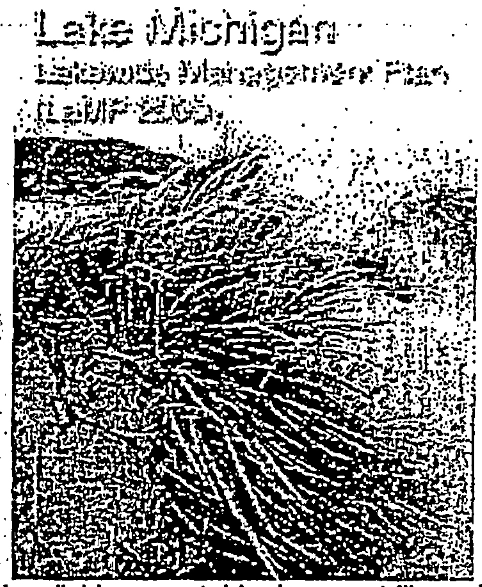
United States Environmental Protection Agency

Lake Michigan Lake Wide Management Plan (LaMP 2000)

(EPA 2000)



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Appendices

About Lake Michigan planning

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URL: http://www.epa.gov/glnpo/lakemich/

Preface:
Lake Michigan Lakewide Management Plan

Introduction

One of the most significant environmental agreements in the history of the Great Lakes was the signing of the Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada. This historic Agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion.

Under the 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 purpose, the Parties agreed to develop and implement, in consultation with state and provincial governments, Lakewide Management Plans (LaMP) for open waters and Remedial Action Plans (RAP) for Areas of Concern (AOC). The LaMPs are intended to identify the critical pollutants that affect the beneficial uses of the lake and to develop strategies, recommendations, and policy options to restore those beneficial uses. Moreover, the Specific Objectives Supplement to Annex 1 of the GLWQA requires the development of Ecosystem Objectives for the lakes as the state of knowledge permits. Annex 2 further indicates that the RAPs and LaMPs "shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses . . . [and] are to serve as an important step toward virtual elimination of persistent toxic substances . . ."

In the case of Lake Michigan, the only Great Lake wholly within the borders of the United States, the Clean Water Act holds the U.S. Environmental Protection Agency (EPA) accountable for the LaMP. EPA has chosen a collaborative approach to the implementation of this responsibility, and a partnership of federal, state, tribal, and local governments in the basin is working with stakeholders in the Lake Michigan Forum to develop and implement the LaMP. The LaMP document serves as the guide to a continuing process of collaborative ecosystem management and partnership activities aimed at achieving the LaMP goals and restoring the 14 beneficial use impairments outlined in the GLWQA. LaMPs are to be completed in four stages: (1) when problem definition has been completed, (2) when the schedule of load reductions has been determined, (3) when remedial measures are selected, and (4) when monitoring indicates that the contribution of the critical pollutants to impairments of beneficial uses has been eliminated. These stage descriptions suggest a LaMP focused solely on the impact of critical pollutants. However, problem definition work revealed other major stressors, in addition to the critical pollutants, impacting the ecosystem. These findings indicated the need to go beyond the requirement that LaMPs address critical pollutants to integrate environmental protection and natural resource management in the process.

The LaMP process has proven to be a resource-intensive effort and has taken much longer than expected. As a result, the public has waited years for a document to review. This has created the impression that actions were delayed pending a completed document. In the interest of advancing the rehabilitation of the Great Lakes and to provide information to the public in a more timely manner, the Binational Executive Committee (BEC) resolved in 1999 to accelerate the LaMP effort (BEC 1999). Acceleration was defined as an emphasis on taking action based on the current body of knowledge and adopting a streamlined LaMP review and approval process. The LaMPs were directed to treat the stages of problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential one. Consistent with the BEC resolution, the LaMPs contain appropriate funded and proposed (non-funded) remediation, restoration, and protection actions for actual improvement of the ecosystem. The LaMP includes examples of commitments by government, tribes, and nongovernment partners.

The BEC also recommended taking an iterative approach with periodic refinements based on the lessons, successes, new information, and public input generated. This adaptive management approach applied to the LaMP process will result in adjustments over time to address the most pertinent issues facing the lake ecosystem. This process begins with LaMP 2000, with LaMP updates planned every 2 years. The LaMPs are presented in a loose-leaf format that can be inserted in a three-ringed binder, which allows for easy updates, additions of new material, and removal of outdated information. The LaMPs for Lake Erie, Lake Michigan, and Lake Superior have common chapter components, but they differ in format and their amount of detail. Some chapters are incomplete, have identified data gaps, or are presented as drafts. It is intended that comments received will fill such gaps and that draft material will be finalized for LaMP 2002. With the help of the many partners and the public, we will be able to take the best qualities from each LaMP and design more concise and user-friendly LaMPs in 2002.

A Focus on Ecosystems

According to the Federal Interagency Ecosystem Management Task Force an *ecosystem* is defined as follows:

> ... 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. 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 (1995).

The foundation of the ecosystem approach is relating human beings and their activities to the ecosystems that contain them.

A Focus on Partnerships

Each government, institution, organization, and individual within the Lake Michigan basin has a potential role in the stewardship of the ecosystem; however, no single government, institution, organization, or individual has the capacity to implement stewardship and achieve sustainability in the basin as a unilateral action.

The past decade 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 changes including federal, state, and local relationships; local community empowerment; increased demands on local partners; and watershed-based institution building. In other words, 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 implementation of the LaMP goals.

The idea of "rafting" originates with river rafting parties that often lash their rafts together to navigate rapids that pose a threat to single vessels. In the field of organizational management, this metaphor describes the development of partnerships of organizations brought together to solve problems too complex to be dealt with by a single organization or agency. The rafting of organizations is important at the local level because of the potential to leverage and direct local, state, and federal resources into coordinated management efforts. In addition, many issues critical to ecosystem integrity in the basin, such as nonsustainable land use, habitat loss, and nonpoint source pollution, fall into the gaps within and between existing federal, state, and local programs. Rafted organizations with diverse memberships have the expanded strength and capacities to address these gaps.

Effective place-based partnerships are the result of the rafting of **"full partners."** Full partners may be governments, organizations, interest groups, and individuals who act in collaboration with one another to achieve sustainable landscapes. 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 sustainable landscape goals and the sharing of resources to achieve these goals. 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.

A Focus on Balance–Sustainable Landscapes

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 across time is a measure of *sustainability.* The ecosystem perspective requires a shift of focus from resource programs to resource systems. It places human activities and communities within an ecosystem and, consequently, within ecosystem management. It recognizes that human beings and their activities are part of the ecosystem and that they affect and are affected by its health. The goals of this LaMP are comprehensive concerns–such as the loss of critical habitats, decreasing biodiversity, nonsustainable land use, nuisance species, and threats to human health join the initial emphasis on critical pollutants.

The LaMP identifies the goals, necessary partnerships, and locations where ecosystem management must occur in order to attain sustainable landscapes in the Lake 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 activity. For example, wetland systems can absorb and store storm waters and thereby aid in flood control and ensure more routine flows and water levels in streams.

- *Enhancing social well-being.* Healthy landscapes provide services that make communities more enjoyable and rewarding. For example, they provide opportunities for outdoor recreation. To many, they also serve as a source of civic pride and personal and spiritual well-being.

- *Supporting local economies.* In sustainable landscapes, people meet the needs of the present without compromising the ability of future generations to meet their needs.

A Focus on Shared Information

Key to the engagement of a number of partners is the need for a common, accessible and scientific sound body of knowledge. It requires open dialogue between academia and agencies. It also necessitates a collaborative plan for monitoring in order to ensure currency in the knowledge base.

The LaMP is both a reference document and a proposal for a process to remediation of past errors and the achievement of sustainable integrity in the basin ecosystem. To this end, every effort has been made to insure that this LaMP 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. It is also meant to serve as the foundation upon which can be built multi-disciplinary, place-based, public-private partnerships–the institutional arrangements required for the implementation of the plan and achievement of its goals.

A Focus on the Future

Finally, it is critically important to recognize that local partnerships cannot develop and prosper without resources. Partnerships provide capacities that extend beyond those possessed by their individual members. These capacities–the ability to conduct coordinated ecological assessments; to set shared goals, objectives, and indicators; and to align systems, plans and budgets–are recognized as necessary prerequisites for achieving the LaMP vision. This recognition must be accompanied by appropriate support and resources. Certain activities fall within the mission of governmental agencies that have a resource base of staff and funds. Other activities will be privately funded, and some may need to have diverse funds "rafted" together.

It is perhaps fitting that this version of the Lake Michigan LaMP will foster discussion and initial implementation during the first years of the new millennium, for just as the year 2000 serves as a symbolic point of historical demarcation, so too does this document and the process that it describes point to a new page in the management history of Lake Michigan. Because LaMP 2000 has embraced the goal of a sustainable Lake Michigan ecosystem, much of the required work will need to be accomplished by partnerships in local communities. The ability of these partnerships to achieve this goal will depend on the support of federal and state initiatives, programs, and resources as well as the committed engagement of the private sector on both the local and regional level. The extent to which this engagement provides such support for *place-based partnerships*, *ecosystem management*, and *sustainability* will determine the ability of the LaMP process to achieve its goal.

Executive Summary
Lake Michigan Lakewide Management Plan

One of the most significant environmental agreements in the history of the Great Lakes was the signing of the Great Lakes Water Quality Agreement (GLWQA) in 1972 between the United States and Canada. This historic Agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion.

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The Lake Michigan LaMP work began in the early 1990s with a focus on critical pollutants just as monitoring showed that regulatory controls put into place in the late 1970's and 1980's were successfully reducing the levels of persistent toxic substances such as PCBs, mercury, dioxin, and pesticides. Monitoring also provided insights on system stress from nonpoint source pollution as well as aquatic nuisance species. The LaMP Committees, addressing all stressors, developed a set of ecosystem goals and objectives in 1998. The Lake Michigan LaMP states that "pathogens, fragmentation and destruction of terrestrial and aquatic habitats, exotic nuisance species, uncontrolled runoff and erosion are among the stressors contributing to ecosystem impairments."

In the 1994 SOLEC Integration Paper developed by EPA and Environment Canada it is stated:

> Governments have traditionally addressed human activities on a piecemeal basis, separating decision making on environmental quality from decision making on natural resource management or on social or economic issues ... An ecosystem approach to management is a holistic approach that recognizes the interconnectedness of and addresses the linkages occurring among air, water, land, and living things.

Status of the Lake

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

Lake Michigan supports many beneficial uses: drinking water for 10 million, internationally significant habitat and natural features; food production and processing; fish for food, sport and culture; and valuable commercial and recreational uses. The quality and quantity of the Great Lakes has attracted proposals to export the water and has begun an international discussion on bulk water exports.

Despite 20 years of regulation that brought about overall reduction in conventional and toxic pollutants loads, data indicate pollutants still exert negative impacts on the chemical, physical and biological components of the Lake Michigan ecosystem. The remaining toxic challenges are significantly related to legacy contamination that results in fish consumption advisories, and impairment to aquatic organisms and wildlife. Nonpoint source pollution results in episodic beach closures, and drinking water impacts, and pesticides have been detected in the open water.

The long-range transport of both airborne pollutants and non-native species into the ecosystem pose serious environmental, as well as national and international management issues. The irreversible damage from aquatic nuisance species demands immediate attention across the basin and nation. The zebra mussel is an example of an organism that has caused physical chemical and biological damage by closing water in-take pipes, concentrating contamination, disrupting the food web of the lake, and competing for food needed by native species.

Habitat

The Lake Michigan ecosystem is a composite of a number of subecosystems and habitats: atmosphere/climate, open water, wetlands, tributaries and coastal systems. Many of these habitats rank as globally rare or imperiled due to restricted distribution, level of threat, ecological fragility, widespread damage or because they are part of the single largest source of fresh surface water in the world.

Open Lake System

The aquatic ecosystem of Lake Michigan has experienced profound changes in the past 140 years. The current status of the ecosystem is changing and heavily dependent on human management in the form of the stocking of predator fish. Any assessment of the status and trends of ecosystem health must begin with an understanding of the loss of habitat, biological diversity and subsequent establishment of non-indigenous populations.

The plankton communities (phytoplankton and zooplankton) of Lake Michigan are the base of the food web and therefore are one of the most important components of the lake's ecosystem. The abundance and types of phytoplankton are highly variable within the lake depending on time of year, area of the lake and availability of phosphorous and other nutrients. The amount of phosphorous has been the largest man-induced change to phytoplankton communities, especially in nearshore areas. Changes to plankton communities may also be occurring as a result of exotic species such as the spiny water flea (*Bythotrephes cederstroemi*) and the zebra mussel (*Dreissena polymorpha*). Many species of non-indigenous algae have also been introduced into Lake Michigan and studies indicate that increased salinity and other environmental changes are enabling introduced algae to adapt more readily to the environment of the Great Lakes. Zooplankton includes many different invertebrates and fish fry and comprises the bulk of the diet of planktivorous fish. Because most zooplankton feed on phytoplankton, their abundance and geographic occurrence are similarly dependent upon water temperature, seasonal changes and availability of food. Research conducted in the past 15 years also indicates that zooplankton populations may be experiencing changes induced by *Bythotrephes*. Dramatic declines in local *Daphnia* have coincided with increases in *Bythotrephes* populations.

Lake Michigan benthic or lake bottom communities are also under stress. Studies suggest that zebra mussels are having a significant impact on benthic 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 include increased competition for plankton at the expense of fry from nearshore species (such as yellow perch), increased biomagnification of contaminants in piscivores feeding on benthivores and possible zebra mussel induced mycrocystis blooms.

Fish communities represent the highest trophic levels within the Lake Michigan aquatic ecosystem. They are also the most visible indicators of the health of the ecosystem and represent, to most people one of the most important resources of the lake. The alteration of fish communities has been the most obvious impairment to the aquatic ecosystem in Lake Michigan. The current status of the fish community is dependent upon human management by the various agencies responsible for the fisheries of Lake Michigan.

Multiple stressors continue to degrade the open lake system. Toxic chemicals contaminate water and sediment quality. Fish advisories are still in effect. Some beaches, particularly in the southern part of the lake, are closed episodically. Aquatic habitats do not naturally sustain healthy and diverse fish communities. Exotic species continue to disrupt native plant and animal communities. Unsustainable human activities, like habitat destruction resulting from urban sprawl and construction and sand mining in dune areas or other coastal regions, continue to threaten the ecosystem. Overall, ecosystem stewardship activities are currently not sufficient to overcome human-induced stressors.

Coastal and Inland Wetland System

The coastal wetland system supports the greatest diversity and biological productivity in the basin. Wetlands are important because they collect nutrients and organic materials that are washed off the land into tributaries. Tributaries carry the materials to the lake, where they are deposited on the shore by longshore currents. These materials support both the aquatic food web and habitat for bird, mammal, reptile, amphibian, and invertebrate resident and migratory species. Migratory birds use coastal wetlands as staging and feeding areas. Both lake level fluctuations and longshore sediment transport are important in maintaining this highly productive system because of their roles in bringing the materials needed to nourish and protect it.

The diverse coastal wetland is habitat for numerous species of wildlife dependent on wetlands. Many insects have an aquatic larval stage; amphibians also depend on wet conditions, at least during the larval stage. Many reptiles spend their entire lives in or near these coastal wetlands.
Most Lake Michigan fish also spend a portion of their life cycle in coastal wetlands when they move to the shallow, wetland waters to spawn. Fish have very specific spawning needs: a certain kind of substrate, current, water depth, and temperature available during a specific timeframe. Fish often return to the same places where they hatched. Similar to waterfowl, spawning fish populations become concentrated in a small area of habitat. For those spawning populations, the spawning habitats become far more important than their relative size would suggest. Although artificial reefs have been created in marine waters and in small freshwater lakes and reservoirs for decades, their effectiveness as a fishery management technique in the Great Lakes is still being evaluated. Three of eleven intentionally-placed artificial reefs in the Great Lakes are found in Lake Michigan.

The inland wetland system – wetlands away from the Lake Michigan shoreline – is the reservoir for water in the Lake Michigan drainage basin. There are many types of inland wetlands, including fens, bogs, wet meadows, and wet forests. The health of inland wetlands is dependent on the quantity and quality of groundwater and surface water. Inland wetlands help to regulate the basin's volume of water, as well as sediment and certain pollutant loads. They also store nutrients and serve as the nutrient exchange vehicle for the diversity of species which use inland wetlands as habitat and feeding areas. Both wetland and upland species breed and feed in Lake Michigan's inland wetlands.

Millions of acres of inland wetlands have been lost in the Lake Michigan basin to agriculture, industry and urban development. Over the last two centuries, wetland losses in the four states at least partially within the Lake Michigan basin have been disproportionately greater than in many other U.S. regions. Since the 1780s, Lake Michigan basin states have lost an estimated 21.9

million (62.9 percent) acres of wetlands out of their 34.8 million original wetland acres. This compares with an average loss of 52.8 percent nationwide. There are an estimated 12.9 million acres of wetland remaining in the four states, representing more than 12.3 percent of the wetlands within the lower 48 states.

Coastal Shore System: Sand Dunes

From northern Indiana and continuing northeasterly into Michigan, the most colossal shore feature in all the Great Lakes is apparent: the massive coastal dunes that flank the shore. The dunes were formed following the last glaciation and are 2,500 to 10,000 years old. They run along the entire shore to heights of 300 feet and widths of more than one mile, except when interrupted by river valleys, cities, and roads. The Lake Michigan dunes are numerous, diverse, and irreplaceable.

The dunes are subjected to residential development with summer homes and permanent residences, often very close to the shore. Ancient high lake levels formed the beach ridges, and as the lake receded, the prevailing on-shore winds continued to blow beach sand up the slopes. Lake Michigan is now home to the largest collection of freshwater sand dunes in the world.

Dune and swale or ridge and swale community complexes are found in several places through the Lake Michigan basin. They were formed as the ancestral Great Lakes receded. In the south, the dunes or ridges stretch parallel to the Lake Michigan shore and are rich in oak savanna species. The wet swales between these ridges support rich prairies and sometimes rare coastal plane marsh communities. In the north, ridges are typically dominated by red and white pine and other conifers, and the swales by white cedar swamps or sedge meadows.

On the eastern shore of Lake Michigan an invasive non-indigenous species is threatening dune ecosystems. Baby's breath is moving into sensitive areas and out-competing native species. Control measures such as hand pulling and herbiciding are being utilized at Point Betsie and at the outskirts of Sleeping Bear Dunes National Lakeshore.

The coastal system is also home to prime waterfowl habitat. Diminished populations of top predators such as bald eagles and osprey have made a come back while some species still experience localized deformities and reproductive problems. Gulls, geese, and cormorants are now numerous in the basin, necessitating studies of possible management options.

Coastal Shore System: Global Climate Change

Global warming resulting from human activities poses the threat of increased temperatures and changing precipitation rates. Shorelines could change quickly, submerging or exposing ecosystems accustomed to harshness and variability but unable to cope with rapid change. An abrupt change in climate could prevent ecosystems that now survive in small, isolated areas from adapting.

Of particular concern are the predictions of poorer water quality and shifts in species composition. Increases in fish yields (warm water species) will be concurrent with eutrophic-like conditions and increased contaminant loading and bioavailability. While a warmer climate will provide longer seasons for agriculture and commercial shipping, changes in seasonal runoff patterns, decreases in total basin moisture and lake level decline will have negative consequences. Lake level decline will also result in significant loss, migration and changes in wetlands. Most impact assessment efforts have been concentrated on physical responses. The biological consequences of the physical responses to climate change have yet to be seriously explored.

Tributary System

Tributary streams and rivers are connected to Lake Michigan in several ways. Energy is transferred from lake to tributary and tributary to lake by way of fish movement up and downstream and material movement downstream. Diverse plant and animal habitats are found throughout the tributary system. The range of tributary habitats depends upon the size, slope, substrate, geology and land-use in the drainage basin, groundwater characteristics, climate, and the nature of the terrestrial vegetation. Many of these habitats accommodate Lake Michigan fish. Sediments and vegetative materials are sent downstream to the lake and are transported around the coastal shores and marshes of the lake to create habitats. The connectivity to the lake maximizes fish biodiversity and production.

The quality of many tributary rivers in the Lake Michigan basin has been significantly impaired due to channelization, dredging, damming, sedimentation, loss of bankside vegetation, eutrophication, increased spring flooding, and toxic contamination. Large areas of inland forests and wetlands that once served to regulate the quantity and quality of water flowing into tributaries have been lost. As a result, tributaries pass on their pollutant and sediment loads to the lakes and their suitability as spawning habitat has been seriously impaired. In urban areas, degradation has been most severe. Pollution from agriculture, industry and urban development has polluted rivers and contaminated sediments. The result is the contamination of fish and wildlife that depend on river habitats. Many rivers, particularly at the rivermouths, have been declared Areas of Concern and have many impaired beneficial uses.

Areas of Concern: Legacy Sites

Lake Michigan has 10 Areas of Concern that have documented from 5 to 14 beneficial use impairments on a local level. A number of major and hot spots removals have been successfully completed including: (1) a Superfund removal of 150,000 cubic yards of PCB-contaminated materials (containing 20,000 lbs. PCBs) from Bryant Mill Pond on the Kalamazoo River, Michigan; (2) a removal of over 12,000 cubic yards of arsenic contaminated sediments in the Menominee River, Wisconsin where arsenic levels so high the dredged material was classified as a hazardous waste; (3) a dredging demonstration in the Fox River, in Wisconsin, that removed over 10,000 cubic yards of PCB-contaminated sediments from the river that is the major source of PCBs to Lake Michigan; and (4) a Superfund action in Waukegan Harbor that removed more than approximately 453,600 kg (1 million pounds) of PCBs from the sediments.

Human Health Issues

The interaction of contaminates in the environment and impacts on human health is a complex issue since factors other than environmental exposures are also at work including genetics, lifestyle and many other factors. The major concerns are possible exposure from pathogens contaminating drinking water and beaches, and chemical contamination that bioaccumulates in fish causing the need for fish advisories. While levels of persistent toxic substances have declined in the Great Lakes the scientific understanding of the implications of exposures to these substances has increased such that there is now a broader range of concerns from effects of endocrine disruptors on human health. There is a need for the development of a methodology to assess the effects of endocrine disruptors on community health.

Air Pollution Pathway

The role of air pollution as an important contributor to water pollution has long been recognized and, in recent years, has been the subject of growing scientific study and concern. 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 long distances and be deposited on land or water at locations far from their original sources. Most notably, PCBs and some persistent pollutants, including several pesticides that have not been used in significant amounts in the U.S. since the 1970's have become widely distributed in the environment and are now part of the global background.

Loadings of pesticides, canceled or restricted in the U.S., to Lake Michigan are primarily from atmospheric sources that may not be possible to regulate or control. Although there are no current commercial sources of banned pesticides in the U.S., loadings continue from remaining consumer stocks, evaporation from soils, resuspension of contaminated sediments, and airborne transport from other countries that continue to apply these substances. Further reductions must come from clean up of contaminated sites, collection and disposal of existing stockpiles (clean sweeps), and reduction in use in other countries.

Air Pollution Science

New models have been developed that combine meteorology with measured chemical compositions to locate probable air emission sources. These methods depend on estimating the movement of the air backward in time from the sampling location using wind speed and direction as well as barometric pressure. This back tracing or back-trajectory model will be applied to the southern end of Lake Michigan to help locate sources.

Pollutant Cycling

These toxic chemicals remain in the environment and continue to cycle between air, water, soil and plants and animals long after their manufacture or use has stopped. Contaminated sediments stirred up by storm or boat traffic can be ingested by fish or move to the surface where pollutants can evaporate into the air and be carried significant distances only to be redeposited again. As lake levels fall, there is the possibility of additional contaminated areas being exposed. Old pesticides may be released from agricultural lands when plowed. Pollutants can be either in the gas phase or attached to dust particles. The transport will depend on the physical state and weather patterns. This process explains pesticides used years ago in the southern United States being found in samples taken from Lake Michigan.

Nonpoint Source Pollution

While long- range transport of pollution is an important source, recent studies also point to influences of local sources, particularly nearby older urban areas. Air sampling over Lake Michigan, when the wind is carrying pollution from the Chicago area out over the lake, shows contributions of PCBs, PAHs and mercury to the lake. The relative importance of each source to the overall loadings is variable depending on season, weather and activities

Agricultural land use is found throughout the Lake Michigan basin, predominately in the southern portion. The breakdown is approximately 37 percent in the western basin with more than 99 percent of it in cropland and pasture. Small areas of orchards, groves and vineyards are located on the Door Peninsula. The second largest land use (after urban) in the southern part of the basin, approximately 37 percent , is agricultural and found mostly in the St. Joseph River basin. The eastern basin is approximately 28.5 percent agricultural, including cropland, pasture land and orchards. Parts of these areas are classified as three of the top 20 most threatened, high quality (prime farm land and/or unique soils and climatic requirements) lands under development pressure by the American Farmland Trust. The three are: Southern Wisconsin and Northern Illinois Drift Plain, Southwestern Michigan Fruit and Truck Belt, and Western Michigan Fruit and Truck Belt.

These areas are important to the overall balance and sustainability of the basin in order to achieve the LaMP vision /desired outcome of " A sustainable Lake Michigan ecosystem that ensures environmental integrity, that supports and is supported by economically viable, healthy human communities." The current management of these lands stress the Lake Michigan ecosystem by contributing sediment that carries with it pesticides and nutrients. Urban runoff also contributes sediments contaminated with not only pesticides and nutrients but also chemicals, oils, and road salt. These substances accumulate or persist in the lake because, unlike rivers that are constantly flushed with water, the lake is a sink. A drop of water entering Lake Michigan will take an average of 100 years to either evaporate or be washed into Lake Huron. For a particle of soil, the retention time is even longer and its attached contamination can be taken up into the food chain of the lake, including the human population.

Sediments also impact the habitat systems of the lake. Lake Michigan contains 40 percent of the coastal wetlands system of the entire Great Lakes system. The location of these with access to tributaries and inland systems as well as the lake provide habitat for larval stages and an abundant food supply. Too much sediment can bury submergent and emergent plants while nutrients cause too much growth and chemicals remain a long term source of contamination. Many of these chemicals are persistent and bioaccumulate in fish and aquatic organisms, resulting in limiting commercial fisheries and announcements of fish consumption advisories.

Sediment Science

To further define this complex and important problem of understanding how nutrients, contaminants and sediments continue to recycle in the lake a number of scientific investigations are underway with the major reporting of the results expected in 2001-2002 time frame. The Episodic Events: Great Lakes Experiment (EEGLE) led by the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory began in 1996. That year, a massive turbidity plume, 10 miles off shore, 200 miles long, with as much as 1 million tons of material was observed by satellite. The plume can appear as early as February or as late as May and for 5 years has been being studied by over 40 environmental scientists from federal and state agencies and universities. www.glerl.noaa.gov/eegle/

Mass Balance Science

The Lake Michigan Mass Balance Study led by U.S. EPA's Great Lakes National Program Office in 1994-95 collected data from air, water, sediment, and the open lake and from selected tributaries to improve the understanding of key environmental processes governing contaminant cycling and availability within a relatively closed ecosystem. The data will be entered into a number of models, one of which is a sediment transport model. The model will help predict how particles from near-shore locations such as tributary mouths are transported to depositional zones usually in deep water. www.epa.gov/grlakes/lmmb/sedtrans.html

In the winter of 1999 the Lake Michigan Forum held a work shop on sediment issues in the basin, followed by a summer 1999 work shop on stewardship projects. The Forum has formed an Agriculture Pollution Prevention Task Force to address specific pollution prevention projects for sediments and pesticides in the Lake Michigan Basin. www.lkmichiganforum.org

Recommendations for 2000-2010

The Lake Michigan Technical Coordinating Committee developed the following recommended management actions and activities to be completed over the next 15 years.

1. **Ballast Water Control** - The Great Lakes are not only impacted by aquatic nuisance species causing irreversible damage but also serve as a pathway to other connected ecosystems. Standards or guidelines should be developed for ballast water treatment, working toward zero discharge.

2. **Clean Legacy Sites** - The Lake Michigan Mass Balance Study has confirmed that contaminated sediment sites in the lake remain an ongoing source of contamination into the food web causing fish advisories and delaying dredging of navigable waterways, both of which affect the local economies. In order to move swiftly to clean up contaminated legacy sites, both on land and at sediment sites, we will convene federal and state Superfund, RCRA Corrective Action, Drinking Water and Surface Water programs for planning discussions focused on the Lake Michigan ecosystem. The goal is to complete almost all plans by 2005 and actions by 2010. A few of the major sediment sites may require additional time.

3. **Protect Source Water** - As the drinking water source for 10 million with globally significant features, it is important to determine if the level of protection is sufficient utilizing the state assessments that delineate source areas and assess significant potential sources of contamination. If the assessment indicates that the intake is not impacted by potential shoreline contaminants, then RAP, LaMP, and mass balance materials would be used. Consideration should also be given to the question of exporting the resource.

4. **Protect Habitat** - Determine a priority for preservation sites within the recently mapped bio-rich clusters, including connecting corridors between clusters as well as the sites identified in the North American Waterfowl Management Plan. Wetland areas, particularly those with connection to the lake that are important to many species, and restoration of coastal brownfields to greenfields ,should be highlighted. Natural areas not only provide habitat but also serve to filter sediments and nutrients runoff , as well as store flood waters and recharge ground water. Provide this information on line.

5. **Fish Collaboration** - Develop joint projects with the Great Lakes Fishery Commission that implement both the LaMP and the Joint Strategic Plan for Management of Great Lakes Fisheries. Collaborate on the development of fish spawning maps to aid protection and provide adjacent land use planners with tools and data.

6. **Match Decision Makers with Issues** - Convene and engage the appropriate level of government and other nontraditional groupings to accomplish LaMP goals and match the needed control with

the most likely control point by promoting the following:

- National dialogue for control of aquatic nuisance species and air deposition of toxics
- Academic and agency dialogue to promote sharing of data, define research needs and develop lake-related courses
- Local dialogue to provide tools and a lakewide perspective to land use planners

7. **Control Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO)** - The mixed discharge of storm water and domestic waste causes beach closings and is a pathway for pathogens to enter the lake. Provide tools, training, and data to local governments to promote full compliance with CSO, SSO, and storm water regulations, and system maintenance with awareness of land use planning on a watershed basis.

8. **Develop Agriculture Pollution Prevention Strategy** - Includes and coordinates among States, NRCS, and the Lake Michigan Forum's Agriculture Task Force to promote nonpoint source pollution prevention using stream planted buffer strips, and pollution prevention for pesticides, confined animal feed operations and nutrient controls. Food web disruptions in Lake Michigan relate to sedimentation and continuing nutrient pollution.

9. **Implement Area of Concern (AOC) Remedial Action Plans (RAP)** - AOC RAPs are in various stages of completion. Many RAP and watershed groups, as well as local communities, have included the watershed in their planning and have developed a list of priorities found in Addendum 6-B. These groups need support that include tools, technical assistance and training, and some level of funding to provide the ability to leverage scarce resources.

10. **Fill Data Gaps** - Promote research with the following goals:
    - Define in-basin and out-of-basin air pollution
    - Develop technology to control aquatic nuisance species in ballast water
    - Understand pesticides, pathways, and longevity in open water
    - Reuse contaminated sediments
    - Understand endocrine disrupters and their effects, sources, and possible controls
    - Identify fish spawning site locations
    - Review and refine Lake Michigan pollutants list

11. **Clean Sweep Strategy** - Years after certain pesticides were canceled and restricted, such as DDT/DDE, dieldrin, chlordane, they are still recovered in clean sweep operations, indicating the effectiveness of the tool. However, there is no special source of funding for these activities; therefore, there is a need to develop a strategy to ensure long-term consistent funding or ownership of annual pesticide, household hazardous waste and small business PCB/mercury Clean Sweep programs for each state.

12. **Measure and Report** - Continue development of the Lake Michigan Monitoring Coordinating Council and jointly develop a Monitoring Plan for Lake Michigan that includes expanding the USGS National Water-Quality Assessment Program (NAQWA) monitoring to Michigan's eastern shore and drainage. Develop a strategy for duplicating the coordinated monitoring (simultaneous air, water, land, open water and tributary mouths) of the Lake Michigan Mass Balance Project (LMMB 1994) in 2004 to have data for a 10-year analysis. Establish a beach community monitoring network and a volunteer basin monitoring network.

13. **On-Line Information, Public Involvement Activities** - Promote sharing of public information and public involvement by providing the following: (1) on-line data site that includes public health information, (2) an on-line habitat atlas of the basin showing ecologically-rich areas, and (3) a running summary of comments and responses. Continue the Forum's public meetings, workshops and boat tour in partnership with organizations such as Grand Valley State University, which also sponsors the State of Lake Michigan Conference.

14. **TMDL Strategy** - Total Maximum Daily Loads (TMDL) must be developed when waters do not meet state-adopted water quality standards, even after the implementation of technology-based controls. TMDLs are calculated to return waters to their designated uses. States develop TMDLs for their tributaries, and a strategy for cooperative TMDL work for Lake Michigan that includes a public involvement process is needed.

15. **Stewardship Actions** - The majority of the land that drains to the lake is privately owned and managed. America's cities and towns account for 80 percent of energy use. Of that 80 percent, land use planning and urban design affect about 70 percent, or 56 percent of the nation's total energy use. Energy production and transportation are major sources of air pollution. The message from these statistics is that every basin resident is a "Lake Michigan Manager." We need to strengthen partnerships with other education and outreach efforts to promote the activities necessary to accomplish the following: (1) promote recycling efforts, energy and water conservation, and trash barrel burning awareness; (2) place special emphasis on preventing the spread of aquatic nuisance species by boat owners for the next two years; (3) communicate the importance of private efforts in habitat preservation on both public and privately owned land; and (4) develop an Areas of Stewardship program for local communities and watersheds.

Table ES-1 Lake Michigan LaMP Summary Table

CHAPTER 2	CHAPTER 3		CHAPTER 4		
Lake Michigan LaMP: Vision, Goals and Ecosystem Objectives	Indicators and Monitoring of the Health of the Lake Michigan Ecosystem		Lake Michigan LaMP: Current Status of the Ecosystem, Beneficial Use Impairments and Human Health		
Endpoint Goal	Monitoring	Human Activity	Impairment	Spatial	Temporal
1. We can all eat any fish.	• Chemical contamination in fish • Site assessments • Eagle reproduction	• Fish advisories • Congressional reports on: - Great Waters - Mercury - Dioxin	• Restrictions on fish and wildlife (F/W) consumption • Tainting of F/W flavor	Local Local	Ongoing Episodic
2. We can all drink the water.	• Raw water quality data • Source water assessments	• Water utility notifications • Source water protection	• Restrictions on drinking water consumption or taste and odor problems	Local	Episodic
3. We can all swim in the water.	• *E Coli* levels in recreational water	• Beach closing advisories • State 305(b) WQ reports	• Beach closings	Local	Episodic
4. All habitats are healthy, naturally diverse and sufficient to sustain viable biological communities.	• Fish assessments • Bird counts • Wetlands inventories and assessments • Stream flows • Eco-rich area assessments	• Endangered species list • Wetlands mitigation and protection • Zoning • Fish stocking • Fish refuges • USFWS refuges • Ballast water exchange • Dune protection • Eco-rich cluster map	• Degradation of F/W populations • Fish tumors, or other deformities • Degradation of Benthos • Eutrophication or undesirable algae • Degradation of phytoplankton and zooplankton • Loss of F/W habitat • Bird or animal deformities	Regional Local Local Local Lakewide Lakewide Local	Evolving Episodic Ongoing Episodic Ongoing Ongoing Episodic
5. Public access to open space, shoreline and natural areas is abundant and provides enhanced opportunities for human interaction with the Lake Michigan ecosystem.	• Urban density • Coastal parks acreage • Conservation easements	• Open space funding and protection statutes • Coastal zone management	• Degradation of aesthetics	Local	Evolving
6. Land use, recreation and economic activities are sustainable and support a healthy ecosystem.	• Contaminants in recreational fish • Sustainable forests	• Superfund cleanups, dredging • CRP percent of eligible farm lands • Brownfields to greenfields redevelopment	• Restrictions on dredging • Added cost to agriculture or industry	Local Local	Evolving Evolving

Table ES-1 Lake Michigan LaMP Summary Table (continued)

CHAPTER 5		CHAPTER 6	
Lake Michigan Stressor Sources and Loads		Strategic Action Agenda: Next Steps	
Stressors	Source	Means to an End Goal	Recommendations
• Chemical - PCBs - Mercury - Dioxin - DDT - Chlordane	• Air deposition • Legacy sites • Sediments • Incinerators • Burn barrels		Implement AOC RAPs Clean Legacy Sites Clean Sweep Strategy TMDL Strategy Stewardship Actions
• Biological - Pathogens - ANS	• Land use • Point source • Nonpoint source		Protect Source Water Fill Data Gaps
• Biological - Pathogens • Physical • Chemical	• Land use • Point source • Storm water • CSO/SSO		Control CSO, SSO Develop Agricultural P2 Strategy On-Line Information, Public Involvement Activities
• Physical - Sedimentation - Habitat destruction • Biological - ANS • Chemical - Nutrients - Toxics	• Land use/sprawl • Point source • Air deposition • Ballast water • Storm water • Agriculture runoff	Control pathways Manage ANS Ecosystem stewardship Collaboration Research	Ballast Water Control Protect Habitat On-Line Information, Public Involvement Activities Stewardship Actions Fish Collaboration Fill Data Gaps Measure and Report
• Physical - Sprawl • Biological - ANS	• Land use		On-Line Information, Public Involvement Activities Stewardship Actions
• Physical • Biological • Chemical	• Land use • Point source • Legacy sites		Fill Data Gaps On-Line Information, Public Involvement Activities Stewardship Actions Match Decision Makers with Issues