and technology for the Agency. ORD conducts research on ways to prevent pollution, protect human health, and reduce risk. The work at ORD laboratories, research centers, and offices across the country helps improve the quality of air, water, soil, and the way resources are used.

Great Lakes National Program Office (GLNPO) — www.epa.gov/glnpo

GLNPO brings together federal, state, tribal, local, and industry partners in an integrated, ecosystem approach to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes. The program monitors Lake ecosystem indicators; manages and provides public access to Great Lakes data; helps communities address contaminated sediments in their harbors; supports local protection and restoration of important habitats; promotes pollution prevention through such activities as the Canada-U.S. Binational Toxics Strategy; and provides assistance for community-based Remedial Action Plans for Areas of Concern and for Lakewide Management Plans. GLNPO uses its funding to assist Great Lakes partners through grants, interagency agreements, and contracts.

United States Department of Commerce

National Oceanic and Atmospheric Administration (NOAA) — www.noaa.gov
Great Lakes Environmental Research Laboratory (GLERL) — www.glerl.noaa.gov
Lake Michigan Field Station — www.glerl.noaa.gov/lmfs
Great Lakes Bathymetric Data — www.ngdc.noaa.gov/mgg/greatlakes/greatlakes.html

NOAA administers programs in cooperation with states to inventory and manage coastal resources. It funds and performs basic research and assessment relating to coastal eutrophication, and maintains data bases for agricultural pesticides and nutrient loadings. NOAA provides funds to state coastal programs; staff for technical assistance; data, reports, and educational materials; and special demonstration projects.

NOAA Office of Ocean and Coastal Resource Management — www.ocrm.nos.noaa.gov/czm
Illinois Lake Michigan Coastal Management Program — www.dnr.state.il.us
Indiana Lake Michigan Coastal Program — www.in.gov/dnr/lakemich
Michigan Coastal Management Program — www.michigan.gov/deq/0,1607,7-135-3313_3677_3696---,00.html
Wisconsin Coastal Management Program — www.doa.state.wi.us/section_detail.asp?linkcatid=108

The Coastal Zone Management Program (CZM) is housed under the Office of Ocean and Coastal Resource Management. CZM administers a quasi-regulatory coastal protection program (in cooperation with EPA) that sets performance-based management measures for control and prevention of nonpoint source pollution in coastal areas for land-use activities. CZM provides technical assistance and grant funds for plan development.

NOAA Sea Grant — www.nsgo.seagrant.org
Illinois-Indiana Sea Grant (IISG) — www.iisgcp.org
Michigan Sea Grant — www.miseagrant.umich.edu
Wisconsin Sea Grant — www.seagrant.wisc.edu

University-based program designed to support greater knowledge and wise use of Great Lakes resources. The Sea Grant program provides a staff network of advisory agents, researchers, and educators, and offers grant funds for research and workshops.

United States Department of Homeland Security

United States Coast Guard — www.uscg.mil/USCG.shtm
Hazardous Waste National Spill Response Center — www.nrc.uscg.mil/nrcrpttxt.htm

The U.S. Coast Guard is responsible for spill response and ballast water sampling and water intake protections. It has implemented ballast water sampling in Lake Michigan under the Nonindigenous Aquatic Nuisance Species Prevention and Control Act of 1990 and the National Invasive Species Act of 1996.

U.S. Department of Defense, www.defenselink.mil

U.S. Army Corps of Engineers, Detroit District www.lre.usace.army.mil/
U.S. Army Corps of Engineers, Great Lakes and Ohio River Division, www.lrd.usace.army.mil/

The Army Corps of Engineers (COE) oversees construction and operation of flood control and public water supply reservoirs, conducts water-quality monitoring on lakes, regulates in-lake activities and shoreline development, administers the wetlands dredge and fill permit program with EPA and FWS. COE enforces permit requirements for wetland BMPs or other mitigation measures. The Water Resources Development Acts authorize environmental restoration by the COE at certain Great Lakes sites. Offices are located in Washington D.C., the Great Lakes and Ohio River Division, and Detroit District offices.

United States Federal Partners (continued)

United States Department of the Interior (DOI) — www.doi.gov

The DOI conducts oversight, management, and monitoring of national natural and cultural resources, including land, water, and wildlife. Offices located in Washington D.C. and regional centers with field offices in each management area. The DOI provides staff, maps, reports, demonstration sites, educational materials, and monitoring equipment.

Bureau of Indian Affairs (BIA) — www.doi.gov/bureau-indian-affairs.html

The BIA provides technical assistance to tribes on tribal lands mainly for social services and assistance for assistance for conservation work and educational programs, natural resource inventories and monitoring of ground and surface water. The BIA offers funds for special projects, staff for technical assistance to tribes, and maps and natural resource inventories of tribal lands.

United States Fish and Wildlife Service (FWS) — www.fws.gov
U.S. Fish and Wildlife Service Great Lakes-Big Rivers Region — www.fws.gov/midwest
U.S. Fish and Wildlife Service Coastal Program — www.fws.gov/coastal/CoastalProgram

FWS oversees and regulates the nation's wildlife resources, manages national wildlife refuges, enforces federal game and fish laws, administrates the national wetlands program with the Corps of Engineers and EPA, and participates in cooperative projects to enhance wildlife habitat and special studies including fisheries investigations. FWS provides staff for enforcement of the Endangered Species Act and other laws on public and private land; reports and data on habitat, populations, and management of wildlife; and funds for cooperative projects, educational materials, teacher training, curricula, and maps.

National Park Service (NPS) — www.nps.gov

The National Park Service (NPS) administers and manages national parks for preservation of natural and cultural resources and recreation. NPS provides staff for oversight and administration, and funds for special studies and occasionally cooperative projects on land adjoining park boundaries.

Great Lakes Inventory and Monitoring Network — www1.nature.nps.gov/im/units/glkn

The Great Lakes Inventory & Monitoring Network is an office of the National Park Service that helps the nine Great Lakes national park units inventory and monitor significant natural resources. The units extend from the boreal forests of northern Minnesota to the sand dunes of southern Lake Michigan and represent the major freshwater ecosystems of the Upper Midwest.

United States Geological Survey (USGS) — www.usgs.gov
Great Lakes Science Center Research Programs — www.glsc.usgs.gov
Water Resources of Illinois — http://il.water.usgs.gov
Water Resources of Indiana — http://in.water.usgs.gov
Water Resources of Michigan — http://mi.water.usgs.gov

USGS conducts long-term baseline monitoring of water resources, hydrologic and geologic investigations and data, and special intensive short- term studies. USGS provides maps, data, and information on hydrology and water-quality status and trends, and staff for technical assistance in designing a monitoring plan.

U.S. Department of Health and Human Services — www.hhs.gov
Agency for Toxic Substances and Disease Registry — www.atsdr.cdc.gov

The Agency for Toxic Substances and Disease Registry (ATSDR) provides health information to prevent harmful exposures and disease related to toxic substances. ATSDR performs specific functions concerning the effect on public health of hazardous substances in the environment. These include public health assessments of waste sites, health consultations concerning hazardous substances, health surveillance and registries, response to emergency releases of hazardous substances, research in support of public health assessments, information development and dissemination, and education and training concerning hazardous substances.

U.S. Food and Drug Administration — www.fda.gov

The FDA works with EPA to develop national fish advisories that provide important food health safety information for consumers of fish. FDA assists in identifying the information regarding how much of specific fish species can be consumed safely by different groups at risk to toxins that accumulate in fish tissues.

United States Federal Partners (continued)

United States Department of Agriculture (USDA) — www.usda.gov
Natural Resources Conservation Service (NRCS) — www.nrcs.usda.gov
Farmers Services Agency (FSA) — www.fsa.usda.gov
Cooperative State Research, Education, and Extension Service (CSREES) — www.csrees.usda.gov
Cooperative Extension Service (CES) — www.csrees.usda.gov/Extension/USA-text.html

USDA is the steward of our nation's 192 million acres of national forests and rangelands. It is the country's largest conservation agency, encouraging voluntary efforts to protect soil, water, and wildlife on the 70% of America's lands that are in private hands. Responsibilities and resources within the following programs are divided among USDA departments:

USDA Forest Service — www.fs.fed.us

Established in 1905, the Forest Service manages public lands in national forests and grasslands, which encompass 193 million acres of land — an area equivalent to the size of Texas. The Forest Service provides technical and financial assistance to state and private forestry agencies, and manages national forests for additional multiple uses and benefits and for the sustained yield of renewable resources such as water, forage, wildlife, wood, and recreation.

Conservation Reserve Program (CRP) — www.nrcs.usda.gov/programs/crp

CRP is a program to conserve and protect highly erodible or other environmentally sensitive land from production by putting it in vegetative cover through easements and annual rental payments. CRP provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement.

Wetlands Reserve Program — www.nrcs.usda.gov/programs/wrp

The Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The program's goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.

National Association of Conservation Districts (NACD) — www.nacdnet.org

The NACD is the nonprofit organization that represents the nation's 3,000 conservation districts. Conservation districts are local units of government established under state law to carry out natural resource management programs at the local level. Districts work with more than 2.5 million cooperating landowners and operators to help them manage and protect land and water resources on nearly 98% of the private lands in the U.S. NACD supports voluntary, incentive-driven natural resource conservation programs that benefit all citizens.

Sustainable Agricultural Research and Education Program (SARE) — www.sare.org

SARE is a practical research, education, and grant program to promote lower input methods of farming. The program has helped advance farming systems that are profitable, environmentally sound and good for communities through a nationwide research and education grants program. The program funds projects and conducts outreach designed to improve agricultural systems.

U.S. Department of Transportation, Federal Highway Administration — www.fhwa.dot.gov

The National Scenic Byways Program is a grass-roots collaborative effort established to help recognize, preserve, and enhance selected roads throughout the United States. Since 1992, the program has provided funding for almost 1500 state and nationally designated byway projects in 48 states. The U.S. Secretary of Transportation recognizes certain roads as All-American Roads or National Scenic Byways based on one or more archeological, cultural, historic, natural, recreational, and scenic qualities.

Great Lakes Maritime Research Institute (GLMRI) — www.glmri.org/glmri/main.htm

GLMRI was established in 2004 as a consortium of the University of Wisconsin-Superior Transportation & Logistics Research Center and the University of Minnesota Duluth College of Science & Engineering and Labovitz School of Business & Economics to oversee and coordinate research on Great Lakes maritime issues.

State and Local Partners

State Water Quality Agencies

Illinois Environmental Protection Agency — www.epa.state.il.us
Indiana Department of Environmental Management — www.state.in.us/idem
Michigan Department of Environmental Quality — www.michigan.gov/deq
Wisconsin Department of Natural Resources — www.dnr.state.wi.us

State water quality agencies administer many programs for protection of water quality in ground and surface waters, including the National Pollutant Discharge Elimination System (NPDES) permit program, water-quality standards regulations, the nonpoint source program, and ambient statewide monitoring programs. Agencies provide staff for technical assistance to local governments and individuals implementing BMPs; water-quality monitoring, data, and reports; and funds for pollution control projects, educational materials, and programs.

National Association of Regional Councils — www.narc.org
Chicago Metropolitan Agency for Planning (Chicago) — www.cmap.illinois.gov
Northwestern Indiana Regional Planning Commission (Gary) — www.nirpc.org
Michiana Area Council of Governments (MACOG) — www.macog.com
St. Joseph River Basin Commission (housed within MACOG) — www.sjrbc.com
West Michigan Shoreline Regional Development Commission — www.wmsrdc.org
Northwest Michigan Council of Governments — www.nwm.org
Southeastern Wisconsin Regional Planning Council (Milwaukee) — www.sewrpc.org
Bay-Lake Regional Planning Commission — www.baylakerpc.org

Planning commissions work with local governments and organizations to promote sensible growth, and conduct regional planning related to transportation, the environment, and economic and community development. Commissions provide geographic and demographic information such as forecasts of population, employment, and other socio-economic indicators. These commissions listed above participate in the Lake Michigan Watershed Academy overseen by USEPA's Lake Michigan program.

Tribal Partners

United Indian Nations of the Great Lakes (UINGL) — www.anishinabek.ca/uoi/greatlakes.htm

Several First Nations from Ontario and Quebec and tribes from New York, Pennsylvania, Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota joined to create the UINGL. They came together to sign the Great Lakes Water Accord in which a number of united principles, values, concerns, and demands are identified. They have been active in the Great Lakes Regional Collaboration.

Chippewa-Ottawa Resource Authority (CORA) — www.1836cora.org

CORA regulates most Indian fishing in portions of Lake Michigan 1836 Treaty waters. A 1985 Consent Agreement allocated the fishery resource among user groups, such as the tribes, sports fishers, the state, and the federal government. Disputes are settled by an Executive Council comprised of CORA chairmen and state and federal representatives.

Individual Tribes in the Lake Michigan Basin — www.epa.gov/Region5/tribes/r5tribes.htm

Michigan
Grand Traverse Band of Ottawa and Chippewa — www.gtb.nsn.us
Hannahville Indian Community — (No web site)
Little River Band of Ottawa Indians — www.lrboi.com
Little Traverse Bay Bands of Odawa Indians — www.ltbbodawa-nsn.gov
Pokagon Band of Potawatomi — www.pokagon.com

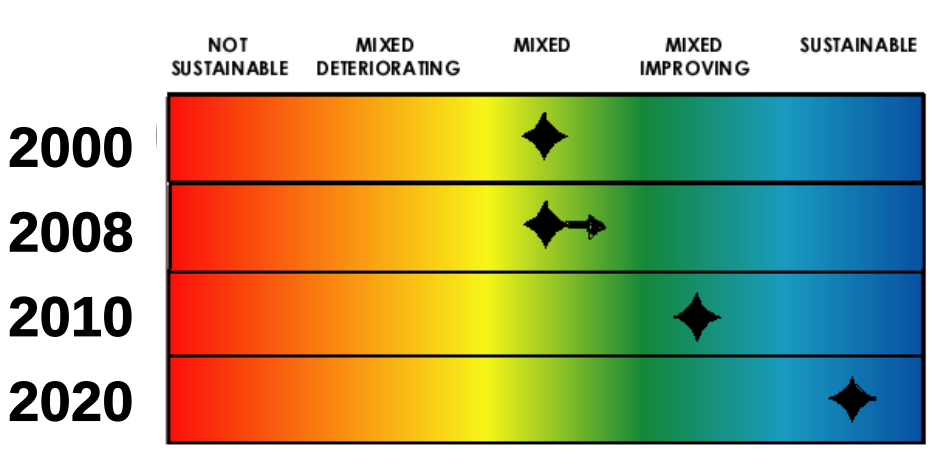
Wisconsin
Forest County Potawatomi Community — www.fcpotawatomi.com
Menominee Indian Tribe — www.menominee-nsn.gov
Oneida Nation of Wisconsin — www.oneidanation.org
Sokaogon Chippewa Community — www.sokaogonchippewa.com
Stockbridge-Munsee Band of Mohicans — http://unr.edu/homepage/shubinsk/mohican.html

Subgoal 10
Is collaborative ecosystem management the basis for decision-making in the Lake Michigan basin?

What is our target for sustainability?

The promise of the GLRC is realized where awareness and responsibility is shared among different levels of government, non-governmental groups and wide spread basin stewardship actions.

Lake Michigan Target Dates for Sustainability



Why is this important?

The environmental problems in the Great Lakes ecosystem have become increasingly complex over the years. The myriad of jurisdictions and programs with responsibility for the lakes is similarly complex. According to a 2003 Government Accountability Office report, the government presence overseeing Great Lakes resources includes two countries, multiple tribes, and First Nations, more than 140 Federal programs, and numerous city and state programs all dealing with environmental restoration activities. While these organizations have experienced individual opportunities for successes during the last 30 years, there has been no overarching strategy to deliver coordinated restoration and protection efforts in the future.

What is the current status?

- There has been a significant increase in collaborative action over the last two years.
- The Great Lakes and St. Lawrence Cities Initiative mayors announced a conservation framework in which cities commit to reducing water use within their city limits. Cities will work towards a 15 percent reduction in 15 years using 2000 as a base year.

What are the major challenges?

- Developing a lake level framework for clear goals and objectives that facilitates coordinated actions among agencies and stakeholders in alignment with the Great Lakes Regional Collaboration
- Providing and facilitating opportunities for partnerships and leveraging resources
- Providing opportunities for involved stakeholders

What are the next steps?

- Continue publication of the Lake Michigan Partnership Directory in each LaMP
- Continue development and linkage of local watersheds with basin-wide issues and activities through the Watershed Academy and partnering with state programs
- Coordinate LaMP and GLBTS efforts on PCBs and mercury
- LMMCC continues leadership role for collaborative monitoring in 2010
- Coordinate with the four Coastal Management programs to explore partnership opportunities
- Explore partnerships with key EPA volunteer programs like Climate Change, Clean Ports, Clean Marinas, and Pesticide Environmental Stewardship

- **What are some tools for addressing the challenges?**
- Building Collaborative Efforts in the Lake Michigan and Great Lakes Watersheds
- CMAP Framework Plan with Tools for Officials and Planners
- NIRPC Water Conservation and Protection Toolkit
- Coastal America
- Watershed Planning Brochure Wisconsin

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

- Access to Information About the Great Lakes
- Value of Great Lakes to Basin residents

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Major New Efforts Build on Lakewide Efforts

Since 1991, the states, tribes, and federal agencies in the Lake Michigan basin have been collaborating to restore and protect Lake Michigan through the Lakewide Management process. New activities at Great Lakes wide scale may strengthen and enhance LaMP work.

The Great Lakes Regional Collaboration

On May 18, 2004, President Bush signed Executive Order 13340 creating a cabinet-level Interagency Task Force, led by USEPA, to bring an unprecedented level of collaboration and coordination to restore and protect the Great Lakes. USEPA's Great Lakes National Program Office (GLNPO), established under the Clean Water Act, remains a focal point for Great Lakes responsibilities. GLNPO was cited in the Executive Order and given the responsibility of providing assistance in carrying out the goals of the Order. In addition, the Order directed that a "Regional Collaboration of National Significance" be convened to bring the many partners, both governmental and nongovernmental together to protect and restore the Great Lakes.

The Great Lakes Regional Collaboration (GLRC) developed a Strategy that is different from any plan proposed in the past. The collaborative activities of federal, local, and state agencies, the tribes, elected officials, industry, and non-governmental groups demonstrate a unified effort to reach our goals. Eight Strategy Teams, each focusing on a different issue affecting the Great Lakes basin, began work in January 2005 to develop recommendations for action. More than 1,500 people from diverse backgrounds participated in the process.

The Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes was released in December 2005. A GLRC Executive Committee is overseeing implementation of the Strategy in accordance with the GLRC Strategy Implementation Framework which was issued in March 2006. The GLRC Executive Committee brings together representatives from the Great Lakes and St. Lawrence Cities Initiative together with representatives from the Council of Great Lakes Governors, the Great Lakes Congressional Delegation, and the Federal government. The GLRC Executive Committee is responsible for directing the ongoing activities of the GLRC, developing and implementing mechanisms to promote accountability (tracking), identifying and resolving major implementation issues, facilitating coordination of Great Lakes restoration and protection activities among the GLRC participants, communicating with stakeholders and providing for ongoing public participation.

Eight stakeholder teams helped develop the Collaboration's recommendations.

- Nonpoint Source Strategy Team
- Persistent Bioaccumulative Toxics (PBT) reduction Team
- Invasive Species Strategy team

EPA, U.S. Forest Service Sign Agreement to Restore Water Quality in National Forests

The Environmental Protection Agency's Office of Water and the U.S. Forest Service signed a September 2007 memorandum of agreement under which they have agreed to pool efforts to develop plans to restore impaired water quality in national forests and grasslands. The two agencies will jointly develop total maximum daily loads (TMDLs) or federally approved alternative approaches to tackle impaired waters in national forests and grasslands.

EPA estimates that about 8 percent of all impaired waters are located on National Forest System lands. Leading causes of impairments include high temperatures, excess sediment, and habitat destruction.

The Forest Service has already assisted EPA and states in developing more than 300 TMDLs in roughly 30 national forests, according to the agreement. In addition, the Forest Service also uses a variety of watershed management approaches. These include best management practices such as erecting silt fences to prevent sediment from entering streams.

The memorandum of agreement is available at www.epa.gov/owow/tmdl/usfsepamoa/.

- Habitat/Species team
- Areas of Concern Restoration/Sediments Strategy Team
- Indicators and Information Strategy Team
- Sustainable Development Strategy team
- Coastal Health Strategy Team

The Strategy is being used to guide Federal, State, Tribal and other partners' actions to restore the Great Lakes.

Federal commitments from the Strategy have been identified in the Federal Near Term Action Plan (48 Actions) and are being implemented and tracked. Fifteen of the 48 original near terms actions are completed; two have been moved to long-term status; the other 31 are on track. Highlights of Plan accomplishments include:

- EPA, working with state and local partners, has developed a standardized sanitary survey form for state and local governments to use in assessing their beaches, and is supporting implementation pilots using the new survey.
- The U.S. Fish and Wildlife Service has listed the Asian Silver Carp, Largescale Silver Carp, and Black Carp as injurious under the Lacey Act.
- In its FY 2008 budget, NOAA has requested funding to establish habitat restoration partnerships focused on Areas of Concern in the Great Lakes, and to create a special NOAA Office on Great Lakes Habitat Restoration that would provide a focal point for all of NOAA's restoration efforts in the Great Lakes.
- Twenty-two environmental restoration projects around the Great Lakes are being funded this year under the Great Lakes Watershed Restoration Grant program. The program is providing $1.1 million in federal money and leveraging an additional $1.9 million in contributions by non-federal partners. Partner agencies are: EPA, the Fish & Wildlife Service, NOAA, the Forest Service, and the Natural Resources Conservation Service.
- EPA has completed 5 Legacy Act projects (4 remediation /1 monitor and evaluate), and has 6 additional projects (all monitor and evaluate) underway.
- The Corps of Engineers recently announced that two projects from the Great Lakes region were selected from a nationwide competition for habitat restoration funding under the Estuary Restoration Act of 2000.
- The Great Lakes Interagency Task Force (IATF) Regional Working Group has been meeting weekly for over a year to oversee implementation of the Near Term Actions, as well as other provisions of the President's Executive Order on the Great Lakes. The meetings have also become an important forum to share information about new programs/initiatives and funding opportunities among members.
- The IATF created the Wetlands Subcommittee and the Aquatic Invasive Species Rapid Response Subcommittee to improve interagency coordination on two high priority areas for the Great Lakes. Both subcommittees are also bringing in non-federal partners through joint projects in cooperation with the Great Lakes Regional Collaboration.
- In addition to individual agency actions, the GLRC Executive Committee is moving forward to implement a series of joint initiatives to address issues from the GLRC Strategy, including aquatic invasive species, toxic pollutants, habitat protection and restoration and clean beaches.

Aquatic Invasive Species:

Aquatic Invasive Species Rapid Response Initiative. While preventing the introduction of Aquatic Invasive Species (AIS) is the first line of defense against

The Lake Michigan Toolbox
Building Collaborative Efforts in the Lake Michigan and Great Lakes Watersheds

Collaboration among a variety of stakeholders to improve the Lake Michigan ecosystem continues to increase since LaMP 2000. This chapter documents several of these collaborative activities, Some of the collaborative efforts include:

- The Great Lakes Regional Collaboration: www.glrc.us
- The Binational Executive Committee
- Great Lakes Binational Toxics Strategy: www.epa.gov/glnpo/p2/bns.html
- The Great Lakes Human Health Network: www.epa.gov/glnpo/health.html
- The Great Lakes Fishery Commission: www.glfc.org/
- The Great Lakes and St. Lawrence Cities Initiative: www.glslcities.org/
- Council of Great Lakes Governors: www.cglg.org
- Great Lakes Commission: www.glc.org
- Great Lakes Legislative Caucus: www.csgmidwest.org/About/GLLC.htm

Binational Toxics Strategy Under Review

Experts from industry, environmental groups and regulatory agencies are reviewing the Great Lakes Binational Toxics Strategy (BTS) to determine if and how it might be adapted to meet changing environmental needs in the Great Lakes region related to reducing toxics and addressing new contaminants of concern.

The BTS is a voluntary agreement between the United States and Canada to restore and maintain the chemical, physical and biological integrity of the waters in the Great Lakes ecosystem. This has led to significant non-regulatory pollution prevention activities. For example, green chemistry, which designs toxicity out of chemicals, is among the more recent areas of interest for environmentalists and some in industry. The strategy is driven by the review of and potential changes to the underlying agreement --- the Great Lakes Water Quality Agreement (WQA) --- and increasing levels of chemicals not included in the current strategy. Emerging contaminants of concern include polybrominated diphenyl ethers and perfluoroctanesulfonate.

In 1997, EPA and Environment Canada established 17 source and emissions reduction goals for the United States and Canada. Over the past 10 years, both governments (with the help of state, provincial, tribal and local governments and stakeholders from industry, academia, environmental and community groups) have worked together to reduce the use and release of targeted toxic substances. To date, 12 of the 17 goals have been met, and the rest are well advanced. The report discusses the significant voluntary projects of the Strategy, such as the burn barrel outreach campaign and the wood stove exchange campaign, some of which have been adopted nationally on both sides of the border. The report also presents trends of these substances in gull eggs and fish as well as open water, air and sediment. Overall, significant environmental improvements have been realized for legacy pollutants in the Great Lakes. Looking forward, new challenges are presented by emerging substances of concern, such as flame retardants. The U.S. - Canadian Great Lakes Binational Toxics Strategy Tenth Anniversary Edition 2006 Annual Progress Report is available at http://binational.net/bns/2006.

The 2006 BTS progress report released by the USEPA and Environment Canada indicated that the strategy has made significant progress toward meeting its goals, including Canada's 85 percent reduction in mercury releases since 1988 and the United States' estimated 50 percent reduction in mercury use nationwide and a 50 percent reduction in national mercury emissions. A stakeholder forum held in Chicago in late May focused on whether the current BTS structure, is sufficient to address new substances. The question raised was whether the strategy should focus on specific industry sectors, families of substances, or a combination of approaches.

Possible changes to the current approach could include using the BTS to identify chemicals of concern and then having specific workgroups target sectors where the chemicals are widely used. Other possible approaches include encouraging sustainable manufacturing, behavior modification, green chemistry and "practical" precaution. Any specific changes to the BTS will likely not be considered until after any changes in the WQA.

General Outcomes. Overall, the environmental analyses show many of the level 1 substances remain in the Great Lakes environment at levels which exceed health based criteria, particularly mercury, PCBs, and the cancelled pesticides. These substances continue to impair the Great Lakes, and limit fish consumption, particularly among sensitive populations such as pregnant women and children, and among and indigenous fishers, such as many of the Tribes and First Nations. With regard to source reductions, much progress has been made to date. Of seventeen reduction goals, ten have been met, three more will be met by 2006, and the remaining four will be well advanced toward their respective targets. Notwithstanding these accomplishments, much remains to be done to achieve the ultimate goal of virtual elimination in the Great Lakes.

Analyses suggests that significant source reduction opportunities remain for the "active substances" (i.e., substances for which we have ongoing workgroup activities), which include mercury, PCBs, dioxins and furans, HCB and B(a)P). With respect to the "inactive" (i.e., no ongoing workgroup activity) level 1 substances, cancelled pesticides, alkyl lead, and OCS, the Parties have decided to suspend GLBTS workgroup activities indefinitely, pending periodic review, and to defer to other programs, as appropriate. However, these substances will continue to be tracked and monitored in the Great Lakes. Finally, the GLBTS will continue to monitor and report on progress of sediment remediation activities in Areas of Concern in the Great Lakes basin, and will continue to study issues associated with long-range transport of toxic substances from world-wide sources, in order to better inform our priorities moving forward.

Conclusions. The GLBTS presents a unique model of how international cooperation and collaborative problem solving of issues that are beyond the reach of regulations, can lead to real results in environmental protection. There may be an important ongoing role for the GLBTS, not only with respect to the current level 1 substances, but also for newer chemicals of emerging concern. The Parties intend to focus on next steps for the GLBTS in the coming months. Protecting the chemical integrity of the Great Lakes, advancing the goals of the Great Lakes Water Quality Agreement, and virtually eliminating PTS from the Great Lakes basin are of paramount importance. The GLBTS may be one important tool to move us toward these goals.

The Lake Michigan Toolbox
NIRPC Water Conservation and Protection Toolkit

The Northwest Indiana Regional Planning Commission released a Water Conservation and Protection Toolkit. The toolkit consists of a series of fact sheets that provide overviews of the specific water resource protection and conservation issues. It also identifies a series of resources saved on a CD that assists people, local governments, and developers in making choices that better protect, conserve, and sustain local water resources.

Addressing water resources problems associated with a developing area requires a comprehensiveapproach. This means:

- Protecting water resources from pollution and making sure that water sources are not pumped dry;
- Conserving water resources; and
- Restoring and improving water resources so that quality, quantity, flow, and timing align more closely with the natural water cycle.

Overview Issues

- What is Water Use and Availability in Lake, Porter, and LaPorte Counties in Northwest Indiana?
- The Great Lakes Charter Annex and Protecting, Conserving, Restoring, and Improving Water Resources

Fact Sheets for Local Officials

- How Can Stormwater Management Protect and Conserve Water Resources?
- How Can Sourcewater Protection Conserve and Protect Water Resources?
- How Can Land Use Planning and Zoning Protect and Conserve Water Resources?
- What Conservation Requirements Can Protect Water Resources?
- How Does Better Site Planning Protect and Conserve Water Resources?

Fact Sheets for Developers and the Public

- How Can Homeowners Protect and Conserve Water Resources?
- How Can Watershed Planning and Assessment Protect and Conserve Water Resources?

Many of the resources identified in the NIRPC toolkit, are reproduced in the Lake Michigan Toolbox resources throughout LaMP 2008. More information is available at www.nirpc.org.

invasions, even the best prevention efforts may not stop all AIS introductions. In 2007, the GLRC Executive Committee endorsed the formation of an Aquatic Invasive Species Rapid Response Initiative to increase the likelihood that invasions will be addressed successfully through early detection and rapid response efforts, while populations are still localized and can be contained and eradicated. In the Summer of 2007, a Communication Protocol was developed at the direction of the GLRC Executive Committee and Points of Contact were identified by participating GLRC agencies. In December 2007, a compendium of the Points of Contact and Communication protocol was finalized and distributed to GLRC agencies. GLRC agencies are now developing plans for a Mock Exercise to test the Communication Protocol in Early Summer 2008.

Great Lakes Clean Boat Initiative. GLRC partners and the media will promote a "Great Lakes Clean Boat Day" early in the 2008 boating season. This effort will celebrate recreational boating in the Great Lakes and promote practices which will reduce the spread of aquatic invasive species. The Great Lakes are one of the top recreational boating destinations in the nation. Nearly 4.3 million boats are registered in the eight Great Lakes states. These boaters spend nearly $16 billion on boats and boating activities in a single year, directly supporting 107,000 jobs. Outreach efforts to this user group can help ensure a healthy

Great Lakes ecosystem, as well as help support a strong and sustainable recreational economy. Agencies are compiling educational material over the winter of 2008. At the same time, the Great Lakes States are determining the preferred day or days for holding "Great Lakes Clean Boat Day".

Toxic Pollutants

Toxic Pollutants Initiative. The Toxic Pollutants Initiative sets forth a series of near term activities undertaken by members of the Collaboration to reduce or virtually eliminate persistent toxic substances such as mercury and PCBs in the basin, as well as prevent new toxic threats to the basin through pollution prevention and enhanced surveillance, protect public health through education and outreach, and work with international forums to address sources outside the basin. Activities include:

- A Mercury Phase-down Strategy: In 2007, a workgroup of state, tribal, and city staff developed a basin-wide Great Lakes mercury product stewardship strategy to fulfill the Strategy recommendation to phase down mercury in products and waste. The Draft Mercury In Products Phase-Down Strategy is posted at: http://www.glrc.us/initiatives/toxics/drafthgphasedownstrategy.html
- A Burn Barrel Education and Outreach Campaign: U.S. EPA with Great Lakes states, tribes, and cities are jointly developing an education and outreach program to address open burning across the Great Lakes Basin. This project targets local and tribal waste management officials with information on infrastructure and alternatives to burning in communities and tools to strengthen burning ordinances and support greater compliance with current regulations. Staff is presenting this program at meetings in all Great Lakes states.
- A Pharmaceutical and Electronic Waste Disposal Education and Outreach: U.S. EPA, Great Lakes states, tribes, and cities are developing an education and outreach effort to address pharmaceutical and electronic wastes in the Great Lakes Basin, targeting waste management officials with information about disposal and recycling policies and options. IL/IN Sea Grant, Great Lakes states, and U.S. EPA staff have presented information to local solid waste management officials and others on pharmaceutical at numerous conferences throughout the basin.
- Great Lakes Sport Fish Consortium Project: The Great Lakes Sport Fish Consortium, the Wisconsin Department of Health and Family Services, and representatives of Great Lakes states and tribes finalized the Protocol for Mercury-based Fish Consumption Advice: An addendum to the 1993 Protocol for a Uniform Great Lakes Sport Fish

The Lake Michigan Toolbox
Coastal America

Coastal America is a federal agency partnership to protect coastal habitat in the United States. It engages in a range of activities nationwide. It has begun work on several activities in the Lake Michigan basin.

Corporate Wetlands Restoration Partnership

The Corporate Wetlands Restoration Partnership is a collaborative effort led by Coastal America between the federal government, state agencies and private corporations and non-profits to restore wetlands across the country. Companies contribute funds and services to match funding for aquatic habitat restoration, education and research projects. To date, over 225 corporations, 13 Federal agencies, over 125 non-governmental partners, including The Nature Conservancy, Chesapeake Bay Foundation, Atlantic Salmon Commission, Ramsar Secretariat and several foundations have partnered with the program.

Coastal America Activity in the Lake Michigan Basin

There has been preliminary activity in Illinois and Wisconsin. In October of 2004 the Shedd Aquarium became the first Coastal America Ecosystem Learning Center in the Great Lakes. As part of that partnership program, Chicago's Shedd Aquarium, USFWS, IL/IN Sea Grant and Purdue sponsored a new exhibit on Great Lakes Invasive species.

Great Lakes and St. Lawrence Cities Initiative Develop Water Conservation Framework and Goals

The Great Lakes Mayors announced the Great Lakes and St. Lawrence Cities Initiative Water Conservation Framework. The Framework is a voluntary program in which cities commit to reducing water use within their city limits. Cities will work towards a 15 percent reduction in total water usage below year 2000 water consumption levels by the year 2015. Re-evaluation will take place in 2015 to determine an appropriate target reduction to achieve by the year 2025.

Recognizing that some cities already have water conservation programs and others do not, the Framework consists of two groups of cities. Group 1 includes cities that have conservation plans in place and Group 2 includes cities that do not have conservation plans, as of now.

The Framework allows cities to work together on the issue. Cooperation will be fostered through a focus on the sharing of best practices and annual recognition of efforts to reduce water use. The Framework is an opportunity for cities to take a unified and collaborative step to conserve the Great Lakes and St. Lawrence.

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) is a binational coalition of mayors and other local officials that works actively with federal, state, and provincial governments to advance the protection and restoration of the Great Lakes and the St. Lawrence River. GLSLCI enables mayors and other local officials to be active participants in Great Lakes issues relating to governance, economics, and science.

The GLSLCI Board of Directors includes Mayors Richard Daley of Chicago, IL (Founding United States Chairman and Director); David Miller of Toronto, Ontario (Founding Canadian Chairman and Director); Gary Becker of Racine, WI (Chairman and Director); Lynn Peterson of Thunder Bay, Ontario (Vice Chairman, Treasurer and Director); George K. Heartwell of Grand Rapids, MI (Secretary and Director); Ellen Anderson of The Town of the Blue Mountains, Ontario; Rudolph Clay of Gary, IN; Robert J. Duffy of Rochester, NY; Carleton S. Finkbeiner of Toledo, OH; Eddie Francis of Windsor, Ontario; Régis Labeaume of the Québec Metropolitan Community; Denis Lapointe of Salaberry-de-Valleyfield, Québec; Brian McMullan of St. Catharines, Ontario; Don Ness of Duluth, MN; Joseph Sinnott of Erie, PA; and Gérald Tremblay of Montréal, Québec.

More information is available at www.glslcities.org/watercons.htm#Overview.

Consumption Advisory, with funding from U.S. EPA. Basin-wide consumption outreach materials related to mercury will be produced by the end of 2008.

- A Mercury Emission Reduction Initiative: In 2007, the GLRC decided, under its Toxic Pollutants Initiative, to develop a strategy for reducing mercury emissions across the Great Lakes region. This effort should produce institutionalized activities to sustain mercury emissions reduction from new and existing sources whose mercury emissions have not been regulated, and from sources where regulations have been implemented but additional reductions are technically feasible and economically reasonable. Examples of potential sources include manufacturing processes that produce mercury emissions, and the disposal of mercury-containing products. A Strategy will be drafted in 2008, including an evaluation of the major sources of mercury deposition in the Great Lakes region, identification of priority sectors, and reduction approaches.

Habitat/Species

Habitat/Wetlands Initiative. The GLRC Strategy outlined the problems associated with habitat loss and degradation and provided recommendations for protecting and restoring Great Lakes habitat. To address the Strategy's key habitat and wetland issues, the Collaboration launched a Wetlands Initiative with two near-term goals: A wetlands challenge to federal and non-federal partners to protect and restore 200,000 acres of wetlands in the Great Lakes Basin; and improving coordination of federal wetlands management programs.

An estimated 65,000 acres of wetlands have been protected, improved and restored across the Great Lakes basin since December 2005 by federal agencies and their partners. This estimate was obtained from a data call to the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Natural Resources Conservation Service, U.S. Forest Service, National Oceanic and Atmospheric Administration and U.S. EPA that adopted reporting conventions of the Council of Environmental Quality's annual, national wetlands report. Agencies were asked to report 2006 and 2007 accomplishments for completed wetlands restoration projects only. The

information is intended to provide an estimate of where Federal agencies and their partners are in contributing to the Great Lakes Regional Collaboration's goal of protecting and restoring 200,000 acres of wetlands across the basin.

At the same time, the U.S. Army Corps of Engineers (Corps) launched a $1 million Great Lakes Habitat Initiative that builds upon the recommendations of the Collaboration's Strategy. The initiative will help partners advance habitat and wetland restoration projects by connecting partners with the information and resources they need to make projects happen. This effort includes developing a database and detailed inventory of potential habitat and wetlands restoration projects.

The two initiatives share similar goals and have been merged into one overarching Habitat/Wetlands Initiative, focusing initially on coordination to accomplish the wetlands challenge to federal and non-federal partners to protect and restore 200,000 acres in the Great Lakes Basin. Activities include:

- Providing a stakeholder forum for partners to communicate, leverage resources and identify shared opportunities for partnering. The initiative brings together federal agencies, states, tribes, local governments and other Great Lakes stakeholders to identify on-the-ground restoration projects that contribute to the 2005 Strategy, and to identify ways to implement such restoration projects as well as ways to facilitate partnerships and overcome hurdles to implementation. A Steering Committee, Project Delivery Team and Federal Wetlands Subcommittee have been meeting regularly to share information and provide regional coordination.
- Providing partners with the necessary information to facilitate collaborative restoration work. The initiative is connecting partners with information about potential projects, programs and funding sources. The Corps has created a Funding Programs Inventory with information on more than 150 funding governmental and nongovernmental programs for habitat restoration work. The initiative has also developed a Restoration Projects Database with over 200 potential projects, and will be updated periodically.
- Monitoring Great Lakes wetland restoration progress. Progress will be measured and assessed against the 200,000 acre goal using the same definitions and methodology as the President's annual Earth Day Wetlands Report. Great Lakes restoration progress will be reported beginning in December 2007. Since December 2005, an estimated 65,000 acres of wetlands have been protected, improved or restored by federal agencies working with partners. Significant additional acreage has been protected and restored by states, local and tribal governments, and other partners.
- Developing a User Manual. In addition to the three activities initially approved, a user manual is being developed to guide partners in how to use the database and tools to restore and protect habitat in the Great Lakes.

The Lake Michigan Toolbox
Wisconsin Watershed Planning Brochure

The Wisconsin Department of Natural Resources (WDNR) works with many partners. Planning commissions, county conservationists, municipalities, lake and river groups, and individual citizens are critical stewards of our water. WDNR is reframing its watershed planning to reflect the interactive nature of watershed work to move us toward a truly shared vision for ***Wisconsin's Waters.*** In creating the ***Wisconsin Watershed Planning Network***, WDNR hopes to promote watershed work and encourage collaboration on research, planning, and projects. The ***Network*** provides electronic access to interconnected databases for watershed planning information and activities. Whether you are developing watershed plans, smart growth plans, or other resource strategies, the ***Network*** is a centralized place to share and research data and planning efforts.

More information is available at:

http://dnr.wi.gov/org/water/watersheds/network/

http://www.dnr.state.wi.us/org/water/watersheds/planning/WisconsinWatersheds.pdf

Coastal Health

Beach Project Initiative. The GLRC identified coastal health as a challenge recognizing the significance of beaches to the economic well-being, health and

The Lake Michigan Toolbox
CMAP Framework Plan with Tools for Officials and Planners

The Chicago Metropolitan Agency for Planning (CMAP) (formerly the Northeastern Illinois Planning Commission) released its "2040 Regional Framework Plan". It provides a series of tools for local elected officials and planners to aid land-use decisions. The plan is the culmination of an extensive public-involvement process that included 200 workshops where 4,000 participants expressed their vision of how the region should address growth through the year 2040. CMAP's "Common Ground" process engaged these communities' residents, elected officials, planners, developers and other stakeholders, who expressed five top priorities for 2040 on behalf of the region:

- We want livable communities.
- We want a region that views the diversity of its people as an asset.
- We want a healthy natural environment.
- We want a regional economy that is competitive globally.
- We want governments to collaborate at the local and regional levels.

The 2040 Plan describes 17 implementation strategies that require close partnership at the regional and local levels. They include steps toward achieving a balance between jobs and housing, promoting alternative modes of travel such as walking and biking, sustaining the water supply from Lake Michigan and other sources, preserving farmland and other strategies.

More information is available at: www.nipc.org/2040/.

quality of life of the region's citizens. Because contamination leading to beach advisories continues to be a concern in the Basin, the GLRC called for identification of sources of contamination and remediation. Several federal, state, local, and tribal partners who work together with the Great Lakes Beach Association are creating and improving the use of sanitary surveys and beach forecasting models. The GLRC will increase this cooperation by supporting and encouraging the use of sanitary surveys and predictive modeling. Ultimately, the GLRC hopes to recognize and integrate sanitary survey tools and predictive modeling as a coastal health initiative to enhance the health of beaches along the Great Lakes to promote recreational activity and reduce risk to human health. In 2008, the partners are developing outreach materials for distribution and utilization of the sanitary survey tools and predictive models.

Proposed Great Lakes Legislation in the 110th Congress

The National Aquatic Invasive Species Act (S. 725): Amends existing law to: require the Coast Guard to implement ballast water regulations; require ships to take steps to minimize the introduction of invasive species; establishes an early detection and monitoring programs along with state, regional and federal rapid response networks; improves research; authorizes the construction of a second barrier in the Chicago Ship and Sanitary Canal; and gives the International Joint Commission a reference to coordinate prevention efforts with Canada.

Aquatic Invasive Species Research Act (H.R.260): Requires the National Oceanic and Atmospheric Administration (NOAA), the Smithsonian Institution, and the U.S. Geological Survey to develop a marine and freshwater research program to support efforts to assess introduction rates and patterns of invasive, nonnative species and efforts to detect, prevent, and eradicate them. Reauthorizes the ship pathway technology demonstration program. Requires the Environmental Protection Agency (EPA) to develop a grant program to fund research, development, demonstration and verification of environmentally sound, cost-effective technologies and methods to control and eradicate such species.

Great Lakes Invasive Species Control Act (H.R.801): Amends current law to require vessels equipped with ballast water tanks but not ballast water on board

(NOBOB) to carry out ballast water exchange or alternative ballast water management methods prior to entry into any port within the Great Lakes. Directs the Coast Guard to conduct a study of the effectiveness of alternative ballast water management methods in reducing the threat of invasive species to the Great Lakes.

Prevention of Aquatic Invasive Species Act (H.R.889): Amends current law to require vessels to conduct ballast water treatment so that the discharged ballast water will contain no more than a specified level of living organisms or microbes. Urges the Secretary to negotiate with foreign countries to develop and implement an international program for preventing the unintentional introduction and spread of aquatic invasive species.

Ballast Water Management Act (H.R.2423/S. 1578): To provide for the management and treatment of ballast water to prevent the introduction of nonindigenous aquatic species into coastal and inland waters of the United States, and for other purposes.

Coast Guard Authorization (H.R. 2830): Authorizes appropriations for the Coast Guard for: (1) operation and maintenance; (2) aids to navigation, facilities, vessels, and aircraft; (3) Coast Guard research and development; (4) retired pay; (5) bridges; (6) environmental compliance; and (7) the Coast Guard Reserve program. Amends the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 with provisions relating to the introduction and spread of species from ballast water and other ship-borne vectors.

Great Lakes Asian Carp Barrier Act (H.R. 553/S. 336): This bill authorizes the Corps of Engineers to upgrade Barrier I into a permanent barrier, complete construction of Barrier II, operate and maintain both barriers, and to study additional measures to prevent carp from entering the Great Lakes.

Asian Carp Prevention and Control Act (H.R 83. /S. 726): This bill amends the Lacey Act to legislatively list three species of Asian carp as injurious wildlife. A listing under the Lacey Act would prohibit the interstate transport and importation of these fish.

Great Lakes Collaboration Implementation Act (H.R 1350/S. 791): The Great Lakes Regional Collaboration Implementation Act makes many of the necessary legislative changes to implement the policy recommendations made by the Collaboration strategy addressing aquatic invasive species, habitat and species, toxic pollution, and many other issues.

Recreational Boating Act (H.R. 2550/S. 2067): Amends the Clean Water Act to redefine the term "pollutant" to exclude any deck runoff from a recreational vessel, any engine cooling water, gray water, bilge water effluent from properly functioning recreational marine engine, laundry, shower, and galley sink wastes from a recreational vessel, or any other discharge incidental to the normal operation of a recreational vessel.

Water Resources and Development Act (H.R. 1495): This legislation directs the U.S. Army Corps of Engineers to undertake projects and is normally reauthorized every two years. Regarding the Great Lakes, it authorizes in-kind contributions to count towards the non-federal cost-share requirement of the John Glenn Basin program and the Great Lakes Fishery and Ecosystem Restoration Program. The bill authorizes the Corps of Engineers to convert Barrier I into a permanent facility, to complete construction of Barrier II, and to operate and maintain both dispersal barriers at full federal cost. The legislation also increases the authorization for section 206 (Restoration of the Environment for Protection of Aquatic and Riparian Ecosystems Program) and section 1135 (Environmental Modification of Projects for Improvement and Restoration of Ecosystems

Chicago Area waterways map showing location of carp barrier (Illustration courtesy of Phil Moy, University of Wisconsin Sea Grant Institute)

Program), two programs that are used frequently throughout the Great Lakes region.

Great Lakes Migratory Bird Research and Management Act (H.R.469): This bill would enable the Great Lakes Fishery Commission to investigate effects of cormorants on stocks of fish of common concern in the Great Lakes.

Great Lakes Short Sea Shipping Enhancement Act of 2007 (H.R.981/S. 1683): Amends the Internal Revenue Code to exempt from the harbor maintenance tax commercial cargo (other than bulk cargo) loaded or unloaded at U.S. ports in the Great Lakes Saint Lawrence Seaway System.

H.R.1842: Amend the Safe Drinking Water Act to prevent acid mine drainage into the Great Lakes.

Coastal and Ocean Observation System Act of 2007 (S.950/H.R. 2342): Directs the Secretary of Commerce to establish within NOAA a Coastal Ocean Observation System to support coastal and fishery management activities and an integrated national ocean observation system, including the Great Lakes. Authorizes the Secretary to: (1) designate as a unit of the System any Federal agency or non-Federal entity that operates marine sensors that collect observation data in U.S. ocean and coastal waters; and (2) coordinate such units' activities.

Water Quality Financing Act (H.R.720): Amends the Federal Water Pollution Control Act to authorize the EPA to make grants to nonprofit organizations to provide technical assistance to rural and small municipalities for wastewater infrastructure financing. Authorizes appropriations through FY2012 for: (1) state pollution control programs; and (2) watershed pilot projects. Revises: (1) eligibility requirements for grants for sewage collection systems; and (2) state water pollution control revolving fund provisions. Authorizes and increases funding for capitalization grants for state water pollution control revolving funds for FY2008-FY2012. Revises funding allocations for activities serving Indian tribes and reservations. Requires the Comptroller General to study the funding mechanisms and funding sources available to establish a Clean Water Trust Fund. Requires the EPA, in consultation with the State Department and Canadian government, to study wastewater treatment facilities that discharge into the Great Lakes and provide recommendations to improve monitoring, information sharing, and cooperation between the U.S. and Canada.

H.CON.RES.187: Expressing the sense of Congress regarding the dumping of industrial waste into the Great Lakes.

H.R.1842: To amend the Safe Drinking Water Act to prevent acid mine drainage into the Great Lakes.

H.R.1844: To amend the Federal Water Pollution Control Act to prevent acid mine drainage into the Great Lakes.

Great Lakes Water Protection Act (H.R.2907): To amend the Federal Water Pollution Control Act to establish a deadline for restricting sewage dumping into the Great Lakes and to fund programs and activities for improving wastewater discharges into the Great Lakes.

Bad Polluters Act of 2007 (H.R.3276): To amend the Internal Revenue Code of 1986 to deny refinery expensing to owners of refineries that are permitted to increase the discharge of pollutants into the Great Lakes.

Beach Protection Act of 2007 (S. 1506/H.R. 2537): Amends the Clean Water Act to include among eligible grant activities the development and implementation of programs for source tracking, sanitary surveys, and prevention efforts to address the identified sources of beach water pollution.

H.R. 2836: To authorize appropriations for the National Sea Grant College Program Act for fiscal years 2009 through 2013.

Great Lakes Pollution Prevention Act of 2007 (H.R.3360): Amends the Federal Water Pollution Control Act to prohibit either the EPA or any Great Lakes state from issuing a permit for the discharge of a pollutant into a body of water that is part of the Great Lakes without the concurrence of all such states. Authorizes a state to concur only after providing notice in the vicinity of the portion of the body of water within its boundaries and an opportunity for public comment

The Binational Executive Committee

The Binational Executive Committee (BEC) is charged with coordinating the implementation of the binational aspects of the 1987 Great Lakes Water Quality Agreement (GLWQA). The BEC is co-chaired by Environment Canada and USEPA, and includes

members of the Great Lakes states, the Province of Ontario, and other federal departments and agencies in Canada and the United States and tribes. The BEC addresses binational, basinwide issues of concern and provides strategic direction to the LaMPs, RAPs, and other Great Lakes programs such as the Binational Toxics Strategy, and the State of the Lakes Ecosystem Conference.

Great Lakes Water Quality Agreement

The Canada-United States Great Lakes Water Quality Agreement (GLWQA), first signed in 1972 and renewed in 1978, expresses the commitment of each country to restore and maintain the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem and includes a number of objectives and guidelines to achieve these goals. It reaffirms the rights and obligation of Canada and the United States under the Boundary Waters Treaty and has become a major focus of International Joint Commission (IJC) activity.

The IJC is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. It has oversight to the implementation of the GLWQA.

The 1972 Agreement set general and specific water quality objectives and called for programs to meet them. It gave priority to point-source pollution from industrial sources and sewage plants. Point-source pollution was dramatically reduced and many visible and noxious pollution problems were alleviated by regulatory programs like the Clean Water Act.

In 1978, the two governments replaced the 1972 Agreement with a new agreement. The 1978 Agreement built upon the foundation established in the earlier Agreement, as well as new information from scientists both in and out of government. It shifted the focus from conventional pollutants, such as phosphorus and bacteria, to toxic and hazardous polluting substances. Persistent toxic substances remain in the environment for very long periods, can accumulate in living organisms, and can have serious impacts on the health of wildlife and humans. Through the 1978 Agreement, the two countries adopted a policy that the discharge of any or all persistent toxic substances be virtually eliminated in the Great Lakes and international section of the St. Lawrence River. Timelines were then established for municipal and industrial pollution abatement and control programs.

The Agreement was amended in 1987 and added several new programs and initiatives to restore beneficial uses in open waters of the 5 lakes and in 43 of the most contaminated local areas in the basin. Conditions have improved significantly in a number of these local Areas of Concern (AOCs) and in the open waters of the lakes.

But now, despite considerable progress to date, new challenges are emerging while some old ones persist. What does this mean for the Agreement? Should it – or how should it – address issues like alien invasive species, population growth and urbanization, new chemical pollutants, climate change and human health.

The governments of Canada and the United States asked the IJC to seek the public's views on how well the GLWQA has worked so far and how effective it has been. In response, the IJC held public meetings in 14 Great Lakes and St. Lawrence cities in Fall 2005, wrapping up its consultations with a Web Dialogue. It also received comments from individuals and organizations by hand, mail, fax, phone, e-mail and online. More than 4000 individuals and organizations took part.

The governments of Canada and the United States conducted a year long review process involving over 350 stakeholders representing a broad cross section of the Great Lakes community. Upon completion of public comment period, a final Agreement Review Report was presented for consideration to the Binational Executive Committee of Environment Canada and USEPA in Fall 2007. Environment Canada and USEPA are considering the Final Agreement Report and will provide advice, respectively, to Foreign Affairs Canada and the U.S. Department of State. The governments will then determine next steps for the Agreement, including whether it will be revised. The mandated review of the GLWQA every six years, does not obligate the governments to amend or modify the Agreement.

For more information about the Agreement, view or download the Guide to the Great Lakes Water Quality Agreement at: www.ijc.org/glconsultations.

Great Lakes Human Health Network

A Great Lakes-wide human health network was formed by the Binational Executive Committee to maximize resources and efficiencies of scale. The USEPA's GLNPO provides staff resources to facilitate the exchange of information and expertise among health and environmental agencies. The human health network brings together experts and agencies from throughout the basin to share information and provide technical assistance on human health issues for inclusion in the LaMP. Currently, the Network has representative from six federal government agencies, five tribal government agencies, eleven state and provincial government agencies, and one county government agency. The Network anticipates that the membership will continue to grow as the Network becomes more widely known. Current information on the Network and its work may be found at www.epa.gov/glnpo/health.html.

The Great Lakes Fishery Commission

The Great Lakes Fishery Commission (GLFC) is a critical partner in achieving a balanced and healthy fish community in Lake Michigan, both in terms of controlling exotic species and rehabilitating native species in the lake. GLFC has adopted and implemented an integrated management of sea lamprey (IMSL) approach to control sea lamprey in the Great Lakes. The IMSL process involves using a variety of control methods instead of relying solely on chemicals. For example, GLFC is reducing the minimum lethal concentrations of chemicals used to kill larval sea lampreys in order to protect young lake sturgeon and is scheduling chemical treatments later in the summer to reduce the effects on young lake sturgeon. GLFC has reduced chemical use by 50 percent compared to the amounts used in the 1990s.

Great Lakes Legislative Caucus

State lawmakers from the eight states and two Canadian provinces that surround the Great Lakes have formed a caucus to coordinate legislative action on Great Lakes issues. The group, comprised of lawmakers from the 10 states and provincial Legislatures, will serve as a clearinghouse for information, policies and coordination on issues such as beach closings, water diversion, and invasive species. The caucus focused its activities around aquatic nuisance species and the Great Lakes Charter Annex.

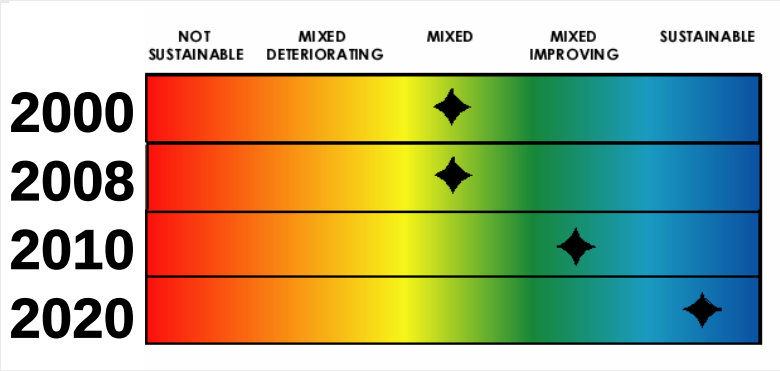
Subgoal 11

Do we have enough information, data, understanding, and indicators to inform the decision-making process?

What is our target for sustainability?

A five year cycle of monitoring and reporting is routinely published on line, in the LaMP, utilized by the Lake Michigan Monitoring Coordinating Council (LMMCC) and the subject of conferences.

Lake Michigan Target Dates for Sustainability



Why is this important?

Accurate information is critical for making informed decisions about Lake Michigan ecosystem management. Legacy or existing systems for monitoring are planned and funded separately and are not formally tied to research. Further, data are often incompatible across agencies and organizations, making it difficult to identify trends.

What is the current status?

- Positive movement was achieved by not only the collaborative FY 2005 intensive monitoring, but also the attention to the issue as one of the Great Lakes Regional Collaboration issues.

What are the major challenges?

- Data remains incompatible across organizations, reducing the value of this asset
- Time lag from sample collecting through analysis to interpretation
- Compare the data gathered from the 1995 Lake Michigan Mass Balance samplings with the 2005 year of intensive monitoring data to determine if trends exist
- More monitoring and research needs on cladophora, botulism, and nearshore issues
- There is inadequate information for some of the SOLEC indicators

What are the next steps?

- Report on Lake Michigan nearshore and food web issues for Great Lakes Regional Research Information Network
- Review monitoring and research to identify LaMP pollutants and trends to determine if LaMP pollutants list needs to be changed
- Complete, analyze, and publish coordinated monitoring results for the lake intensive monitoring year 2005
- Ensure Lake Michigan models will be documented further, and additional scenarios simulated with results shared through the LaMP and in other ways
- Assist coordination for the intensive year and the national coastal assessment year monitoring programs for 2010
- Use 2008 Lake Michigan Pilot funding, for sampling and analysis, to refine monitoring plans
- Utilize FY05 and other monitoring data to aid in adaptive management review of LaMP Pollutant List (See page 11-2 and Appendix A for more information)

What are some tools for addressing the challenges?

- Lake Michigan Online GIS
- Communicating Ecological Indicators
- Permit Data on the Web

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

- Access to Information about the Great Lakes
- Research/Educational Opportunities

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

What are the next steps for adaptive management review of the LaMP pollutant list?

- Conforming to or deciding not to conform to the NMN definitions of "shallow nearshore" (0 to 30 meters depth), "medium nearshore" (30 to 80 meters depth), and "off shore" (greater than 80 meters depth) for pollutant categorization. Conforming to the NMN would eliminate the first scenario which relied on the Great Lakes Water Quality Guidance definition of "open waters" in 40 CFR 132.2 to categorize pollutants.
- Using the spreadsheet, created from state water quality and federal monitoring programs for the Lake Michigan Pilot to summarize existing monitoring, to identify what is monitored where in the Lake Michigan Basin.
- Updating Table A-5 in the 2004 Appendix A to show where potential watch list pollutants have been detected. With the summary of monitoring programs, we will be better able to determine whether these substances are monitored in Lake Michigan.
- Comparing detected chemicals to state water quality standards and water quality criteria (i.e., do they exist?) and toxicological information. As an example of the latter, there was a talk at the Surface Water Monitoring and Standards 2008 conference regarding use of TSCA and FIFRA data by States when IRIS doesn't include data for a particular chemical.
- Decide whether the criteria to identify a "watch list" pollutant should include "potential to impact the Lake Michigan ecosystem" or "potential to impact Lake Michigan.

Background

LaMP collaborators identified the need for coordinated collaboration in 1998 and sponsored a lake basin monitoring inventory and the formation of the Lake Michigan Monitoring Coordinating Council (LMMCC). The LMMCC enabled the 2005 Intensive Year of Monitoring as follow up to the 1995 Lake Michigan Mass Balance Monitoring. In 2005, the LaMP Technical Committees also conducted a review of the State of the Lakes Ecosystem Conference indicators to determine the appropriateness for Lake Michigan and to identify any gaps. Work on these issues are in alignment with reviews at the national level conducted by the President's U.S. Commission on Ocean Policy and the Great Lakes Regional Collaboration (GLRC) Strategy Report on indicators and monitoring (www.glrc.us). Highlights and excerpts follow.

The U.S. Commission on Ocean Policy (www.oceancommission.gov) highlighted the need for "unbiased, credible and up to-date scientific information" to properly manage the human activities that effect the nation's oceans coasts and Great Lakes. The Commission, which presented its findings in 2004, found that new scientific findings demonstrate the complexity and interconnectedness of natural systems and that management approaches have not been updated to reflect this complexity with responsibilities remaining dispersed among a confusing array of agencies at the federal, state, and local levels. Managers, decision makers, and the public require timely access to reliable data and solid scientific information that have been translated into meaningful products. The Commission urged Congress to double the federal research budget over the next five years and to fund and adopt an integrated observing system on a regional basis.

The GLRC found that the volume of data collected for the Great Lakes and their tributary watersheds has expanded considerably in recent years, coinciding with an increase in the complexity of issues that need to be addressed. The current lack of accessible, integrated information management systems limits decision-making abilities and application of adaptive management principles for the protection and restoration of ecological resources. Adaptive management requires one to identify priority issues, gather information, establish metrics, evaluate options, implement actions, track progress, reevaluate actions based on observed responses, communicate results and adjust both management approaches and monitoring activities. Although such capabilities are advancing within the Great Lakes basin, they exist only in piecemeal fashion and have not been fully integrated for the comprehensive management of the Lakes. To further complicate matters, decisions made on one issue often affect other issues. Observing systems, monitoring programs, indicators, research, modeling and analysis, information management and communication must therefore be integrated into a holistic decision-making process.

- **Observing systems**, including sensors, stations, networks and field data collection are the primary means for gathering information on the chemical, biological and physical characteristics of the Great Lakes ecosystem.
- **Monitoring Programs** use these observations to take the pulse of the Great Lakes, assess natural variability, drive ecosystem forecasting models, and assess the progress of restorations efforts. Current monitoring challenges include: incomplete inventories of federal, state/provincial and municipal observation and monitoring

Lake Michigan Groundwater Pilot Study

The U.S. Geological Survey is conducting a pilot study in the Great Lakes Basin for a national initiative to assess water availability and use. In this study, key indicators for assessing water availability are being identified and refined. The pilot study also aims to provide scientific information desired by the Great Lakes States in development and refinement of water policies. Ground-water availability in the Great Lakes Basin is being quantified through regional assessments of recharge and storage, estimates of baseflow, and assessments of ground-water data collection. A ground-water-flow model is being developed for the contributing area to Lake Michigan to demonstrate the use of a large regional model to address water-availability questions. In the Great Lakes Basin; however, many water-availability issues are local, and the regional model may not be able to address these issues directly. Modeling techniques to address ground-water/surface-water interaction and local water availability issues will be refined and tested in this project. The ground-water model is an important component of the study because it provides a framework for the system, allows for estimation of indicators that include ground-water flux, and links flow processes to field data.

More information is available at http://acwi.gov/monitoring/network/

The Lake Michigan Toolbox
Lake Michigan Online GIS

Lake Michigan Online Atlas

The Lake Michigan Online Atlas provides Internet access to a number of information resources related to the Lake Michigan basin. Reference maps offer an overview of the region. Computer-compatible data layers can be downloaded for use in a geographic information system (GIS). Hyperlinks and contact information improve access to regional resources. And an online mapping tool allows internet users to explore data and create custom maps using a web browser.

More information is available at http://mapserver.glc.org/website/atlas/viewer.htm.

Great Lakes Fishery Commission GIS

The Great Lakes Fishery Commission is developing an aquatic atlas in GIS format that pulls together data from the Lake Michigan Mass Balance studies, historical sediment surveys, coastal wetland data as well as dam databases to facilitate a holistic approach to managing the Great Lakes basin. These layers of aquatic habitat information will complement the current on-line atlas work of the Great Lakes Commission.

More information is available at www.glfc.org/glgis.

Openlands and Center for Neighborhood Technology

Openlands and the Center for Neighborhood (CNT) technology are updating a website that details the green infrastructure for the greater Chicago region. In the first phase of the project, Openlands and CNT collected 170 layers of valuable data on wetlands, floodplains, rivers, protected open space, threatened and endangered species, greenways, trails and soils. The website has been utilized as a planning tool for creating linkages between existing protected lands and for identifying opportunities for natural resource protection and restoration. Phase II will improve the existing website with new and updated information and expand the project's geographic reach by adding data layers for 5 new counties. Upon completion of Phase II, the website will be interactive and allow users to create customized maps of specific geographic areas with the data layers which are most significant to them.

More information is available at: www.greenmapping.org.

activities; insufficient spatial density of basic observations across the system; incomplete coverage over varying time scales (real-time to historic).

- **Goals or end point examples** were developed by the Great Lakes governors and adopted by the GLRC. The LaMP goals were set through a stakeholder process in 1998 and adopted by the LaMP management committee (See page i-2 for LaMP goals).
- **Indicators** provide information on the state of the Great Lakes and progress toward achieving goals. Continued efforts are needed to ensure the viability of an informative and scientifically-based set of indicators (e.g., the State of the Lakes Ecosystem Conference (SOLEC) indicator suite) that are useful for management decisions and to inform the public. The SOLEC indicator suite has been refined over the last decade to be comprehensive yet practical and actionable. In addition, indicators should be used in relation to realistic "end points" or desired results that are accepted by most stakeholders. When identifying end points, stakeholders must recognize that variability is the norm in natural systems, therefore, many targets and goals should not be expressed as discrete numbers but rather as ranges of desired, natural levels (See LaMP 2000, Chapter 3).

- **Research** and observations have traditionally been focused on single issues. This focus must transition to an ecosystem approach with greater emphasis on predictive forecasting and adaptive management. Research should be directed towards improving the understanding of natural fluctuations and interactions of ecosystem

components. Improvements in predictive capabilities are needed, particularly regarding the impacts of chemical, biological and physical changes on ecosystem structure and function. Development of such capabilities requires a comprehensive research coordination strategy across partnering institutions.

- **Information produced by research and observations** must be made readily available to managers, decision-makers and the public. This will require information integration, management and communication. The LaMP sponsors the Lake Michigan Forum's State of the Lake Michigan Conference every two years, the LMMCC work and the LaMP document itself to inform managers and the public of current status and trends.

  Various methods are used to communicate information to those that require it, but coordination needs strengthening for the sheer breadth of information collected over the region. The lack of a coordinated message can make it difficult for audience groups to interpret and understand information. The audiences that require information are also diverse, requiring that complex information needs to be sufficiently repackaged to meet their needs. Some information, such as lake conditions and beach closings, requires rapid delivery. In addition, two-way communication needs to be promoted so that user needs are conveyed back to those producing the information. A comprehensive, two-way communication strategy has not been developed to address these needs.

Lake Michigan Serves as National Monitoring Pilot

Lake Michigan was selected as one of three pilot studies across the nation to test and improve upon the design of the National Monitoring Network (NMN) for U.S. Coastal Waters and Their Tributaries. The other two pilot studies were the Delaware River and San Francisco Bay. The pilot report provides background information, discusses management issues, an inventory of monitoring under resource components of the NMN, a gap analysis and projected costs to implement the NMN for Lake Michigan.

The Great Lakes and Lake Michigan in particular, are in a period of changing conditions due to a wide spectrum of watershed stressors from toxic pollutants, nonpoint source pollution and water level fluctuations to invasive species disrupting the food web and ecosystem and rampant developmental pressures throughout the region. Thus, unique needs exist in the region; however, consistent monitoring and assessment approaches with other regions of the nation may be necessary to address these issues under a common framework.

With these issues at the forefront, partners working on or around Lake Michigan - including federal and state agencies and academic institutions - have established a robust framework of research and collaborative monitoring efforts. The Lake Michigan Pilot Study will enable partners in the basin to better address these stressors and management issues. It also helped to point out the level to which Lake Michigan Lakewide Management Plan (LaMP)-expressed needs are being met. Results of the Study will serve as a catalyst for assessing and improving upon observing, monitoring and reporting needs for the above-mentioned and other rapidly emerging ecological problems both in the Lake Michigan basin and in the Great Lakes region. Moreover, the explicit linkage between upland, coastal and offshore waters necessitates a more coordinated monitoring network.

The Lake Michigan Pilot Study is also as an excellent surrogate for most coastal marine environments, with its focus on integrating observations of complex physical, chemical and biological processes and development of enhanced monitoring strategies. The Lake Michigan Pilot Study will ultimately generate a monitoring design that could be applied to the other four Great Lakes to better assess the ecological status of the entire Great Lakes basin, while complementary with monitoring parameters in other coastal regions of the United States through its cooperation in the National Monitoring Network for U.S. Coastal Waters and Their Tributaries.

Summary and Major Conclusions from Pilot Study

In spite of their large size, the Great Lakes are sensitive to the effects of a wide range of pollutants from permitted discharge, urban and agricultural run-off, leachate and ground water. The large surface area of the lakes also makes them vulnerable to direct atmospheric pollutants, transported by weather that falls with rain snow or dust from extreme distances.

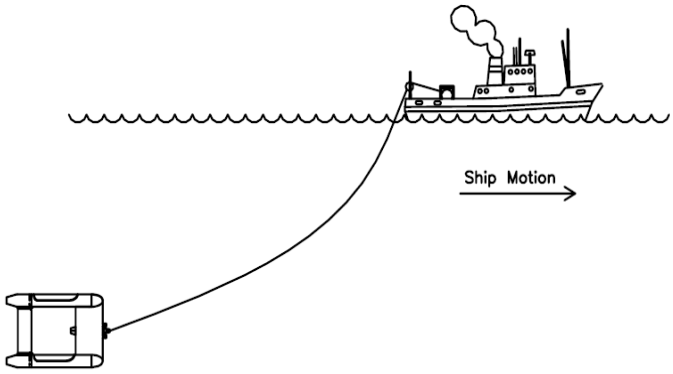
New Nearshore Monitoring Tool

In 2008, the EPA Great Lakes National Program Office will begin additional monitoring nearshore and offshore waters using a sensor package towed behind the R/V Lake Guardian. The main work to be accomplished in the first year is learning the capabilities of the sensor package and beginning the development of a monitoring program that will address the lack of long-term data on the nearshore areas of the Great Lakes. The towed sensor package, the Triaxus, will include: a CTD which will measure temperature, depth, conductivity and dissolved oxygen; a laser optical plankton counter which counts and sizes particles in the Mysis through zooplankton ranges; two fluorometers which will provide information on the main algae groups and on the "health" of the algae; a nitrate analyzer, which can be configured for other chemicals also, will measure this nutrient and identify river plumes and other nutrient sources; finally, sidescan sonar will be used to identify and map underwater habitat and other underwater structures and/or find objects on the lake bottom.

Nearshore efforts will begin by towing a Triaxus at the 20 or 30 meter depth contours around the lakes, beginning with Lake Michigan in 2008. The sensors will help to provide a synoptic characterization of basic biological, physical and chemical aspects of the nearshore area of each lake.

In addition to the nearshore program, the Triaxus will be used to enhance existing offshore monitoring program by providing data as the R/V Lake Guardian travels from one sampling site to another. This information will help us to expand understanding of the variability in plankton, algae and chemistry throughout the lakes. The towed sensors are similar to sensors used on anchored buoys around the Great Lakes. The information from tows near the buoys could be used to determine what water mass is represented by the buoy sensors. Finally, the towed sensor information will be used to provide "ground truth" data for satellite image analyses for chlorophyll and other measurements.

Triaxus being lowered into the water



Triaxus in use
Source: USEPA

Outflows from the Great Lakes are relatively small (less than 1 per cent per year) in. comparison with the total volume of water. Pollutants that enter the lakes are retained and recycled in the system and can become more concentrated with time.

Although part of a single system, each lake is different. Because of the large size of the watershed, physical characteristics such as climate, soils and topography vary across the basin. To the north, the climate is cold and the terrain is dominated by granite bedrock called the Canadian or Laurentian shield consisting of Pre-Cambrian rocks under a generally thin layer of acidic soils. Conifers dominate the northern forest. In the southern areas, the climate is warmer with deeper soils developed on a variety of sediments deposited by glaciers and as lakes, beaches, outwash plains, wetlands and streams. In addition, there are over 30,000 islands and very large bays (Green Bay, Grand Traverse Bay, Saginaw Bay, Georgian Bay) that are also unique in how pollutants arc processed in the sub-bay system thus requiring special or additional sampling.

As receiving bodies of tributaries which are, in turn, receiving bodies for industrial and agricultural discharges, the lakes also serve as drinking water for 40 million people. As the only fresh coast of the United States, the lakes provide recreation through fishing, boating, and the world's largest collection of freshwater sand dunes. Biological monitoring is important not only from an ecosystem perspective but also for public health. Monitoring and research for the last six years has begun to show a great contrast between the near shore and the open lake. This also varies by lake but we see almost two

The Lake Michigan Toolbox
Communicating Ecological Indicators

Ecological indicators need to be made more understandable to the public (including decision makers). Methods for articulating environmental values to make the connection between indicators and what the public (individuals) value about the environment should be considered.

Translating the indicators of regional ecological condition used by USEPA into common language for communication with public and decision-making audiences is critical.

A study by researchers from Clark University, Pacific Southwest Research Station of the USDA Forest Service, University of Tennessee-Knoxville, Oak Ridge National Laboratory, USEPA, and Vanderbilt University revealed that people did not want to know what these indicators measured, or how measurements were performed. Rather, respondents wanted to know what such measurements can tell them about environmental conditions. Most positively received were descriptions of the kinds of information that various *combinations* of indicators provide about broad ecological conditions. Descriptions that respondents found most appealing contained general reference to both the set of indicators from which the information was drawn and aspects of the environment valued by society to which the information could be applied. These findings can assist with future efforts to communicate scientific information to nontechnical audiences, and to represent societal values in ecological programs by improving scientist-public communication.

More information about this issue can be found in a paper titled "Communicating Ecological Indicators to Decision Makers and the Public" at: http://www.ecologyandsociety.org/vol5/iss1/art19/.

separate systems within each lake basin providing another monitoring complexity.

Monitoring currently being conducted does not fully meet the Network design in any of the resource component groups. In some components (e.g., Rivers, Atmospheric Deposition) the current monitoring locations are similar to the proposed design. In other resource components (e.g., Beaches) the constituents proposed for the Network design are currently being sampled. In other resource component groups (e.g., Groundwater, Atmospheric Deposition, Rivers) the temporal approach proposed in the design is for the most part being met Monitoring protocols being used across the resource components are comparable across the various monitoring entities in some cases but not in all cases; and these protocols do not in all cases meet the Network design requirements. QA/QC activities across most of the resource component groups meet the NMN design requirements; however, this is not true for all of them. Data management approaches are not fully integrated for any of the resource components; however, for some components (i.e. Beaches, Atmospheric Deposition, Off Shore) coordinating data management will be easier than for others (i.e. Near Shore, Wetlands). The cost of filling the monitoring gaps varies considerably across the various resource components, from several hundred thousand dollars to close to ten million dollars. The total monitoring gap for the Lake Michigan Pilot Study is in the neighborhood of $25 million.

Finally, even if the NMN is implemented as designed, we still would need to compare the data to benchmarks before we could identify the condition of the resource and know whether additional protective measures are needed.

Federal and state agencies monitor contaminants in Lake Michigan's offshore and shallow near shore waters. No monitoring programs were identified in the medium near shore as defined by the NMN for Lake Michigan. States monitor Lake Michigan watershed water quality in rivers and specific contaminants such as those bioaccumulated in predator fish in order to prepare fish consumption and advice and to prepare Clean Water Act Consolidated Section 303(d)/305(b) reports. The Green Bay and Milwaukee wastewater utilities monitor nutrients and/or pathogens.

Beaches. Strategic monitoring that involves spatial, temporal, and source-tracking methods is needed. Strategic monitoring in conjunction with a thorough knowledge of the beach and its watershed can lead to improvements in beach quality. However, to

develop more progressive monitoring strategies, limited funding for routine monitoring programs may need to be redirected towards start-up costs associated with improved technology.

Wetlands. Prior to the establishment of the GLRC and the release of the U.S. EPA's guidelines for development of a wetland monitoring program in 2006, few coordinated monitoring efforts had been initiated for coastal wetlands. Historically, each agency and organization has had disparate goals and monitoring techniques, and no organization has overarching responsibility for data management. This has lead to significant fragmentation of biological, chemical, physical and landscape information across federal, state, provincial, tribal and local agencies. It is clear that glaring gaps exist in wetland monitoring. With the establishment of new guidelines and reiteration of the importance of wetland monitoring, several new efforts have begun to allow better monitoring of wetland resources.

The MDEQ and WDNR are completing Rapid Assessment Methods (RAMs) for their states, and both Indiana and Illinois are considering utilizing the well established Ohio RAM, since their states are in similar ecoregions. These programs correspond to the Level II analysis recommended by the U.S. EPA, RAMs, however, are likely to classify any coastal wetland resource as a very high quality wetland, thus, these protocols are best utilized at inland wetlands. A more thorough analysis may be conducted in coastal wetlands using a Tier III analysis. In addition, the Great Lakes Coastal Wetlands Consortium (GLCWC) released a complete wetland assessment protocols corresponding to the Tier I. It recommended monitoring parameters. The protocols cover assessment of wetland chemistry and landscape features, as well as biological indicators for fish, macroinvertebrates, vegetation, birds, and amphibians. With the establishment of these protocols, it is hoped that coastal wetland monitoring data will be less fragmented across the basin and more easily shared among agencies and organizations.

Currently, the largest Lake Michigan monitoring effort is organized through Bird Studies Canada's Marsh Monitoring Program. This program sends volunteers in to the field to collect data on wetland bird and amphibian species. Data from the monitoring is compiled into reports every five years. A second major monitoring effort includes the ongoing National Wetlands Inventory (NWI) program conducted by the U.S. Fish and Wildlife Service (USFWS). This program maps wetlands using remote sensing and follows the status and trends of wetland loss and gain throughout the nation. Minor monitoring efforts include the Natural Resources Conservation Service's (NRCS) National Resource Inventory, fish collection by the State of Michigan's Department of Natural Resources (MDNR), Fisheries Division, wetland status and trends analysis and wetland inventory mapping by the Wisconsin Department of Natural Resources (WDNR) and a number of smaller volunteer or local efforts. More information is available at www.glc.org.

Embayments. The NMN design recommends sampling using a probability based design (illustrated in Figure 3-6 on page 49 of the Network design report). The NMN protocol defined 87 embayments within the Great Lakes basin. Fifteen of these are along the Lake Michigan shoreline. The Network design report lists organic and inorganic contaminants, biological, sediments, and physical setting measurement for this resource component, for which the recommended monitoring frequency is once per year. At this point, there is no

The Lake Michigan Toolbox
Permit Data on the Web

Envirofacts (http://www.epa.gov/enviro/) is a single point of access to select U.S. EPA environmental data. This website provides access to several EPA databases to provide you with information about environmental activities that may affect air, water, and land anywhere in the United States. With Envirofacts, you can learn more about these environmental activities in your area or you can generate maps of environmental information.

The Permit Compliance System (PCS) (http://www.epa.gov/enviro/html/pcs/) provides information on companies which have been issued permits to discharge waste water. You can review information on when a permit was issued and expires, how much the company is permitted to discharge, and the actual monitoring data showing what the company has discharged.

STORET (short for STOrage and RETrieval) (http://www.epa.gov/storet/) is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others.

comprehensive monitoring program focused specifically on embayments in the basin. Seven of 15 Lake Michigan embayments are not currently a part of any monitoring program. State fish chemical and sediment monitoring is incomplete. However, various elements are sampled within a number of embayments as part of some other monitoring program, as fallows:

- Indiana Harbor: Mussel Watch, IDEM water sampling, AOC sampling
- Calumet Harbor: Mussel Watch, TEPA south shore lake survey, AOC sampling
- Milwaukee Harbor Mussel Watch, MMSD, WDNR sampling, AOC sampling
- Grand Traverse embayment at Leelanau State Park: Mussel Watch
- Little Traverse Bay; Tip of the Mitt Watershed Council's water quality studies (ongoing monitoring?)
- Little Bay de Noc: MDNR fishery
- Big Bay de Noc: MDNR fishery

Off Shore. Currently, U.S. EPA, Great Lakes National Program Office and NOAA Great Lakes Environmental Research Laboratory are the entities with long-term monitoring programs on Lake Michigan. U.S. EPA visits eleven or more offshore sites twice per year collecting water chemistry and biological data as part of its mandate based on the Great Lakes Water Quality Agreement and the Clean Water Act. NOAA visits one site on a more frequent basis throughout each year. These monitoring programs complement each other, giving both wide spatial coverage and frequent temporal coverage.

Elsewhere, the NMN design for monitoring is based on a randomized grid. An exception is made for this subcomponent. Targeted sampling of the Great Lakes will use fixed sites and continue historical monitoring efforts in the offshore waters conducted under the Great Lakes Water Quality Agreement and the International Joint Commission. Sampling locations for existing monitoring networks on the Great Lakes, dating from the early 1980's are based on alternative criteria. In the offshore area, water mass movement appears to be sufficient to "randomize" the sampling resource being sampled. As part of the original Great Lakes Environmental Monitoring and Assessment Program (EMAP) in the late 1980's and early 1990's, a comparison study of the existing deterministic sample sites and a randomized grid was performed. The results of that comparison were that very little difference existed between the water chemistry values obtained from either design, with the exception that some randomized grid sites were placed at locations not representative of the offshore area.

Recommendation: Maintain the current offshore programs for both agencies, and supplement the temporally more intense NOAA program with at least one more station in the offshore area located near Milwaukee, WI.

Rivers and AOCs. All 20 of the river sites being proposed for the Lake Michigan portion of the national monitoring network currently have streamflow gauging stations on them. Fifteen sites have some ongoing water quality monitoring. None of the sites has the complete proposed constituent monitoring data set or is monitored at the proposed frequency. All stream gauging is being done according to proposed protocols. All water quality monitoring is being done according to protocols approved by either USGS or U.S. EPA for the constituent of interest. Three additional rivers (Grand Calumet, Sheboygan, and Manitowoc) are also proposed for addition to the NMN design. Each of these rivers has ongoing streamflow and water quality monitoring. These 20 proposed network sites will only provide coverage for about 71% of the river inflow to Lake Michigan. While we do not feel this is adequate coverage, in and of itself, we believe that when coordinated with monitoring at other river sites in the basin it is possible to determine if short-term added monitoring is needed to supplement the network.

Additionally, regarding Great Lakes AOCs, a complete and thorough set of monitoring protocols to measure the restoration of their beneficial use impairments is currently lacking. Since most have a contaminated sediment component, the monitoring of the AOCs cannot be met by near shore or tributary river monitoring. GLNPO is working with the states to develop delisting targets for each of the AOC Beneficial Use Impairments by January 2009. These targets will inform the AOC monitoring plan.

Data Management Issues. Access to accurate and timely data by members of the scientific, management, and policy community is critical to decision making that affects Great Lakes water resources. To support this need, significant time and money has been spent collecting monitoring data

GLNPO Water Quality Surveys

The USEPA Great Lakes National Program Office's water quality surveys generally focus on the offshore waters of the lakes (water greater than 30 meters in depth, or greater than 3 miles from shore). To ensure that sampling activities are representative of lake conditions, samples are collected from multiple sites within each lake basin. The number and locations of the sites needed to obtain a representative sampling of each basin was statistically determined using historical data collected during intensive surveys of each lake. Each basin consists of several routine monitoring stations and a "master station". The master stations generally represent the deepest area of the basin and are often used to collect supplementary data for other (non-survey) purposes. The spring surveys are designed to collect water quality information during unstratified (isothermal) conditions of the lake, and the summer surveys are designed to monitor the Lakes during stratified conditions. As a result, the number of depths sampled during the summer is greater than the number of depths sampled during the spring surveys.

The surveys provide data to detect and evaluate trends and annual changes in chloride, nitrate nitrogen, particulate nitrogen, silica, total phosphorus, total dissolved phosphorus, particulate phosphorus, chloride, and reactive silica.

The biology program monitors phytoplankton, zooplankton, benthic invertebrates, and chlorophyll a in the water column. Zooplankton and phytoplankton samples are collected twice per year, in spring and summer. The majority of benthos samples are collected in summer, although a small number of stations are visited in spring. Some benthos-only stations are located closer to shore.

The Peter L. Wise Lake Guardian

Maps of sampling stations can be found at: www.epa.gov/glnpo/monitoring/guard/sampling_stations.html. Chemical monitoring data are found on GLENDA at: http://www.epa.gov/greatlakes/monitoring/data_proj/glenda/index.html. Some graphs of information on water chemistry through 2006 are at: http://www.epa.gov/glnpo/monitoring/limnology/index.htm.

including physical, chemical, biological, and cultural data for the domain, These data have been, and are being collected by a variety of agencies, organizations, and institutions over space and time, and represent a significant asset in better understanding and managing the Great Lakes.

Unfortunately, much of these geographic data remain inconsistent and/or incompatible across organizations and boundaries, and subsequently are not readily available for downstream analysis. This general unavailability of data in the region can be attributed to many things including institutional barriers, security concerns, differing languages (computer and otherwise), and financial constraints, among others.

One such limiting factor is legacy systems, or "stovepipes," used to collect, store, and transfer data throughout the region. Owing to antiquated software, hardware, and/or engineering methodologies, stovepipes present a significant obstacle to sharing data by making it too expensive (In terms of time and money) to access the data. Another issue affecting the usability of monitoring data throughout the region relates to the general "discoverability" of the data. Despite the trove of data being collected, much of it remains hidden

behind firewalls or scattered across different web pages. For decision makers and resource managers who depend on timely access to information, it is critically important to make data more readily available.

Efforts toward making monitoring data more available are those concerned with the integration and normalization of data across the region. The Great Lakes Observing System (GLOS) is a forerunner in this regard, providing real-time access to Great Lakes observing and monitoring data. GLOS provides access to data on climate, meteorology, chemistry, geology, biology and human activities that affect the Great Lakes, their interconnecting waterways and the St. Lawrence River, GLOS draws data about the Great Lakes system from numerous sources, consolidates it, and makes it available via the Internet. This resource helps to meet the needs of resource managers, researchers, educators, commercial shippers, recreational boaters, beach users and homeland security personnel.

The Middleton Data Center (MDC) is another example of a multi-jurisdictional data aggregation and integration effort. MDC, co-located with the USGS Wisconsin Water Science Center, is involved in several projects to develop better coordinated dam management systems. One of these projects is a cooperative effort with Milwaukee Metropolitan Sewerage District (MMSD) to aggregate disparate data from universities and local, state, and federal agencies affecting areas within the MMSD's purview. The MDC is also involved with the development of water quality and quantity databases, leveraging XML-based mechanisms (i.e. Web Services) for sharing data across the region. These MDC projects provide positive potential and a baseline for further collaborative data management activities throughout the Lake Michigan watershed.

Another important development in the arena of sharing monitoring data through the region is the advent of metadata-driven, web-based data clearinghouse nodes. These clearinghouses make disparate data infinitely more discoverable through keyword, thematic, and spatially-based queries that allow users to readily find and acquire data.

At the national level, several such portals have sprung up over the past several years. In the U.S. these include Geospatial One Stop (GOS: http://geodata.gov), USGS' National Map (http://nationalmap.gov) and NASA's Global Change Master Directory (GCMD: http://gcmd.nasa.gov). On the Canadian side, there are the GeoConnections (GeoConnections: (http://www.geoconnections.org) and GeoGratis (GeoGratis: http://geogratis.cgdi.gc.ca) clearinghouses. Regionally, the Great Lakes Information Network (GLIN) is providing similar functionality through its GLIN GIS (http://gis.glin.net). The GLIN GIS provides user and organizations the ability to publish their Great Lakes-specific datasets, and makes these data available in a variety of formats and Web Services.

Lake Michigan Monitoring Coordinating Council

The Lake Michigan Monitoring Coordinating Council was established to enhance coordination, communication, and data management among agencies and other organizations that conduct or benefit from monitoring efforts in the Lake Michigan basin in the interest of supporting the Lake Michigan LaMP.

The Council has members representing federal, state, tribal, and local governments, nonprofit watershed groups, and other environmental organizations, educational entities, and the regulated community. The Council meets twice each year in locations throughout the watershed. Council meetings, biennial conferences, and feedback from constituents shape the Council's work plan and activities.

The Council framework has been developed to increase coordination between appropriate monitoring entities, allow the development of a strategic plan for monitoring, and add value to the individual efforts of the Council's member organizations. The framework takes advantage of the logical interactions between the various resource-based monitoring entities and other affected stakeholder groups.

The working groups formed under this framework will build on the efforts to coordinate monitoring within individual resources by groups such as the Lakewide Management Plan Committees, the Wisconsin Groundwater Coordinating Council, and the Great Lakes Fishery Commission. Each of these resource-based working groups will coordinate existing monitoring networks around several common considerations: monitoring objectives; spatial, temporal and parameter network design; methods

comparability; quality assurance and control planning; database sharing; and data analysis approaches. More information is available at http://wi.water.usgs.gov/lmmcc/.

Great Lakes National Parks Monitoring

Two national parks in the Lake Michigan basin are participating in a Great Lakes Network made up of 9 national park units from four states in the Great Lakes region. At the southern end of the Lake, work is progressing on assessing the extent of invasive plant species in interdunal wetlands of the Indiana Dunes National Lakeshore and State Parks. These special wetlands are highly vulnerable to invasives such as purple loosestrife and Phragmites. Park staffs are working with The Nature Conservancy, Save the Dunes Council, and Shirley Heinze Trust Fund to formulate a control program that will eliminate invasives and protect the native plant species.

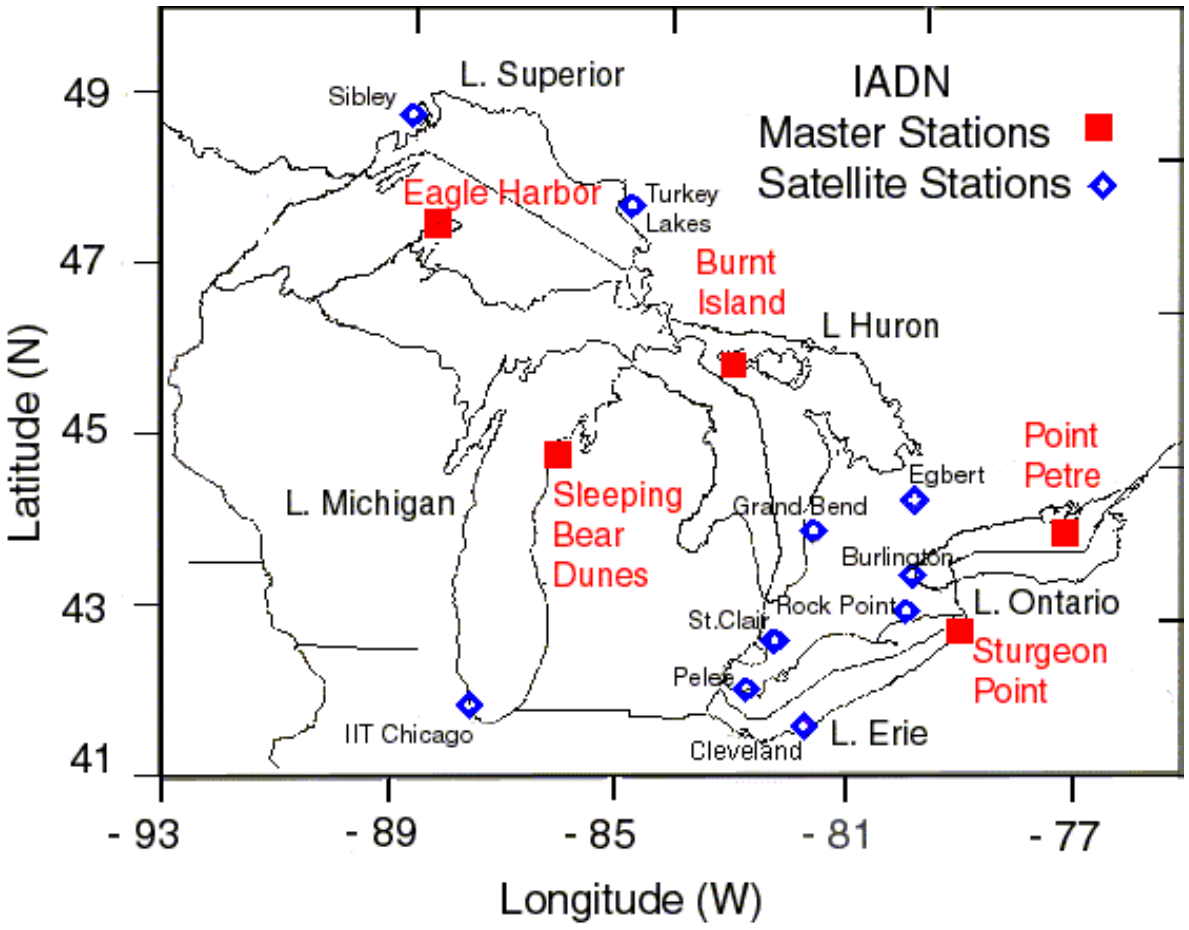
The Sleeping Bear Dunes and the Indiana Dunes National Lakeshore are working as a unit for monitoring, fostering the exchange of information and resources between parks with similar issues, reducing per park costs through multi-park studies and providing network-based expertise that would not be affordable to the parks individually. The overall purpose is to develop broadly-based scientific data on current status and long-term trends in composition, structure, and function of the parks' ecosystems.

State of the Lakes Ecosystem Conference

Additional work has been completed on the Great Lakes indicators over the past 2 years through the State of the Lakes Ecosystem Conference (SOLEC) process. The SOLEC is hosted every two years by USEPA GLNPO and Environment Canada. The next conference will be held in Niagara, Ontario in October 2008. The conferences are intended to provide a forum for exchange of information on the ecological condition of the Great Lakes and surrounding lands. A major goal is to bring together a large audience of government (at all levels), tribal, corporate, and not-for-profit managers to discuss problems that affect the lakes. The conferences have led to information gathering by a variety of agencies and organizations. In the year following each conference, a State of the Great Lakes Report is prepared by the governments based on the conference and public comments following the conference (www.binational.net).

Integrated Atmospheric Deposition Network

The Integrated Atmospheric Deposition Network (IADN) was created under Annex 15 of the Great Lakes Water Quality Agreement in 1990 to determine the magnitude and trends of atmospheric loadings of toxic substances to the Great Lakes. IADN is operated jointly by the USEPA-GLNPO and Environment Canada. Five master stations (1 per Lake) are located in rural areas within one kilometer of the shore to represent background conditions. There are also 10 satellite stations that provide additional detail on levels of toxics in the air around the Lakes. USEPA operates 5 stations: the master stations on Lakes Superior, Michigan, and Erie, as well as two satellite stations in Cleveland and Chicago,



IADN Master and Satellite Stations
Source: USEPA

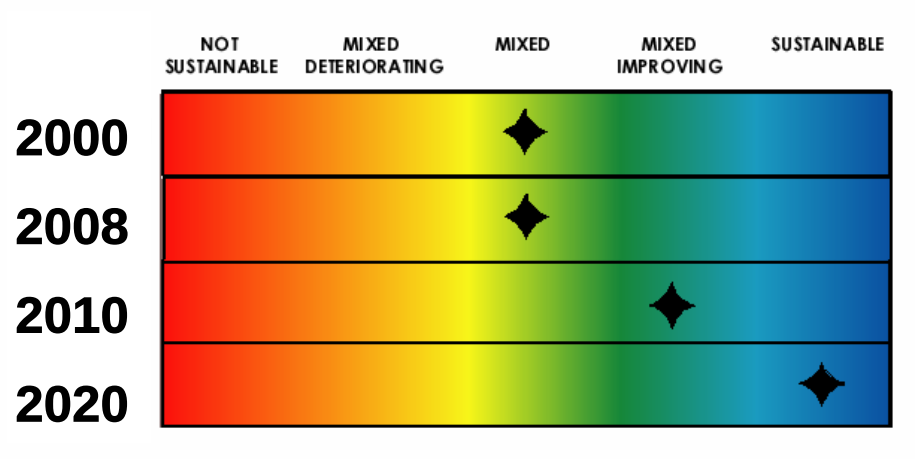
People on beach at Warren Dunes, Indiana
US Environmental Protection Agency, Karen Holland

Subgoal 12
What is the Status of Lake Michigan Subwatersheds?

What is our target for sustainability?

Watershed boundaries are routinely used as the unit for planning and integrating human activities and achieving an environmental, economic, and social balance.

Lake Michigan Target Dates for Sustainability



What is the current status?

While possessing globally significant biodiversity resources, all but three of the 33 major watersheds within the Lake Michigan basin have some river and stream reaches listed as impaired.

What are the major challenges?

- Climate Change: USEPA Office of Water is working to adapt more water programs to climate change challenges at the watershed scale
- Building better understanding of the watershed approach
- Working with local communities to use watersheds as a basis for environmental decision making across political boundaries
- Providing data for the 1,467 12-digit subwatersheds.

What are the next steps?

- Make watershed fact sheets available to state, regional and watershed groups
- Identify information to develop restoration targets for each watershed and facilitate the process
- Provide accessible data at the 12-digit subwatershed level online
- Provide training on information access and developing a watershed plan
- Work with other watershed programs and efforts to leverage and integrate tools
- Utilize the Watershed Academy to expand awareness of the watershed fact sheets

Indicators (State of the Lakes Ecosystem Indicators by Number)

- Indicator # 7002 - Land Cover/Land Conversion - Lake Michigan Status: Mixed; Trend: Undetermined
- The Nature Conservancy Biodiversity Areas and Species Protected
- Stream Reaches Listed as Impaired
- Number of Total Maximum Daily Loads Completed
- Number of projects supported through the 319 grants program with successful follow through

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Watershed Management

The first 11 chapters of the LaMP look at specific environmental goals and issues. This chapter focuses on bringing much of that information together on a graphic and watershed basis.

Lake Michigan's 33 Tributary Watersheds

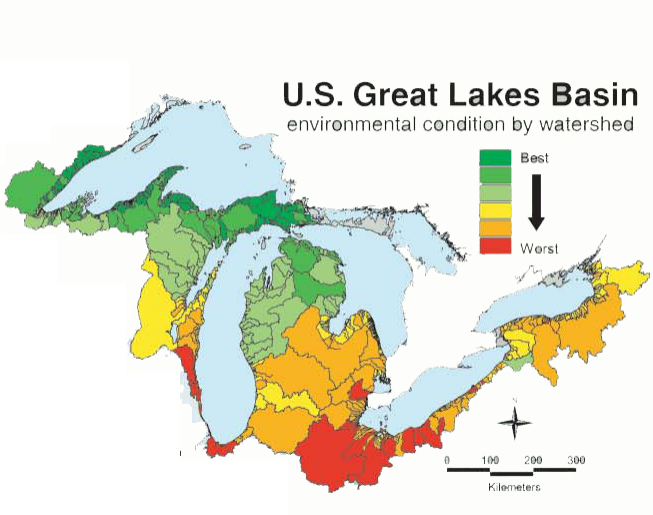
The first step in advancing work watershed by watershed is to provide available data in a watershed-based format. Lake Michigan has 33 tributary watersheds at the 8-digit hydrologic unit code (HUC) as defined by the U.S. Geological Survey (USGS). Wisconsin manages its watersheds through watershed management units that do not always correspond with USGS HUCs. Instead, they follow a combination of watershed and political boundaries. Michigan's watershed management boundaries also differ and generally use smaller watersheds.

Although a decade of effort has resulted in a general awareness of the watershed approach within EPA, recent evaluations show substantial gaps in implementation. The watershed approach should not be seen as merely a special initiative targeted at just a selected set of places or involving a relatively small group of EPA or state staff. Rather, it should be the fulcrum of our restoration and protection efforts, and those of our many stakeholders, private and public. Failure to fully incorporate the watershed approach into program implementation will result in failure to achieve our environmental objectives in many of our nation's waters.

Following are overviews of the 33 Lake Michigan tributary sub-watersheds as well as an overview of the Chicago Waterways system. They provide a picture of Lake Michigan divided into watersheds, showing the special and important elements present in the watershed as well as the impairments that currently exist. Also provided is an overview of the planning underway and the groups involved. We seek comments on these fact sheets as to their content and usefulness.

Actions to Address Feedback

Feedback on the watershed fact sheets from LaMP 2004 to the present indicates the need for more detailed information similar to the fact sheets at the 8 digit level. Work just completed in early 2008 by a



Scientists with the Great Lakes Environmental Indicator (GLEI) Project (glei.nrri.umn.edu) have developed a Condition Index that indicates the region's environmental condition by watershed. The index is based on 207 individual stressors* that fall into five dominant human-derived stresses to ecological condition: 1) type of land use, 2) amount of agricultural activity, 3) point sources of pollution, 4) atmospheric deposition, and 5) human population density. The stresses in each watershed were summarized and the resulting scores were distributed over a gradient from worst (red) to best (green) indicating the Environmental Condition of each coastal watershed, as depicted on the map of the U.S. Great Lakes basin. Using updated versions of appropriate databases and GIS techniques, managers can produce similar Condition Indexes for their area.
Source: New Index of Environmental Condition for Coastal Wetlands in the Great Lakes Basin, glei.nrri.umn.edu.

* The Geographic Information Retrieval and Analysis System (GIRAS) was developed in the mid 1970s to put into digital form a number of data layers which were of interest to the USGS. One of these data layers was the Hydrologic Units. The map is based on the Hydrologic Unit Maps published by the USGS Office of Water Data Coordination, together with the list descriptions and name of region, subregion, accounting units, and cataloging unit. The hydrologic units are encoded with an eight- digit number that indicates the hydrologic region (first two digits), hydrologic subregion (second two digits), accounting unit (third two digits), and cataloging unit (fourth two digits).

partnership of EPA, states and USGS makes it possible to list and map the 12 digit sub-watersheds in LaMP 2008. At this smaller sub-watershed level the number of watersheds and amount of data preclude development of fact sheets. Our next step is to investigate a digital and/or cd format and to determine what data are available. Some of the Lake Michigan states are working on or have similar efforts that need to be integrated.

Currently, a significant amount of data is available on line at www.epa.gov/surf and www.epa.gov/watershedwebcasts/live

Linking LaMP Goals to Effective Implementation: The Watershed Scale

The development of the LaMP holds great promise for achieving environmental improvement in the Lake Michigan basin, but it also offers significant challenges in terms of practicing environmental restoration and protection on this scale. One of the most significant of these challenges is the need for cross-program and cross-jurisdictional coordination. This includes coordination among the U.S. and Canada, between federal agencies, and among states, provinces, and tribes, as well as coordination across a variety of statutory authorities. Because of this, EPA has taken the approach of using existing tools, as well as developing new and innovative ones, in concert with federal, tribal, state, and local partners to achieve environmental results that are relevant to a given place. To simplify the myriad of statutes, regulations, and resources affecting the management of Lake Michigan, Chapter 9 of the LaMP presents the Lake Michigan Stakeholder Directory, a listing of the major governmental units, regulatory agencies, and other significant stakeholders that are responsible for managing some aspects of the Lake Michigan ecosystem. Each watershed fact sheet in this chapter also lists groups involved in watershed management.

Information from The Nature Conservancy

The fact sheets also provide information from the Nature Conservancy from their just released "Conservation Blueprint for the Great Lakes". Jointly funded by GLNPO, the Ontario Ministry of Natural Resources, the Gund Foundation, the Charles Stewart Mott Foundation, the Richard Ivey Foundation, and the Living Legacy Trust, the blueprint was a binational, collaborative effort to identify areas of biodiversity significance throughout the Great Lakes basin.

A total of 501 places were identified, mapped, and inventoried, and an analysis of threats to each place conducted by more than 200 scientists from federal and state/provincial agencies and private organizations. The results are impressive: the basin contains 46 species found nowhere else in the world and 279 globally rare plants, animals and natural communities in a region of boreal, mixed and deciduous forests, tallgrass prairies, wetlands, sand dunes, alvars and islands. The areas are critical to the preservation of biodiversity and represent the best opportunities to preserve species, natural communities and ecological systems. For each area, the blueprint contains information about Great Lakes species, natural communities and ecological systems; maps of where conservation is underway; summaries of current projects and strategies; information on threats to biodiversity; and, detailed descriptions of plans. The blueprint also offers actions that can be taken to protect these areas.

The Nature Conservancy is making this information available to the Great Lakes Regional Collaboration for use in Great Lakes indicator and habitat protection and restoration work. The Conservation Blueprint is available online at: http://nature.org/wherewework/northamerica/greatlakes/files/conservation_blprnt_final.pdf.

Lake Michigan Overview

- Lake Michigan, the second largest Great Lake by volume with just under 1,180 cubic miles of water, is the only Great Lake entirely within the United States.
- Approximately 118 miles wide and 307 miles long, Lake Michigan has more than 1,600 miles of shoreline.
- Averaging 279 feet in depth, the lake reaches 925 feet at its deepest point.
- It has a water surface area of 22,300 square miles. The drainage basin, approximately twice as large as the 22,300 square miles of surface water, includes portions of Illinois, Indiana, Michigan and Wisconsin.

- On average, a molecule of water will spend 100 years in Lake Michigan before exiting to Lake Huron at the Straits of Mackinac.
- The lake's northern tier is in the colder, less developed upper Great Lakes region, while its more temperate southern basin contains the Milwaukee and Chicago metropolitan areas.

Additional Lake Michigan overview information on the following pages is an excerpt from the State of the Lakes Ecosystem Report. This is followed by the fact sheets on the individual subwatersheds.

Locations of The Nature Conservancy's Areas of Biodiversity
Source: The Nature Conservancy

3.6 Lake Michigan

Assessment: The physical integrity of the Lake Michigan ecosystem is *mixed.*

"Lake Michigan is an outstanding natural resource of global significance, under stress and in need of special attention" (Lake Michigan LaMP 2000). Since the original 2000 assessment, there has been both positive and negative change in the Lake Michigan basin. Positive work includes sediment clean ups, the purchasing of large land parcels for preservation purposes, and the rebounding of terrestrial species. Some negative changes include continued pressure from invasive species on the aquatic food web and land development in the near coastal areas.

Background Summary

Lake Michigan is one of the most complex ecosystems of the Great Lakes due to its length of 307 miles (494 km). It varies from north woods forest to southern dune and swale environments. The largest collection of fresh water sand dunes in the world is a prominent feature, as are Lake Michigan's islands which are grouped into two northern archipelagoes of 19 Grand Traverse Islands and Beaver Islands. Many of the islands have suffered a loss of natural habitat due to development and are moderately degraded. Several of the Beaver Islands are part of the Michigan Islands National Wildlife Refuge providing 235 acres (95 ha) of habitat for migratory and colonial nesting birds and federally threatened plants like dwarf iris and Pitcher's thistle. There are three islands totalling 29 acres (12 ha) in the Green Bay National Wildlife Refuge that offers similar habitats. Underwater reefs in both the nearshore and offshore are thought to play an important role in Lake Michigan spawning.

Lake Michigan is the second largest Great Lake by volume and

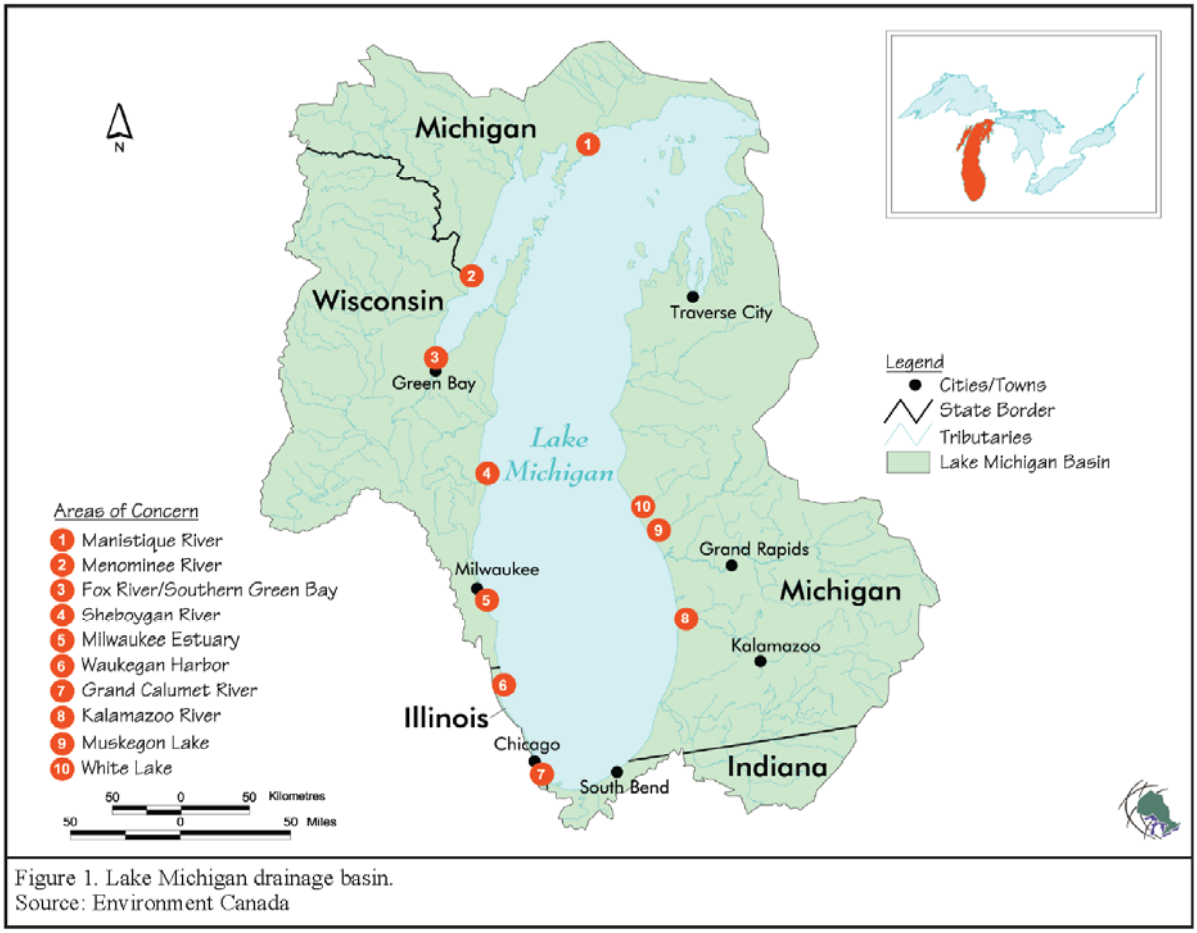


Figure 1. Lake Michigan drainage basin.
Source: Environment Canada

contains over 20% of the Great Lakes' coastal wetlands which are responsible for the quantity and diversity of aquatic life seen in the lake. Protection and enhancement of these areas are key to the future sustainability of the coastal ecosystem.

Lake Michigan is uniquely positioned with a direct connection to the Mississippi River System through the Chicago Diversion, and as such, has become a transfer point for many non–native species which threaten the biological integrity of all the Great Lakes and the Mississippi River.

Lake Michigan has 33 8–digit hydrologic unit code (HUC) tributary watersheds, with all but three listed as impaired and 10 estuaries designated as Areas of Concern (Figure 1). Many Michigan and Wisconsin tributaries have been dammed in the past, but recent dam removals in southeastern Wisconsin have resulted in improved fish habitat, water quality and diversity of species including the appearance of the rare greater redhorse in the Milwaukee River.

Over 10 million people are dependent on Lake Michigan for high quality drinking water and recreation. Since the passing of the U.S. Beaches Environmental Assessment and Coastal Health (BEACH) Act in 2000, the four Lake Michigan states are on track for implementing these provisions with an average of 50% more monitoring using enhanced water quality standards. The results have led to increased advisories and the need for studies to determine contamination sources and management options.

Groundwater Flow

Groundwater beneath the Great Lakes has a different and changeable divide than the Great Lakes surface/watershed divide. In the Great Lakes basin, most shallow flow discharges to local streams; the Great Lakes watershed divide (i.e. the sub–continental divide) also serves as a groundwater divide for shallow flow. Most deep flow discharges are to regional sinks with the deep aquifer divide being distant from the surface watershed divide (Figure 2).

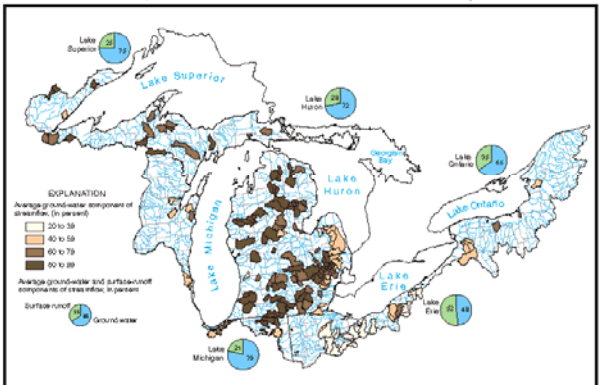


Figure 2. Average groundwater and surface runoff components of selected watersheds in the U.S. portion of the Great Lakes basin.
Source: Holtschlag and Nicholas, 1998

Groundwater divides move in response to pumping. Studies from the western Lake Michigan groundwater basin report that the 1950 pre–development divide and the year 2000 divide for the deep bedrock aquifer, show a pattern of movement. The western basin groundwater that once flowed east toward Lake Michigan is now intercepted by pumping and diverted west under the surface–water divide.

Groundwater, once used, can be discharged to surface water bodies in a different basin. Since the late 1940s, development on the Mississippi basin side of the sub–continental divide has reversed deep flow patterns between west of the divide and the Milwaukee area. The groundwater levels are low enough that Lake Michigan can migrate into the groundwater, a reversal of the normal flow (U.S. Geological Survey 1998).

Groundwater's Role in the Health of the Lake Michigan Ecosystem

The Great Lakes are in a topographically low setting that, under natural flow conditions, causes them to function as discharge areas or "sinks" for the groundwater–flow system. Most groundwater that discharges directly into the lakes is believed to take place near the shore (Grannemann and Weaver 1999). Of all the Great Lakes, Lake Michigan has the largest amount of direct groundwater discharge (2,700 ft^3/s or 76 m^3/s) because it has more sand and gravel aquifers near the shore than any of the other Great Lakes (Grannemann and Weaver, 1999). Although this is a relatively low inflow compared to the total stream flow into the lake from land areas (41,200 ft^3/s or 1167 m^3/s) (Croley and Hunter 1994), it is nearly equal to the amount of water diverted from Lake Michigan through the Chicago Ship and Sanitary Canal (Table 1) (Oberg and Schmidt 1994).

Lake	Overlake Precipitation (percent)	Surface-Runoff (percent)	Indirect groundwater discharge (percent)
Superior	56.3	11.0	32.7
Michigan	56.2	9.3	34.5
Huron	42.2	16.3	41.5
Erie	53.5	24.3	22.2
Ontario	34.8	22.8	42.4

Table 1. Basin water supply for the Great Lakes.
Source: U.S. Geological Survey, 1998. Water Supply Paper

Groundwater Provides Refuge for Aquatic Organisms

Groundwater discharge to streams may help provide important habitat for aquatic organisms, including fish. In addition, because groundwater temperatures are nearly constant throughout the year, stream reaches with relatively large amounts of groundwater discharge can provide refuge to organisms from heat in summer and from cold in winter. For example, some stream reaches in the region remain unfrozen even though air

temperatures are well below 32 degrees Fahrenheit (0 degrees Celsius). Other possible benefits to the survival of aquatic organisms related to groundwater discharge to streams include increasing concentrations of dissolved oxygen, adding small amounts of nutrients that are essential to the health of organisms, providing cold pockets of water in summer, and maintaining stream flow during dry periods.

Lake Levels

Lake Michigan's water level was measured at 2 feet (61 cm) below the long–term average in 2001, having dropped more than 40 inches (102 cm) since 1997 when it was at near record highs. Levels increased for 2002, but were still below average. The decrease in precipitation over the last five years resulted in Lake Michigan being at its lowest point since 1966. Lake levels rose between the mid–1960s and the late 1990s.

The lower lake level has caused problems for the shipping and boating industry. Cargo ships were forced to lighten their loads, and many boat ramps became inaccessible. According to the U.S. Great Lakes Shipping Association, for every inch (2.5 cm) of water that Lake Michigan loses, a cargo ship must reduce its load by 90 to 115 metric tons, leading to losses of between $22,000 and $28,000 U.S. per trip.

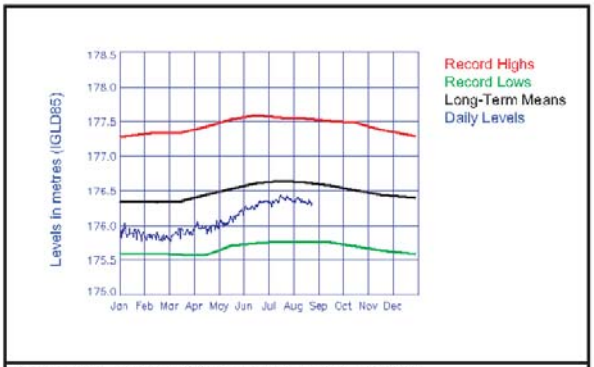


Figure 3. Lake Michigan-Huron water levels.
Source: Great Lakes Environmental Research Laboratory-National Oceanic and Atmospheric Administration

Early reports for 2004 indicated that the lake level was at an average depth due to increased rainfall early in the year. The lake measured one foot higher (30.5 cm) in the summer of 2004 than 2003 with the mean average of 579 feet or 176 metres. This fluctuation may be part of a 30–year cycle that deserves continued monitoring (Figure 3). (U.S. ACE, Detroit District)

Beaches

Lake Michigan contains the world's largest collection of fresh-water sand dunes and associated beaches, particularly along its eastern shore. Of a total of 3,100 acres (1,255 ha) along the coast, 1,200 acres (486 ha) are publicly owned and available for use, while another 1,200 acres (486 ha) are privately owned and have significant potential for public use. In addition to swimming advisories due to poor water quality, there has been a resurgence of the macro algae *Cladophora* along the coast. *Cladophora* blooms result in reduced water quality and beach use. Causes of this problem may be attributed to multiple factors, such as lower lake levels, increased water temperature, nearshore nutrients and zebra mussel activity (Great Lakes Water Institute, University of Wisconsin at Milwaukee).

Aquatic Food Web

The Lake Michigan aquatic food web is threatened due to invasive species competing for food and changing the physical environment (Figure 4). Zebra mussels have the ability to filter water allowing sunlight to penetrate to greater depths, possibly causing algae blooms. The invertebrate *Diporeia* is decreasing rapidly in Lake Michigan thus removing a foundation component of the food web (Figure 5). The yellow perch population remains low and zebra mussels, first introduced in 1989, have shown a decline in certain areas. Sea Lamprey populations have increased in abundance and are now higher than in Lakes Superior or Huron. Lake Trout are stocked and have not recovered to the point of natural reproduction in the lake.

Lake Sturgeon survive in the Great Lakes only in scattered remnants, even though large scale commercial fishing for them ended a century ago. There were remnant populations known to spawn in the waters of 8 tributaries with connections to Lake Michigan. In 2003, enhanced stocking was undertaken with the hopes that the stocked sturgeon would flourish, but not genetically impact the small remnant native population. There are currently 16 agencies and institutions involved with Lake Sturgeon monitoring and investigations are coordinated by the U.S. Fish and Wildlife Service Great Lakes Basin Ecosystem Team.

The most dramatic threat to Lake Michigan is from the Asian carp species which is working its way up the Illinois waterway system from the Mississippi River. The Asian carp was reported to have escaped from aquaculture ponds adjacent to the Mississippi River in the 1980s and the 1990s. An experimental electrical barrier is currently in place. Improvements to this barrier as well as an additional barrier are planned. This large carp species weighs up to 90 pounds (41 kg) and is considered a major threat to the Great Lakes food web.

Other Species

Land–based species are fairing better. The grey wolf is now listed as a recovered species and bald eagles have nested in the area of the Little Calumet River for the first time in 100 years.

Kirtland's warbler, piping plover, Hine's emerald dragonfly and the Karner blue butterfly all have recovery plans in place. An aggressive program to train whooping cranes to migrate and return to Wisconsin's wetlands (west of Lake Michigan) for future nesting is underway.

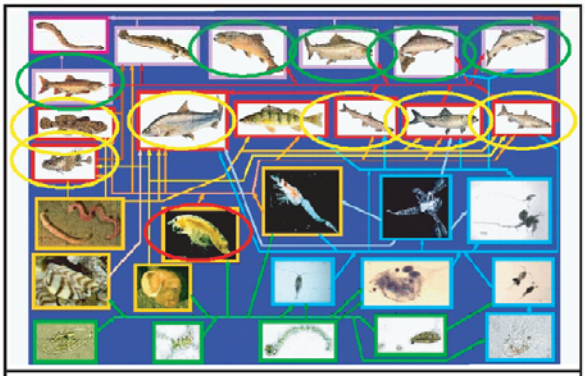


Figure 4. Lake Michigan foodweb. *Diporeia*, central in the diagram, was historically an important food for the fish on the second line of the figure (species in the red squares). *Diporeia* are the prey for the large predator fish like salmon and lake trout at the top of the chart and foodweb (species in the purple squares). Non-native species are competing with, and possibly replacing the *Diporeia* in the Lake Michigan ecosystem. The loss of *Diporeia* threatens the species that feed upon it and the whole foodweb.
Source: Mason, Krause and Ulanowicz, 2002

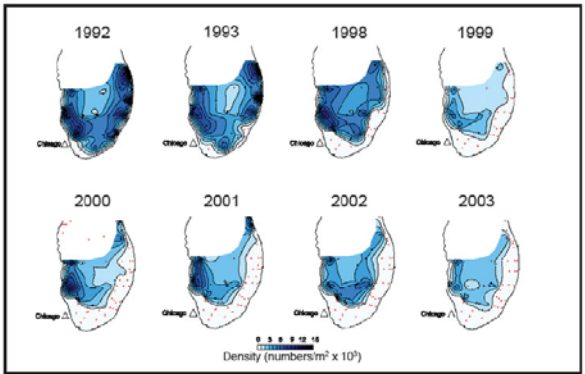


Figure 5. *Diporeia* density.
Source: Great Lakes Environmental Research Laboratory-National Oceanic and Atmospheric Administration

Natural Areas

The dune and swale systems of the eastern lakeshore are a dominant feature of Lake Michigan and provide unique habitat that foster biodiversity. While afforded some protection under law, this system faces extreme pressure as it is a sand product for industry. This area also has development pressures in the coastal communities.

Wetlands, which naturally help control runoff from urban areas by storing flood and surface water and slowly release and filter it, have been destroyed in the Lake Michigan basin states to a greater degree than elsewhere in the country. An estimated 21.9 million acres (8.9 million ha) of wetlands or 62.9% have been lost. An estimated 12.9 million acres (5.2 million ha) of wetlands remain in the four Lake Michigan states, equivalent to approximately 12.3% of the wetland area in the lower 48 states. While this percentage is for the U.S. states not just the Lake Michigan basin, it is indicative of the pressure on the wetland systems. Wetland status in the Lake Michigan basin is therefore mixed (Dahl 1990).

Forest status in the basin is good due to revisions to national forest plans (September 2003 U.S. Federal Register Notice) and the continued practice of sustainability forestry management by the Menominee Tribal Enterprises. The new forest plans address old growth management issues. The Menominee Reservation 235,000 acres (95,102 ha) of forest land represent 150 years of sustainable forest practice in the Wisconsin portion of the Lake Michigan basin.

Lakeplain system of prairies and savannas found in the southern part of the basin are two of the most imperiled ecological communities in North America. Alvars, open areas of thin soils over bedrock found in the northern basin, provide habitat for a number of rare plants and animals. Both of these systems are facing fragmentation and destruction due to land use development.

Pressures on the System

The 10 Areas of Concern in the Lake Michigan basin have contaminated sediment problems and either combined sewer overflows (CSO) and/or storm water problems. All 10 AOCs had some remedial sediment work completed with much more remediation still required. For most of the sediment sites and CSOs there are plans in place but implementation is often forecasted for the year 2020 or beyond. PCBs are the main contaminant in sediment and fish consumption advisories are in place around the lake thus keeping the assessment for fish communities in the Lake Michigan basin as mixed.

The urbanized land area in the United States has quadrupled since 1954. To compound the problem, populations in coastal areas, which contain some of the most sensitive ecosystems, have been increasing even faster than in the rest of the country. From 1982 to 1996, the population in the Chicago–Northwest Indiana area grew by 10.9% but consumed 44.2% of the land (Urban Roadway Congestion: Annual Report 1998). The

Northeastern Illinois Planning Commission's portion of the area is estimated to grow by 21% from 2000 to 2030. This growth pattern is similar to other growth areas around the lake and will further tax water infrastructure and resources.

USEPA's Office of Environmental Information states "the construction of impervious surfaces such as roads and rooftops leads to the degradation of water quality by increasing runoff volume, altering regular stream flow and watershed hydrology, reducing groundwater recharge, and increasing stream sedimentation and water acidity." A one acre (0.4 ha) parking lot produces a runoff volume 16 times as large as that produced by an undeveloped meadow. Many impervious construction materials have higher surface temperatures that may cause ambient air temperatures to rise. When combined with a decrease in natural vegetation, areas are subject to the "urban heat island" phenomenon, which may increase utility bills, cause health problems associated with heat stress, and accelerate the formation of harmful smog. Clearly the effect of urban development on our communities and environment is a cross–cutting issue.

Both the urban and agricultural uses of the land impact the lake. The Lake Michigan Mass Balance Study has modelled the pesticide atrazine in the basin and a draft report and models have determined the need for over a 50% annual reduction in loadings from agriculture lands and the air in order to keep this pesticide at a steady state in the lake. While nutrient levels are increasing in the nearshore areas due to urban runoff, these levels are not at concentrations of concern in the open lake.

Management Actions

For a lake the size and complexity of Lake Michigan, it is not surprising that there are some measures of improving conditions as well as measures of deteriorating conditions. As some issues approach resolution, other new issues are developing such as chemicals of emerging concern and new invasive species. Since the overall status of the lake involves the interactions of chemical, physical and biological changes, it is necessary to understand the interactions of how improvements in one of these categories will affect the other conditions in the lake.

There are many research and reporting needs required for Lake Michigan which include:

- determining the groundwater status, mapping and groundwater and surface water interactions;
- identifying sources of *Cladophora and E. Coli* including the interactions between physical and biological forces which affect the health of Lake Michigan beaches;
- tracking invasive species and their impact on the food web and natural areas;
- identifying protected natural areas, ground areas below flyways, unique features and wetlands and educating the public

Lake Michigan Statistics	
Elevation[a]	
feet	577
metres	176
Length	
miles	307
kilometres	494
Breadth	
miles	118
kilometres	190
Average Depth[a]	
feet	279
metres	85
Maximum Depth[a]	
feet	925
metres	282
Volume[a]	
cu.mi.	1,180
km^3	4,920
Water Area	
sq.mi.	22,300
km^2	57,800
Land Drainage Area	
sq.mi.	45,600
km^2	118,000
Total Area	
sq.mi	67,900
km^2	175,800
Shoreline Length[b]	
miles	1,638
kilometres	2,633
Retention Time	
years	99
Population: USA (2000)[c]	15,351,202
Totals	15,351,202
Outlet	Straits of Mackinac

[a] measured at low water datum
[b] including islands
[c] 2000 population census data were calculated based on the total population of each county, either completely or partially, located within the watershed.

Sources:
The Great Lakes: An Environmental Atlas and Resource Book

Statistics Canada, Environment Accounts and Statistics Division, Spatial Environmental Information System and Censuses of Population 2001.

U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, 2000 Census of Population and Housing, 1990 Census of Population and Housing

about these areas and;
- modelling and GIS training for local officials to assist with land use decision making.

Acknowledgments/Sources of Information

Croley, T.E., and Hunter, T.S. 1994. Great Lakes monthly hydrologic data. In *National Oceanic and Atmospheric Administration (NOAA) Technical Report*. ERL Great Lakes Environmental Research Laboratory (GLERL).

Dahl, T.E. 1990. *Wetlands losses in the U.S., 1780s to 1980s*. U.S. Department of the Interior, Fish and Wildlife Service.

Grannemann, N.G., and Weaver, T.L. *An annotated bibliography of selected references on the estimated rates of direct ground–water discharge to the Great Lakes*. U.S. Geological Survey. Water–Resources Investigations Report, pp. 98–4039.

Great Lakes Environmental Research Laboratory–National Oceanic and Atmospheric Administration. http://www.glerl.noaa.gov, last accessed June 7, 2005.

Great Lakes Water Institute–Wisconsin Aquatic Technology and Environmental Research, University of Wisconsin at Milwaukee. http://www.uwm.edu/Dept/GLWI/, last accessed June 7, 2005.

Holtschlag, D.J., and Nicholas, J.R. 1998. *Indirect ground–water discharge to the Great Lakes*. U.S. Geological Survey Open–File Report 98–579, 25 p.

Mason, D., Krause, A.E., and Ulanowicz, R.E. 2002. *Impact of exotic invertebrate invaders on food source structures and function in the Great Lakes, a network analysis approach*. http://www.glerl.noaa.gov/res/Task_rpts/2002/nsmason10-1.html, last accessed June 8, 2005.

Oberg, K.A., and Schmidt, A.R. 1994. *Measurements of leakage from Lake Michigan through three control structures near Chicago, Illinois, April–October 1993*. U.S. Geological Survey, Water–Resources Investigations Report, pp. 94–4112.

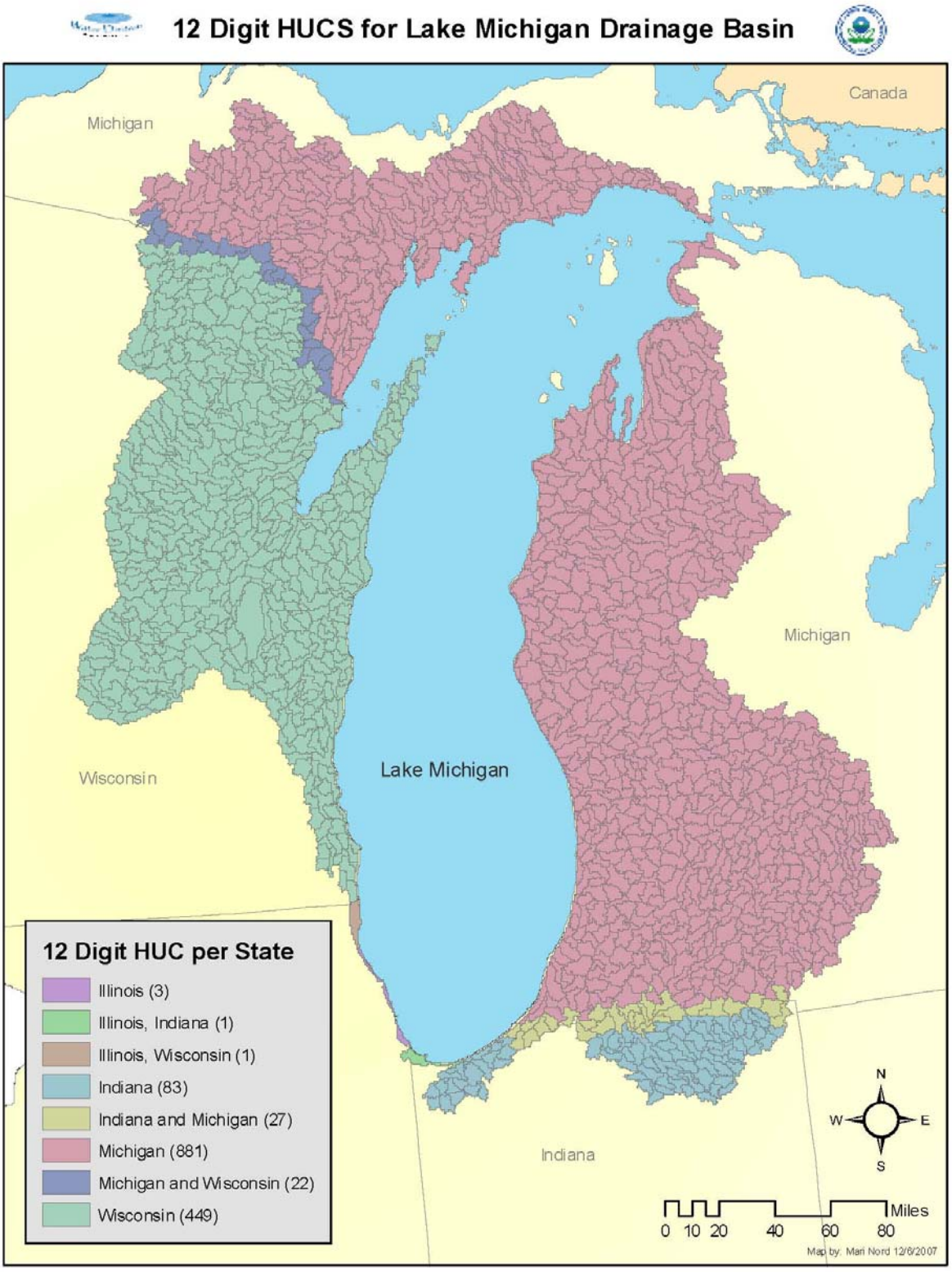
Schrank, D., and Lomax, T.J. 1998. *Urban roadway congestion: annual report 1998*. Texas Transportation Institute. The Texas A&M University System. http://mobility.tamu.edu, last accessed June 9, 2005.

SOLEC 2004 Presentations, Toronto, Ontario. 2004. *Lake Michigan*. http://www.epa.gov/solec/solec_2004/presentations/index.html, last accessed June 8, 2005.

U.S. Army Core of Engineers, Detroit District. http://www.lre.usace.army.mil/, last accessed June 8, 2005.

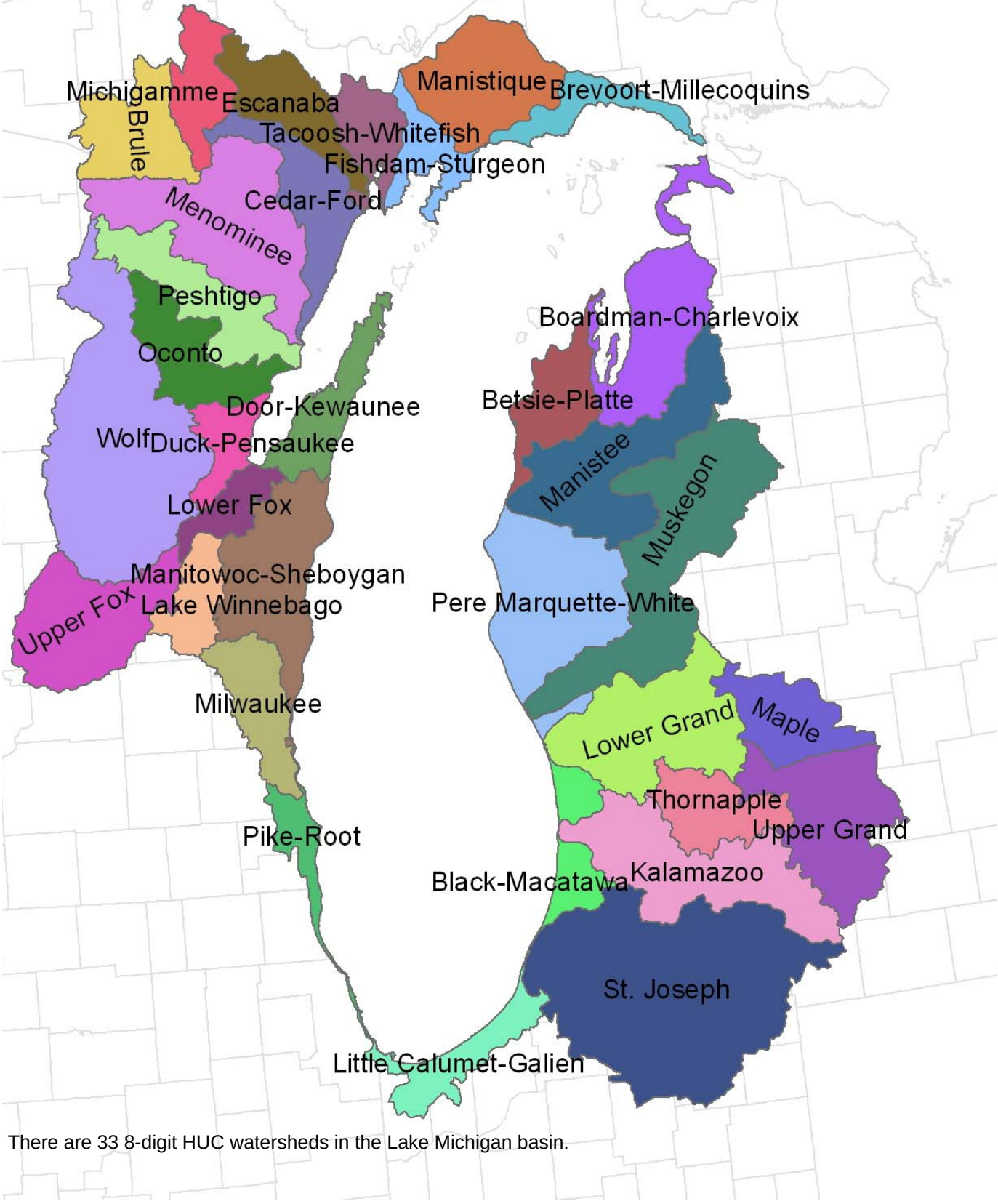
U.S. Environmental Protection Agency (EPA). 2004. *Lake Michigan LaMP 2004 status report*. http://www.epa.gov/glnpo/lakemich/2004update/, last accessed June 8, 2005.

U.S. Environmental Protection Agency's Office of Environmental Information. http://www.epa.gov/oei, last accessed June 9, 2005.



There are 1,4,67 12-digit HUC watersheds in the Lake Michigan basin.

8-Digit HUCs for the Lake Michigan Watershed



There are 33 8-digit HUC watersheds in the Lake Michigan basin.

Lake Michigan 8-Digit HUC Watersheds

Watershed	HUC Code
Betsie-Platte	04060104
Black-Macatawa	04050002
Boardman-Charlevoix	04060105
Brevoort-Millecoquins	04060107
Brule	04030106
Cedar Ford	04030109
Chicago Area Waterway System	
Door-Kewaunee	04030102
Duck-Pensaukee	04030103
Ecsanaba	04030110
Fishdam-Sturgeon	04030112
Lower Fox (AOC)	04030204
Upper Fox	04030201
Lower Grand	04050006
Upper Grand	04050004
Kalamazoo (AOC)	04050003
Little Calumet-Galien (AOC)	04040001
Manistee	04060103
Manistique (AOC)	04060106
Manitowoc-Sheboygan (AOC)	04030101
Maple	04050005
Menominee (AOC)	04030108
Michigamme	04030107
Milwaukee (AOC)	04040003
Muskegon (AOC)	04060102
Oconto	04030104
Pere-Marquette-White (AOC)	04060101
Peshtigo	04030105
Pike-Root (Waukegan) (AOC	04040002
St. Joseph	04050001
Tacoosh-Whitefish	04030111
Thornapple	04050007
Lake Winnebago	04030203
Wolf	04030202

Appendix A
Lake Michigan LaMP Pollutant Identification and Classification

I. Background

The Lake Michigan LaMP in 2000[1] 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 A[2]. 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 uses[3] 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 1990[4] 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 2000[5]. 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 Program[6]. 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 water[10], air[11] and international[12] 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 formed[13]. 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 2004[15]. 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 Criteria[18] 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 atrazine[19], nonylphenol[20], and selenium[21]. 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-transported[23]. 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 list[24] 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, polychorobiphenyls, 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, polychorobiphenyl, 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-1[25]. 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, polychorobiphenyl, 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 EEGLE[26] 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 2000[27], 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, Rosscommon, 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 regulate45 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.glrc.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.

Appendix B
State of the Lakes Ecosystem Conference (SOLEC) Indicators

Indicators: Background

The State of the Lakes Ecosystem Conference (SOLEC) was established by the US and Canada in 1992 to hold biannual conferences to meet the reporting requirements of the Great Lakes Water Quality Agreement (GLWQA). SOLEC has led the effort to collect, develop and refine a set of science-based, not programmatic, indicators and taken an adaptive management approach to continually improve the effort.

In LaMP 2000, Chapter Three presented a cross walk of the SOLEC indicators and the Lake Michigan Lakewide Management Plan goals. In preparation for LaMP 2006, the LaMP Technical Coordinating Committee conducted a review of current SOLEC indicators in association with the Lake Michigan LaMP Goals. An extremely strong alignment was found to still be in place.

The Lake Michigan LaMP has also adopted the SOLEC sustainability target gauge to help provide a quick, summary visual of a measurement of where we are in achievement of the goal. For LaMP 2006, the titles at each end of the gauge have changed from good and poor to sustainable and unsustainable. It is hoped this action will help underscore the need to take action. In addition, following the" Status of the Goal" at the beginning of each chapter a list of indicator titles are included to inform the reader as to the data used to inform the status conclusion.

SOLEC Great Lakes Revised Indicator Framework

SOLEC has also been reviewing the indicators and has under gone a peer review process. A strong message that emerged from both internal and external Peer Review sessions was the need to reduce the overall number of indicators by identifying and eliminating those indicators that may be unnecessary or redundant. An additional and related comment was that in order to accomplish this reduction, categorical groupings of indicators by topic, issue or theme could be developed. Based on these recommendations, SOLEC organizers grouped related indicators into the following categories and sub-categories (or “bundles” and “sub-bundles”) for ease in and presentation of related information and understanding of the larger issue:

1. Contamination
   a. Nutrients
   b. Toxics in Biota
   c. Toxics in Media
   d. Sources and Loadings

2. Biotic Communities
   a. Fish
   b. Birds
   c. Mammals
   d. Amphibians
   e. Invertebrates
   f. Plants
   g. General

3. Invasive Species
   a. Aquatic
   b. Terrestrial

4. Coastal Zones
   a. Nearshore Aquatic
   b. Coastal Wetlands
   c. Terrestrial

5. Aquatic Habitats
   a. Open Lake
   b. Groundwater

6. Human Health

7. Land Use - Land Cover
   a. General
   b. Forest Lands
   c. Agricultural Lands
   d. Urban/Suburban Lands
   e. Protected Areas

8. Resource Utilization

9. Climate Change

In this approach, many indicators are relevant to more than one category. For example, "Contaminants in Sport Fish" is included in both "Contamination: Toxics in Biota" and "Human Health." All of the indicators within a category, however, contribute to a more complete evaluation of environmental conditions pertaining to that category.

Other categories are possible, and they may of greater usefulness in the future. Likewise, the "old" categories previously used for reporting Great Lakes indicators may still be relevant for some users. As originally conceived, the Great Lakes suite of indicators was developed around the topics of open and nearshore waters, coastal wetlands, nearshore terrestrial, land use, human health, societal, and unbounded. Each indicator was associated with one primary category, but all the indicators were also evaluated for relevancy to other SOLEC categories and to other major environmental groupings (e.g., land, water, air, biota), issues (e.g., contaminants, invasive species, urban sprawl), or indicator systems (e.g., IJC Desired Outcomes, Great Lakes Water Quality Agreement Impaired Beneficial Uses).

The categories currently listed are incomplete, and others may be incorporated in the future. For example, under "Aquatic Habitats," indicators have yet to be identified and developed for inland surface waters, including tributaries, inland lakes, and inland wetlands. The category "Resource Utilization" is also very incomplete and will require quite extensive consideration of socio-economic indicators relevant to the assessment of Great Lakes ecosystem components. Likewise, "Human Health" could be expanded to "Human Health and Well Being" and include indicators to assess social values of residents in the Great Lakes basin.

Changes to the Indicator Assessment Process

In response to suggestions from the peer reviews that the SOLEC process for the assessment of indicators was not sufficiently transparent or standardized, some changes were made to make assessments more credible and internally consistent. Previously, the available assessment options were restricted to Good, Mixed Improving, Mixed, Mixed Deteriorating, and Poor. These were not always sufficient or helpful. For SOLEC 2004, a system is being used to better express the relative condition and trend for all indicators. Authors have

provided a qualitative assessment for their adopted as they have done in the past, but the assessment categories are now less ambiguous. Specifically, authors have provided a "condition" of the ecosystem related to their indicator by selecting a "good, fair, poor or mixed" status and then assigning a "direction" of "improving, unchanged, deteriorating or undetermined" to each indicator.

Five broad ranking categories were used to characterize the assessments:

- Good. The state of the ecosystem component(s) is/are presently meeting ecosystem objectives or otherwise is in acceptable condition.
- Fair. The ecosystem component(s) is/are currently exhibiting minimally acceptable conditions, but it is not meeting established ecosystem objectives, criteria, or other characteristics of fully acceptable conditions.
- Poor. The ecosystem component(s) is/are severely negatively impacted and it does not display even minimally acceptable conditions.
- Mixed. The ecosystem component(s) displays both good and degraded features.
- Not Assessed. There is insufficient information to make an assessment

In addition, four ecosystem trajectories (or trends over time) were recognized:

- Improving. Information provided by the report shows the ecosystem component(s) to be changing toward more acceptable conditions.
- Unchanging. Information provided by the report shows the ecosystem component(s) is/are neither getting better nor worse.
- Deteriorating. Information provided by the report shows the ecosystem component(s) to be changing away from acceptable conditions.
- Undetermined. Data are not available to assess the ecosystem component(s) over time, so no trend can be identified.

For Lake Michigan: Sustainability would be beyond meeting ecosystem objectives and would include a system to maintain that status which might include monitoring, a watershed plan and local or state programs or regulations to prevent regression and the ability to address new issues should they occur.

In the following pages, the status and trends are represented in the following manner..

Status					Trend			
					➡	◆	⬅	?
Not Assessed	Good	Fair	Poor	Mixed	Improving	Unchanging	Deteriorating	Undetermined
Note: Progress Reports and some Reports from previous years have no assessment of Status or Trend								

CONTAMINATION

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
Nutrients						
111	Phosphorus Concentrations and Loadings — open lake	?	➡	?	?	➡
	Phosphorus Concentrations and Loadings — nearshore	?	?	?	?	?
7061	Nutrient Management Plans	2005 Report				
Toxics in Biota						
114	Contaminants in Young-of-the-Year Spottail Shiners	➡	?	➡	➡	➡
115	Contaminants in Colonial Nesting Waterbirds	➡	➡	➡	➡	➡
121	Contaminants in Whole Fish	➡	➡	➡	➡	➡
124	External Anomaly Prevalence Index for Nearshore Fish	?	?	?	◆	◆
4177	Biologic Markers of Human Exposure to Persistent Chemicals	?				
4201	Contaminants in Sport Fish	➡	➡	➡	➡	➡
4506	Contaminants in Snapping Turtle Eggs	?	?	?	?	?
8135	Contaminants Affecting Productivity of Bald Eagles	➡ 2005 Report				
8147	Population Monitoring and Contaminants Affecting the American Otter	? 2003 Report				
Toxics in Media						
117	Atmospheric Deposition of Toxic Chemicals — PCBs & others	➡				
	Atmospheric Deposition of Toxic Chemicals — PAHs & mercury	◆ & ➡				
118	Toxic Chemical Concentrations in Offshore Waters	?	?	?	?	?
119	Concentrations of Contaminants in Sediment Cores	➡ & ?				
4175	Drinking Water Quality	◆				
4202	Air Quality	➡				
9000	Acid Rain	➡ 2005 Report				
Sources and Loadings						
117	Atmospheric Deposition of Toxic Chemicals — PCBs & others	➡				
	Atmospheric Deposition of Toxic Chemicals — PAHs & mercury	◆ & ➡				
4202	Air Quality	➡				
7065	Wastewater Treatment and Pollution	Progress Report				
9000	Acid Rain	➡ 2005 Report				

BIOTIC COMMUNITIES

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
Fish						
8	Salmon and Trout	→	→	→	→	◆
9	Walleye	?	?	◆	◆	◆
17	Preyfish Populations	→	←	←	←	←
93	Lake Trout	→	←	→	◆	←
125	Status of Lake Sturgeon in the Great Lakes	?→	?→	?→	?	→
4502	Coastal Wetland Fish Community Health	Progress Report				
Birds						
115	Contaminants in Colonial Nesting Waterbirds	→	→	→	→	→
4507	Wetland-Dependent Bird Diversity and Abundance	?	←	←	←	←
8135	Contaminants Affecting Productivity of Bald Eagles	→ 2005 Report				
Mammals						
8147	Population Monitoring and Contaminants Affecting the American Otter	? 2003 Report				
Amphibians						
4504	Wetland-Dependent Amphibian Diversity and Abundance	?	◆	←	←	◆
7103	Groundwater Dependent Plant and Animal Communities	2005 Report				
Invertebrates						
68	Native Freshwater Mussels	2005 Report				
104	Benthos Diversity and Abundance - Aquatic Oligochaete Communities	◆	◆ ←	◆	◆ ←	◆
116	Zooplankton Populations	◆	?	?	?	?
122	*Hexagenia*	?	?	?	⇆	?
123	Abundance of the Benth Amphipod *Diporeia* spp.	◆	←	←	←	←
4501	Coastal Wetland Invertebrate Community Health	2005 Progress Report				
Plants						
109	Phytoplankton Populations	? 2003 Report				
4862	Coastal Wetland Plant Community Health	◆	◆	←	◆	◆
8500	Forest Lands - Conservation of Biological Diversity	?				

INVASIVE SPECIES

ID #	Indicator Name	2007 Assessment (Status, Direction)				
		Lake				
		SU	MI	HU	ER	ON
Aquatic						
18	Sea Lamprey	➡ 2005 Report				
9002	Non-Native Species (Aquatic)	◆	⬅	⬅	⬅	⬅
Terrestrial						
9002	Non-Native Species (Terrestrial)	?				

HUMAN HEALTH

ID #	Indicator Name	2007 Assessment (Status, Direction)				
		Lake				
		SU	MI	HU	ER	ON
4175	Drinking Water Quality	◆				
4177	Biological Markers of Human Exposure to Persistent Chemicals	?				
4200	Beach Advisories, Postings and Closures	?	?	◆?	?	?
4201	Contaminants in Sport Fish	➡	➡	➡	➡	➡
4202	Air Quality	➡				

RESOURCE UTILIZATION

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
3514	Commercial/Industrial Eco-Efficency Measures	2003 Report				
7043	Economic Prosperity	? 2003 Report				
7056	Water Withdrawls	◆ 2005 Report				
7057	Energy Consumption	? 2005 Report				
7060	Solid Waste Disposal	?				
7064	Vehicle Use	⬅				
7065	Wastewater Treatment and Pollution	Progress Report				

COASTAL ZONES and AQUATIC HABITATS

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
COASTAL ZONES						
Nearshore Aquatic						
4861	Effect of Water Level Fluctuations	? 2003 Report				
8131	Extent of Hardened Shoreline	← 2001 Report				
Coastal Wetlands						
4501	Coastal Wetland Invertebrate Community Health	2005 Progress Report				
4502	Coastal Wetland Fish Community Health	Progress Report				
4504	Wetland-Dependent Amphibian Diversity and Abundance	?	◆	←	←	◆
4506	Contaminants in Snapping Turtle Eggs	?	?	?	?	?
4507	Wetland-Dependent Bird Diversity and Abundance	?	←	←	←	←
4510	Abundance of the Benth Amphipod *Diporeia* spp.	◆	←	←	←	←
4861	Effect of Water Level Fluctuations	? 2003 Report				
4862	Coastal Wetland Plant Community Health	◆	◆	←	◆	◆
4863	Land Cover Adjacent to Coastal Wetlands	Progress Report				
Terestrial						
4861	Effect of Water Level Fluctuations	? 2003 Report				
8129	Area, Quality and Protection of Special Lakeshroe Communities - Alvars	? 2001 Report				
8129	Area, Quality and Protection of Special Lakeshroe Communities - Cobble Beaches	← 2005 Report				
8129	Area, Quality and Protection of Special Lakeshroe Communities - Islands	?				
8129	Area, Quality and Protection of Special Lakeshroe Communities - Sand Dunes	2005 Progress Report				
8131	Extent of Hardened Shoreline	← 2001 Report				
AQUATIC HABITATS						
Open Lake						
111	Phosphorus Concentrations and Loadings — open lake	?	→	?	?	→
	Phosphorus Concentrations and Loadings — nearshore	?	?	?	?	?
118	Toxic Chemical Concentrations in Offshore Waters	?	?	?	?	?
119	Concentrations of Contaminants in Sediment Cores	→ & ?				
8131	Extent of Hardened Shoreline	← 2001 Report				
Groundwater						
7100	Natural Groundwater Quality and Human-Induced Changes	2005 Report				
7101	Groundwater and Land: Use and Intensity	2005 Report				
7102	Base Flow Due to Groundwate Discharge	←				
7103	Groundwater Dependent Plant and Animal Communities	2005 Report				

LAND USE - LAND COVER

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
General						
4863	Land Cover Adjacent to Coastal Wetlands	Progress Report				
7002	Land Cover - Land Conversion	?	?	?	?	?
7054	Ground Surface Hardening	2005 Progress Report				
7101	Groundwater and Land: Use and Intensity	2005 Report				
Forest Lands						
8500	Forest Lands - Conservation of Biological Diversity	?				
8501	Forest Lands - Maintenance and Productive Capacity of Forest Ecosystems	?				
8503	Forest Lands - Conservation & Maintenance of Soil & Water Resources	?	?	?	?	?
Agricultural Lands						
7028	Sustainable Agriculture Practices	2005 Report				
7061	Nutrient Management Plans	2005 Report				
7062	Integrated Pest Management	2005 Report				
Urban/Suburban Lands						
7000	Urban Density	?				
7006	Brownfields Redevelopment	➡				
7054	Ground Surface Hardening	2005 Progress Report				
Protected Areas						
8129	Area, Quality and Protection of Special Lakeshroe Communities - Alvars	?	2001 Report			
8129	Area, Quality and Protection of Special Lakeshroe Communities - Cobble Beaches	⬅	2005 Report			
8129	Area, Quality and Protection of Special Lakeshroe Communities - Islands	?				
8129	Area, Quality and Protection of Special Lakeshroe Communities - Sand Dunes	2005 Progress Report				
8164	Biodiversity Conservation Sites	Proposed Indicator				

CLIMATE CHANGE

ID #	Indicator Name	2007 Assessment (Status, Trend)				
		Lake				
		SU	MI	HU	ER	ON
4858	Climate Change: Ice Duration on the Great Lakes	←				

Glossary

Aquatic Nuisance Species (ANS)
Water-borne plants or animals that pose a threat to humans, agriculture, fisheries, and/or wildlife resources.

Area of Concern (AOC)
Areas of the Great Lakes identified by the International Joint Commission as having serious water pollution problems requiring remedial action and the development of a Remedial Action Plan. AOCs are defined in the Great Lakes Water Quality Agreement as: "a geographic area that fails to meet the general or specific objectives of the Great Lakes Water Quality Agreement, or where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life." Initially, there were 43 AOCs in the Great Lakes Basin.

Area of Stewardship
An Area of Stewardship watershed focus is an area, most often a watershed, for which a level of ecosystem integrity has been established as a goal and where an integrated, multi-organizational initiative or partnership is actively working to achieve that goal. The Lake Michigan Watershed Academy is being established to promote the concept of stewardship. Examples of such areas include the Chicago Wilderness, the Kalamazoo Multi-Jurisdictional Watershed Agreement, and the work in Grand Traverse Bay, Michigan and Door County, Wisconsin.

Basin
The land area that drains into a lake or river. This area is defined and bounded by topographic high points around the waterbody.

Beneficial Use
The role that the government decides a waterbody will fulfill. Examples of these uses include healthy fish and wildlife populations, fish consumption, aesthetic value, safe drinking water sources, and healthy phytoplankton and zooplankton communities. Restoring beneficial uses is the primary goal of the Remedial Action Plans for the Areas of Concern and of the Great Lakes Water Quality Agreement.

Beneficial Use Impairment
A negative change in the health of a waterbody making it unusable for a beneficial use that has been assigned to it. Examples of the 14 use impairments designated in the Great Lakes Water Quality Agreement include: restrictions on fish and wildlife consumption, beach closings, degradation to aesthetics, loss of fish and wildlife habitat, and restrictions on drinking water consumption. Local use impairments occur in Areas of Concern or other areas affecting the lake. Regional use impairments occur in an Area of Concern cluster or multi-jurisdictional watershed. Open water or lakewide impairment is a condition of pervasive impairment.

Binational Executive Committee (BEC)
The Binational Executive Committee (BEC) is a high-level forum composed of senior-level representatives of the USPC and Canadian counterpart agencies who are accountable for delivering major programs and activities to fulfill the terms of the GLWQA. The BEC derives its mandate from the provisions of the GLWQA which relate broadly to notification, consultation, coordination, and joint activity. In particular, Article X specifies the commitments of the Parties to consultation and review: "The Parties (U.S. and Canada), in cooperation with State and Provincial Governments, shall meet twice a year to coordinate their respective work plans with regard to the implementation of this Agreement and to evaluate progress made."

Biological Integrity
The ability of an ecosystem to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region.

Boundary Waters Treaty
The international treaty between the United States and Great Britain signed on January 11, 1909, regarding the waters joining the United States and Canada and relating to questions arising between the two nations. It gave rise to the International Joint Commission and the Great Lakes Water Quality Agreement.

Buffer Strips
Vegetated buffer strips along waterways act as filters

for sediment, nutrients and pesticides that are washing off the land heading for the nearest stream. They are often wetlands that can also mitigate flood water movement and serve as habitat for wildlife.

Cladophora
A natural occurring macroalgae found predominantly along the coast. Large blooms lead to unsightly and foul-smelling beaches and have negative health and economic consequences. The blooms can result in reduced drinking and swimming water quality. Possible causes include increased nutrient inputs, increased water clarity and /or temperature and changing lake levels.

Conservation Easement
A conservation easement is a deed restriction placed on a piece of property to protect resources associated with that parcel, sometimes irrevocable. It can cover a whole parcel or be for a stream bank or lake shore. The easement is often held by government entities while land owners receive tax reductions or other payments

Criteria Pollutants
A group of air and water pollutants regulated by the EPA under the Clean Air Act and Clean Water Act on the basis of criteria that includes information on health and environmental effects. Criteria pollutants include particulates, some metals, organic compounds, and other substances attributable to discharges.

Critical Pollutant
Chemicals that persist at levels that are causing or could cause impairment of beneficial uses lakewide. The Lake Michigan LaMP has identified six critical pollutants: PCBs, dieldrin, chlordane, DDT and its metabolites, mercury, and dioxins/furans. *See also* Great Lakes Critical Pollutants. Related program: Lakewide Management Program.

Designated Uses
The role that a waterbody is slated to fulfill, such as a drinking water source. Uses are specified in water quality standards for each waterbody or segment, whether or not the current water quality is high enough to allow the designated use. Other typical uses of a waterbody include propagation of fish and wildlife, recreation, agriculture, industry, and navigation.

Ecosystem
A biological community and its environment working together as a functional system, including transferring and circulating energy and matter. It is an interconnected community of living things including humans, and the physical environment with which they interact.

Ecosystem Indicator
An organism or community of organisms that is used to assess the health of an ecosystem as a whole. When tracked over time, an ecosystem indicator provides information on trends in important characteristics of the system. Also known as an environmental indicator.

Ecosystem Integrity
A measure of the capacity of ecosystems to renew themselves and continually supply resources and essential services. Ecosystem integrity is the degree to which all ecosystem elements-species, habitats, and natural processes-are intact and functioning in ways that ensure sustainability and long-term adaptation to changing environmental conditions and human uses.

Ecosystem Management
The process of sustaining ecosystem integrity through partnerships and interdisciplinary teamwork. Ecosystem-based management focuses on three interacting dimensions: the economy, the social community, and the environment. Ecosystem-based management seeks to sustain ecological health while meeting economic needs and human uses.

Emerging Pollutant
The Lake Michigan Lakewide Management Plan addresses emerging pollutants, which include those toxic substances that, while not presently known to contribute to use impairments or to show increasing loadings or concentrations, have characteristics that indicate a potential to impact the physical or biological integrity of Lake Michigan. These characteristics include presence in the watershed, ability to bioaccumulate, persistence (greater than 8 weeks), and toxicity. Emerging pollutants include atrazine, selenium, and PCB substitute compounds.

End Point Subgoal
End point subgoals describe the desired levels of ecosystem integrity and ecological services required to restore beneficial uses and provide for healthy human natural communities in the basin.

Fish Consumption Advisory (FCA)
An advisory issued by a government agency recommending that the public limit their consumption of fish. Advisories are issued to limit exposure to toxic substances in the fish that have the potential to impact human health. A fish consumption advisory is prepared annually by each state. Fish caught from selected lakes and streams are tested for toxic substances.

Great Lakes Water Quality Agreement (GLWQA)
An international agreement signed by the United States and Canada in 1972 and updated in 1978 and 1987. The Agreement seeks to restore and maintain full beneficial uses of the Great Lakes system. Language committing the two nations to virtually eliminate the input of persistent toxic substances in order to protect human health and living aquatic resources was included when the Agreement was updated in 1978. The philosophy adopted by the two governments is zero discharge of such substances.

Habitat
That space that is or can be successfully occupied (inhabited) by a species or biotic community or some broader (taxonomic or phylogenetic) entity. Habitat is simply the place where an organism or group of closely related organisms live.

Lake Michigan
Lake Michigan is the only one of the five Great Lakes wholly within the U.S. border. It is bounded by the states of Michigan, Indiana, Illinois, and Wisconsin. It is connected with and flows into Lake Huron through the Straits of Mackinac.

Lake Michigan Basin
Used to describe Lake Michigan and the surrounding watersheds emptying into the lake.

Lake Michigan Lakewide Management Plan (LaMP)
This document is both a reference document and a proposal for a process that will guide remediation of past errors and the achievement of sustainable integrity of the basin ecosystem. It contains clear, comprehensive goals, specific objectives, a strategic plan, and a system of indicators and monitoring for use in judging environmental status and effectiveness of current actions.

Lake Michigan Management Committee (LMMC)
The LMMC guides the overall development and implementation of the Lake Michigan LaMP. The current membership includes: EPA (Lake Michigan Team, Great Lakes National Program Office, and Office of Research and Development), U.S. Fish and Wildlife Service, Army Corps of Engineers, U.S. Geological Survey, U.S. Department of Agriculture (Natural Resources Conservation Service), Illinois Environmental Protection Agency, Indiana Department of Environmental Management, Michigan Department of Environmental Quality, Wisconsin Department of Natural Resources, Great Lakes Fishery Commission, Chippewa/Ottawa Treaty of Fishery Management Authority, and the Grand Traverse Band of Ottawa and Chippewa Indians, Michigan.

Lake Michigan Mass Balance Study (LMMB)
This mass balance research project begun in 1994 is part of the Lake Michigan Lakewide Management Plan and is designed to develop a sound, scientific base of information that will guide future toxic pollutant load reduction and prevention activities.

Lake Michigan Monitoring Coordinating Council (LMMCC)
The Council provides a forum for identifying gaps and establishing monitoring priorities, exchanging information, and forming partnerships. It responds to the need for enhanced coordination, communication, and data management among the many agencies and organizations that conduct or benefit from environmental monitoring efforts in the basin.

LaMP Technical Coordinating Committee (TCC)
The TCC develops documents and programs, and recommends strategies, goals, and objectives. The current membership includes the same agencies/entities as the Management Committee, plus the Oneida Tribe of Wisconsin. There is a steering committee and six subcommittees under the TCC.

Methyl Mercury
Any of several extremely toxic compounds formed from metallic mercury by the action of microorganisms and capable of entering the food chain. Methyl mercury is an organic form of mercury created when inorganic mercury is released into the environment where it volatilizes back to the atmosphere as a gas or as adherents to particulaltes. Methylmercury biomagnifies up the food chain as it is passed from a over food chain level to a higher food chain level through consumption of prey organisms or predators.

Nutrients
Elements or compounds essential as raw materials for organism growth and development, such as carbon, nitrogen and phosphorus. If out of balance can cause impairment of waterways

Pressure-State-Response Approach
The pressure-state-response approach involves linking environmental indicators to stressors that impact the environment and to program activities. The use of this approach should promote consistency in the development and application of environmental indicators. It is an organizing framework used by U.S. EPA Region 5 in its "Guide for Developing Environmental Goals, Milestones and Indicators," found in LaMP Appendix H.

Remedial Action Plan (RAP)
These are federally-mandated local plans designed to restore environmental quality to Areas of Concern on the Great Lakes (there are 10 in Lake Michigan and there were initially 43 throughout the Great Lakes). The Areas of Concern were identified for their persistent pollution problems. Remedial Action Plans were called for by a protocol added to the Great Lakes Water Quality Agreement in 1987.

Sediments
soil particles that are or were at one time suspended in and carried by water as a result of eroison and /or suspension. The particles are deposited in areas where the water flow is slowed such as in harbors, wetlands and lakes.

Stressor
Any chemical, physical, or biological entity that can induce adverse effects on individuals, populations, communities, or ecosystems and be a cause of beneficial use impairments. Examples of stressors include: pathogens; fragmentation and destruction of terrestrial and aquatic habitats; exotic nuisance species; nutrients; and uncontrolled runoff and erosion.

Sustainable Development
Sustainable development is the process of economic development to meet the needs of the present without compromising the ability of future generations to meet their own needs.

Total Maximum Daily Load (TMDL)
TMDLs are set by regulators to allocate the maximum amount of a pollutant that may be introduced into a waterbody and still assure attainment and maintenance of water quality standards.

Type E Botulism
A common bacteria (Clostridium botulinum) produces a toxin under certain conditions, namely the anaerobic (oxygen-free) conditions that occur in dead organisms. Animals, especially fish-eating birds, ingest the toxin and get sick and die.

U.S. Policy Committee

The U.S. Policy Committee is a forum of senior-level representatives from the Federal, State, and Tribal governmental agencies that share responsibility for environmental protection and natural resources management of the Great Lakes – to advance the restoration and protection of the Great Lakes Basin Ecosystem. U.S. Policy Committee Partners include the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Department of Agriculture, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, U. S. Geological Survey, Agency for Toxic Substances and Disease Registry, U.S. Forest Service, Great Lakes Fishery Commission, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, Great Lakes Tribal Governments.

Water Table
The upper surface of the groundwater or that level below which the soil is saturated with water

References

Selected Chapter 7 references

Alexander, R.B., Smith, R.A., Schwarz, G.E., Boyer, E.W., Nolan, J.V., and Brakebill, J.W., 2008, Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi River Basin, Environ. Sci. Technol., 42, 3, 822-830, 10.1021/es0716103

Ambrose, R.B., Jr., S.I. Hill, and L.A. Mulkey. 1983. *User=s Manual for the Chemical Transport and Fate Model (TOXIWASP), Version I.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Athens, George. EPA-600/3-83-005, 178 pp.

Ambrose, R.B., T.A. Wool, J.P. Connolly, and R.W. Schanz. 1988. *WASP4, A Hydrodynamic and Water Quality Model - Model Theory, User=s Manual and Programmer=s Guide*. U.S. Environmental Protection Agency, Office of Research and Development, ERL-Athens, Georgia. EPA-600/3-87-039, 297 pp.

Ambrose, R.B., J.L. Martin, and T.A. Wool. 1993. WASP5, *A Hydrodynamic and Water Quality Model - Model Theory, User=s Manual and Programmer=s Guide.* U.S. Environmental Protection Agency, Office of Research and Development, ERL-Athens, Georgia.

Bamford, H.A., D.L. Poster and J.E. Baker. 2000. Henry's Law Constant of polychlorinated biphenyl congeners and their variation with temperature. J. Chem. Engin. Data 45:1069-1074.

Bamford, H.A., D.L. Poster and J.E. Baker. 2002. Using extrathermodynamic relationships to model temperature dependance of Henry's Law Constants of 209 PCB congeners. Environ. Sci. Technol. 36: 4395-4402.

Beletsky, D., W.P. O=Connor, and D.J. Schwab. 1997. Hydrodynamic Modeling for the Lake Michigan Mass Balance Project. In: G. Delic and M.F. Wheeler (eds)., Next Generation Environmental Models and computational Methods, Chapter 13, pp. 125-128. Soc. Industr. Appl. Mathemat., Philadelphia, PA.

Bertram, P., G.Warren and P. Horvatin. 2000. Lake Michigan (USA) Mass Balance Study: modeling fate, transport and bioaccumulation of PCBs, atrazine, trans-nonachlor and mercury.

Verh. Internat. Verein. Limnol**.** 27:795-799.

Endicott, D.D., W.L. Richardson, and D.J. Kandt. 2005. 1992 MICHTOX: A Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Michigan. Part 1 *in* Rossmann, R. (ed.), *MICHTOX: A mass balance and bioaccumulation model for toxic chemicals in Lake Michigan*. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Laboratory, Mid-Continent Ecology Division, Large Lakes Research Station, Grosse Ile, Michigan. EPA/600/R-05/158, 140 pp.

Endicott, D.D. 2005. 2002 Lake Michigan Mass Balance Project: modeling total polychlorinated biphenyls in using the MICHTOX model. Part 2 *in* Rossmann, R. (ed.), *MICHTOX: A mass balance and bioaccumulation model for toxic chemicals in Lake Michigan*. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Laboratory, Mid-Continent Ecology Division, Large Lakes Research Station, Grosse Ile, Michigan. EPA/600/R-05/158, 140 pp.

Franz, T.P.; Eisenreich, S.J.; Holsen, T. 1998. Dry deposition of particulate polychlorinated biphenyls and polycyclic aromatic hydrocarbons to Lake Michigan. Environ. Sci. Technol. 32(23): 3681-3688.

Green, M.L.; DePinto, J.V.; Sweet, C.W.; Hornbuckle, K.C. 2000. Regional Spatial and Temporal Interpolation of Atmospheric PCBs: Interpretation of Lake Michigan Mass Balance Data. Environ. Sci. Technol. 34(9): 1833-1850.

Hall, D.W. and D. Robertson. 1998. Estimation of Contaminant Loading from Monitored and Unmonitored Tributaries to Lake Michigan for the USEPA, Lake Michigan Mass Balance Study. Quality Systems and Implementation plan. Report to the USEPA Great Lakes National Program Office, Chicago, IL. U.S. Geological Survey, Middleton, WI., 19pp.

Hall, D.W.; Behrendt, T.E.; Hughes, P.E. 1998. Temperature, pH, conductance, and dissolved oxygen in cross-sections of 11 Lake Michigan Tributaries, 1994-5. U.S. Geological Survey Open-File Report 98-567, 85pp.

Hall, D.W. 2000a. Lake Michigan Mass Balance Tributary Loads: Atrazine and Metabolites. Data Report/ Spreadsheet to the USEPA Great Lakes National Program Office, Chicago, IL. U.S. Geological Survey, Middleton, WI.

Hall, D.W. 2000b. Lake Michigan Mass Balance Tributary Loads: Nutrients, Suspended Solids, Carbon, Chlorophyll, and Chloride. Data Report/Spreadsheet to the USEPA Great Lakes National Program Office, Chicago, IL. U.S. Geological Survey, Middleton, WI.

Hall, D.W 2000c. Lake Michigan Mass Balance Tributary Loads: Regression, Stratified Beale Ratio Estimator, and Descriptive Statistics for all parameters with the exception of mercury and PCB congeners. Data Report/Spreadsheet to the USEPA Great Lakes National Program Office, Chicago, IL. U.S. Geological Survey, Middleton, WI.

Hall, D.W., F. Blondin, and G.J. Warren. 2001. Lake Michigan Mass Balance Tributary Loads: PCB congeners. Data Report/Spreadsheet to the USEPA Great Lakes National Program Office, Chicago, IL. U.S. Geological Survey, Middleton, WI.

Hawley, N. 1999. Sediment resuspenmsion and transport in Lake Michigan. Final report to the USEPA, Office of Research and Development, NHEERL, MED- Duluth, MN and Grosse Ile, MI. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Ann Arbor, MI. 240 pp.

Holson, T.M.; Keeler, G.J.; Noll, K.N.; Fang, G.; Lee, W.; Lin, J. 1993. Dry Deposition and Particle Size Distributions Measured during the Lake Michigan Urban Air Toxics Study. Environ. Sci. Technol. 27(7): 1327-1333.

Hornbuckle, K.C.; Sweet, C.W.; Pearson, R.F.; Swackhamer, D.L.; Eisenreich, S.J. 1995. Assessing annual water-air fluxes of polychlorinated biphenyls in Lake Michigan. Environ. Sci. Technol. 29(4): 869.

HydroQual, Inc. 1996. Green Bay food chain model documentation. Report to the U.S. Environmental Protection Agency, Office of Research and Development, NHEERL, Mid-Continent Ecology Division-Duluth, Large Lakes Research Station, Grosse Ile, Michigan, 107pp.

Madenjian, C.P.; DeSorcie, T.J.; Stedman, R.M.; Brown, Jr., E.H.; Eck, G.W.; Schmidt, L.J.; Hesselberg, R.J.; Chernyak, S.M.; Passino-Reader, D.R. 1999. Spatial Patterns in PCB Concentrations of Lake Michigan Lake Trout. J. Great Lakes Res. 25(1): 149-159

Madenjian, C.P.; Hesselberg, R.J.; Desorcie, T.J.; Schmidt, L.J.; Stedman, R.M.; Quintal, R.T.; Begnoche, L.J.; Passino-Reader, D. 1998. Estimate of Net Trophic Transfer Efficiency of PCBs to Lake Michigan Lake Trout from Their Prey. Environ. Sci. Technol. 32(7): 886-891.

Miller, S.M.; Sweet, C.W.; DePinto, J.V.; Hornbuckle, K.C. 2000. Atrazine and Nutrients in Precipitation: Results from the Lake Michigan Mass Balance Study. Environ. Sci. Technol. 34(1): 55-61.

Miller, S.M., M.L. Green, J.V. DePinto and K.C. Hornbuckle. 2001. Results from the Lake Michigan Mass Balance Study: Concentrations and fluxes of atmospheric polychlorinated biphenyls and trans-nonachlor. Environ. Sci. Technol. 35: 278-285.

Pauer, J.J., W. Melendez, K.W. Taunt, and R.G. Kreis, Jr. 2006. Resurrections of the Lake Michigan Eturophication Model, MICH1. Submitted to the Journal of Great Lakes Research.

Richardson, W.L., D.D. Endicott, R.G. Kreis, Jr., and K.R. Rygwelski**.** 1999 (2004). *Quality Assurance Plan for Mathematical Modeling - The Lake Michigan Mass Balance Project.* USEPA, Office of Research and Development, NHEERL, MED, Community-Based Scientific Support Staff, Large Lakes Research Station, Grosse Ile, MI, 233 pp.

Richardson, W.L., D.D. Endicott, and R.G. Kreis, Jr. 1999. *Managing Toxic Substances in the Great Lakes: The Lower Fox River/Green Bay Mass Balance Study*. USEPA Report, ERL-Duluth, LLRS, Grosse Ile. In Internal Review.

Robbins, J.A., N.R. Morehead, R.W. Rood, D.N. Edginton, and S. Meyer. 1999. Accumulation and near-surface mixing of sediments in tLake Michigan as determined for the Lake Michigan Mass Balance Program, Volumes 1 and 2. Project Report. Final report to the USEPA, Office of Research and Development, NHEERL, MED- Duluth, MN and Grosse Ile, MI. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Ann Arbor, MI.

Rodgers, P.W. and D. Salisbury. 1981. Water Quality Modeling of Lake Michigan and Consideration of the Anomalous Ice Cover of 1976-1977. J. Great Lakes Res., 7(4):467-480.

Rygwelski, K. R., W. L. Richardson, and D. D. Endicott, 1999. A screening-level model evaluation of atrazine in the Lake Michigan basin. *J. Great Lakes Res*. 25:94-106.

Schwab, D. And D. Beletsky. 1998. Lake Michigan Mass Balance Study: Hydrodynamic modeling project. Final report to the USEPA, Office of Research and Development, NHEERL, MED- Duluth, MN and Grosse Ile, MI. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Ann Arbor, MI. 53 pp.

Stow, C.A. 1995. Factors associated with PCB concentrations in Lake Michigan salmonids. Environ. Sci. Technol. 34: 361-367.

Stow, C.A., S.R. Carpenter, and L.A. Eby. 1995. Evidence that PCBs are approaching stable concentrations in Lake Michigan fishes. Ecological Applications 5(1):248-260.

Tierney, D.P., P.A. Nelson, B.R. Cristensen, and S.M.K. Watson. 1999. Predicted atrazine concentrations in the Great Lakes: implications for biological effects. Journal of Great Lakes Research 25(3): 455-467.

Thomann, R.V. and J.P. Connolly. 1984. Model of PCB in the Lake Michigan Lake Trout Food Chain. Environ. Sci Technol., 18(2):65-71.

U.S. EPA. 1993. *Reducing Uncertainty in Mass Balance Models of Toxics in the Great Lakes B Lake Ontario Case Study*. Great Lakes Program, State University of New York at Buffalo.

USEPA, 1995. *Lake Michigan Mass Balance Project: Modeling Work Plan*. Office of Research and Development, National Health and Environmental Effects Research Laboratory, Mid-Continent Ecology Division, Community-Based Science Support Staff, Large Lakes Research Station, Grosse Ile, Michigan, 37 pp.

U.S. Environmental Protection Agency. October 1997. *Lake Michigan Mass Budget/Mass Balance Work Plan.* USEPA Great Lakes National Program Office., Chicago, IL. EPA-905-R-97-016, 145pp.

U.S. Environmental Protection Agency. June 1997. *Lake Michigan Mass Balance Study (LMMB) Methods Compendium Volume 1: Sample Collection Techniques*. Great Lakes National Program Office, Chicago, IL. EPA 905-R-97-012a, 403pp.

U.S. Environmental Protection Agency. June 1997. *Lake Michigan Mass Balance Study (LMMB) Methods Compendium Volume 2: Organic and Mercury Sample Analysis Techniques*. Great Lakes National Program Office, Chicago, IL. EPA 905-R-97-012b, 532pp.

U.S. Environmental Protection Agency. June 1997. *Lake Michigan Mass Balance Study (LMMB) Methods Compendium Volume 3: Metals, Conventionals, Radiochemistry, and Biomonitoring Sample Analysis Techniques.* Great Lakes National Program Office, Chicago, IL. EPA 905-R-97-012c, 505pp.

U.S. Environmental Protection Agency. October 1997. *Lake Michigan Enhanced Monitoring Quality Assurance Program Plan*. Great Lakes National Program Office, Chicago, IL. EPA 905-R-97-017, 134pp.

U.S. Environmental Protection Agency. 2001. *Results of the Lake Michigan Mass Balance Study: Atrazine Data Report*, December 2001, USEPA Great Lakes National Program Office, Chicago, IL. 905R-01-010

U.S. Environmental Protection Agency. 2001. *Results of the Lake Michigan Mass Balance Study: Polychlorinated Biphenyls and trans-Nonachlor Data Report,* December 2001, USEPA Great Lakes National Program Office, 905R-01-011

U.S. Environmental Protection Agency. 2001. *The Lake Michigan Mass Balance Study: Quality Assurance Report,* December 2001, USEPA Great Lakes National Program Office, 905R-01-013

U.S. Environmental Protections Agency. 2004. R. Rossmann (ed..) Results of the Lake Michigan Mass Balance Project: PCB Modeling Report. USEPA, Office of Research and Development, NHEERL, MED - Duluth, MN and Grosse Ile, MI. In revision.

Van Hoof, P. 2000. PCBs in Lake Michigan Surficial Sediments. Report tothe USEPA Great Lake National Program Office, Chicago, IL. U.S. Department of Commerce, National Atmospheric and Oceanic Administration, Ann Arbor, MI.

Velleux, M. L. and D. Endicott, 1994. Development of a mass balance model for estimating PCB export from the Lower Fox River to Green Bay. *J. Great Lakes Res.* 20(2):416-434.

Velleux, M., D. Endicott, J. Steuer, S. Jaegar, and D. Patterson, 1995. Long-term simulation of PCB export from the Fox River to Green Bay. *J. Great Lakes Res*. 21(3):359-372.

Velleux, M. S. Westenbroek, J. Ruppel, M. Settles, and D.E. Endicott. 2001. *A User=s Guide to IPX, the In-Place Pollutant Export Water Quality Modeling Framework, Version 2.7.4.* U.S. Environmental Protection Agency, Office of Research and Development, NHEERL, MED, Grosse Ile, MI. EPA/600/R-01/074, 179 pp.

Wanninnkhoff, R.J. 1992. Relationship between gas exchange and wind speed over the ocean. J. Geophys. Res., 97: 7373-7381.

SOURCES OF INFORMATION RELATED TO THE LAKE MICHIGAN MASS BALANCE STUDY

HOME PAGES:

Lake Michigan Mass Balance Study
http://www.epa.gov/glnpo/lmmb/index.html

U.S. EPA Great Lakes National Program Office
http://www.epa.gov/glnpo

U.S. EPA Large Lakes and Rivers Forecasting Research Branch
http://www.epa.gov/med/grosseile_site/index.html

Lake Michigan Lakewide Management Plan
http://www.epa.gov/glnpo/michigan.html

LAKE MICHIGAN MASS BALANCE STUDY REPORTS AND PUBLICATIONS

Lake Michigan Mass Balance Study Project Reports:

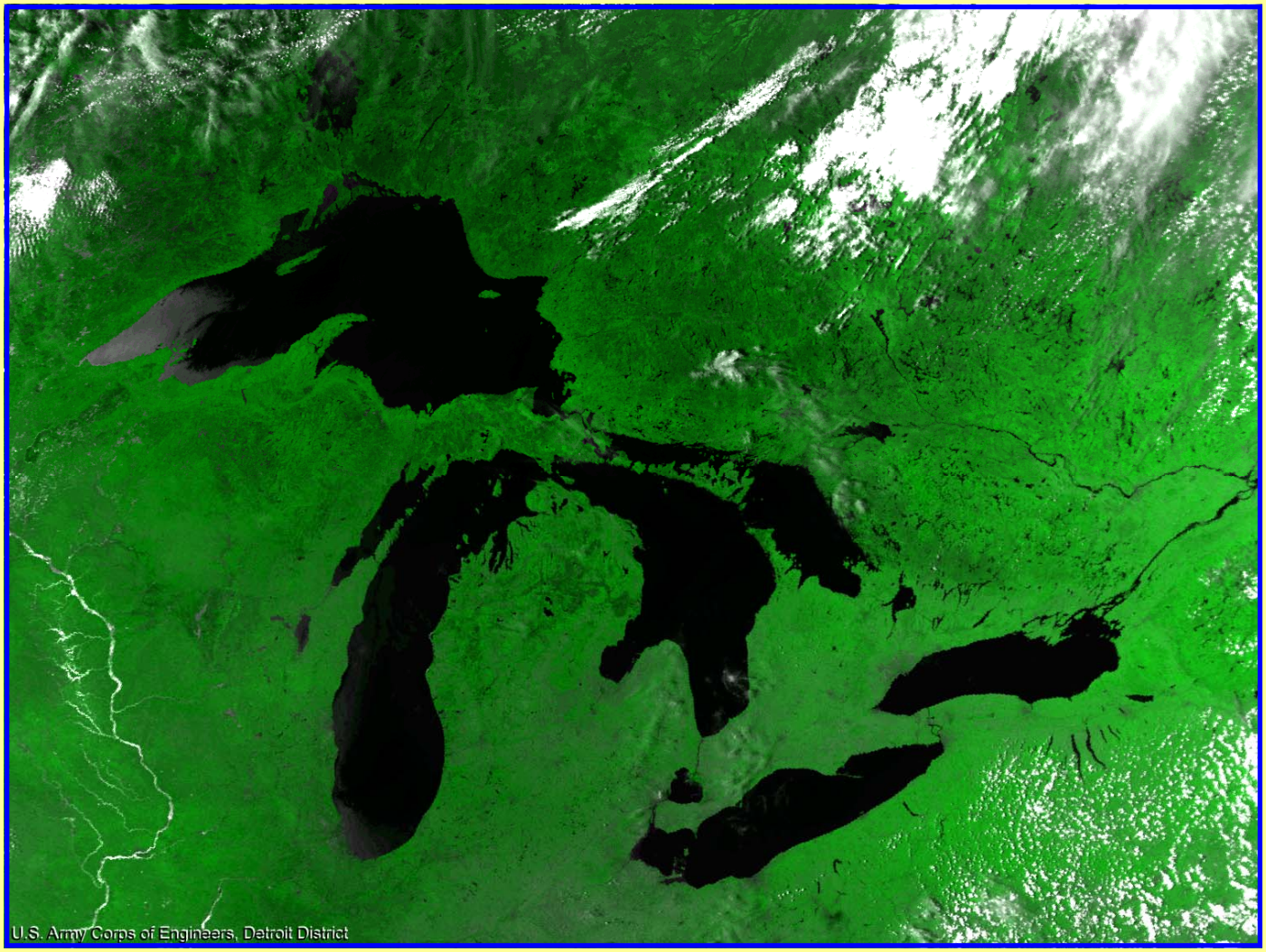
The Lake Michigan Mass Balance Project: Quality Assurance Plan for Mathematical Modeling, 1999 (March 2004)
http://www.epa.gov/med/grosseile_site/qa_lmmbp.pdf

Results of the Lake Michigan Mass Balance Study: Polychlorinated Biphenyls and trans-Nonachlor Data Report. April 2004
http://www.epa.gov/glnpo/lmmb/results/pcb/index.html

Results of the Lake Michigan Mass Balance Study: Atrazine Data Report. December 2001
http://www.epa.gov/glnpo/lmmb/results/atra_datarpt.html

Lake Michigan Mass Balance Methods Compendium
http://www.epa.gov/glnpo/lmmb/methods/index.html

Links to other peer-reviewed journal publications (citations and abstracts) that resulted from the Lake Michigan Mass Balance Study:
http://www.epa.gov/glnpo/lmmb/results/pubs.html



ACKNOWLEDGEMENTS

The Lake Michigan Management Plan 2008 was developed by the Lake Michigan Technical Committee with assistance from the Lake Michigan Forum and various other agencies and organizations. The LaMP benefited from the publicly and privately funded research of many institutions, results of pilot projects and generous critiques throughout the process. Our goal is to restore and protect the integrity of the Lake Michigan ecosystem through collaborative, place-based partnerships. The following is a list of some of the major contributors to the LaMP.

Agency for Toxic Substances and Disease Registry

Chippewa-Ottawa Resource Authority

Illinois Environmental Protection Agency

Indiana Department of Environmental Management

Lake Michigan Forum

Michigan Department of Environmental Quality

U.S Army Corps of Engineers

Great Lakes Fishery Commission

U.S. Department of Agriculture, Natural Resources Conservation Service

U.S. Environmental Protection Agency (Region 5, Great Lakes National Program Office, Office of Research and Development)

U.S. Fish and Wildlife Service

U.S. Geological Survey

Wisconsin Department of Natural Resources

The Nature Conservancy

The Lake Michigan LaMP 2000, 2002, 2004, 2006, and 2008 are available at:
http://www.epa.gov/glnpo/michigan.html