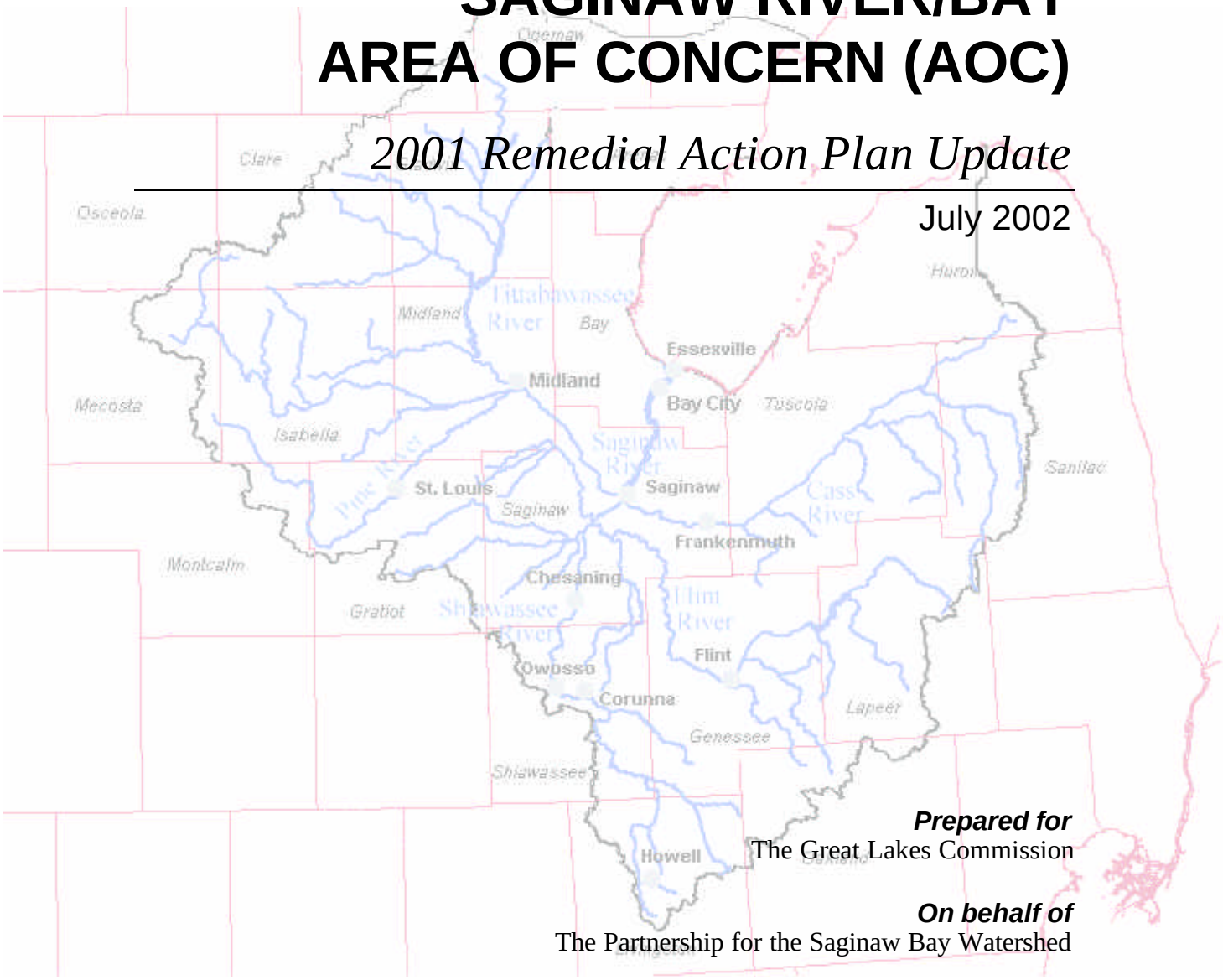
TARGETING ENVIRONMENTAL RESTORATION IN THE SAGINAW RIVER/BAY AREA OF CONCERN (AOC)

2001 Remedial Action Plan Update

July 2002



Prepared for
The Great Lakes Commission

On behalf of
The Partnership for the Saginaw Bay Watershed

Prepared by
Public Sector Consultants, Inc.
Lansing, Michigan
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Introduction

The Saginaw River and Bay was designated by the International Joint Commission (IJC) as one of the major pollution areas in the Great Lakes in 1973, a year after the first Great Lakes Water Quality Agreement between the United States and Canada was signed—a commitment by both countries to cooperatively manage their shared water resources and recommend actions for protection. Objectives were specified that would reduce nuisance conditions and the discharge of substances toxic to human, animal, and aquatic life (IJC 1987).

The Agreement, as amended by Protocol in 1987, resulted in the designation of Saginaw River/Bay as one of 43 Areas of Concern (AOCs) because degraded water quality conditions impaired certain beneficial uses as defined by the Agreement. Contaminated sediments, excessive nutrients such as phosphorus and nitrogen runoff, soil erosion, fish consumption advisories, degraded fisheries, and the loss of significant recreational opportunities were the primary causes for the AOC designation (MDNR SWQD 1994). Fourteen of the AOCs are located within Michigan, including three that are shared with Canada.

The IJC was established as part of the Boundary Waters Treaty of 1909, a formal acknowledgement between the U.S. and Canada that actions by either country can affect the lakes and river systems that cross both sides of the border. The focus of the IJC—and that of the cooperating federal, state, and provincial agencies for the past 25 years—has been to develop and implement remedial action plans (RAPs), a process to identify and implement pollution abatement measures for each AOC that will restore designated water uses that are presently impaired.

The goal of the RAP is to restore and maintain beneficial uses. Subsequent actions carried out to meet the goal will eventually result in the removal of the AOC designation through a "delisting" process. Until recently, however, the delisting process has been ambiguous, with many questions of how and when to formally delist. The goal for delisting revolves around the implementation of remedial actions that target beneficial use impairments and lead to restored and maintained conditions. In addition, the AOC may pursue an interim "recovery stage" designation. The critical test for any such process and associated criteria is to insure that it is rigorous, scientifically defensible, and allows for full review and comment from interested and affected stakeholders (EPA 2001, December 6).

In November 1994, Collingwood Harbour, located in Canada, became the first AOC in North America to be delisted, primarily due to its limited, narrowly defined impairments. No large AOC with complex and numerous impairments such as those cited in the Saginaw River/Bay area has been delisted.

Completed in September 1988, the *Saginaw River/Bay Remedial Action Plan*, a nearly 600-page document, was submitted by the State of Michigan to the IJC. The RAP summarized water quality data on the Saginaw Bay drainage basin and outlined remedial actions that should be taken to further address the pollution problems in the

Saginaw River and Bay (PSC 2000). The 1988 Saginaw River/Bay RAP cited 12 impairments of the 14 categories specifically listed by the IJC for the Saginaw River/Bay AOC:

- Restrictions on fish or wildlife consumption
- Tainting of fish or wildlife flavor (taste and odor concerns)
- Degradation of fish and wildlife populations
- Degradation of fish and wildlife habitat
- Bird or animal deformities or reproductive problems
- Degradation of benthos (bottom-dwelling organisms)
- Restrictions on dredging
- Eutrophication (nuisance algal blooms, oxygen depletion, and nutrient loadings)
- Restrictions on drinking water (taste, odor, or other problems)
- Beach closings (exposure to waterborne human pathogens)
- Degradation of aesthetics
- Degradation of phytoplankton (minute aquatic plants)

A draft RAP update completed in 1994 suggested that over two-thirds of the 101 proposed RAP activities had been implemented, and that all 37 priority actions had been implemented, at least partially (MDNR SWQD 1994). The 1994 RAP describes many of these actions and goals; the environmental status of Saginaw Bay and the watershed; the maturation of the RAP process; and additional actions needed to move forward with the RAP effort. In addition, the RAP update was much more comprehensive than previous planning documents because it examined environmental quality from an ecosystem perspective, an approach that addresses impairments on a watershed basis, rather than focusing on a single pollution source or issue.

In August 2000, The Partnership for the Saginaw Bay Watershed, a local stakeholder group comprised of citizens, government representatives, and environmental groups, released a study entitled, *Measures of Success: Addressing Environmental Impairments in the Saginaw River and Saginaw Bay* (PSC 2000). The study provides an accounting of environmental progress that has been made to restore the area's water resources and represents the collective thoughts of technicians, public officials, stakeholders, and watershed citizens who participated in the process.

A top priority of the project was development of clear targets for restoring the beneficial uses of the Saginaw River and Bay that are environmentally sound, understandable to the general public, and acceptable to the community. The process led to consensus among diverse stakeholders regarding future actions needed to restore the Saginaw River and Bay that will ultimately lead to AOC delisting. The *Measures of Success* project focuses on the impairments that originally led to the designation of the Saginaw River/Bay as an AOC and provides a foundation for redirecting and targeting efforts required to achieve and sustain the full potential benefits of this valuable natural resource.

A primary goal of the present RAP update is to assess and support the validity of the targets identified in the *Measures of Success* report. The five indices identified in the *Measures of Success* report are each discussed in separate sections of this report. Each section contains a brief discussion of the current status of the resource and impaired beneficial uses; target(s) to address the impairments; and scientific evidence to support the identified target(s). References cited are listed at the end of the report.

In addition, the purpose of this 2001 RAP update is to

- examine the status of the existing conditions of natural resources and beneficial use impairments (BUIs) by reviewing and summarizing data currently available;
- conduct a scientific review of established targets for restored conditions identified in the *Measures of Success* report by developing information to determine if the targets are reasonable, accurate and achievable; and
- establish links between beneficial use impairments and target measures to ensure that they lead to reduction or elimination of the BUI with a view toward AOC delisting.

THE SAGINAW BAY WATERSHED

The Saginaw Bay watershed is one of Michigan's most diverse areas. Its rich resources support agriculture, manufacturing, tourism, outdoor recreation, and a vast variety of wildlife. It is also Michigan's largest watershed and includes all or part of 22 counties and America's largest contiguous freshwater coastal wetland system. This wetland extends along the shores of Saginaw Bay and provides vital habitat for millions of migrating waterfowl and songbirds and over 90 fish species. The watershed also features more than 175 inland lakes, about 7,000 miles of rivers and streams, and drains approximately 15 percent of Michigan's total land area. Its nearly 8,700-square-mile area is home to more than 1.4 million people and over 138 endangered or threatened species (MDNR SWQD 1994). In addition to supplying water to the wildlife, the watershed provides residents with water for recreation, irrigation, electrical power generation, industrial processes, and drinking water.

Located in the east central portion of Michigan's lower peninsula, the Saginaw Bay watershed consists of all of the land area and waterways that drain into Saginaw Bay. This watershed extends from Iosco, Ogemaw, and Roscommon Counties in the north to Livingston and Oakland Counties in the south. It includes parts of Huron and Sanilac Counties in the east. The bay has a large surface area of 2,960 square kilometers and a drainage basin of 22,557 square kilometers. Twenty-eight rivers, creeks and agricultural drains flow directly into Saginaw Bay, but approximately 75 percent of the tributary hydraulic load comes from the Saginaw River (MDNR SWQD Great Lakes 1988).

The physical boundaries of the Saginaw River/Bay watershed AOC are defined as extending from the head of the Saginaw River, at the confluence of the Shiawassee and Tittabawassee Rivers upstream of the city of Saginaw, to its mouth, and all of Saginaw Bay out to its interface with open Lake Huron at an imaginary line drawn between Au Sable Point and Point Aux Barques (see Exhibit 1). Areas outside these

physical boundaries, but within the Saginaw Bay drainage basin, are included in the RAP if they are known or suspected sources of contaminants to the Saginaw River and/or Saginaw Bay.

EXHIBIT 1
Features of the Saginaw River/Bay Watershed

SOURCE: Michigan Department of Environmental Quality, 2000.

The regional economy is centered on agriculture, industry, recreation, and forestry. The agricultural community produces sugar beets, corn, dry beans, barley, wheat, and potatoes. Hogs, poultry, and dairy and beef cattle are also raised in the watershed. Automobile manufacturing and suppliers dominate industry. Forestry provides additional economic stimulus, including recreation and timber harvesting in the state and national forests.

Land use is very diverse in the Saginaw Bay watershed, ranging from relatively undisturbed natural areas to intensive agriculture lands and heavily industrialized urban settings. Many of the impairments in the Saginaw Bay watershed are the result of land-use practices. Current land use in the watershed consists of:

- Agriculture (46 percent)
- Forest (29 percent)

- Open lands (11 percent)
- Urban (8 percent)
- Wetlands (4 percent)
- Water (2 percent)

The majority of industrial activity takes place in one of the four major urban centers in the watershed: Bay City, Saginaw, Flint, and Midland. Agriculture production is concentrated in the eastern and southern portions of the watershed (MDEQ OGL 1997, Saginaw Bay).

The Saginaw River and Bay are important to domestic and international waterborne commerce and serve as the major ports connecting Midwestern agricultural and mining industries to other Great Lakes and international ports.

OVERVIEW OF EXISTING CONDITIONS

The major water quality problems are eutrophication (excessive nutrients that accelerate growth of aquatic plants and reduce oxygen levels), toxic chemical contamination, and sedimentation (MDNR SWQD 1994). Existing physical, chemical, and biological problems impact plant and animal populations, result in public health fish consumption advisories, affect taste in drinking water and fish, create nuisance aesthetic conditions, and to a lesser extent, restrict dredging activity for navigation. In addition, loss of fish and wildlife habitat resulting from human encroachment is an ongoing concern.

A variety of sources continue to contribute contaminants to the Saginaw River and Saginaw Bay, including industrial and municipal discharges, combined sewer overflows, separated sanitary sewer overflows, contaminated sediments in the river and bay bottom, agricultural nonpoint source runoff, urban storm water runoff, leachate from former waste disposal sites, and inputs of contaminants through atmospheric deposition.

Since completion of the 1988 Remedial Action Plan, over two-thirds of its recommended 101 actions have been implemented, at least partially. The estimated cost of fully implementing these actions over a ten-year period was over $170 million (MDEQ OGL 1994). These costs were shared by local, state, federal, and private entities. This estimate did not include any costs associated with sediment remediation, which would add considerably to the total.

Municipalities in the Saginaw Bay Watershed have invested over $700 million since 1972 to improve wastewater treatment facilities (MDEQ 1997, Phosphorous). These expenditures have largely achieved compliance with the effluent discharge standards, especially in the area of phosphorus reduction. There has been an 80–90 percent reduction in municipal phosphorus loads. Water quality should continue to improve as communities address their combined sewer overflow (CSO) and separated sanitary sewer overflow (SSO) problems and implement compliance strategies related to federal Phase II storm water requirements.

Natural Resources Damage Assessment for Saginaw River/Bay

A 1998 court consent order capped a seven-year effort to resolve issues surrounding the historical industrial and municipal PCB discharges. This settlement included $28.2 million for remediation and mitigation projects for the Saginaw River/Bay. Signatories to the consent order include the Michigan Department of Environmental Quality (MDEQ), Michigan Attorney General, U.S. Departments of Interior and Justice, Saginaw Chippewa Indian Tribe, General Motors Corporation, and the cities of Saginaw and Bay City. Also involved in the settlement are the Michigan Department of Natural Resources (MDNR), Michigan Department of Transportation, U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency (EPA).

This collaborative, innovative settlement will benefit the community through dredging of sediments; acquisition and preservation of ecologically significant lands, including Big Charity Island and Little Charity Island in Saginaw Bay; restoration of unique wetland and fishing habitat; construction and/or enhancement of three public boat launches; and operation of an environmental learning center.

Part of the agreement called for the removal of a total of 345,000 cubic yards of PCB-contaminated sediments. Removal began in April 2000 and finished in July 2001 and represents approximately 90 percent of the residual PCBs in the lower river that have now been removed from the Saginaw River and stored at a confined disposal facility near the river mouth (U.S. Fish and Wildlife Service 2001).

MEASURES OF SUCCESS

The Partnership for the Saginaw Bay Watershed, a local watershed group comprised of citizens, government representatives, and members of the environmental community, received funding in 1999 from the Saginaw Bay Watershed Initiative Network (WIN) and the Bay Area Community Foundation to identify what success for the Saginaw River and Bay looks like through the development of understandable and achievable endpoints. Environmentally sound restoration measures were developed that are sensitive to the regional economy and community concerns. Twelve out of 14 beneficial uses are currently identified as being impaired. The end products of the project are threefold:

- Development of clear targets for restoring the beneficial uses of the Saginaw River/Bay that are environmentally sound, understandable to the general public, and acceptable to the community;
- Development of a concise summary of past success in the Saginaw River/Bay AOC that celebrates accomplishments; and
- Development of an action agenda identifying next steps to be taken. This agenda will generate priority projects to restore the Saginaw River/Bay. The process is intended to develop concurrence among diverse interests on what needs to be done to restore the Saginaw River/Bay.

The project involved the formation of five task groups to develop measures of success and the strategic plans to achieve that success. The public was invited to participate in the five task groups and summary focus group. Public meetings were held in the

watershed to announce the initiation of this process and seek representation from interested parties.

Each task group produced a status report on specific issues that includes an evaluation and celebration of the successes already achieved. The reports provide an update of the status of the Saginaw River/Bay and document the improvements that have already been made in this AOC.

Consensus among bay area stakeholders was achieved on (1) the restoration targets and (2) the actions needed to document when the targets have been achieved. The targets represent a collective effort by concerned citizens and responsible government entities to establish reasonably obtainable, measurable conditions that, if achieved, will indicate restoration of previously impaired beneficial use; or alternatively, demonstrate that all reasonable remedies within the AOC have been exhausted. Once the targeted restored conditions have been met, the intent is to petition the IJC's Water Quality Board to remove the Saginaw River/Bay from the list of Great Lakes Areas of Concern. The report groups the impairments in the Saginaw River/Bay into the following five indices, which include all 12 BUIs that led to the original AOC designation:

- Bacteria (beach closings and other impacts on human health related to microorganisms)
- Contaminated Sediments (restrictions on dredging and related issues)
- Fisheries (restrictions on consumption, tainting, and habitat degradation)
- Wildlife (deformities and reproductive problems and habitat degradation)
- Bay Ecosystem (restrictions on drinking water, aesthetics, eutrophication, and degradation of benthos—bottom-dwelling organisms)

Each section of the report describes the nature of the impairment(s), outlines where we have been and summarizes what we have accomplished, and proposes goals and suggests ways for measuring success, including the identification of targeted restored conditions, and recommends next steps. In some sections, important emerging issues that potentially affect the targeted restored condition or the speed at which the targeted condition can be achieved are summarized at the end of the section.

While much work has been done to identify and outline the scope of the environmental challenges in the Saginaw River/Bay AOC, the *Measures of Success* report was the first attempt to demonstrate what success looks like for a healthy Saginaw River/Bay ecosystem. Historically, environmental successes have often gone unnoticed by the general public. Without clear end points, it is difficult to gauge progress and garner continuing public support for improving the resource. The measures of success identified in the present report are necessary to provide an initial benchmark for evaluating attainment of beneficial uses in this AOC, and to gauge progress toward eventual delisting.

Scientific Support for Targeted Restored Conditions

A primary goal of the present RAP update is to assess and support the validity of the targets identified in the *Measures of Success* report. In order for a target to be valid and technically accurate, it must not only be necessary, sufficient, and feasible (Shear 2000), but also measurable. Indicators measured against the target determine if progress and restored conditions are being achieved. Indicators provide an overview of conditions of an ecosystem, consistency of information, efficient allocation of resources, a measure over time, and consensus on information needed. Indicators are interconnected, e.g., wetland area/wetland bird diversity and abundance, and they are not static but evolve over time. Indicators also require end points so that achievement of a targeted restored condition can be measured.

Targeted Restored Conditions

Exhibit 2 contains a description of the beneficial use impairments and indicators for recovery that were developed in the *Measures of Success* project (PSC 2000) and are the focus of this RAP update.

Targeted restored conditions outlined in the *Measures of Success* report are important steps in achieving restoration of the Saginaw River/Bay. Achieving the restoration targets may allow the Saginaw River/Bay to be removed from the list of the most polluted sites in the Great Lakes. Achievement of targets alone will not, however, assure restoration of the natural resources that have been impaired over the last 150 years, particularly as new issues emerge that threaten this valuable natural resource. The restoration targets should be viewed as a major interim step in an iterative process of achieving the restoration goal, not as a final step that precludes further action.

EXHIBIT 2
Beneficial Use Impairments and Targeted Restored Conditions, 2000, and Current Status

Beneficial Use Impairment	Targeted Restored Condition/Indicators
BACTERIA	
Beach closings (exposure to waterborne human pathogens)	A. Three consecutive years of testing for *E. coli* bacteria, an indicator of the presence of harmful microorganisms, confirm that the state water quality standards for full-body recreation are being met in the Saginaw River. **Status:** Wet and dry weather sampling for *E. coli* on the Saginaw River is limited. Some sampling has occurred in association with the limited number of beaches that are along the river. The information from this sampling, collected by the Bay County Health Department for the 1996–2000 swimming seasons, indicates that the single-event total body-contact recreation water quality standard was exceeded once in the river at Veteran's Memorial Park in May of 1996. Heavy seasonal rainstorms and subsequent sewage overflow events contributed to the elevated bacteria levels detected during this period. During dry weather, the targeted restored condition (TRC) is being met. Additional monitoring is needed during dry and wet weather periods to confirm conformance with state water quality standards, with an emphasis on dry weather conditions when full-body recreational contact is reasonably expected to occur. B. No more than three swimming beaches are closed per year and closures last no more than two days each in Saginaw Bay. **Status:** This TRC has been revised, see p. 37. Limited sampling at swimming beach locations on the Saginaw Bay and the lower portions of minor tributaries (e.g., the Kawkawlin River) indicate that the TRC is being met; however, the frequency of monitoring bacterial contamination at swimming beaches around the bay and the response to beach closures by county is highly variable. Additional monitoring is needed to confirm whether or not this TRC is being met.
CONTAMINATED SEDIMENTS	
Restrictions on dredging	The level of contaminants in Saginaw River/Bay sediments no longer imposes additional costs due to requirements for the removal, confinement, and remediation of dredge spoils. **Status:** Identifying cost estimates on a large scale is difficult until comprehensive sediment assessment work is completed, including delineation of hot spots and identification of disposal options, and new treatment methods are developed.

Beneficial Use Impairment	Targeted Restored Condition/Indicators
FISHERIES	
Restrictions on fish consumption due to contaminants	A. Levels of PCBs and dioxin in walleye taken from the Saginaw River/Bay are equal to or less than the levels found in comparable fish taken from other areas of the Great Lakes not listed as AOCs. **Status:** Results of caged-fish studies at the mouth of the Saginaw River indicate that PCB levels have declined significantly since the mid-1980s (see Exhibit 15). However, no trends can be discerned based on available data for dioxin and PCBs in the bay or dioxin in the river. B. PCB and dioxin levels in fish tissues from caged-fish studies in the Saginaw and Tittabawassee Rivers indicate that the former sources of these contaminants have been effectively controlled and/or remediated. **Status:** Fish consumption warnings in the AOC are likely to continue into the distant future due to the slow degradation of these chemicals in sediments and upland soils, and atmospheric transport and deposition of at least dioxin and PCBs from sources outside the region.
Tainting of fish or wildlife flavor (taste and odor concerns)	Taste and odor problems reported by anglers for any species taken from the Tittabawassee River downstream from Midland and the Saginaw River/Bay represent less than 1 in 10,000 of the estimated total annual catch for that species for three consecutive years. In addition, no specific sites of fish tainting have been identified that would justify remedial action. **Status:** Information indicates that the severity and number of fish tainting reports has substantially decreased since the early 1970s, and that the TRC is being met. However, there has not been a systematic effort since 1995 to verify that fish tainting is no longer a significant impairment in the Saginaw River.
Degradation of habitat	A. Dissolved oxygen levels in the river meet or exceed the minimum state water quality standard of 5.0 mg/l during the critical summer months. **Status:** Dissolved oxygen measurements in the Saginaw River indicate that the levels are now consistently better than the minimum state water quality standard for the protection of warm-water fish of 5.0 mg/l and may have met the targeted restored condition. However, additional and continuous monitoring is needed to confirm this condition. B. Critical coastal marsh areas are adequately protected (see Wildlife section). **Status:** *See Wildlife section.*

Beneficial Use Impairment	Targeted Restored Condition/Indicators
FISHERIES (cont.)	
Degradation of fish populations	A. Walleye—Increase abundance in the bay, ultimately through natural reproduction, such that growth rates approximate more closely statewide averages for this species and reflect improved use of available forage in the bay. **Status:** In 2001, walleye growth rates were 128 percent of the statewide average for three-year-old walleye, demonstrating limited progress toward meeting the targeted restored condition of 110 percent of the statewide average. Additional stocking of predators and habitat restoration to foster natural reproduction are needed to meet the TRC. B. Yellow Perch—A sustained annual harvest of 750,000 pounds per year with increasing abundance of larger, faster-growing individuals. **Status:** No direct management of yellow perch will be required to achieve the target if forage species that directly compete with yellow perch for food or prey on their young are reduced by increases in predator species in the bay. C. Lake Sturgeon—Documented evidence of natural reproduction in the Saginaw River. **Status:** Sturgeon spawning has not been documented in the Saginaw River. Additional monitoring is needed.
WILDLIFE	
Bird or animal deformities or reproductive problems	A. Bald Eagles—The reproductive success of bald eagles in the Saginaw Bay area is equivalent to that found in other Lake Huron costal areas in Michigan. **Status:** Bald eagle reproduction is above the goal set for recovery in the Saginaw River, yet there appear to be differences in the ability to successfully reproduce along the bay. B. Herring Gulls—PCB levels in herring gull eggs taken from Saginaw Bay area nest sites are not significantly higher than those found in other Lake Huron sampling locations. **Status:** Limited population studies in several species of fish-eating birds, including herring gulls, suggest continued population-level problems such as reduced recruitment at highly contaminated sites. Additional monitoring is necessary.

Beneficial Use Impairment	Targeted Restored Condition/Indicators
WILDLIFE (cont.)	
Degradation of habitat	A. At least 60 percent of the coastal marsh areas (below the 585-foot contour) and adequate upland buffers representing essential fish and wildlife habitat is preserved through public ownership, covered under conservation easements, or otherwise protected under agreements with landowners. B. The most vulnerable portions of the remaining 40 percent of the essential coastal marsh areas have been clearly identified so that governmental agencies, local conservation/environmental organizations, and concerned citizens can monitor their status, enforce existing laws, and conduct public educational programs to better protect these areas. **Status:** (A and B) Status is unknown at this time. However, ongoing inventory work by Ducks Unlimited will help determine protected coastal marsh areas below the 585-foot contour.
Degradation of wildlife populations	*(See Bird or animal deformities or reproductive problems.)*
BAY ECOSYSTEM	
Restriction on drinking water (taste, odor, or other problems)	The N:P ratio measured in Saginaw Bay is at least 29:1 for three successive years, indicating that conditions once favoring blue-green algal populations responsible for former taste and odor problems in drinking water withdrawn from the bay are no longer present. **Status:** The nitrogen/phosphorous ratios measured in the bay are approaching the point that no longer favors the production of problematic blue-green algae and dramatic decreases in certain blue-green algal species have occurred in the Saginaw Bay in recent years. Additional monitoring is necessary.
Degradation of aesthetics	*(See Eutrophication, i.e., nuisance algal blooms, oxygen depletion, and nutrient loadings.)*
Eutrophication (nuisance algal blooms, oxygen depletion, and nutrient loadings)	The average concentration of total phosphorus for three consecutive years is 15 ug/l or less, in accordance with the supplement to Annex 3 of the 1978 Great Lakes Water Quality Agreement. **Status:** Virtually all sampling sites demonstrate phosphorous levels greater than 0.010 mg/l and most are in excess of 0.020 mg/l, exceeding targets for the bay. While three sites were near or below the target concentration from 1996 to 1998, levels did not continue to drop in 1999. The remaining sites continue to exhibit levels that are substantially above the target total phosphorous concentration.

Beneficial Use Impairment	Targeted Restored Condition/Indicators
BAY ECOSYSTEM (cont.)	
Degradation of benthos (bottom-dwelling organisms)	Samples of mayfly nymphs collected in the open waters of Saginaw Bay exceed 30/m^2 for two consecutive years, based upon established sampling methods. **Status:** Anecdotal evidence suggests occasional "hatches" of mayflies occurring in the bay, although such observations have not been verified by benthos sampling.
Degradation of phytoplankton	*(See Restriction on drinking water, i.e., taste, odor, or other problems.)*

The goal of restoration is not unrealistic. The problems identified in the river and bay 30 years ago when it was first designated as an AOC appeared to many to be insurmountable. However, through the persistent efforts of many people and organizations and the investment of hundreds of millions of dollars, major improvements have been realized. What has already been accomplished can be used to motivate the public to complete the task of fully restoring the river and bay.

Bay Ecosystem

IMPAIRMENTS

Ever since the 1972 Great Lakes Water Quality Agreement was signed by Canada and the United States, it has been widely accepted that one of the major challenges to the long-term health of the Great Lakes is the control of excessive nutrient loading caused by human activity. Because the Saginaw Bay is shallower than the rest of Lake Huron, and because it possesses a unique shape and topography that impedes the mixing and circulation of water, it is particularly vulnerable to eutrophication (MDNR SWQD Great Lakes 1988).

The 1988 Saginaw River/Bay remedial action plan (RAP) identified impairments of the bay that reflected significant adverse changes in the ecosystem. Many of the impairments cited were directly linked to the effects of increased productivity and accelerated aging caused by excessive nutrient and sediment loading into the bay. These included degradation of the bottom-dwelling community of organisms (benthos), growth of nuisance algae in the bay, restrictions on drinking water due to taste and odor problems, and a general decline in the aesthetics of the bay (MDNR SWQD Great Lakes 1988).

Eutrophication

Generally, the Great Lakes are *phosphorous limited*, meaning that the amount of phosphorous determines the basic productivity of the lake. Higher levels of phosphorous support increased plant growth and greater productivity. Scientists classify lakes based on the level of productivity. Lakes low in nutrients and productivity, like Lake Superior, are classified as *oligotrophic*. Historically, Lake Huron and Saginaw Bay were described as *mesotrophic*, or in the middle of the productivity scale. At least since the 1960s, Saginaw Bay waters have contained much higher levels of phosphorous than the remainder of Lake Huron, and the bay has moved up the productivity scale to be classified as *eutrophic*. While moving up the productivity scale (i.e., eutrophication) is a slow, natural evolutionary process for most lakes that occurs over thousands of years, human activities can accelerate eutrophication through the addition of nutrients. When eutrophication occurs, many beneficial uses associated with lower productivity levels are impaired (MDNR SWQD Great Lakes 1988).

During the 1970s and 1980s, the Saginaw River added nearly two metric tons of total phosphorous per day to the bay, the largest contribution of phosphorous to the Great Lakes by any river in Michigan. Total phosphorous concentrations in the inner bay reached their highest level of 47.3 micrograms/liter (ug/l) in measurements taken in the spring of 1978. The added phosphorous increased the growth of nuisance blue-green algae that was likely responsible for the foul odors and poor taste of drinking water withdrawn from the bay (MDNR SWQD 1994).

In addition, increased biological productivity in the bay resulted in an increase in the organic debris washing up on area swimming beaches. This consisted of decomposing

algae, aquatic plants, and small invertebrate animals. The smell and unsightliness of this beach debris prompted citizen complaints and concern about pollution entering the bay. Because of these complaints, reduced aesthetics was a listed impairment for the bay.

The Benthic Community

The1988 RAP defined the degradation of the benthos of Saginaw Bay as an impaired use because the benthic community structure in the bay is significantly degraded from that which occurs in unpolluted sites elsewhere in the Great Lakes. In 1998, the Great Lakes National Program Office of the Environmental Protection Agency conducted surveys of the benthic communities in the main basin of Lake Huron as well as in the Saginaw Bay. The survey results indicated that while there is no lakewide impairment of the benthic community, significant problems with the benthic community were observed in the Saginaw Bay (EPA 2000, Jan. 22).

The sporadic benthos studies in the bay have documented that what was once a rich array of small animal organisms characteristic of an unpolluted benthic community has undergone dramatic changes in response to increased pollution. The high oxygen demand created by increased decomposition of organic debris in the sediments has decreased dissolved oxygen levels below that needed to support certain pollution-intolerant organisms such as mayflies.

Benthic species in the bay are now characterized by those that are tolerant of pollution, a situation characteristic of a eutrophic system. Studies conducted during the 1980s found that all the benthic macroinvertebrate samples collected at a number of locations in the Saginaw River channel, from Carrollton to the mouth of the river, were dominated by pollution-tolerant species, principally bottom-dwelling worms and midges. The same study collected benthic macroinvertebrate samples at 11 locations in the Saginaw Bay navigation channel. All organisms collected were pollution tolerant (NOAA 1996). In neither sampling were pollution-intolerant species found. Significant changes have occurred over time in *oligichaete* (worm) populations, *amphipod* (crustacean) populations, and *pisidium* (fingernail clam) populations.

Perhaps the most striking change has occurred in the abundance of burrowing mayfly nymphs, most notably *Hexagenia sp*. These “fish flies” were once prolific in Saginaw Bay. Long-time residents remember the days when “fish flies covered buildings and streets after a big hatch.” Sampling by the National Oceanic and Atmospheric Administration (NOAA) since 1970 has identified only a few individual nymphs where once there were millions.

The benthic community of Saginaw Bay has been affected by the introduction of exotic invaders into the system in addition to “traditional” pollution. The most influential of these is the zebra mussel, which was first found in Saginaw Bay in 1989. In just a few short years, its introduction has significantly altered the benthic structure of the bay. Its proliferation has compounded the challenge of measuring improvements in benthic communities.

Drinking Water

Five areas draw water from Saginaw Bay for public water supplies: Bay City, Saginaw/Midland, Caseville, Port Austin, and East Tawas. There has been a history of taste and odors in the drinking water taken from the bay, with the problem particularly pervasive before 1980 (MDNR SWQD Great Lakes 1988).

The Saginaw/Midland water intake, which accounts for 85 percent of all drinking water taken from the Saginaw Bay, had significant taste and odor problems during the 1970s. In all but one of the years between 1974 and 1979, test results at the Saginaw/Midland water intake exceeded the federal threshold odor standard. The Bay City raw water intake also has had severe taste and odor problems. Ozonation was added to the Bay City treatment sequence in 1979 in order to address taste and odor problems and is still in use at the Bay City water supply treatment plant today. The RAP cited restrictions on drinking water taken from the bay as an impairment, since use of the water from the bay required treatment of raw water beyond the standard treatment for similar water supplies elsewhere in the Great Lakes (MDNR SWQD Great Lakes 1988).

The taste and odor problems associated with drinking water taken from the Saginaw Bay have been traced to two organisms that thrive under nutrient-rich conditions: blue-green algae and *actinomycetes*, common soil bacteria. High levels of nutrients were recorded in the period from 1974 to 1986. Studies undertaken during the early 1970s clearly point to the fact that blue-green algal populations were associated with taste and odor problems at all water filtration facilities that drew their supplies from Saginaw Bay (MDNR SWQD 1994).

EVIDENCE OF RECOVERY

Major steps have been taken to control sources of phosphorous entering the Saginaw Bay. Communities in the Saginaw Bay drainage areas have spent nearly $700 million to improve the treatment of sanitary waste since 1972. These investments in improved wastewater treatment were in large part responsible for the estimated 50 percent reduction of phosphorus inputs into the bay between 1975 and 1978. The statewide limit on phosphorus levels in home laundry detergents sold in Michigan since 1978 has also contributed to the reduction of nutrient loading in the bay. Phosphorus contributions from wastewater treatment plants in the Saginaw River watershed have been reduced by an estimated 70 metric tons per year (MT/yr) since the early 1970s. Improved agricultural management practices to control fertilizer runoff in the watershed have resulted in an estimated phosphorus reduction of another 233 MT/yr from these nonpoint (or diffuse) sources. Total phosphorous loads to Saginaw Bay declined from an estimated 1,700 MT/yr in 1973 to 665 metric tons in 1982 (MDNR SWQD 1994).

Nevertheless, problems remain with nonpoint sources of phosphorous in many of the subwatersheds draining to the bay. Estimates indicate that 80–90 percent of phosphorous now entering the bay is coming from nonpoint sources. A 1998 report entitled *The Impact of Watersheds on Tributary Water Quality in Saginaw Bay* (Jude and Deboe 1998) found increasing concentrations of total phosphorous progressing

from the more natural areas on the western side of the Saginaw Bay toward the more agriculturally influenced tributaries on the east side of the bay. The report also found that phosphorous concentrations in the rivers studied were higher under high water-table regimes (wet weather) than under drier conditions.

Steps toward Controlling Degradation of the Benthic Community

Eutrophication (and the associated decrease in dissolved oxygen and increase in sedimentation) and contamination due to the discharge of toxic chemicals are the two primary factors that have been linked to the changes that have occurred in the benthic community of the bay.

This report's section on Sediment Contamination documents the substantial progress that has been made over the last 25 years in the control of toxic organic chemicals and heavy metals within the area that drains to the bay. State and federal water-pollution control programs, federal controls on the use of pesticides and certain industrial compounds, and enforcement actions for the targeted removal of severely contaminated sediments have significantly reduced the quantity of toxic chemicals reaching the bay, although some persist. While residual levels of these toxic chemicals persist in the sediments of the bay, studies have shown that natural decomposition of some chemicals, and deposition of sediments covering remaining contaminants, can alleviate sources of impairment to the benthic community.

Decline in Taste and Odor Problems in Drinking Water

While formal records have not been kept, it is clear from interviews with water treatment plant personnel that drinking water taste and odor problems from the bay water intakes have declined dramatically in recent years. One plant operator pointed out that complaints dropped significantly during the 1980s, spiked during the early years of zebra mussel invasion, and have been at relatively low levels since (PSC 2000).

Blue-green algal growth has been reduced in the bay, primarily as the result of an improved nitrogen/phosphorous (N:P) ratio. Data show that while nitrogen concentrations have declined somewhat, a much more dramatic decline has occurred in phosphorous levels in the bay. It is likely that the dramatic reduction in blue-green algae, particularly in the outer Saginaw Bay region, has been a major factor contributing to reduced taste and odor problem days for all three drinking water systems (PSC 2000).

CURRENT STATUS

While various actions over the past 30 years have resulted in improved water quality in the bay, the collection of data to document improvements has been inconsistent, often haphazard, and subject to the fiscal constraints of public agencies.

Phosphorus

The 1983 amendments to Annex 3 of the Great Lakes Water Quality Agreement required the development of a phosphorus reduction strategy to meet the phosphorus goal for Saginaw Bay. Attainment of the target load of 440 MT/yr (calculated from an

estimated annual average load of 665 MT/yr for the 1982 base year) for Saginaw Bay would result in maintaining a bay phosphorus concentration of 15 micrograms of phosphorus per liter of water (ug/l) and reduce other indicators of eutrophication, including excessive algal growths, taste and odor problems and filter clogging at water filtration plants, and increased turbidity (MDNR SWQD 1994).

The Surface Water Quality Division of the Michigan Department of Environmental Quality (MDEQ) has monitored ambient water quality on the Saginaw Bay since 1993. The target total phosphorus concentration for Saginaw Bay, established by the Michigan Phosphorus Reduction Strategy and in accordance with the U.S./Canada Great Lakes Water Quality Agreement, is 15 ug/l.

The goals of these monitoring efforts have been to

- assess water quality criteria trends in the Saginaw Bay;
- evaluate compliance with the Michigan Water Quality Standards;
- evaluate the overall effectiveness of the MDEQ's regulatory, pollution-prevention, and remedial programs; and
- determine whether the target phosphorus concentrations, pursuant to the Michigan Phosphorus Reduction Strategy for the Michigan Portion of Lake Erie and Saginaw Bay, have been achieved.

The 2000 *Measures of Success* report compiled total phosphorous concentrations beginning in 1974 with data from the National Oceanic and Atmospheric Administration (NOAA), and beginning in 1993, with MDEQ monitoring data. In 2001, the MDEQ released monitoring results for time period 1993–1999 (MDEQ SWQD 2001, January 15). This report suggests that total phosphorus levels, based on seven sampling sites, exhibited variability from year to year at each site and considerable variability among monitoring sites. The results of the 1993–1999 tests were summarized in the MDEQ report, *State of Michigan's Environment 2001* (MDEQ, Office of Special Environmental Projects, 2001). However, virtually all sites demonstrate phosphorus levels greater than 0.015 mg/l and more than half are in excess of 0.020 mg/l, exceeding targets for the bay. While three sites were near or below the target concentration from 1996 to 1998, levels did not continue to drop in 1999. The remaining sites continue to exhibit levels that are substantially above the target total phosphorus concentration. If the high 1998 levels of phosphorus concentrations are discounted due to unusual water conditions, the 1993–1999 trends demonstrate relatively stable total phosphorus levels (see Exhibit 3).

In order to develop a bay-wide assessment, all seven sampling sites were averaged by year. Averaged across all sites, there is a slight increase in total phosphorus from 1993 to 1999, influenced by very high values noted in 1998. The 1998 values may be a result of a pulse of phosphorus from the Saginaw River within the previous 24 hours of testing, although meteorological data were not examined.

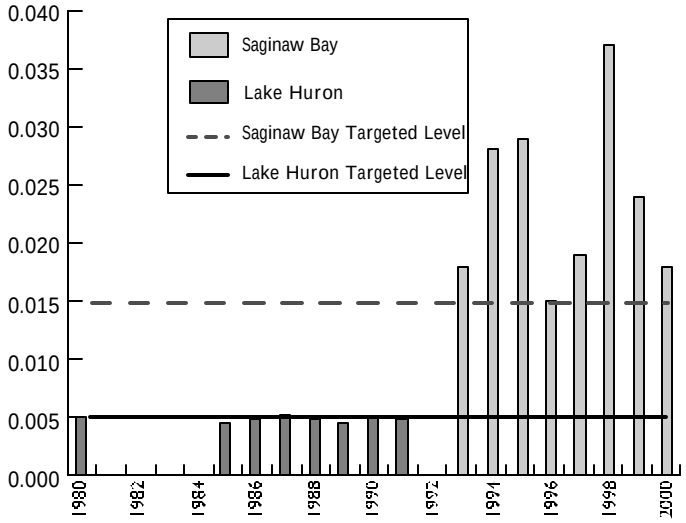
An examination of total phosphorus concentrations by site demonstrates differences that may also be related to general circulation patterns in the bay. Prevailing

counterclockwise circulation patterns may result in an impact of the southeastern region of the bay by nutrient input from the Saginaw River.

Nitrogen/Phosphorus Ratio (N:P)

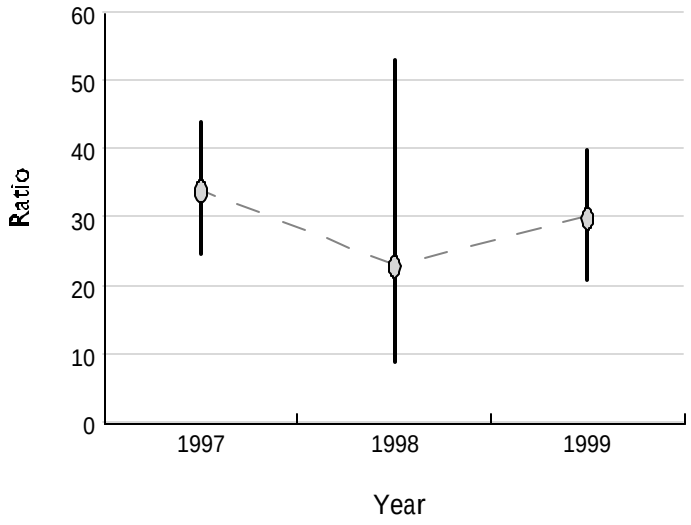
When the N:P ratio goes above 29:1, conditions are no longer favorable for production of blue-green algae (Smith 1983). The nitrogen/phosphorous ratios measured in the bay are approaching the point that no longer favor the production of problematic blue-green algae (see Exhibit 4), and dramatic decreases in certain blue-green algal species have occurred in the Saginaw Bay in recent years.

EXHIBIT 3
Total Phosphorous Levels in Saginaw Bay 1993–2000



SOURCE: Michigan Department of Environmental Quality, *State of Michigan's Environment 2001.*

EXHIBIT 4
N:P Ratio, Saginaw Bay 1997–99
(Mean Value and Range for All Stations, 29:1 = Target Level)



SOURCE: Prepared by PSC. Data from Great Lakes Environmental Center, 2001.

MANAGEMENT OBJECTIVES

The management objective for the bay ecosystem to address eutrophication and restore the benthic community is to reduce phosphorus loading into Saginaw Bay to levels that restore the bay to its historic mesotrophic condition. To accomplish this, the remaining challenges relate to nonpoint sources of phosphorus, and include addressing agricultural and residential use of fertilizers, animal wastes, failing septic systems, and the need to reduce erosion and sediment delivery from land adjacent to stream corridors. Eighty to 90 percent of phosphorous loading to Saginaw Bay now comes from nonpoint sources (MDNR SWQD 1994). Significant progress in reducing nonpoint pollution in the watershed is particularly challenging because of the dramatic loss of the buffering capacity of wetlands and the number of drainage systems that have been installed over the past 100 years. Further improvement efforts will need to focus on subwatershed approaches, targeting the diverse sub-ecosystems in the watershed for phosphorus reduction.

The management objective for drinking water is to reduce taste and odor complaints from those who use water supplies derived from the bay. This condition is largely accomplished today.

TARGETED RESTORED CONDITIONS

Eutrophication

Control of phosphorous inputs was the principal pollution control strategy adopted under the 1972 Great Lakes Water Quality Agreement between the United States and Canada. The 1978 amendments to the Great Lakes Water Quality Agreement led to

specific targets for phosphorous in the bay. The goal was to reduce phosphorous loading into Saginaw Bay to levels that restore the bay to its historical mesotrophic condition (IJC 1987).

Monitoring data for nutrients from 1993–1999 indicate that the water quality in Saginaw Bay is consistent with mesotrophic to eutrophic conditions. Levels of total phosphorus have remained relatively constant, yet continue to be above the Michigan Phosphorus Reduction Target Concentration of 0.015 mg/l. Concentrations of nitrate/nitrite nitrogen are also relatively high, but phosphorus is the limiting nutrient in the bay. Given the relatively high phosphorus concentrations, productivity is quite high. This observation is supported by the high concentration of *chlorophyll a*, which often exceeds 10 ug/l, an accepted threshold for eutrophic conditions and water clarity measurements.

Eutrophication – Targeted Restored Condition

The average concentration of total phosphorous for three consecutive years is 15 ug/l, in accordance with Annex 3 of the 1978 Great Lakes Water Quality Agreement.

It is clear that significant progress has been made in slowing eutrophication in the bay, although target levels of total phosphorus are being exceeded at most sampling locations. While some pollution-intolerant benthic species have not yet returned, there have been dramatic reductions in blue-green algae in the bay. Although the total phosphorous levels have continued to decline since 1998, there is no clear pattern showing that the trend will continue. The MDEQ has taken a number of steps to reduce phosphorous levels in the Saginaw Bay watershed and will continue to monitor the Saginaw Bay to evaluate the effectiveness of these actions (MDEQ Office of Special Projects 2001). It appears that no additional significant increases or decreases in total phosphorous, averaged across Saginaw Bay, are occurring (Great Lakes Environmental Center 2001).

Benthic Community

The goal (PSC 2000) is to reduce nutrient loading in Saginaw Bay to levels that allow restoration of the benthic community in the bay to its historical mesotrophic condition. If the benthic community is restored, it will mean that nutrient loading into the bay has been effectively controlled, the effects of toxic chemicals have been eliminated, and that valuable populations of fish food organisms have been restored.

Data have been collected since 1955 on the number of mayfly nymphs in the open bay. Mayfly abundance is a particularly good indicator of the status of bottom sediments. Burrowing mayflies, particularly those of the genus *Hexagenia sp.*, are an important food source for many species of fish and are intolerant to pollution. The data

show that burrowing mayfly nymphs decreased in the open bay from $63/m^2$ in 1955, to $9/m^2$ in 1956, $1/m^2$ in 1965, and $0/m^2$ in 1970 (MDNR SWQD 1994). Measurements conducted by the National Oceanic and Atmospheric Administration since 1970 indicate that mayfly nymphs remain essentially absent from the bay (NOAA 1996).

In recent years, there have been reports by reliable individuals of moderate, occasional "hatches" of mayflies occurring in the bay, although such observations have not been verified by benthos sampling. *Hexagenia sp.* are intolerant of pollution but capable of making significant recovery once pollution has abated. In fact, *Hexagenia sp.* production in Lake Erie nose-dived during the same period, but significant recovery of the population there has been noted in recent years, following significant reduction of phosphorous sources. Data from Lake Erie suggest that re-established populations demonstrate the ability to colonize and expand their range and density very rapidly (Krieger 1998).

Although NOAA has been collecting samples of *Hexagenia sp*. nymphs in Saginaw Bay for 30 years, funding to maintain that data record ended in 1996. Return of large populations of *Hexagenia sp.* nymphs to the benthic zone of Saginaw Bay would help confirm a significant improvement in the bay's water quality. Because the initial density of nymphs in the sediments will be very low, the chances of detecting them through standard sediment sampling will be low. Unless funding for NOAA sampling is restored, a volunteer program, modeled after the Mayfly Watch for Lake Erie, should be established to monitor emergent mayflies near the shoreline of Saginaw Bay.

However, significant changes that are occurring in the bay as a result of the invasion of numerous exotic species, including benthic organisms, may preclude re-establishment of mayflies even when water quality is restored. Should conditions other than those responsible for designation of this Area of Concern prevent the re-establishment of burrowing mayflies in the bay, a different indicator may be needed to measure restored benthic conditions.

Benthic Community – Targeted Restored Condition

- *Samples of mayfly nymphs collected in the open waters of Saginaw Bay exceed $30/m^2$ for two consecutive years, based upon established sampling methods.*

  (Alternatively, samples of adult mayflies could be collected through a "Mayfly Watch" program to document the occurrence and increase of mayflies over time.)

Drinking Water

The goal (PSC 2000) is to eliminate drinking water taste and odor complaints from those who use water supplies derived from the bay.

> ***Drinking Water – Targeted Restored Condition***
>
> *The N:P ratio measured in Saginaw Bay is at least 29:1 for three successive years, indicating that conditions once favoring blue-green algal populations responsible for former taste and odor problems in drinking water withdrawn from the bay are no longer present.*

Current drinking water treatment systems have effectively eliminated most of the taste and odor complaints related to bay water supplies. Measurement of the nitrogen to phosphorous ratio (N:P) in the bay is the best indirect evidence that conditions no longer favor odor-causing organisms. Data shown in Exhibit 4 suggest that the targeted restored condition was achieved in 1997 and 1999. Two sampling sites in 1998 demonstrated substantial increases in phosphorous, likely from the watershed (i.e., storm-water runoff within the previous 24–48 hours). If these two sites are excluded, the mean would be 28—just below the targeted level.

Sediment Contamination

IMPAIRMENTS

The major issue in many of the Areas of Concern (AOCs), including the Saginaw River/Bay, is how to clean up sediments that contain persistent toxic substances (IJC 2000, July). Specifically, the concentration of chemicals in sediment has impaired navigational uses by restricting dredging and disposal activities because contaminants are resuspended in the water column and dispersed during dredge operations. In addition, contaminated sediments are implicated in other impairments listed for the river and bay because they serve as a principal and ongoing exposure pathway to natural resources via the food chain. These impacts include restrictions on fish and wildlife consumption, degradation of fish and wildlife populations, bird and animal deformities, degradation of benthos (bottom-dwelling aquatic organisms), and tainting of fish. PCBs are one of the contaminants responsible for warnings against eating fish caught in the river. Toxic chemicals bioaccumulate in fish and animals (including humans), and research has shown that PCBs disrupt reproductive function and cause cancer (MDNR SWQD 1994).

The manufacturing boom beginning in the early 1900s, the chemical manufacturing expansion beginning in the 1930s, and the widespread agricultural use of chlorinated pesticides following World War II were the largest sources of contaminants now found in sediments within the Saginaw River watershed. Many of the organic chemicals of greatest concern were not even manufactured until after 1945. Some metals, such as lead, copper, and zinc, began accumulating in the sediments of the river and bay as soon as sewers were built to carry waste to the river. It was not until the 1970s that the amount of chemical contaminants contained in the sediments was widely known and the implications of the contamination to the uses of the river and bay were fully understood (PSC 2000).

The U.S. Environmental Protection Agency (EPA) identifies polluted sediments as the largest major source of contaminants to the Great Lakes food chain. Over 2,000 miles (20 percent) of the shoreline are considered impaired because of sediment contamination. On the U.S. side of the border, sediments have been assessed at 26 Great Lakes locations and over 1,300,000 cubic yards of contaminated sediments have been removed over the past three years (EPA 2000, Feb. 14).

The layers of sediment at the bottom of the Saginaw River and Saginaw Bay provide a historical record of pollution abuses that have occurred in the watershed over the last 150 years. The resulting picture is one of pervasive and widespread contamination, both in surface sediments and in core samples of sediments. Unfortunately, even though most of the original sources of toxic contamination have been addressed, the contaminants in the sediments remain an environmental concern due to the potential for resuspension by dredging, turbulence, floodwaters, and discharge of ground water through the sediments (PSC 2000 and GPO 1998). Both state and federal guidelines have classified dredge spoils—sediments that are excavated during dredging—from the Saginaw River and significant portions of Saginaw Bay as polluted since the early

1970s. Historically, the cost of maintaining navigational channels in the river and bay increased due to the special handling, confinement, and disposal requirements imposed on polluted dredge spoils.

EVIDENCE OF RECOVERY

Since the 1970s, when regulations required polluted dredge spoils to be deposited in confined disposal areas, routine navigational dredging by the U.S. Army Corps of Engineers in the Saginaw River and Bay has removed large quantities of contaminated sediment. Sediment sampling in the Saginaw River indicates that the navigational channel in the Saginaw River contains much lower concentrations of contaminants than areas that have not been routinely dredged (GPO 1998).

In the 1980s, state and federal regulations mandated that all major municipal wastewater treatment systems impose pretreatment requirements on industries using their facilities. These pretreatment requirements reduced the heavy metals contained in industrial waste discharges being sent to municipal systems.

Actions at the state and eventually national level severely curtailed the use, and in some cases the manufacturing, of many of the organic chemicals found in the contaminated sediments. Michigan established controls on the use of DDT in the early 1970s, and a federal ban on the use of this pesticide followed in 1973. Similarly, Michigan controls on industrial uses of PCBs were followed by a federal manufacturing ban in 1978. In the same year, federal restrictions on the general use of chlordane were adopted. Federal and state laws adopted in the 1970s to control the storage, handling, transport, and disposal of toxic materials also helped reduce the sources of heavy metals and organic chemicals that were contaminating sediments in the watershed (PSC 2000).

CURRENT STATUS

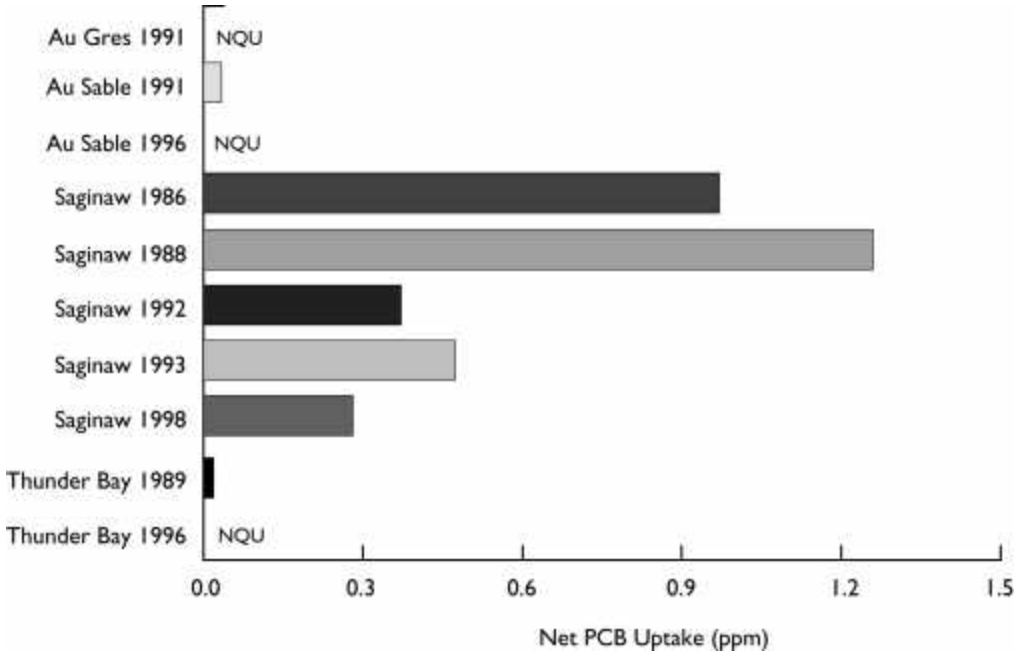
Saginaw River

Sediments in the lower ten miles of the Saginaw River extending into Saginaw Bay contain a wide range of pollutants, including residue from oil and grease discharges, phosphorus and nitrogen in various forms, heavy metals, and organic chemicals. Heavy metals and organic chemicals comprise the greatest cause for concern (MDCH 2001). Heavy metals detected in sediments that remain above acceptable levels include lead, zinc, nickel, arsenic, cadmium, chromium, copper, and mercury. The primary organic chemicals of concern in the river include pesticide residues (e.g., DDT derivatives, dieldrin, and chlordane) and industrial compounds (polychlorinated biphenyls [PCBs], polybrominated biphenyls [PBBs], phenolic compounds, and various chlorobenzenes). These organic chemicals and heavy metals are a concern because they are toxic at low concentrations, they persist for a long periods of time in the environment, and as they bioaccumulate (are passed up the food chain), they increase in concentration (PSC 2000).

Although the major sources of heavy metals and organic chemicals that have contaminated the sediments of the Saginaw River watershed have been reduced,

residual concentrations remain in the sediments themselves, as demonstrated by the presence of PCBs in caged fish (see Exhibit 5). It is not always practical or economically feasible to remove these contaminated sediments. In some cases, natural decomposition of organic chemicals can eventually break down the contaminants into nontoxic components. In some areas of the river system and bay, the deposition of new, uncontaminated sediments can isolate the heavy metals and organic chemicals, thus reducing the uptake by aquatic organisms. Where concentrations of contaminants are high, and where they are subject to resuspension in the water due to dredging or river flows, removal may be necessary.

EXHIBIT 5
Tributary Mouth Caged-Fish Monitoring



*NQU=No quantifiable uptake
SOURCE: Michigan Department of Environmental Quality.

Dredging operations in the Saginaw River associated with the settlement agreement that resulted from the Natural Resource Damage Assessment (NRDA) in 2000 and 2001 removed the largest mass of PCBs practicable—approximately 90 percent, consisting of 345,000 cubic yards, at a cost of nearly $10 million (USFWS 2001). Approximately $260,000 was used for the assessment and design of the remediation project. The signatories to the settlement agreement recognize that some PCBs will nevertheless remain in the Saginaw River/Bay after the dredging (GPO 1998). The dredging goal was to reduce the risks associated with contaminated sediments, not eliminate them entirely.

Contaminated material was removed in five distinct areas between the shoreline and the federal navigation channel. The dredging and depths were determined by the

Michigan Department of Environmental Quality (MDEQ) and the U.S. Fish and Wildlife Service. A review of the data showed that most of the mass of the PCBs in the Saginaw River sediments was in the Bay City reach. The EPA established a "covenant" level of 10 parts per million (ppm) for PCB removal in this reach. The material was placed into the Saginaw Bay Confined Disposal Facility. The project is intended as a one-time dredging and disposal effort; it is believed that periodic dredging in these same areas will not be required. In addition, as part of the settlement agreement, $3 million was placed in a restoration account for future monitoring, modeling, and studies of the assessment area to determine the effectiveness of the dredging activities. If acceptable sediment concentrations are achieved, monies remaining in the restoration account may be used for projects designed to protect, restore, replace, and enhance important land-based habitats within the Saginaw River and Bay.

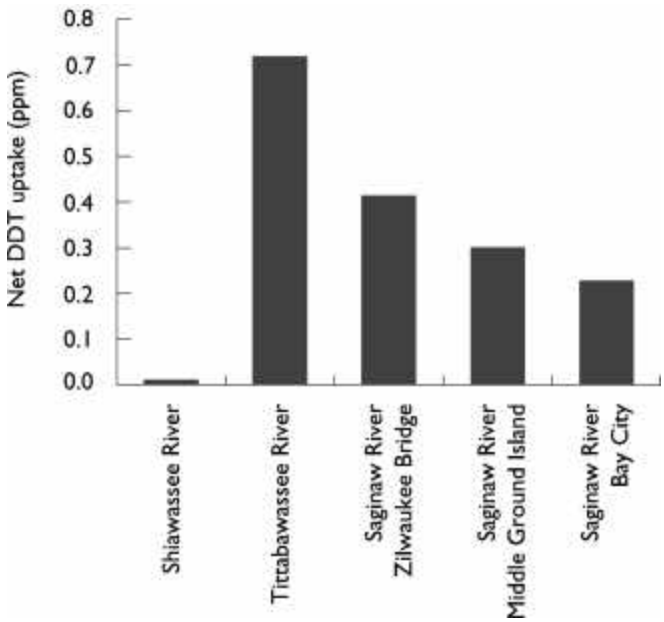
Tittabawassee River

The Tittabawassee River is the largest tributary to the Saginaw River, contributing approximately 50 percent of the flow and draining 2,620 square miles. The Tittabawassee and its major tributaries have been, and continue to be, heavily used by industry and municipalities. Testing in the early 1980s indicated a wide array of heavy metals and organic chemicals above acceptable levels in the sediments downstream of chemical, plastic, metal container, and photographic industries in the vicinity of Midland (MDNR SWQD 1994). Caged-fish studies in 1993 show the continued presence of DDT (see Exhibit 6).

In December 2000, the MDEQ confirmed the presence of high levels of dioxin in soil located in an area of the flood plain near the confluence of the Tittabawassee and Saginaw Rivers exceeding the Agency for Toxic Substances and Disease Registry (ATSDR) action level. The data suggest the possibility that dioxins have migrated along the Tittabawassee River, possibly during snow melt, spring runoff, or other high-flow events and have been deposited onto the Tittabawassee River flood plain. The Michigan Department of Community Health (MDCH) is working with the MDEQ to implement sampling plans to determine if dioxin concentrations in the Tittabawassee River watershed between the city of Midland and the confluence of the Tittabawassee and Saginaw Rivers exceed federal health guidelines. MDEQ and MDCH will begin conducting soil sampling at residential properties in closest proximity to previously identified areas of concern and include contingencies for potential public health actions if dioxin is detected at concentrations greater than federal and state action levels. Fact sheets outlining how people can minimize dioxin exposure from food and soil have been prepared by the Michigan Department of Agriculture and the Michigan Department of Environmental Quality.[1]

[1]See "Food, Farming and Gardening Guidelines for Minimizing Dioxin Exposure," Lansing, Mich.: Michigan Department of Agriculture, May 2002, contact Public Affairs Office, 517-241-4282; and "Dioxins Fact Sheet," Lansing, Mich.: Michigan Department of Environmental Quality [in conjunction with Michigan Department of Community Health and Michigan Department of Agriculture], May 2002, contact 517-241-7397.

EXHIBIT 6
1993 Caged-Fish Study, Total DDT Concentrations



SOURCE: Michigan Department of Environmental Quality.

Shiawassee River

As part of the settlement in the state enforcement action against the Cast Forge Company in Howell, sediments contaminated with high concentrations of PCBs were removed from the Shiawassee River in the 1970s. The Shiawassee River is a tributary of the Saginaw River (MDNR SWQD 1994). Remedial investigations completed in 2000 by the EPA at this site indicate that additional soil removal in the flood plain of the river and sediment dredging within the Shiawassee River will likely be required in the future to adequately control sources of PCBs (PSC 2001).

Pine River

The Velsicol Chemical Superfund site (formerly Michigan Chemical Corporation) is contiguous to the Pine River, a tributary of the Tittabawassee River that flows into the Saginaw River. The drainage area of the Pine River is approximately 300 square miles and originates near Alma. From 1936 until 1978, various chemical compounds and products were produced at this plant site, including DDT and polybrominated biphenyls (PBBs). (PSC 2001)

In 1982, Velsicol entered into a consent judgment in which the company agreed to construct a slurry wall around, and clay cap over, the 54-acre plant site. According to the EPA, on-site groundwater was contaminated with DDT, chlorobenzene, carbon tetrachloride, trichloroethylene, and other chlorinated compounds. Velsicol completed the required construction of the containment system in 1985. The consent judgment

also required that Velsicol maintain water levels within the containment system. In 1994, Velsicol pumped approximately 2.5 million gallons of water out of the containment system to meet this requirement. Between 1996 and 1997, the EPA and MDEQ reassessed contamination in the Pine River/St. Louis Impoundment. Sediment cores, surficial sediment samples, and fish samples were collected. Results from all sediment surveys indicated that the levels of total DDT in the Pine River and the St. Louis Impoundment were extremely high, with a maximum of 32,000 ppm total DDT. Analyses from the 1980, 1981, 1996, and 1997 data showed that the concentration levels, as a whole, have not decreased over time (PSC 2001).

As a result, in June 1998, the EPA began implementation of a plan for removal of sediments at the site, including hydraulic modification of the Pine River (i.e. the use of temporary cofferdams in the St. Louis Impoundment), excavation and dewatering of sediments, water treatment, and disposal of contaminated sediments. The removal action consisted of dredging/excavation of sediments containing 3,000 ppm or greater total DDT (the hot spot), treatment of the sediments with a stabilizing/drying agent, and disposal of the sediments off-site. Monitoring of resuspended sediments was conducted directly downstream of the excavation operations. Sediment removal began in the spring of 1999 and was completed in October of the same year. After completion of the dredging, sediment samples were collected to monitor the effectiveness of the cleanup. The MDEQ will continue to monitor fish tissue levels until the fish advisory can be removed (PSC 2001).

Approximately 70,000 tons of stabilized sediments have been disposed of off-site since June 2000. The average depth of sediment removal was approximately eight feet down to the hard pan. The on-site water treatment plant began treating water in June 2000 and since then, the effluent from the plant has been below reportable limits for total DDT, hexabromobenzene, and PBBs. Remediation efforts and monitoring continue (PSC 2001).

Flint River

Sampling of sediments below the Flint wastewater treatment plant in 1974 indicated that heavy metals from various manufacturing facilities located in that community had contaminated sediments in the Flint River. However, no sediment remediation is planned at this time.

MANAGEMENT OBJECTIVE

The ultimate goal is to eliminate environmental impairments to the Saginaw watershed and Saginaw Bay caused by contaminated sediments. To address the primary impairment cited for contaminated sediments, the short-term goal is to reduce contaminant levels to the extent that the cost of navigational dredging, including dredging activity related to marinas, boat launches, and shoreline activities, is not higher due to the presence of organic chemicals or heavy metals in the dredge spoils (PSC 2000).

TARGETED RESTORED CONDITIONS

The targeted restored condition for sediment contamination in the Saginaw River/Saginaw Bay was established in the *Measures of Success* report (PSC 2000). Other measures were proposed in *Measures of Success* to determine progress in addressing the impairments indirectly related to contaminated sediments, such as restrictions on fish and wildlife consumption, degradation of fish and wildlife populations, degradation of benthos, and tainting of fish. Beyond the planned and completed removal of contaminated sediments in the Saginaw, Shiawassee, and Pine Rivers, no additional remedial actions to remove contaminated sediments are scheduled for the Saginaw River/Bay watershed. However, the recent discovery of high levels of dioxin at the confluence of the Tittabawassee and Saginaw Rivers may require additional sampling and remedial action, including the removal of contaminated soils.

For the impairments to navigation caused by contaminated sediments, the following measure is proposed:

Restrictions on Dredging – Targeted Restored Condition

The level of contaminants in Saginaw River/Bay sediments no longer imposes additional costs due to requirements for the removal, confinement, and remediation of dredge spoils.

It should be noted that contaminated sediments are present in Great Lakes areas that do not carry the AOC designation. The EPA is equally concerned about these areas and is addressing them to mitigate and remove risks to human health and the environment. EPA programs and offices are focusing their efforts on the highest-priority contaminated sediment sites. Prioritization factors include contribution of substantial risks to human health or the environment, location within Great Lakes AOCs, sites where delay could result in the spread of toxic chemicals into areas where remediation is no longer feasible, and adverse impacts on resources.

Many Great Lakes harbors and embayments, including the Saginaw River/Bay, continue to be repositories for pollutants that move through a watershed and settle in these areas. The most likely cleanup scenario in these areas in the foreseeable future is maintenance dredging and dumping in confined disposal facilities. But until comprehensive sediment assessment work is completed, including delineation of hot spots and identification of disposal options, and new treatment methods are developed, identifying cost estimates on a large scale is difficult. After feasibility studies are conducted and a specific site moves toward cleanup, realistic cost estimates can be developed

The EPA and the states are also making greater use of coordinating complementary federal and state authorities, and leveraging government and private resources to address the contaminated sediment problem and its sources. Such approaches and partnerships (EPA 2001, August 14) include the use of

- federal/state dollars as "seed" money to leverage corporate participation for a federal/state/private mix of resources and to ensure long-term corporate commitment (Fraleigh Creek, a.k.a. Unnamed Tributary to the Ottawa River, Ohio);
- enforcement authorities to leverage corporate participation and/or resources and ensure long-term corporate commitment (Ashtabula River Partnership, Ohio; Fox River, Wis.);
- partnership approach (RAP Program model, for example, Ottawa River Remediation Team and Duck and Otter Creek Partnership in the Maumee River AOC); and
- coordinating with federal and state agencies that bring additional authorities to address contaminated sediments. For example, the U.S. Army Corps of Engineers Water Resource Development Act authorities; state cleanup/ superfund programs; state voluntary cleanup programs (Indiana Harbor Ship Canal; Ruck Pond, Wis.).

Bacterial Contamination and Beach Closings

IMPAIRMENTS

Beach closures are one of several impairments affecting the Saginaw River and Bay, according to the 1994 Saginaw River/Bay Remedial Action Plan (MDNR SWQD 1994). The report cites microbial contamination in the Saginaw River as a major contributing factor to beach closings along the Saginaw River/Bay. This contamination was a direct result of combined sewer overflows (CSOs) in the following municipalities: Bay City, City of Essexville, City of Midland, City of Saginaw, Carrollton Township and Saginaw Township. In addition, the City of Flushing was responsible for untreated sewage discharge to the Flint River during wet weather periods (MDNR SWQD 1994).

Combined sewer systems are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. When capacity is exceeded, combined sewer systems are designed to overflow and discharge excess wastewater directly into receiving waters, such as streams, rivers, or other water bodies. These occurrences are referred to as *combined sewer overflow*, or CSOs.

There are a number of other potential sources of bacteria from human waste that contribute to the impairment of the beneficial use of bathing beaches by the public, including sanitary sewer overflows (SSOs), treatment plant bypass discharges, and on-site treatment system failures. SSOs are discharges of raw sewage from separated municipal sanitary sewer systems, which are designed to carry domestic sanitary sewage but not storm water. SSOs occur when excessive storm water enters the sewers through (1) basement footing tiles, (2) downspouts that connect to sanitary sewers, or (3) improper cross-connections with storm sewers. These overflows may also contain industrial wastewater that is present in the sewer system. In some cases, the sewers are large enough to transport the storm-related waste flows to the treatment site, but the facility cannot adequately treat the increased volumes. To avoid damage to the treatment facility during high-flow conditions, the facility is bypassed and the excess sewage is discharged, untreated, directly into the river. This type of discharge is called a treatment plant bypass. In addition, untreated human waste finds its way into water through the failure of on-site treatment systems (commonly a septic tank with a drain field) or illicit connections from sanitary sewers into separate storm drains.

EVIDENCE OF RECOVERY

According to the health departments of the counties surrounding the Saginaw River and Bay, only three beach closures have occurred since the 1994 remedial action plan (RAP) update, all of which were in Huron County in August of 2001. This sign of

recovery can be attributed to recent investments made in infrastructure, which has reduced the amount of untreated or poorly treated sewage entering the Saginaw River and Bay. In the period from 1972 to 1988, 48 communities within the Saginaw River watershed spent more than one-half billion dollars in federal and state grants and local matching funds in the planning, design, and construction of new or upgraded wastewater transport and treatment facilities (MDNR SWQD Great Lakes 1988). More recently (1989–1999), local public agencies within the watershed have obtained an additional $134 million in low-interest loans from the State Revolving Fund to improve wastewater treatment facilities, eliminate SSOs, expand CSO capture and treatment capacity, and provide new sewer service (MDEQ Municipal Facilities 2000).

A significant portion of these investments has been made by public agencies that operate wastewater treatment systems discharging directly to the Saginaw River or upstream tributaries. While the majority of the initial improvements were made before 1989, communities discharging to, or upstream from, the Saginaw River have made substantial improvements to control and treat sanitary waste discharges in the last decade, as shown in Exhibit 7.

These infrastructure investments are paying off. The amount of waste discharged into the Saginaw Bay watershed due to CSOs and SSOs has been substantially reduced. For example, communities in the Saginaw Bay watershed that have separated sewer systems discharged approximately 27 million gallons of raw sewage during the year 1996, 12 million gallons in 1997, and four years later in 2001, only 800,000 gallons. The City of Saginaw, which has a combined sewer system, discharged 271 million gallons of raw sewage in 1994, 24 million in 1995, 2.9 million in 1996, and five years later in 2001, did not discharge any untreated waste (Walkington 1997 and MDEQ SWQD, n.d.).

While some issues still need to be addressed to improve wastewater treatment, increase storage capacity for CSOs, and provide sanitary sewer service where septic tanks are failing, the major sources of untreated sanitary waste that have caused unacceptable bacteria levels have been largely resolved.

EXHIBIT 7
Improvements in Sanitary Waste Control and Treatment

Community	Recent Improvements in Sewer Infrastructure
Saginaw	Six new retention/treatment basins, new chlorination system to improve disinfection of discharges from its wastewater treatment plant, eliminated plant bypasses.
Buena Vista Township	Made several improvements in its wastewater collection and treatment system to control CSOs, SSOs, and treatment plant bypasses in 1998.
Bay City	Upgrading its CSO facilities, built in 1980, so that when completed, they will provide better control and disinfection of discharges.
Essexville	Improved CSO control in 1998 by expanding its retention/treatment basin, separating some sewers, and upgrading previously constructed basins.
Saginaw Township (on the Tittabawassee River)	Constructed a new wastewater treatment plant in 1984 and placed a new storage/treatment basin on-line in 1991 to control its CSO discharges into the Tittabawassee River just upstream of the Saginaw River. The community also constructed two more in-line storage systems tributary to the Saginaw River.
Pinconning (on the Pinconning River)	Completed a project to control remaining SSOs in 1997.
Frankenmuth (on the Cass River)	Made treatment plant improvements in disinfection in 1999 and completed a series of SSO control projects that were begun in 1977.
Chesaning (on the Shiawassee River)	Addressed SSO discharges and upgraded its wastewater treatment plant in 1995 to improve disinfection.
Midland (on the Tittabawassee River)	Completed work in 1991–1995 to address CSOs and upgraded its wastewater treatment plant.
Flint (on the Flint River).	Completing work on addressing SSOs.

SOURCE: Michigan Department of Environmental Quality, Municipal Facilities 2000.

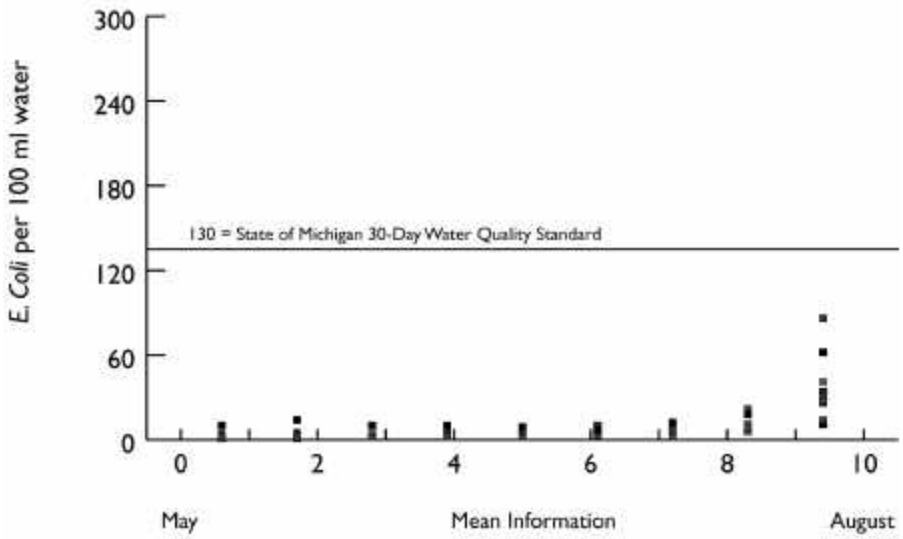
CURRENT STATUS

There have been almost no advisories or beach closures issued in the Saginaw River watershed since the 1994 RAP update, with the exception of Huron County. Monitoring results from the Huron County Health Department beach sampling program, which began in 2001, indicate that there were no exceedances in the 30-day standard (see Exhibit 8) but that the single-event water quality standard was exceeded six times at five different parks during the month of August (see Exhibit 9).[2] As a

[2] County health departments need to take a minimum of three samples each time a beach area is monitored. The daily geometric mean calculated from these samples must be below 300 *E. coli* per 100 milliliters for the water to be considered safe for swimming. Additionally, a minimum of five sampling events (consisting of at least three samples per event) must be collected within a 30-day period. After 30 days, a geometric mean is calculated for all the individual samples collected within that time frame.

result, swimming was prohibited at Oak Beach County Park August 18-19, Port Crescent State Park August 21–22, and Bird Creek County Park August 21–24. Although there were six exceedances, the Huron County Health Department only closed these three beaches because the other three incidents occurred during the last week of the swimming season, and heavy seasonal rainstorms and sewage overflow events were believed to have contributed to the elevated levels of bacteria detected in water samples collected during this time.

EXHIBIT 8
Huron County 30-Day Mean *E. coli* Monitoring Results for 2001 Swimming Season (May–August)

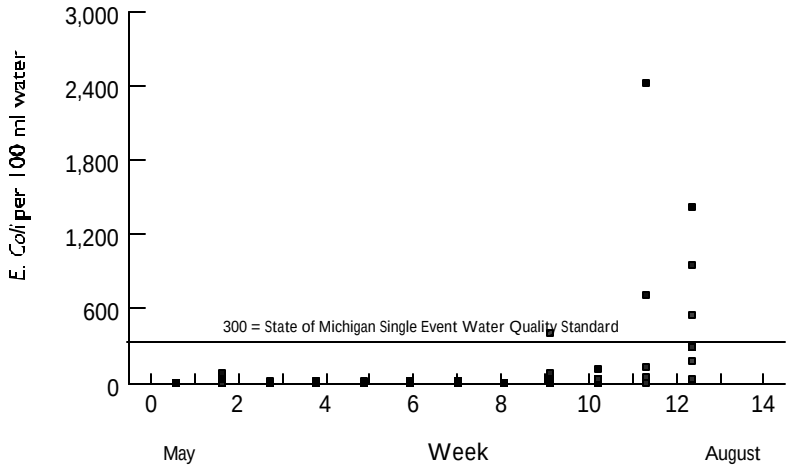


SOURCE: Huron County Health Department.

The only other county to conduct water quality monitoring in the watershed is Bay County. Data collected by the Bay County Health Department for the 1996–2000 swimming seasons indicate that the single-event total body-contact recreation water quality standard was exceeded twice in May of 1996, once in August of 1999, and once in July of 2000; and that the 30-day standard was exceeded once in 2000 (see Exhibits 10 and 11). The Bay County Health Department believes that heavy seasonal rainstorms and sewage overflow events contributed to the elevated levels of bacteria detected in water samples collected during these periods. The Bay County Health Department did not issue any health advisories curtailing the use of its swimming beaches, based upon the results of the bacteriological analysis for water samples collected.

This 30-day geometric mean must be below 130 *E. coli* per 100 ml for the water to be considered safe for swimming.

EXHIBIT 9
Huron County Weekly *E. coli* Monitoring Data for 2001 Swimming Season (May–August)



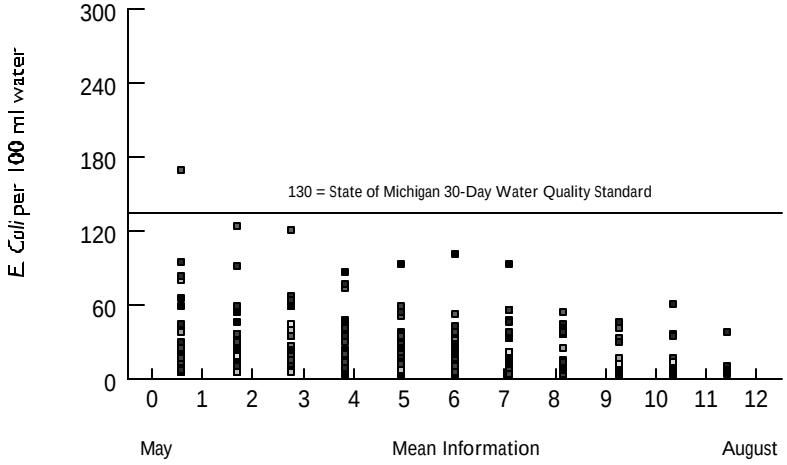
SOURCE: Huron County Health Department.

Beach postings can be useful in tracking beach water quality, but there are several limitations that must be kept in mind. Michigan has recommended bathing-beach guidelines, but these are not requirements for a mandatory water-quality monitoring program. Because of this, water-quality monitoring programs vary across the Saginaw River watershed. Different jurisdictions have different criteria and standards for postings or advisories, and the frequency of monitoring bacterial contamination at public beaches is highly variable around the watershed. For example, Bay and Huron Counties monitor their beaches at least once a week, while Iosco, Tuscola, and Arenac Counties do not conduct any beach water-quality monitoring.

Because of this variation, it is difficult, and potentially misleading, to compare water quality between jurisdictions or summarize data for all beaches. Even within a beach, variability in the data from year to year may result from the process of monitoring and variations in reporting, and may not be solely attributable to actual increases or decreases in levels of microbial contaminants.

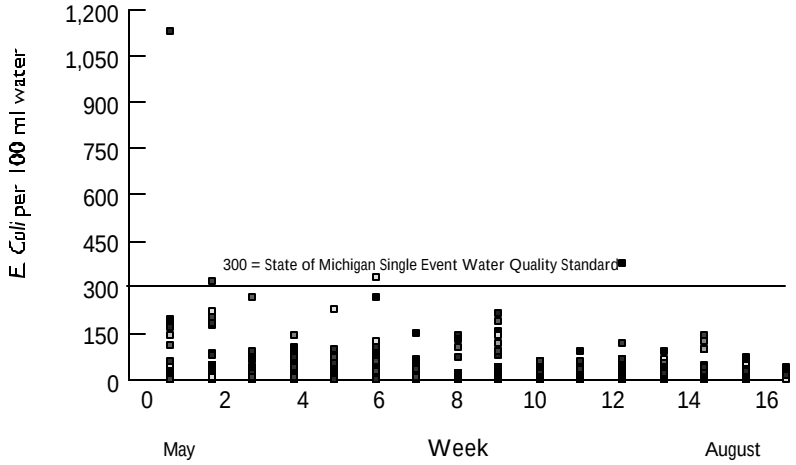
In view of these limitations, the absence of beach closings in recent years does not assume that bacteria levels in the Saginaw River and Bay are at or below the state water quality standards. And although the number and frequency of CSO and SSO discharges also have been substantially reduced, untreated sanitary wastewater discharges upstream from, and directly into, the Saginaw River continue to occur (MDEQ SWQD n.d.).

EXHIBIT 10
Bay County 30-Day Mean *E. coli* Monitoring Results for 1996–2000 Swimming Seasons (May–August)



SOURCE: Bay County Health Department.

EXHIBIT 11
Bay County Bathing Beach Weekly *E. coli* Monitoring Results for 1996–2000 Swimming Seasons (May–August)



SOURCE: Bay County Health Department.

MANAGEMENT OBJECTIVES

The management goal is to eliminate the health risks associated with human waste that have previously impaired recreational use of the Saginaw River. Although frequency of beach closings to indicate elevated pathogen levels has traditionally been used as an indicator of recreational water quality, the limitations in the ability to compare frequency of exceedances of microbiological guidelines has posed a challenge for the development of a lakewide indicator to evaluate trends in recreational water quality. Microbial standard exceedances would be a better measure of actual health risk related

to recreational water quality, but the lack of regular, systematic monitoring in the watershed limits the applicability of this indicator. Therefore, actual monitoring of indicator bacteria levels is essential in order to (1) determine if and when this goal has been achieved and (2) document that the state water quality standards to protect full and partial body-contact recreation have been met.

TARGETED RESTORED CONDITIONS

Bacteria levels that exceed the state water quality standards for body-contact recreation (partial or full) pose an unacceptable health risk to boaters, anglers, and anyone else who comes into contact with the water. Untreated human waste can transmit a variety of bacterial, viral, and parasitic diseases that threaten public health. In fact, the high bacteria level in the Saginaw River and nearshore areas of Saginaw Bay was one of the primary impairments identified in the *Saginaw River/Bay Remedial Action Plan* in 1988. While bacteria levels downstream of major urbanized areas throughout Michigan remain a problem, the high use of the Saginaw River and Saginaw Bay for swimming, fishing, boating and other water-related recreational activities makes this public health concern a priority.

The targeted restored condition established in the *Measures of Success* report (PSC 2000) for microbial contamination in the Saginaw River/Bay watershed is based on beach closings. Because of the limitations related to the use of frequency of beach closures as an indicator of water quality, the targeted restored condition is revised as follows:

Microorganism Contamination

E. coli Bacteria – Targeted Restored Condition

- *Saginaw River: Three consecutive years of testing for* E. coli *bacteria, an indicator of the presence of harmful microorganisms, confirm that the state water quality standards for full-body recreation are being met.*
- *Saginaw Bay: Testing for* E. coli *bacteria confirms that state water standards have not been exceeded more than three times in any one swimming season, and that exceedances did not last more than two days.*

NOTE: The selected target was identified by stakeholders and regulators as appropriate because high *E. coli* levels in lakes and bays can occur due to sources other than human waste (e.g., high waterfowl concentrations).

Fisheries

IMPAIRMENTS

The decline in abundance of important fish species, associated losses of critical fisheries habitat, particularly marsh areas, and limitations on fish consumption were significant impairments cited when the International Joint Commission (IJC) initially designated the Saginaw River/Bay as a Great Lakes Area of Concern (AOC). Specifically, the 1988 Remedial Action Plan (RAP) for the Saginaw River/Bay identified taste and odor problems as well as toxic contaminant levels of fish as limiting factors affecting both commercial and sport fisheries in the river and bay.

The RAP also identified habitat losses associated with shoreline development, wetland drainage, and other physical changes in the river and bay that limit reproduction, growth, and survival of certain fish species (MDNR SWQD Great Lakes 1988). Fish tumors or other deformities were not considered an impairment in the Saginaw AOC in the 1995 Saginaw River/Bay RAP draft biennial report. This conclusion was based upon surveys conducted in 1989 on bullheads that showed no increased incidence of either external or internal tumors (MDNR SWQD 1994).

Persistent toxic chemicals from agricultural and industrial uses in the Saginaw watershed were listed as a major concern from a public health perspective for those who consumed fish taken from the river and bay. The potential detrimental effects these chemicals were having on the reproduction and survival of certain fish species also were cited as a concern. Finally, the RAP noted that increased levels of nutrients from agricultural and urban runoff and inadequately treated sanitary waste discharges were resulting in accelerated eutrophication of Saginaw Bay. This further limited the abundance of certain sensitive fish food organisms and fish species (MDNR SWQD Great Lakes 1988).

This section documents the decline, recovery, current status, and management objectives for the Saginaw River/ Bay fish populations and evaluates present conditions related to the other impairments cited in the 1988 RAP. This information provided the basis for establishment of the targeted restored conditions in the *Measures of Success* report prepared in 2000 for the Partnership for the Saginaw Bay Watershed (PSC 2000).

Decline in Abundance of Important Fish Species

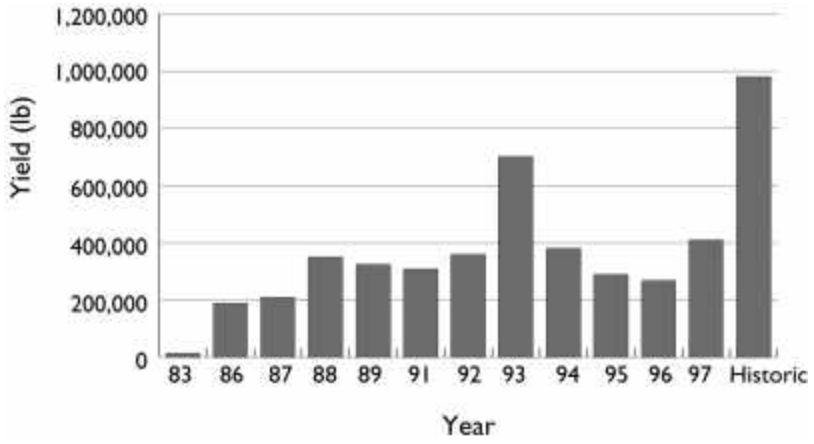
During the period from the early 1900s to the 1940s, Saginaw Bay accounted for more than 28 percent of the commercial fishery harvest from Lake Huron (Baldwin and Saafeld 1962). The commercial catch records for this period indicate that the fish community of inner Saginaw Bay was primarily composed of walleye, yellow perch, channel catfish, white sucker, northern pike, and several members of the sunfish family (centrarchids). In the outer portions of Saginaw Bay, lake trout, lake herring, and lake whitefish were also significant and seasonally provided a fishery in the inner bay areas as well (Keller et al. 1987). The annual harvest of fish from Saginaw Bay peaked in the early part of the 20th century and declined steadily through the 1970s. A

number of factors contributed to the 70-year decline of the Saginaw Bay fishery, including destruction of nearshore spawning and nursery habitat, deterioration of water quality, blocking of spawning migrations in major tributaries, invasion of exotic species, and, particularly beginning in the 1940s, excessive commercial harvest of already stressed populations (Fielder et al. 2000).

EVIDENCE OF RECOVERY

In the 1970s, the Saginaw Bay fisheries began to recover as a result of a combination of factors including new federal and state water pollution control mandates, stringent controls on the commercial harvest of certain species, partial control of exotic planktivores such as alewife through the stocking of salmonids, and the planting of fingerling walleye to supplement natural reproduction (Schneider 1977; Fielder et al. 2000). At the turn of this century, the Saginaw/Tittabawassee Rivers again support large spawning runs of walleye, thought in large part to be in response to the annual stocking of fingerling walleye by the Michigan Department of Natural Resources (MDNR) since 1982. Current evidence suggests that some natural reproduction of walleye is occurring in Saginaw Bay and perhaps in the Saginaw River watershed downstream of existing barriers to fish migration. The average annual harvest of all fish in Saginaw Bay has risen in recent years to approximately 1.2 million, with yellow perch comprising up to 86 percent of the number of fish taken. As shown in Exhibit 12, the resurgence of a walleye fishery in the bay and in the Saginaw/Tittabawassee Rivers has been largely responsible for the increase in sport fishing activity since the early 1980s (Fielder et al. 2000).

EXHIBIT 12
Saginaw Bay Walleye Fishery Yield (Catch)
1983–1997 Sport Fisheries, Including Open Water, Ice, and Saginaw River
(Historic Is Sustained Average by Commercial Fishery 1912–1940)

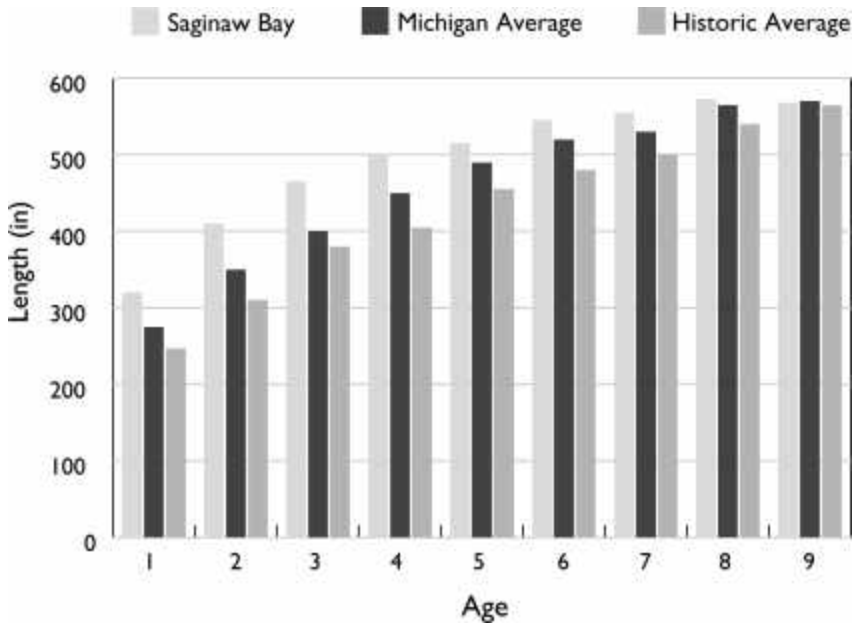


SOURCE: Fielder, D., and M. Thomas, 1997.

CURRENT STATUS

The MDNR has assessed the fish populations in Saginaw Bay routinely since 1989 using test gill nets, bottom trawl sampling, and walleye tagging. In addition, it has monitored the sport fish and commercial harvest. This assessment concluded that despite a resurgence of walleye beginning in the 1980s, "Saginaw Bay remains an ecosystem characterized by an overabundance of forage fish and an underabundance of top predators" (Fielder et al. 2000). The assessment determined that despite the rapid colonization of exotic zebra mussels in the bay during the 1990s and a shift of the forage fish community from pelagic (open water) plankton feeders toward benthic (lake bottom) feeders, the abundance and distribution of walleye in the bay did not change significantly. Yellow perch growth rates over the last decade have increased as abundance has declined in the bay, perhaps due to a combination of factors that include decreased recruitment, improved abundance of benthic food organisms, and reduction in the rate of parasitic infections. Current information indicates that the walleye populations in the bay have growth rates in excess of those documented for walleye in Saginaw Bay between 1912 and 1940 and the current statewide Michigan average (see Exhibit 13), suggesting that forage fish consumed by walleye, principally alewife and gizzard shad, are overabundant (Fielder et al. 2000).

EXHIBIT 13
Saginaw Bay Walleye Growth Rates (Length@Age) Based on 1997 Sample, with the Michigan Average and 1912–1940 Historic Average for Comparison



SOURCE: Fielder, D., and M. Thomas 1997.

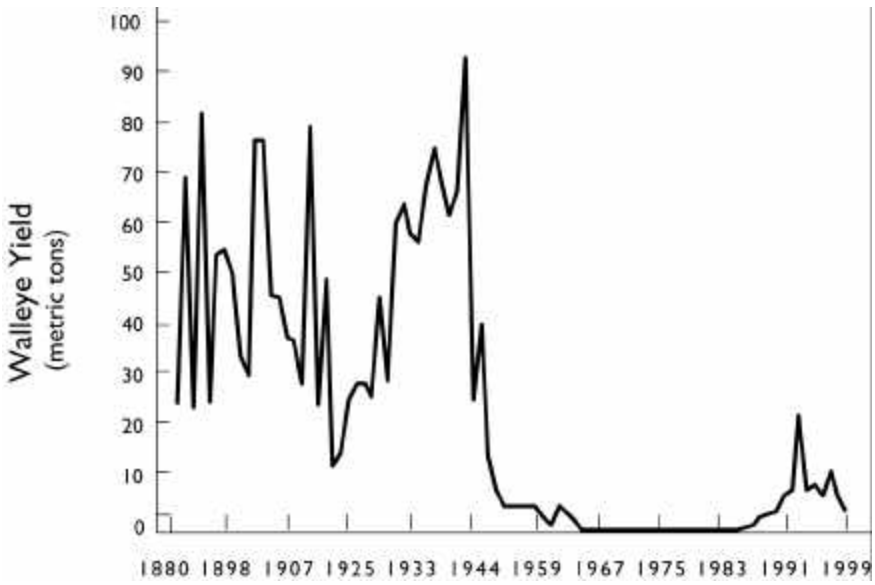
Dissolved oxygen measurements in the Saginaw River indicate that the levels are now consistently better than the minimum state water quality standard for the protection of

warm-water fish of 5.0 mg/l. The water quality of the Saginaw River, at least with respect to dissolved oxygen levels, may have met the targeted restored condition and no longer be a significant limiting factor in the abundance or distribution of important fish species. However, additional and continuous monitoring is needed to confirm this condition.

MANAGEMENT OBJECTIVES

Despite evidence of a recovering fishery in the Saginaw River and Saginaw Bay, the populations of the most desirable sport and commercial species have not reached historical levels. Despite major strides in pollution control, habitat alterations, dams, and the invasion of exotic species have substantially affected reproduction, growth, and/or survival of walleye, yellow perch, lake sturgeon, lake herring, and other native species that once dominated the fishery. The primary objective for managers responsible for the Saginaw Bay/Saginaw River fisheries is the reestablishment of abundant top predator species (e.g., walleye, northern pike, catfish, and muskellunge) to restore the balance between prey and predator species in the ecosystem. Currently, the overabundance of forage prey species such as alewife and gizzard shad are thought to suppress numbers and the growth of yellow perch and lake herring. The managers believe that the best strategy to achieve the objective is to continue to build a sustainable walleye population (Fielder et al. 2000). Exhibit 14 illustrates walleye yield thought to be attributable to natural reproduction.

EXHIBIT 14
Saginaw Bay Walleye Yield (Catch) Thought to Be Attributable to Natural Reproduction



SOURCE: David Fielder, Michigan Department of Natural Resources (personal communication, unpublished data).

In addition, MDNR Fisheries Division biologists recommend reintroductions of Great Lakes muskellunge and habitat improvement and/or supplemental stocking for lake sturgeon and northern pike. They also recommend reintroduction of once-abundant lake herring into the bay now that the numbers of competing alewife have been reduced. Managers believe that increasing the diversity of the Saginaw Bay fish community through the encouragement of native species will bring stability and build resistance in the ecosystem to the negative effects of invasive exotic species (Fielder et al. 2000).

The fisheries management goals for Saginaw Bay are consistent with and contributed to those established for the fish-community objectives in Lake Huron developed under the auspices of the Great Lakes Fishery Commission. The overall objective for Lake Huron over the next two decades is to "restore an ecologically balanced fish community dominated by top predators and consisting largely of self-sustaining indigenous and naturalized species capable of sustaining annual harvest of 8.9 million kilograms" (DesJardine et al. 1995). The lakewide objective for walleye is to "reestablish and/or maintain walleye as the dominant cool-water predator over its traditional range with populations capable of sustaining a (annual) harvest of 0.7 million kilograms." For yellow perch the lakewide objective is to "maintain yellow perch as the dominant nearshore omnivore while sustaining a harvestable annual surplus of 0.5 million kilograms."

These lakewide objectives are based upon the ecological concepts of stability, balance, and sustainability. *Stability* refers to the fish community's ability to persist in the face of possible invaders, to resist change in the face of a disturbance, and to recover quickly from any changes following a disturbance. *Balance* is related to the ratios of predator species to prey species shaped from the bottom up by primary production (photosynthesis) and from the top down by predation. *Sustainability* embodies the concept of long-term, desirable outputs from a natural system to meet the expectations of people today as well as those of future generations. Sustainability implies control of present activities to minimize future increases in management costs and to insure availability of future management options. Critical to the concept of sustainability is the need to preserve the overall integrity of the ecological system through pollution control and habitat protection (DesJardine et al. 1995).

OTHER FISHERIES IMPAIRMENTS CITED IN THE 1988 RAP

Tainting of Fish (Taste and Odor Concerns)

Chemical odors and tastes associated with fish harvested in the Saginaw River, the Tittabawassee River, and Saginaw Bay were frequently reported from the 1940s through the 1970s, according to the 1988 RAP (MDNR SWQD Great Lakes 1988). The sources of these tainting problems were directly related to the discharge of certain industrial chemicals. In the 1994 RAP, the Surface Water Quality Division of MDNR (now MDEQ) reported that no off flavor was detected in taste tests conducted on fish taken from the Tittabawassee River and that there had been no reports of off-flavor fish taken from Saginaw Bay in the years immediately preceding 1994 (MDNR 1990). In 2000, it was reported that the Michigan Department of Environmental Quality

(MDEQ) had received no fish tainting reports from the area in 1999 and only one complaint had been received in 2000 from the Saginaw River (PSC 2000). While the information indicates that the severity and number of fish tainting reports has substantially decreased since the early 1970s, there has not been a systematic effort since 1995 to verify that fish tainting is no longer a significant impairment in the Saginaw River.

Toxic Contaminant Levels in Fish

The chemical contaminants of concern in the Saginaw River/Bay AOC have focused primarily on polychlorinated biphenyls (PCBs), dioxin, DDT (including associated chemicals DDD and DDE), and heavy metals, particularly mercury. While no specific large wastewater discharge sources of mercury have been identified in the AOC, historical production and/or use and subsequent water and sediment contamination by PCBs, dioxin, DDT, and heavy metals have been a significant concern. The toxic contaminants beneficial-use impairments cited in the 1988 RAP related to both the effects of these chemicals on the reproduction and survival of fish and the potential adverse effects on the health of people consuming sport or commercial fish taken from the area (MDNR SWQD Great Lakes 1988).

There is very little direct evidence of impairments to fish populations in the Saginaw River/Bay AOC due to high levels of toxic contaminants. However, the high levels of PCBs and DDT measured in water, sediments, and in fish in the Saginaw Bay watershed in the 1970s would strongly suggest that the toxic chemicals may have had a negative effect on the reproduction of some sensitive fish species. Research on lake trout indicates that relatively low levels of PCBs and DDT decrease the viability of eggs and increase the mortality of fry (Hendrix and Yokum 1984, Wilford et al. 1981). It is unknown whether current toxic contaminants levels found in water, sediments, and fish in the AOC represent a risk to reproduction, growth, or survival of fish. However, the recent recovery of walleye and relatively stable numbers of yellow perch would indicate that for at least these two species, current toxic contaminant levels may not be significantly affecting reproduction, growth, and survival.

The concentrations of DDT in fish from Saginaw Bay appear to have peaked in the late 1960s or early 1970s, based upon data collected on yellow perch and catfish during the years 1967 through 1980 (Kreis and Rice 1985). This declining trend in concentration would correspond roughly to the decline in use and subsequent state prohibition on most uses of DDT in the early 1970s. While in general, DDT and related derivatives in fish within the AOC have declined below levels of human health concern, high concentrations in fish below the former Michigan Chemical facility on the Pine River that once manufactured DDT have prompted the U.S. Environmental Protection Agency (EPA), with the state's cooperation, to undertake dredging and removal of DDT-contaminated sediments (EPA Region 5 1998). DDT, DDD, and DDE are expected to remain detectable for some period of time in the AOC due to slow degradation of residual concentrations still found in contaminated sediments.

During the same time frame (i.e., 1967–1980), however, PCBs increased in concentration in the same two species (Kreis and Rice 1985). Michigan restrictions on

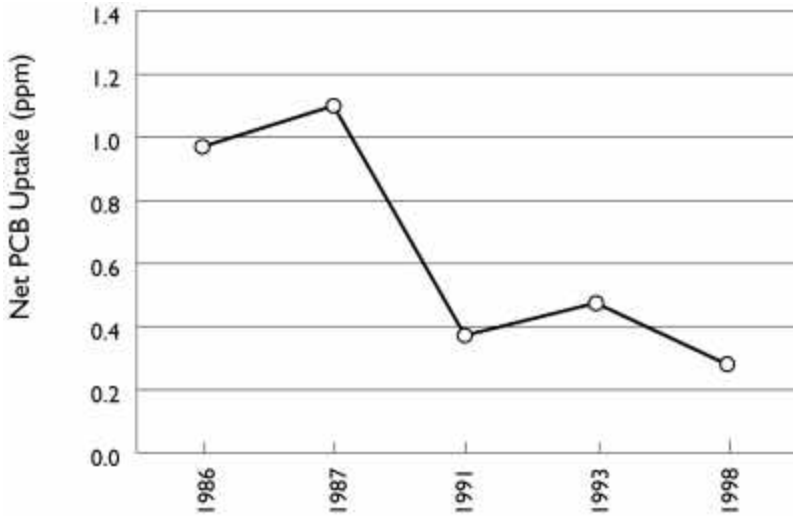
the use of PCBs, and the eventual federal manufacturing ban in 1978, subsequently led to declining PCB levels in fish within the AOC. Caged-fish studies in 1988 indicated that the highest levels of uptake of PCBs by fish were below Bay City in the Saginaw River, indicating a significant source of contaminants somewhere between the upstream sampling location just below the City of Saginaw and the downstream site near Essexville (Morse and Materson 1991). Subsequent testing indicated that sediments highly contaminated with PCBs should be removed and the area was targeted for dredging of some 345,000 cubic yards of material as part of the 1998 court settlement agreement between defendants General Motors, the City of Saginaw, and Bay City and the plaintiffs U.S. EPA and MDEQ (GPO 1998).

The long-term trends of toxic contaminant levels in fish are difficult to establish due to the variability related to age, size, species, diet, and fat content. In addition, contaminant levels found in highly mobile species like walleye may not be representative of conditions found at the location where a specimen was captured in the open environment. Monitoring the uptake of contaminants in caged test-fish species of uniform size provides key information on the rate of uptake of contaminants like PCBs, and can provide a relative measure of the trends in contaminant levels found in a water body. Results of caged-fish studies at the mouth of the Saginaw River indicate that PCB levels have declined significantly since the mid-1980s (see Exhibit 15). Caged-fish PCB uptake levels at the mouth of other major Michigan rivers without large known discharges of PCBs show much lower uptake levels (MDEQ SWQD 2001). Caged-fish studies following the removal of PCB contaminated sediments in the Saginaw River in 2001 could demonstrate that PCB uptake levels in fish will decrease below those observed in 1998.

Some caution should be taken in evaluating contaminant uptake levels from caged-fish studies. Significant rain events upstream of the caged fish can resuspend contaminants, causing higher uptake levels than would otherwise occur. Nonetheless, caged-fish studies offer the best direct evidence of long-term trends.

PCB concentration levels in fish were high enough in 2001 to trigger Michigan Health Department fish consumption warnings on eight species taken from Saginaw River and Saginaw Bay for at least women and children. There is a health warning for the general population advising no consumption of carp of any size and catfish over 18 inches from Saginaw Bay, and a consumption warning for women and children for any catfish over 12 inches due to the levels of PCBs and dioxin found in these species. Fish consumption warnings also apply to the Saginaw River, where they are even more restrictive. Similar consumption advisories for the same species due to PCB contamination apply to fish taken in Lake Huron, Lake Michigan, Lake St. Clair, and Lake Erie, although, in general, they are less restrictive outside the Saginaw Bay watershed (MDCH 2001).

EXHIBIT 15
PCB Caged-fish Uptake, Saginaw River
(Adapted from Michigan Fish Contaminant Monitoring Program)



SOURCE: Michigan Department of Environmental Quality, 2000 Annual Report.

Caged-fish studies in 1988 confirmed that the primary source of dioxin contamination in the lower Saginaw River watershed is in the Tittabawassee River (Morse and Materson 1991). While manufacturing of products thought to be primarily responsible for dioxin discharges at the Dow Chemical Company in Midland has diminished, fish are still bioaccumulating dioxin, presumably from high concentrations remaining in sediments and from other minor sources in the watershed. Carp and channel catfish have fish consumption warnings in Saginaw Bay and the Cass River at least in part due to dioxin levels. All fish in the Saginaw and Tittabawasee Rivers have consumption warnings based in part upon dioxin levels in fish. Dioxin has been detected in fish in other Great Lakes areas at sufficiently high levels to warrant consumption warnings for some species, particularly larger whitefish taken from lakes Superior, Michigan, and Huron (MDCH 2001). Additional fish contaminant monitoring data can be found in the Technical Appendix.

Habitat Losses

Comparative studies of presettlement land cover versus that in the early 1990s indicate that there has been a 40 percent reduction in wetlands in the Saginaw River watershed over the last 150 years (Comer et al. 1993). While not all critical fisheries habitat, a significant percentage of wetlands formerly available to fish in the Saginaw Bay/Saginaw River watershed, including coastal marshes, has been filled, drained, or otherwise degraded and no longer provides spawning, feeding, or nursery areas. In addition, the presence of 454 dams and impoundments in the Saginaw River watershed has restricted the ability of certain species to access important historical spawning areas (MDEQ Land and Water 2001). Former walleye spawning reefs in Saginaw Bay have also been covered by silt and sand through the sedimentation of soil materials

eroded from upland urbanization and agricultural practices over the last century, and many of these former reefs no longer provide suitable spawning habitat for this important species (Fielder 1997).

Protection and restoration of wetlands and coastal marshes are covered in the Wildlife section of this report. Providing access to historical spawning areas through dam removal and/or fish passage is an MDNR objective to restore self-sustaining populations of walleye and lake sturgeon in the Saginaw Bay watershed (Fielder et al. 2000). Tag returns of walleye captured and marked below the Dow dam in Midland on the Tittabawassee River show contributions to the sport fishery in both the inner and outer areas of Saginaw Bay and as far away as Alpena, Lake St. Clair, and Lake Erie. Expanding the availability of walleye spawning habitat above downstream barriers on the Tittabawassee and other Saginaw River tributaries is critical to successfully increasing the current walleye population through natural reproduction (Fielder and Thomas 1997). Dam removal and/or fish passage is also critical to the successful restoration of lake sturgeon that historically used the upper portions of the Saginaw River watershed as spawning and nursery areas (Hay-Chmielewski and Whelen 1997).

The serious degradation of the water quality in Saginaw Bay and the Saginaw River through at least the early 1970s was a major factor limiting the populations of desirable species of fish. The eutrophication of Saginaw Bay due to the discharge of sedimentation and nutrients, particularly phosphorus, significantly changed the chemical as well as physical habitat to the detriment of valuable native fish and fish food organisms (MDNR SWQD Great Lakes 1988). Testing in the Saginaw River in 1965 indicated that dissolved oxygen levels had been reduced to near zero due to pollution from municipal and industrial waste discharges (MDNR SWQD Great Lakes 1988). Large fish kills due to dissolved oxygen depletion and toxic chemical discharges were common in the Saginaw River watershed prior to 1970 (PSC 2000).

Recovery of the bay ecosystem since 1970 and current conditions are discussed elsewhere in this report. Dissolved oxygen measurements in the Saginaw River indicate that the levels are now consistently higher than the minimum state water quality standard for the protection of warm-water fish of 5.0 mg/l. The water quality of the Saginaw River, at least with respect to dissolved oxygen levels, may no longer be a significant limiting factor in the abundance or distribution of important fish species.

TARGETED RESTORED CONDITIONS

The following targeted restored conditions for the fish populations in the Saginaw River/Bay were established in the *Measures of Success* report.

Fish Populations

Three species—walleye, yellow perch, and lake sturgeon—were selected as indicators of recovery of the fish populations in the bay and the river. Two—walleye and yellow perch—represent the primary sport fish of the area. Walleye are also seen as the key to restoring the ecological balance between predator and prey populations in the bay. The Fisheries Division of the MDNR has been routinely assessing the populations of these

two species in Saginaw Bay for several years and plans to continue its monitoring program. Lake sturgeon was selected because it has been targeted for a major restoration effort in the Great Lakes with a focus on rivers, such as the Saginaw, with historical spawning runs (Hay-Chmielewski and Whelen 1997). The Fisheries Division of the MDNR, together with other states, the province of Ontario, the U.S. Fish and Wildlife Service, the Great Lakes Fishery Commission, and the Great Lakes Fishery Trust, is cooperating in research, assessment, and restoration of this historically important Great Lakes species (GLFT 2001). Achievement of all three of the following targeted restored conditions (PSC 2000) would support the contention that fish populations in the bay and the river had recovered to a level that would justify delisting of this impairment.

Walleye – Targeted Restored Condition

Increase abundance in the bay, ultimately through natural reproduction, such that growth rates approximate more closely statewide averages for this species and reflect improved use of available forage in the bay.

Measurement of walleye growth rates in the bay is probably the easiest and best measure of whether the ecological balance objective established by fisheries managers has been achieved. Under current conditions, a decrease in growth rates for walleye will require an increase in the recruitment of adult walleye through expansion of natural reproduction or artificial propagation. Increases in the number of walleye will have the secondary benefit of improving the conditions for yellow perch by reducing the abundance of competing forage species.

Yellow Perch – Targeted Restored Condition

Sustain an annual harvest from the bay of 750,000 pounds per year while increasing the abundance of larger, faster-growing individuals.

No direct management of yellow perch will be required to achieve the target if forage species that directly compete with yellow perch for food or prey on their young are reduced by increases in predator species in the bay.

Lake Sturgeon – Targeted Restored Condition

Documented evidence of successful spawning in the Saginaw River.

Historically, lake sturgeon was an abundant species in Saginaw Bay that used the Saginaw River watershed as a spawning and nursery area. Evidence of natural species reproduction of this native, pollution-intolerant species would demonstrate that water quality had improved in the river sufficient to support restoration of this important species.

Tainting of Fish (Taste and Odor Concerns)

Taste and odor complaints related to fish taken from either Saginaw Bay or the lower portions of the Saginaw River watershed have nearly disappeared in recent years. However, sporadic reports are still received and those reports leave some question as to whether a systematic survey of anglers might reveal additional tainting problems not previously reported. Given the magnitude of the historical problem of fish tainting in the bay and the river, it would be prudent to establish a baseline survey of anglers to determine if a significant problem still exists, and if it does, whether it is confined to specific areas where contributing sources can be addressed.

Fish Tainting – Targeted Restored Condition

Taste and odor problems reported by anglers for any species taken from the Tittabawasee River downstream from Midland and the Saginaw River/Bay represent less than 1 in 10,000 of the estimated total catch of that species for three consecutive years. In addition, no specific sites of fish tainting have been identified that would justify remedial action.

Habitat

Protection and restoration of inland and coastal marsh areas is critical to both fisheries and wildlife resources of the AOC. Specific restoration targets for wetland areas are covered under the Wildlife section of this report. Achieving water quality standards in the Saginaw River for dissolved oxygen necessary to protect warm-water fish species

will demonstrate significant restoration of a previous impairment to the riverine habitat.

Dams and impoundments within the Saginaw River watershed currently limit access of many fish populations to historical spawning areas. Successful passage of fish above these barriers may hold the key to achieving self-sustaining populations of predators like walleye needed to restructure the ecological balance in Saginaw Bay. Targeted restored conditions (PSC 2000) identified for fish populations (i.e., increase abundance of walleye) consider the need to expand areas available for natural reproduction.

Fish Habitat – Targeted Restored Condition

- *Dissolved oxygen levels in the river meet or exceed the minimum state water quality standard of 5.0 mg/l during the critical summer months.*
- *Critical coastal marsh areas are adequately protected (see Wildlife section of this report).*

Note: To meet restored conditions will necessitate the movement of some fish species above existing dams and barriers to carry out natural reproduction in historical spawning areas.

Toxic Contaminants

A majority of the original point sources of DDT, PCBs, dioxin, and a range of other chlorinated hydrocarbons, as well as major discharges of heavy metals, have been controlled or eliminated in the AOC through a series of pollution abatement programs initiated in the early 1970s. However, secondary sources (e.g., contaminated river and bay sediments, runoff from contaminated upland sites, and atmospheric deposition) are high enough to cause bioaccumulation in fish above trigger levels established to protect the health of people consuming fish taken from waters in the AOC. In addition, the levels of these toxic chemicals in fish still impair sensitive fish-eating birds and perhaps other fish-eating wildlife. Targeted restored conditions in the Wildlife section of this report indirectly address the contaminant levels in fish in the AOC.

Fish consumption warnings in the AOC due to concentration of toxic chemicals are likely to continue into the distant future due to the slow degradation of the these persistent organic chemicals in sediments and upland soils, and atmospheric transport and deposition of at least dioxin and PCBs from sources outside the region. The key to delisting toxic contaminants in fish in the Saginaw River/Bay AOC is control of all

known sources in the AOC and ensuring all reasonable remedies have been completed with present day tools. The first listed targeted restored condition related to toxic chemicals is intended to demonstrate that no further reasonable remedies are available and that the slow process of natural recovery is under way. Even though full restoration may not be possible, partial restoration can be achieved, and the second targeted restored condition is intended to demonstrate that toxic chemical levels are not significantly higher for the primary sport species of concern in the Saginaw Bay watershed than those found in fish from other Great Lakes areas. If the restored condition for contaminants in walleye (PSC 2000) is achieved, it will substantiate that the impairment (i.e., fish consumption advisory) remains but is not solely due to locally controllable sources. Additional fish contaminant monitory data can be found in the Technical Appendix.

Contaminants in Fish – Targeted Restored Conditions

- *PCB and dioxin levels in fish tissues from caged-fish studies in the Saginaw and Tittabawasee Rivers indicate that the former sources (including sediments) of these contaminants have been effectively controlled and/or remediated.*
- *Levels of PCBs and dioxin in walleye taken from the Saginaw River/Bay are equal to or less than the levels found in comparable fish taken from other areas of the Great Lakes not listed as AOCs.*

Wildlife

IMPAIRMENTS

Saginaw Bay historically contained one of the largest wetland/lake prairie complexes in the Great Lakes region. Massive land use changes since the mid-1800s have significantly altered the quantity, diversity, and quality of habitat available to support wildlife. The draining of marshes and wet prairies for agricultural production began in the late 1800s; it is estimated that over 40 percent of the wetlands in the Saginaw Bay watershed have been lost and that less than 1 percent of the original lakeplain prairie remains intact (MDEQ OGL 1999).

Wetlands are dynamic and fluctuate as the water levels change in the Great Lakes. Historical documents indicate that there were nearly 37,000 acres of emergent vegetation around Saginaw Bay before development of the area. Only about 15,000 acres of these coastal areas remain today and make up the largest freshwater coastal marsh system in the nation. Currently, approximately 4 percent of the watershed consists of wetlands. Most of these wetland areas exist on public lands such as national wildlife refuges, game areas, state parks, and publicly owned Great Lakes bottomlands. Food crops grown in wetlands, such as wild rice, benefit both wildlife and humans (MDEQ OGL 1999).

The watershed has 138 animal and plant species that have been identified as being endangered, threatened, or of special concern. Coastal wetlands provide habitat for spawning and nursery areas for fish such as northern pike, large-mouth bass, and muskellunge. These areas help support an annual multi-million dollar commercial and recreational fishing industry (MDNR SWQD 1994).

The filling of wetlands to build docks, businesses, homes, and eventually, facilities to process and transport lumber products accompanied early development of the area. Drainage from agriculture followed closely behind early industrial development. In addition, the manufacture, use, and subsequent discharge of persistent toxic chemicals into the waters of the area have had a significant negative impact on the growth and survival of a number of fish-eating wildlife species. The degradation of wildlife populations includes the loss of essential habitat, observed deformities in certain fish-eating birds, and reproductive problems with fish-eating birds and mammals. These were identified as impairments leading to the designation of the Saginaw River/Bay as a Great Lakes Area of Concern (MDNR SWQD 1994).

In the 1970s and 1980s, mounting evidence indicated that in the Saginaw River/Bay, fish-eating birds were accumulating persistent organochlorine compounds such as DDT, dieldrin, chlordane, polychlorinated biphenyls (PCBs), and dioxins. Fish-eating birds have been used as sentinel species for contaminants in the Great Lakes for more than 30 years. Studies in the 1980s linked high concentrations of organochlorines in terns, herons, and eagles in the Saginaw Bay area to eggshell thinning and/or birth deformities. Fish-eating birds are particularly vulnerable to organochlorines because these contaminants tend to increase in concentration as they pass up the food chain

from fish to fish-eating predators. Little was known in the 1970s about the effect of these contaminants on fish-eating mammals in the Saginaw River/Bay area. But there *was* laboratory evidence suggesting that environmental concentrations of PCBs were high enough in the 1970s and 1980s in the bay area to have caused injury to wild mink and perhaps otter. A comparison of statewide trapping records during this 20-year period suggests that populations of mink and otter in the Saginaw Bay area may have been reduced due to the increase in toxic contaminants in fish (MDEQ OGL 2000, March).

Specifically, the evidence that led to the determination that wildlife populations in the Saginaw River/Bay had been impaired (MDNR SWQD 1994) included the following:

- Terns, herons, and eagles were injured due to PCB and/or dioxin eco-toxicological effects on reproduction (i.e., chick deaths and birth deformities).
- The presence of contaminants was linked to death (Caspian terns); malfunctions in reproduction (Caspian terns, common terns, bald eagles); and physical deformities (black-crowned night herons, Caspian terns, common terns).

EVIDENCE OF RECOVERY

Changes in federal and state laws regulating the filling and dredging of wetlands were adopted in the 1970s and provided additional protection to the remaining shore marshes and wet prairies in the Saginaw River/Bay area. While the protection of remaining wetland areas remains a priority, the potential for restoring bay area wetlands has been widely recognized in the last decade. The Saginaw Bay National Watershed Initiative and the 1988 RAP helped to focus concerns on the status and importance of the wetlands in the bay area. Completed in the 1990s, research projects conducted in the Saginaw River watershed and along the Saginaw Bay have mapped the presettlement wetland areas, identified remnant lakeplain prairies and potential seed banks of native wetland plant species, and evaluated several potential wetland restoration sites. This research culminated in a 1997 feasibility study involving the Michigan Department of Natural Resources (MDNR), Michigan Department of Environmental Quality (MDEQ), and Michigan Natural Features Inventory that outlined specific recommendations for restoring wetlands in Saginaw Bay (Wilsman and Paskis 1997).

In addition, state and federal actions to control the primary sources of contaminants in the bay over the last 30 years and the subsequent reduction in contaminant levels in fish (as documented in other sections of this report) have reduced the impairments to the fish-eating wildlife populations in the Saginaw River/Bay area. Lake Huron has the highest number of fish-eating birds that breed along the shoreline of all the Great Lakes. Most populations of fish-eating birds (double-crested cormorants, Caspian terns, and osprey) are increasing, with Caspian terns and osprey no longer showing adverse effects of contaminants (MDEQ OGL 2000, March).

Although concentrations of many contaminants declined markedly during the late 1970s, concentrations have declined slowly, leveled off, or increased slightly during

the 1980s and 1990s (Stow 1995). As biological and chemical assessment methods have improved, the research emphasis for Great Lakes toxics has shifted to examining problems in finer detail. Improvements in analytical chemistry and bioassays have made possible congener-specific chemical analyses that have become important tools for assessing the effects of complex mixtures of contaminants. Although expensive, more detailed chemical analyses have helped to separate the effects of various PCB and dioxin congeners that vary widely in their toxicity and environmental persistence (Grasman et al. 1998).

Bald eagles are one of the top-level fish-eating predatory animals of Lake Huron and a good indicator of ecosystem health. While eagle nesting success in the Saginaw River/Bay watershed area lags behind that found in the interior of the Lower Peninsula of Michigan, there is strong evidence that discreet populations in the Lake Huron area, including the Saginaw River, are recovering. During the past decade, the numbers of nesting pairs, fledged young, and overall productivity has rebounded along the shorelines of Lake Huron. Yet there remain some noticeable differences in the ability to successfully reproduce. Of the 41 breeding areas associated with Lake Huron or the Saginaw River, reproduction is above the goal set for recovery (>/= 1 young per occupied nest) in 11 areas. These are the six breeding areas of eagles that nest along the St. Mary's River (success = 1.42), and the five breeding areas of eagles nesting along the Saginaw River (success = 1.03). Productivity remains below the goal set for recovery in the remaining 30 breeding areas, which are associated with Lake Huron proper. These are the 19 breeding areas along the upper Lake Huron, above Saginaw Bay (success = 0.83), and the 11 breeding areas within Saginaw Bay (success = 0.64). (Bowerman 2001)

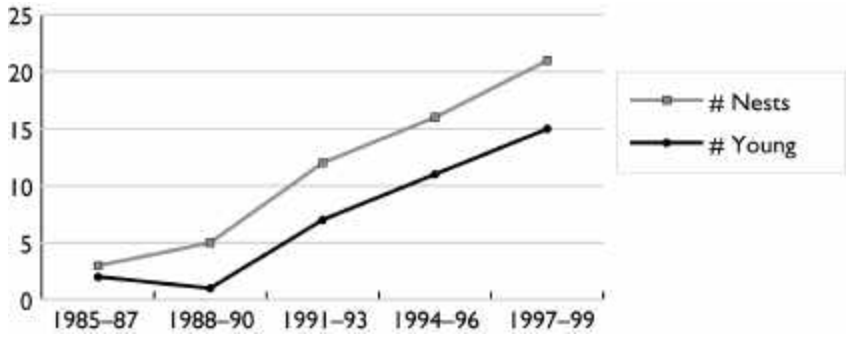
Exhibits 16–18 compare breeding success for bald eagles nesting within 8.0 km of Lake Huron and along the Saginaw River, 1991–2000.

EXHIBIT 16
Breeding Success for Bald Eagles

Location	Breeding Attempts	Breeding Areas	Fledged Young	Successful Nests	Percent Successful	Productivity
St. Mary's River	31	6	44	28	90	1.42
Saginaw River	34	5	35	2	65	1.03
Upper Lake Huron	139	19	115	77	55	0.83
Saginaw Bay	61	11	39	32	52	0.64
TOTAL	265	41	233	159	60	0.88

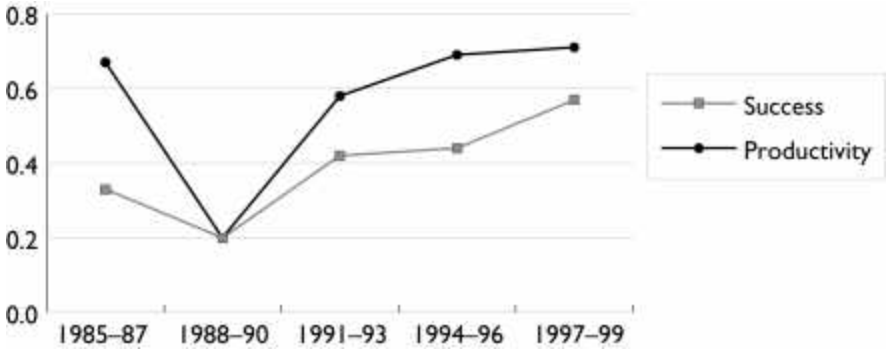
SOURCE: Bowerman 2001.

EXHIBIT 17
Bald Eagle Nests and Number of Young in Saginaw Bay



SOURCE: Public Sector Consultants. Data from Bowerman 2001.

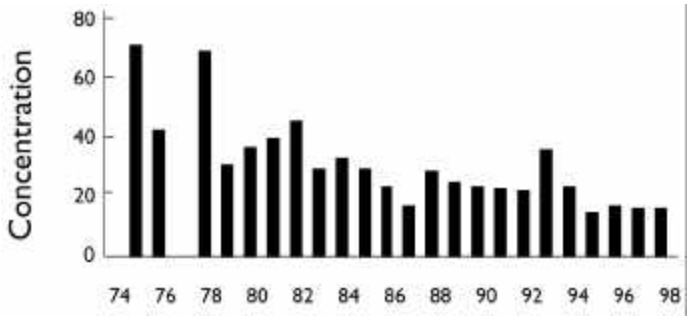
EXHIBIT 18
Bald Eagle Productivity and Nesting Success Rates for Saginaw Bay



SOURCE: Public Sector Consultants. Data from Bowerman 2001.

Exhibit 19 shows PCB concentrations in herring gull eggs from Lake Huron. While these levels have declined, eggs sampled from birds in the Saginaw Bay area have much higher PCB levels than eggs collected from nest sites in other areas of Lake Huron.

EXHIBIT 19
PCBs in Herring Gull Eggs from Lake Huron
(mg/g wet weight)



SOURCE: Ryckman, Weseloh, and Bishop. Data from Canadian Wildlife Service, 1999.

CURRENT STATUS

Saginaw Bay has been recognized nationally as a rich biological resource representing the largest freshwater coastal wetland area (1,143 square miles) in the United States, supporting an annual migrating population of over three million waterfowl. Both the national Wetlands Policy Forum and the Michigan Wetland Advisory Committee have adopted specific objectives as a benchmark for assessing the effectiveness of their respective strategies to protect and restore wetlands. Both organizations have taken into account previous losses and propose to increase the amount of existing wetlands. The national objective proposes a net increase to wetland acreage over the long term. The state objective establishes an ambitious target of 50,000 new wetland acres by the year 2010 and long-term restoration, creation, and enhancement of 500,000 acres (PSC 1994, July).

Between 1987 and 1990, the MDNR acquired 9,845 acres of state park and wildlife areas as part of an intense, focused effort to acquire land in the Saginaw Bay area. Purchases included parcels in Arenac, Bay, Huron, and Tuscola Counties. Since 1990, the MDNR has acquired 5,265 acres in the above counties and Iosco County (MDNR 1990).

In 1998 and again in 2001, Ducks Unlimited received on behalf of its partners grants of $774,750 and $1,000,000, respectively, from the North American Wetlands Conservation Act to conserve wetlands and associated habitats in the Saginaw Bay watershed. These funds will be used to focus on protection and restoration of Great Lakes coastal marshes and their associated habitats along the Saginaw Bay shore, expansion of existing state and federal wildlife areas with the restoration of newly acquired lands where possible, and restoration and enhancement of small wetlands and associated uplands on private lands throughout the watershed (EPA 2001, December 6).

Federal land purchases have been limited to expanding the Shiawassee National Refuge boundaries. The boundaries were established around 1978, at which time

expansion of the refuge slowed or ceased until the mid-1990s, when an active effort to expand its boundaries was undertaken. Since 1994, 320 acres have been added to the refuge, while an additional 380 acres have been acquired through long-term leases. The Saginaw Bay Natural Resources Damage Assessment provided protection of almost 1,700 acres of coastal wetland along Saginaw Bay and restoration of over 200 acres (GPO 1998).

The U.S. Department of Agrigulture and the State of Michigan are implementing a $177 million Conservation Reserve Enhancement Program (CREP) to improve the water quality of the Saginaw Bay watershed and many of the streams and rivers that feed into these bodies of water. CREP is a federal-state conservation partnership program that targets significant environmental effects related to agriculture. It is a voluntary program that uses financial incentives to encourage farmers to enroll in contracts of 10 to 15 years in duration to remove land from agricultural production. In addition, permanent easements are available under the program. The Michigan CREP has been designed to reduce the amount of sediment entering the Saginaw River by over 784,000 metric tons over the next 20 years. CREP will fund filter strips and riparian buffers to be planted next to streams, rivers, and drainage ditches to prevent sediment and pollutants from entering the water bodies. The federal and state shares are $142 million and $35 million, respectively (EPA 2001, December 18).

Very little direct, hard evidence is available on the effects of toxic contaminants on fish-eating mammals in the bay area or their potential recovery. Some assumptions can be made based upon information collected from other areas and from anecdotal reports in the bay area. Fish-eating mammals (mink and otter) appear to be recovering in the bay area. Mink and otter both live in wetland areas near the shoreline and consume fish. Mink are among the most sensitive mammals to the negative effects of PCBs. The mink's diet consists mainly of other mammals, but it supplements its primary food source with birds, fish, and invertebrates. Statewide trends in mink populations have followed those of fish-eating birds: the population began to decline in the mid-1950s, was lowest in the early 1970s, and recovered somewhat in the 1980s. While otter may be less sensitive than mink to contaminants, they may be exposed to higher levels because their diet consists mainly of fish. Statewide data have not shown the same recovery trend for otter populations as for mink and fish-eating birds. However, otter do have a lower rate of reproduction and therefore would be expected to show a slower rate of recovery (PSC 2000).

During the last five years, there has been an apparent increase in both the numbers and habitat range of river otter within the Michigan portion of the Lake Huron watershed. After an absence of at least 30 years, river otter are now being observed regularly at the Nayanquing Point Wildlife Area and nearby Tobico Marsh. River otter also have colonized the Crow Island State Game Area and the Shiawassee River State Game Area. In each of the last three years, otter have also been observed or trapped in Tuscola County (MDEQ OGL 2000, March).

However, limited population studies in several species of fish-eating birds have suggested continued population-level problems, such as reduced recruitment, at highly contaminated sites. Reduced recruitment is more difficult to detect but no less

significant than the more obvious reproductive failures observed in the 1960s and 1970s. Recent research investigating physiological biomarkers has helped strengthen cause-effect relationships between contaminants and population-level effects. Biomonitoring using biomarkers and population-level measures in fish-eating birds will continue to be important for assessing the effects of contaminants on the health of Saginaw Bay and the Great Lakes ecosystem (Grasman et al. 1998).

MANAGEMENT OBJECTIVES

The primary goal for wildlife and fish habitat protection and restoration is to identify and protect existing high-quality wildlife and fish habitat sites as well as the ecosystem processes required to sustain such areas. The secondary goal is to implement strategies that will restore wetlands—particularly high-value coastal marshes and wet-prairie areas—to partially mitigate the significant losses in these habitats that have occurred over the last 150 years.

Based on the Michigan statewide wetland restoration goal of 50,000 acres by 2010, the proportionate share of the goal for the Saginaw River/Bay watershed would be 7,500 acres of new wetlands. This means the creation of 500 acres of wetland in the watershed annually for the next 15 years. While numerous sites have been identified for wetland restoration, it is not the physical limitations but rather the economic and social implications of wetland restoration that may make this targeted goal difficult to achieve in the short term. The social and economic cost of removing land from agricultural production may be too high. For this reason, protecting the ecological integrity of the remaining coastal marsh areas for use by fish and wildlife is the most important single goal in sustaining the diversity and abundance of species that make Saginaw Bay such a unique and valuable natural resource.

Wildlife Contaminants

The ultimate goal of the 1988 Remedial Action Plan (RAP) is to reduce the level of environmental contaminants in the Saginaw River/Bay area so that the reproduction, survival, and consumption of wildlife are no longer impaired. Two significant factors may impede the achievement of this goal in the short term. First, some contaminants like PCBs are attached to particles in the air that are transported from distant locations. Reducing the contribution of these atmospheric sources of contaminants depends on actions beyond the control of regional or even statewide efforts. Second, large quantities of contaminated sediments have been removed from the river and bay in the past and placed in a confined disposal area (Channel/Shelter Island) located near the mouth of the Saginaw River. Evidence suggests that herring gulls, herons, and terns using this confined disposal area for nesting may be exposed to toxic chemicals that are inadequately contained at this site.

While recent evidence suggests that open water within the confined disposal area no longer exists to harbor contaminated fish, there remains a concern that wildlife and/or fish living in the immediate vicinity may still be vulnerable to chemicals migrating from this area. Total containment of the contaminated dredge spoils or prevention of fish and wildlife from using the area may not be feasible. Therefore, a measurable short-term goal is needed to permit the evaluation of remedial actions that already

have been taken across the watershed or that are planned to reduce contaminant levels in wildlife. This short-term goal should focus on successfully controlling watershed sources of contaminants that were responsible for the widespread impairments to wildlife resulting in the listing of Saginaw River/Bay as an Area of Concern (AOC).

TARGETED RESTORED CONDITIONS

The following targeted restored conditions for wildlife focus on the importance of (1) protecting remaining coastal marsh habitat for both fish and wildlife and (2) lowering the level of toxic contaminants in two of the most sensitive species of fish-eating birds (bald eagles and herring gulls). If the ecological integrity of the remaining coastal marshes can be maintained and the bioaccumulative chemical levels in the two indicator bird species lowered to acceptable levels, habitat restoration efforts to expand wildlife populations will have a greater chance of success.

Coastal Marsh Protection (Wildlife and Fish Habitat Protection and Restoration)

The targeted restored condition (PSC 2000) is centered on coastal marshes, primarily because of the importance of this habitat to the fish and wildlife populations of the bay area. While current regulations may adequately protect critical coastal marshes from direct filling and dredging activities, unregulated activities on adjacent uplands may pose an even greater threat. Human alterations or merely occupation of uplands immediately adjacent to sensitive coastal marshes can seriously impair essential attributes needed to support fish and wildlife populations dependent upon these wetland areas. Even in small amounts, storm water runoff from adjacent developments and associated sediment and pollution can subtly alter the functions essential to sustain fish and wildlife. Thus the strategy should be to (1) protect remaining coastal marshes through conservation easements and programs, public acquisition, and by providing adequate buffers, and (2) identify marshes that are particularly vulnerable to upland activities and implement protection and enforcement measures.

Coastal Marsh Protection (Fish and Wildlife Habitat Protection/Restoration) – Targeted Restored Condition

- *At least 60 percent of the coastal marsh areas (below the 585-foot contour) and adequate upland buffers representing essential fish and wildlife habitat are preserved through public ownership, covered under conservation easements, or otherwise protected under agreements with landowners.*
- *The most vulnerable portions of the remaining 40 percent of the essential coastal marsh areas have been clearly identified so that governmental agencies, local conservation/environmental organizations, and concerned citizens can monitor their status, enhance enforcement of existing laws, and conduct public educational programs to better protect these areas.*

Wildlife Contaminants

Toxic chemicals in the Saginaw River/Bay area have impacted a wide range of fish-eating birds and mammals. Two species, bald eagles and herring gulls, have been monitored consistently over the past decade and offer the best indicator to measure success in the control of toxic chemicals. Bald eagles have shown sensitivity to a number of organic chemicals, and measurement of breeding success of this species within the bay area can be used to determine whether contaminant levels emanating from bay area sources are still a source of impairment. Herring gulls are common throughout the Great Lakes, and past monitoring of PCB levels in the eggs of this species has indicated that eggs sampled from birds in the Saginaw Bay area had much higher PCB levels than those found in eggs collected from nest sites in other areas of Lake Huron. Thus monitoring PCB levels in herring gull eggs offers an effective means to monitor PCB control efforts.

Wildlife Contaminants – Targeted Restored Conditions

- ***Bald Eagles****—The reproductive success of bald eagles in the Saginaw Bay area is equivalent to that found in other Lake Huron coastal areas in Michigan.*
- ***Herring Gull****—PCB levels in herring gull eggs taken from Saginaw Bay area nest sites are not significantly higher than those found in other Lake Huron sampling locations.*

Conclusion

DELISTING

Discussion since 1999 about the significant environmental progress that has been made has led to the question of how and when to formally delist AOCs. In spring 2000, the EPA's Great Lakes National Program Office convened the U.S. RAP Workgroup (comprised of representatives from the eight Great Lakes states and U.S. federal agencies, with observers from the Canadian federal and provincial agencies and the IJC) in order to develop guidelines for delisting AOCs, including the development of criteria and related processes. The parties agreed that delisting should not be the goal of the RAP process; rather, the goal and focus should be to restore and maintain beneficial uses.

Many issues were raised concerning delisting criteria, including

- the definition of delisting criteria;
- when criteria have been met;
- when to formally delist an AOC;
- how much monitoring data is sufficient; and
- how to maintain momentum toward delisting at some future date through the use of alternatives, including delisting individual use impairments as they are restored; and/or delisting subwatersheds.

On December 6, 2001, following several meetings, the United States Policy Committee approved a document drafted by the U.S. Remedial Action Plan Workgroup. The document recognizes the progress being made in the U.S. Areas of Concern and presents guidelines to formally delist AOC areas as beneficial uses are restored. The document is intended to guide the restoration and maintenance of beneficial uses and the subsequent formal delisting, in order to achieve a measure of consistency across the Great Lakes basin.

These guidelines offer various options for demonstrating progress, maintaining momentum, and formal delisting, which a RAP implementation group (defined as the state agency and the local public stakeholder group) can use as guideposts and tools. It is not envisioned that all parts of the guidelines will be applicable to all the AOCs; rather, the RAP implementation group can adopt those options that suit the needs of a particular AOC. There will be no sanctions imposed upon a state's RAP program based upon which tools they may choose to use (EPA 2001, December 6).

Three key principles provide the foundation for delisting:

- Delisting targets should be premised on local goals and related environmental objectives for the respective watershed; they should be consistent with applicable federal and state regulations and the principles embodied in Annex 2 of the Great Lakes Water Quality Agreement and related sections.
- Delisting targets should have measurable indicators.

- Delisting targets should be developed and periodically reviewed (allowing for flexibility in addressing local conditions) by the RAP implementation group.

The 1988 Saginaw River/Bay RAP, the 1994 RAP update, the *Measures of Success* project completed in 2000, and this RAP update provide the necessary framework and bring the concept of delisting one step closer to the Saginaw River/Bay AOC. With new and ongoing restoration activities and periodic review of the progress being achieved, the Saginaw River/Bay AOC can proceed toward AOC delisting and ecosystem recovery.

Requirements for the Removal of a Beneficial Use Impairment

Removal of a beneficial-use impairment can occur under any of the following scenarios, according to the delisting guidelines (EPA 2001, December 6, p. 7):

- A delisting target has been met through remedial actions, which confirm that the beneficial use has been restored.
- It can be demonstrated that the beneficial use impairment is due to natural rather than human causes.
- It can be demonstrated that the impairment is not limited to the local geographic extent, but rather is typical of lakewide, region-wide, or area-wide conditions.
- The impairment is caused by sources outside the AOC. The impairment is not restored but the impairment classification can be removed or changed to "impaired-not due to local sources." Responsibility for addressing "out of AOC" sources is addressed pursuant to other restoration initiatives, e.g., Lake and Management Plans (LaMPs).

Recovery Stage Designation

When targeted restored conditions have not been met in all cases, yet substantial efforts and measurable progress toward meeting the restoration goals are achieved, the AOC may pursue "recovery stage" designation. During this stage, the AOC ecosystem is responding to actions taken and a period of recovery is required to fully achieve the delisting targets. The Canadian RAP program has some well-defined operating principles, which the EPA has adopted as guidelines for the recovery stage designation. They are summarized below:

- All reasonable and practical implementation has occurred to address the sources of environmental degradation with present-day tools.
- Commitments to a monitoring program are in place to measure progress and report on a regular basis.
- The strategy and time scale for recovery are agreed upon by the RAP implementation team.
- Partners will develop a maintenance plan and continue to undertake environmental improvements beyond the needs of the RAP.
- Emerging issues must be identified and included as part of a maintenance plan.

Exhibit 20 below summarizes the actions that lead to achieving targeted restored conditions and eventual delisting or recovery stage designation.

EXHIBIT 20
Targeted Restored Conditions 2001 and Restoration Actions

Targeted Restored Condition	Actions
BACTERIA	
A. Saginaw River—Three consecutive years of testing for *E. coli* bacteria, an indicator of the presence of harmful microorganisms, confirm that the state water quality standards for full-body recreation are being met. B. Saginaw Bay—Testing for *E. coli* bacteria confirms that state water standards have not been exceeded more than three times in any one swimming season, and that exceedances did not last more than two days. *NOTE: The selected target was identified by stakeholders and regulators as appropriate because high E. coli levels in lakes and bays can occur due to sources other than human waste (e.g., high waterfowl concentrations).*	• Through the cooperative efforts of (1) the Michigan Department of Environmental Quality (MDEQ), (2) local wastewater treatment plant operators, and (3) local health officials, establish appropriate sampling methods (including frequency of sampling) and locations to monitor bacteria levels in the Saginaw River. • Encourage local health departments with public access sites on Saginaw Bay to monitor *E. coli* levels at bathing beach sites from April through October. • Expand and encourage reporting under the existing voluntary database and annually summarize (in a report made available to the public) the bacteria sampling results from the river and bay and from wastewater discharge points. • Conduct an annual review of the data collected to determine whether sample numbers and/or locations should be increased or decreased, and whether new potential sources of human waste entering the river need to be addressed.
CONTAMINATED SEDIMENTS	
The level of contaminants in Saginaw River/Bay sediments no longer imposes additional costs due to requirements for the removal, confinement, and remediation of dredge spoils.	• Document the improvements in PCB contamination levels in the sediments of the Saginaw River following the remedial action now under way. • Following completion of the PCB-contaminated sediment removal project, conduct an economic analysis of the cost of routine navigational dredging in Saginaw River/Bay compared to the cost of comparable dredging in rivers and harbors of the Great Lakes where sediments are not classified as polluted. • Fully evaluate cuts/slips along the Saginaw River for sediment contamination and work to develop remediation alternatives for any significant sites of sediment contamination identified. In particular, remediation alternatives should be developed for the Weiss Street Channel.

Targeted Restored Condition	Actions
FISHERIES	
Fish Contaminant Levels A. Levels of PCBs and dioxins in walleye taken from the Saginaw River/Bay are equal to or less than the levels found in comparable fish taken from other areas of the Great Lakes not listed as AOCs. B. PCB and dioxin levels in fish tissues from caged-fish studies in the Saginaw and Tittabawassee rivers indicate that the former sources of these contaminants have been effectively controlled.	• Establish a baseline of data on the levels of contaminants currently found in representative fish species in the Saginaw River/Bay that can be compared to contaminant levels found for similar species in Lake Huron and other Great Lakes on a periodic basis. • Conduct low-level PCB and dioxin/furan water chemistry sampling on the Tittabawassee River downstream of Midland and in the Saginaw River near the mouth after remedial dredging on the Saginaw River is completed. • Implement sediment monitoring on the Tittabawassee River downstream of Midland and on the Saginaw River and Bay after remedial dredging on the Saginaw River is completed to provide a comprehensive baseline for PCB and dioxin/furan levels in this AOC. • Evaluate alternatives and develop a strategy to effectively disseminate information on Fish Consumption Advisories in the Saginaw River/Bay.
Fish Tainting Taste and odor problems reported by anglers for any species taken from the Tittabawassee River downstream from Midland and the Saginaw River/Bay represent less than 1 in 10,000 of the estimated total annual catch of that species for three consecutive years. In addition, no specific sites of fish tainting have been identified that would justify remedial action.	• Conduct a survey of area anglers to determine the location and frequency of any fish taste and/or odor problems. • Implement investigations/remediation at any sites identified as the source of a pollutant responsible for fish tainting.

Targeted Restored Condition	Actions
FISHERIES (cont.)	
Habitat A. Dissolved oxygen levels in the river meet or exceed the minimum state water quality standard of 5.0 mg/l during the critical summer months. B. Critical coastal marsh areas are adequately protected (see Wildlife section).	• Reestablish effective dissolved oxygen monitoring in the Saginaw River during critical low-flow summer periods to determine whether the water quality standard is being achieved. • Ensure that all dam releases are in compliance with Federal Energy Regulatory Control (FERC)/state negotiated release levels to help maintain adequate flows and dissolved oxygen levels below dams. • Work with individual communities/citizens/ businesses within the watershed to identify dams for potential removal or for installation of fish passage devices. • Expand public information and education efforts to inform the public about the critical role the watershed's rivers play in restoring and sustaining the bay's fisheries. • Develop a computer-based geographic information system (GIS) to systematically inventory coastal marsh habitat areas critical to fish and wildlife. The system will identify those areas most at risk and allow for monitoring the success of programs intended to protect these areas.
Fish Populations A. Walleye—Increase abundance in the bay, ultimately through natural reproduction, such that growth rates approximate more closely statewide averages for this species and reflect improved use of available forage in the bay. B. Yellow Perch—A sustained annual harvest of 750,000 pounds per year with increasing abundance of larger, faster-growing individuals. C. Lake Sturgeon—Documented evidence of natural reproduction in the Saginaw River.	• Continue to monitor the annual harvest of walleye and yellow perch and conduct annual netting surveys to determine whether (1) targeted restored conditions are being met and/or maintained and (2) natural reproduction of walleye continues to provide evidence of improved habitat conditions. • Identify opportunities provided by the MDNR Fisheries Division Lake Sturgeon Recovery Plan to expedite restoration of this important species in the bay area.

Targeted Restored Condition	Actions
WILDLIFE	
Wildlife Contaminants A. Bald Eagles—The reproductive success of bald eagles in the Saginaw Bay area is equivalent to that found in other Lake Huron coastal areas in Michigan. B. Herring Gulls—PCB levels in herring gull eggs taken from Saginaw Bay area nest sites are not significantly higher than those found in other Lake Huron sampling locations.	• Continue support for routine monitoring of bald eagle nesting success within Michigan's Lake Huron shoreline. • Continue comparative analysis of PCB levels in herring gull eggs from nest sites within Saginaw Bay and those in other areas of Lake Huron.
Coastal Marsh Protection A. At least 60 percent of the coastal marsh areas (below the 585-foot contour) and adequate upland buffers representing essential fish and wildlife habitat are preserved through public ownership, covered under conservation easements, or otherwise protected under agreements with landowners. B. The most vulnerable portions of the remaining 40 percent of the essential coastal marsh areas have been clearly identified so that governmental agencies, local conservation/ environmental organizations, and concerned citizens can monitor their status, enhance enforcement of existing laws, and conduct public educational programs to better protect these areas.	• Expand and incorporate existing information and compile new data within the geographic information system (GIS) that clearly identifies Saginaw Bay coastal marsh areas that are essential habitat for fish and wildlife. Parcel-based maps showing the area riverward or bayward of the 585-foot contour line will be essential for analysis. • Coordinate with the county drain commissioners to evaluate opportunities for fish and wildlife habitat restoration. • Establish a coastal habitat index and monitoring system that can be used to periodically document the status of a representative sample of the vulnerable wetland areas important to sustaining bay fish and wildlife populations. • Identify marshes that are particularly vulnerable to upland activities and implement actions to safeguard them and control upland threats. • Evaluate sustainable development issues regarding costal marsh areas of the Saginaw Bay and develop recommendations that strive to balance social, economic, and environmental issues.

Targeted Restored Condition	Actions
BAY ECOSYSTEM	
Drinking Water The N:P ratio measured in Saginaw Bay is at least 29:1 for three successive years, indicating that conditions once favoring blue-green algal populations responsible for former taste and odor problems in drinking water withdrawn from the bay are no longer present.	• Periodically determine N:P ratios in the bay, particularly at or near water system intakes.
Eutrophication The average concentration of total phosphorus for three consecutive years is 15 ug/l or less, in accordance with the supplement to Annex 3 of the 1978 Great Lakes Water Quality Agreement.	• Prioritize subwatersheds (or smaller sub-eco-systems) that are tributary to the bay on the basis of how much phosphorus they contribute, and develop and support plans that will result in significant reductions. • Track the success of local programs (like the federally funded Conservation Reserve Enhancement Program) that make full use of available state and federal funds to protect watercourses by providing buffer strips or protective strips of land surrounding bodies of water that can trap and hold nutrients contained in runoff. • Continue to support efforts designed to improve waste management techniques and document the management of crop residue, fertilizer, and animal and human waste applications on agricultural land in the basin. • Monitor Saginaw Bay annually for phosphorus concentrations.
Benthic Community Samples of mayfly nymphs collected in the open waters of Saginaw Bay exceed 30/m^2 for two consecutive years, based upon established sampling methods. (Alternatively, samples of adult mayflies could be collected through a "Mayfly Watch" program to document the occurrence and increase of mayflies over time.)	• Support funding for annual monitoring and reporting of the abundance of *Hexagenia sp*. in the bay.

PUBLIC MEETING

A public meeting was held on April 17, 2002 to present the draft remedial action plan update document to the public. Co-sponsored by The Partnership for the Saginaw Bay Watershed and the Michigan State University Extension Office of Bay County, the meeting was held at the Bay County Building, located at 515 Center Avenue, Bay City, Michigan. Several members of the public attended, although feedback on the

document was limited and focused primarily on the vegetation problems faced by landowners on the western shoreline of the bay. Many residents of Bay County who live along the shoreline are concerned about a letter and actions by the U.S. Army Corps of Engineers, advising them to stop vegetation removal and alteration of coastal areas, which has expanded in recent years to due low water levels. It was urged that public and private efforts to preserve coastal wetlands under the remedial action plan framework should demonstrate a better balance with personal property rights.

Other comments focused on the robust data included in the document, derived from approximately 50 citations referenced in the report's bibliography. It was suggested that the release of the RAP update document presents an excellent opportunity to promote the report in the scientific community. In addition, it was recommended that future dissemination efforts of the report continue, especially to local organizations and businesses that have a stake in a clean river and bay and could help with restoration efforts.

SUMMARY

The Saginaw River/Bay RAP process has been very successful at identifying key issues to achieve ecosystem restoration. Significant remedial actions are being taken, extensive studies are underway to fill important data gaps, and comprehensive coordination efforts continue among local, state, and federal organizations.

However, work remains to be done. As with most AOCs, available funds are not sufficient to support desired levels of effort. Consequently, though many actions are currently being implemented, few of these are being implemented fully.

Continued work is in progress, including the development of future projects to restore, enhance, and protect the Saginaw River/Bay watershed. Pollution prevention and agricultural projects and educational outreach activities must be continued. In addition, new issues related to urban sprawl and land-use planning require greater attention. All the activities taking place within the scope of the Saginaw River/Bay RAP indicate

- an enhanced interest in this area since inception of the RAP process, and
- a belief among local, state, and federal organizations that this valuable natural resource can be significantly enhanced and maintained into the future.

The support of local communities, the general public, the private sector, and local, state, and federal agencies for the RAP is encouraging. Through continued cooperation, progress toward restoring impaired beneficial uses in the Saginaw River and Bay, with delisting targets in mind, will continue to benefit the watershed and its inhabitants.

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EXHIBIT A
2,3,7,8–TCDD Toxic Equivalents, Lake Huron Edible Portion Samples*

Location	Species	Number Exceeding 10 ppt	Maximum (ppt)	Median (ppt)	Years
Saginaw Bay	Carp	12 of 15	107.6	16.0	1991
Thunder Bay	Carp	2 of 6	46.7	6.6	1999
Saginaw Bay	Channel Catfish	4 of 10	19.3	8.8	1999
Port Austin	Lake Trout	10 of 20	28.4	10.0	1991–96
Saginaw Bay	Lake Trout	8 of 10	25.6	11.6	1993
Thunder Bay	Lake Trout	7 of 8	16.8	12.2	1993
Port Austin	Lake Whitefish	6 of 10	47.1	13.1	1996
Thunder Bay	Lake Whitefish	4 of 10	16.8	8.2	1998
Thunder Bay	Lake Whitefish	3 of 10	16.8	8.0	1999
Saginaw Bay	Walleye	0 of 10	5.3	1.5	1994

*Criteria: 10 parts per trillion trigger level by Michigan Department of Community Health and Ontario Ministry of Environment.
SOURCE: Michigan Department of Environmental Quality.

EXHIBIT B
2,3,7,8–TCDD Toxic Equivalents, Lake Huron Watershed Edible Portion Samples*

Location	Species	Number Exceeding Criteria	Maximum (ppt)	Median (ppt)	Years
Cass River	Carp	2 of 5	25.5	7.0	1992
Cass River	Channel catfish	4 of 5	56.7	24.6	1992
Saginaw River	Carp	6 of 6	55.6	40.2	1992
Tittabawassee R.	Carp	11 of 11	373.4	43.0	1992–99
	Walleye	0 of 2	4.4	4.1	1992
	White Bass	6 of 10	23.8	14.4	1995
	Smallmouth Bass	2 of 5	12.8	9.9	1999

*Criteria: 10 parts per trillion trigger level by Michigan Department of Community Health and Ontario Ministry of Environment.
SOURCE: Michigan Department of Environmental Quality.

EXHIBIT C
Total Chlordane, Lake Huron Watershed Edible Portion Samples*

Location	Species	Number Exceeding Criteria	Maximum (ppm)	Median (ppm)	Year
Au Sable River	Carp	1 of 10	0.493	0.05	1998
Cheboyganing Cr.	Carp	1 of 10	0.31	0.10	1994
Lake Huron	Lake Trout	8 of 58	0.45	0.16	1991–96
	Channel Catfish	1 of 38	0.63	0.06	1991–99
Saginaw River	Carp	1 of 10	0.41	0.17	1992
St. Mary's River	Walleye	1 of 15	0.33	0.066	1991–95
Tittabawassee R.	Carp	1 of 3	0.42	0.05	1992–99

*Criteria: 0.3 parts per million trigger level by Federal Drug Administration and Michigan Department of Community Health.
SOURCE: Michigan Department of Community Health.

EXHIBIT D
Total DDT, Lake Huron Watershed*

Location	Species	Sample Type	Number Exceeding Criteria	Maximum (ppm)	Median (ppm)	Year
Cheboyganing Creek	Carp	Fillet	2 of 10	1.8	0.68	1994
Flint River	Carp	Fillet	1 of 29	1.8	0.11	1993–98
Pine River	Carp	Whole	21 of 22	161.0	45.50	1994–97
	Sm. Bass	Fillet	10 of 10	21.4	9.20	1997
Saginaw River	Carp	Fillet	4 of 10	2.3	0.61	1992
St. Mary's River	Carp	Whole	1 of 30	1.1	0.29	1993–98
	Carp	Fillet	1 of 9	2.0	0.17	1995
	Walleye	Whole	1 of 40	2.1	0.38	1991–98
	Walleye	Fillet	1 of 15	1.1	0.17	1991–95
Tittabawassee River	Carp	Whole	1 of 3	2.9	0.12	1992
	Carp	Fillet	6 of 13	3.8	0.91	1992–99

*Criteria: 1 part per million trigger level in whole fish, in Great Lakes Water Quality Agreement.
SOURCE: Michigan Department of Community Health.

EXHIBIT E
Total Mercury,
Lake Huron Watershed, Edible Portion Samples*

Location	Species	Number Exceeding Criteria	Maximum (ppm)	Median (ppm)	Year
Au Sable R.	Carp	1 of 20	0.49	0.21	1997–99
	Walleye	3 of 9	0.55	0.37	1997–99
Bad River	Channel Catfish	3 of 10	0.71	0.36	1994
	Northern Pike	1 of 5	0.55	0.35	1994
Cass River	Channel Catfish	3 of 10	0.70	0.26	1992
Lake Huron	Channel Catfish	2 of 38	0.56	0.11	1991–99
	Lake Trout	3 of 68	0.70	0.16	1991–99
St. Mary's River	Northern Pike	1 of 9	0.57	0.26	1995
	Walleye	9 of 15	1.0	0.55	1991–95
	Carp	3 of 9	0.5	0.41	1995
Tittabawassee R.	White Bass	5 of 10	0.65	0.42	1995

*Criteria: 0.45 parts per million trigger level by Ontario Ministry of Environment
SOURCE: Michigan Department of Environmental Quality.

EXHIBIT F
PBB (Firemaster BP-6), Edible Portion Samples*

Location	Species	Number Exceeding Criteria	Maximum (ppm)	Median (ppm)	Year
Pine River	Black Crappie	9 of 10	1.45	0.74	1995
	Smallmouth Bass	1 of 10	0.8	0.18	1997

*Criteria: 0.3 parts per million trigger level Michigan Department of Community Health.
SOURCE: Michigan Department of Community Health.

EXHIBIT G
Mirex*

Location	Species	Number Exceeding Criteria	Maximum (ppm)	Median (ppm)	Year
Lake Huron	Chinook	3 of 3	0.002	0.001	1998
	Coho	1 of 3	0.002	<0.002	1998

*Criteria: Less than detection levels as determined by the best scientific methodology available by Great Lakes Water Quality Agreement.
SOURCE: Michigan Department of Environmental Quality.