MILWAUKEE ESTUARY

REMEDIAL ACTION PLAN

A Plan to Clean Up
Milwaukee's Rivers and Harbor

March 1991

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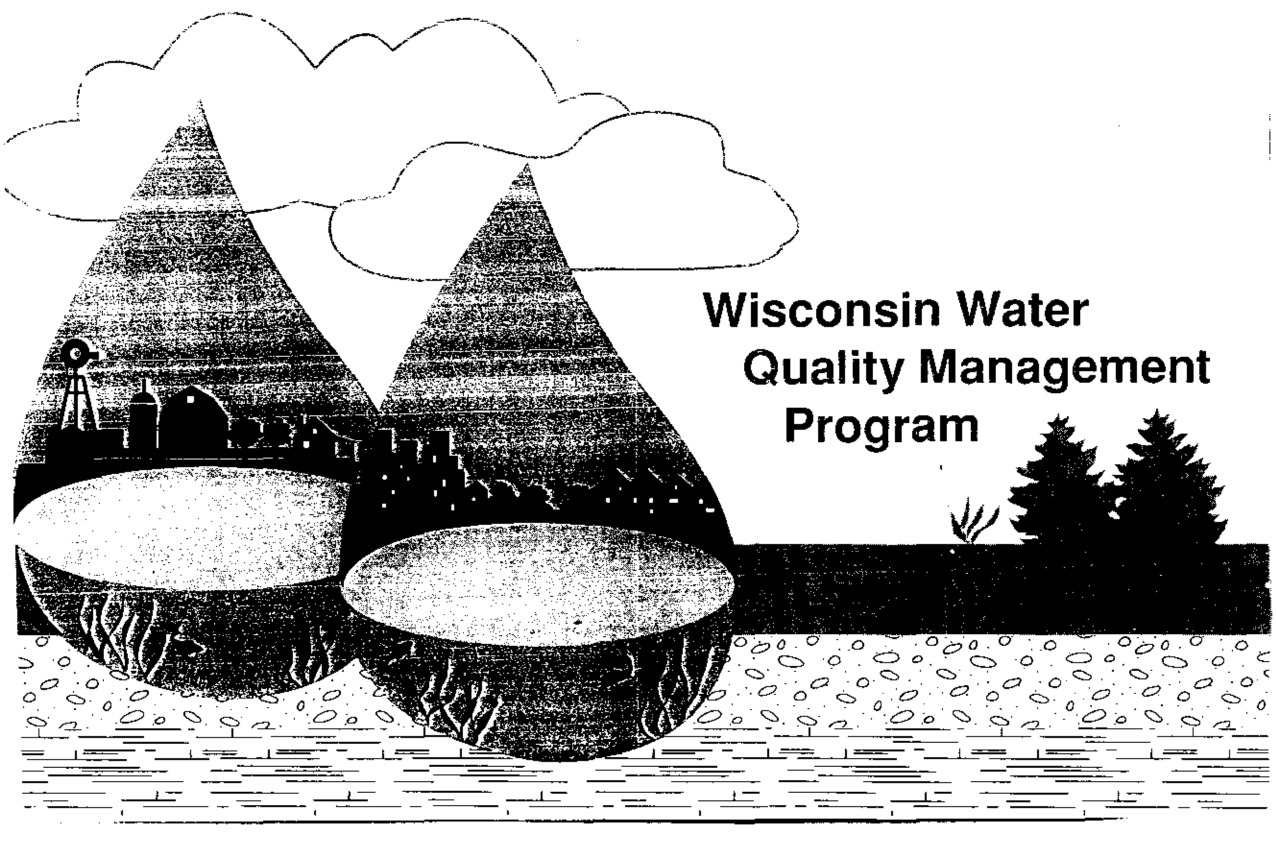

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CHAPTER TWO - INTRODUCTION

BACKGROUND

The Great Lakes Water Quality Agreement, signed by the United States and Canada in 1972 and amended in 1978 and 1987, identifies specific goals and remedial objectives for improving water quality by cleaning up toxic "hot spots"--called Areas of Concern (AOCs)--in ports, harbors, and river mouths tributary to the Great Lakes. Forty-three AOCs have been identified in the Great Lakes Basin by the International Joint Commission (IJC), an organization that advises Canada and the United States and helps the two governments resolve issues of water quality and quantity, pollution problems and border disputes in the Great Lakes. In addition to restoring these AOCs through remedial action plans (RAPs), the states and provinces, local governments and citizens living in these areas believe the cumulative effects of their actions will improve water quality throughout the Great Lakes region.

The IJC, the United States Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (WDNR), have targeted the Milwaukee Estuary and near shore Lake Michigan as one of the 43 AOCs requiring remedial action. The RAP program initiated by the IJC, together with on-going clean up activities, provide an unprecedented opportunity to dramatically improve the water quality in the Greater Milwaukee area.

Existing water quality problems were handed down through decades of use and misuse which, through ignorance and negligence, resulted in contaminated sediments and waterways, contaminated and declining fish and wildlife populations, habitat loss, poor water quality, and possible health threats to the residents of this region. Now, this pollution must be cleaned up to provide for a healthy environment to be used and enjoyed by future generations.

The Milwaukee Estuary RAP is the blueprint for this task. From the perspective of the WDNR, local governments, and the numerous business leaders, organizations and citizens involved in preparing this document, the RAP is an evolving, dynamic plan symbolizing readiness for and commitment to environmental restoration to sustain future environmentally sound waterways.

Through the RAP and the on-going clean up efforts underway in the Milwaukee River Basin, environmental quality will be significantly improved, leaving for future generations a legacy of aesthetically pleasing and healthy waters.

The Milwaukee AOC includes the Milwaukee harbor, the Milwaukee River downstream of the North Avenue Dam, the Menomonee River downstream from 35th Street, the Kinnickinnic River downstream from Chase Avenue and the near shore areas of Lake Michigan. Milwaukee is a typical AOC because it is a major urban and industrial center where pollution from a variety of sources, developed shoreline areas, and adverse ecosystem impacts restrict desired uses. Contaminated sediments are found in Milwaukee as well as almost all AOCs.

PURPOSE

This RAP identifies management strategies which will control existing sources of pollution, correct environmental contamination already present, and restore desired uses in the AOC such as fish you can safely eat and beaches safe for swimming. As defined in the 1987 Great Lakes Water Quality Agreement, an impaired beneficial use refers to a change in the chemical, physical or biological integrity of the Great Lakes system, reflected in situations such as health advisories restricting fish and wildlife consumption, degraded fish and wildlife populations, restrictions on dredging, deteriorated lake and river aesthetics and restrictions on recreational uses such as swimming and canoeing. An impaired use results from deteriorated water quality caused by toxic or conventional pollutant contamination.

The identified impaired uses, their causes and the sources of pollution problems are discussed in depth in chapters five and six. Water quality problems in the Milwaukee Estuary include:

* urban nonpoint pollution in the AOC such as construction site erosion, runoff from streets, yards, rooftops, bulk storage piles, and industrial sites,
* rural nonpoint pollution from upstream sources such as barnyard runoff, construction site erosion, streambank erosion, pesticide and fertilizer runoff,
* combined sewer overflows and sewer bypasses,
* bioaccumulation of contaminants by aquatic organisms (such as benthic organisms and fish) and wildlife,
* current and historical point source discharges of toxic substances,
* loss of habitat for wildlife, fish and aquatic life,
* contaminated sediments,
* the expanding presence of exotic species, such as the zebra mussel and sea lamprey,
* filling of wetlands and the presence of migratory barriers upstream of the AOC such as dams, constricted stream reaches and concrete channelization.

HISTORY

The Milwaukee Estuary RAP builds on the progress and accomplishments of numerous pollution abatement and planning efforts in the Milwaukee River Basin. Some of the more noteworthy clean up efforts and studies are noted below.

- The Areawide Water Quality Management Plan for southeastern Wisconsin (Southeastern Wisconsin Regional Planning Commission (SEWRPC), 1979) identifies water resources management recommendations to be implemented by WDNR and local governments.

- WDNR's Nonpoint Source Priority Watershed Program has prepared plans for the Milwaukee River East and West Branches, the Milwaukee River North Branch, Cedar Creek, Menomonee River, and the Milwaukee River South watersheds (WDNR, 1990). Plans developed for these watersheds identify significant sources of nonpoint pollution and recommend management practices for all source contributors which will reduce pollutant and sediment loadings to the rivers of the basin.

- The WDNR Milwaukee River Program has completed Integrated Resource Management Plans for the following watersheds: Milwaukee River East and West Branches, the Milwaukee River North Branch, Cedar Creek, Menomonee River, and the Milwaukee River South (WDNR, 1990). These plans update SEWRPC's Areawide Water Quality Management Plan and expand upon the Nonpoint Source Priority Watershed Plans for the Milwaukee River surface water drainage basin. Each plan establishes objectives and makes recommendations for WDNR and local governments to use in managing water resources in the watershed.

- The Milwaukee Metropolitan Sewerage District's (MMSD) Water Pollution Abatement Program is a long range program to reduce point source pollution discharges, improve wastewater treatment and abate combined sewer overflows and sanitary overflows.

- The Greater Milwaukee Toxics Minimization Task Force is preparing a reduction strategy for MMSD, to minimize toxic waste discharged to the MMSD system and the surrounding environment, which accounts for financial, social and public health impacts. Task force members represent industries, consulting engineers, educational institutions, environmental advocacy groups, trade associations, WDNR and MMSD.

- SEWRPC has prepared A Water Resources Management Plan for the Milwaukee Harbor Estuary (also called the Milwaukee Harbor Estuary Study, SEWRPC, 1990), in cooperation with MMSD, the U.S. Geological Survey and WDNR. The report reviews MMSD's Water Pollution Abatement Program and makes additional recommendations to address water quality problems that may remain within the Milwaukee Harbor estuary upon completion of MMSD's abatement program.

- The Milwaukee River Revitalization Council promotes strategies to draw people to the waterways. The council advises WDNR on environmental, economic and recreational revitalization of the Milwaukee River. By preparing a master land use plan, the council encourages and promotes recreational, cultural and business development along the waterways. In May 1990, the Revitalization Council published its first annual status report on the environmental quality of the Milwaukee basin.

- The Milwaukee Harbor Strategic Plan was developed by the University of Wisconsin-Milwaukee in 1989. This plan is a long-range plan that evaluates future scenarios and from these options determines opportunities for growth and development of the Milwaukee harbor and waterways. The plan recommends actions local government, WDNR, industry and citizens can take to achieve a clean environment, healthy economy and multiple uses of Milwaukee's waterways.

- The Port of Milwaukee developed a Strategic Plan for 1988-1993. This strategic business plan identifies port objectives: becoming a major regional transportation and distribution center, achieving financial self-sufficiency to minimize local taxes, providing satisfactory customer services, renewing and upgrading infrastructure and establishing a business team to monitor and direct future port growth and development.

- The City of Milwaukee prepared a draft Milwaukee Riverlink Plan, a Menomonee Valley Master Plan, two plans to guide land use along the Milwaukee River and River Development Guidelines.

- Milwaukee County prepared a Riverland Acquisition, Preservation, and Development Study and the Lakefront Park System-North Harbor-McKinley-Lake Park Sites Masterplan.

Chapter Three, Historical Record of Remedial Actions, provides an in-depth explanation of these and other clean up plans, as well as studies and activities occurring in the AOC.

PLAN PREPARATION AND CITIZEN PARTICIPATION

The WDNR has primary responsibility for development of the Milwaukee Estuary RAP. Advisory committees serve an instrumental role in preparing and implementing the RAP. The Technical Advisory Committee (TAC), the Citizens Advisory Committee (CAC), and its subcommittee, the Citizens Education and Participation Subcommittee (CEPS) direct the development of the RAP and assist in implementation of RAP recommendations.

A cooperative effort among numerous and diverse interests is necessary to successfully prepare a RAP and restore and protect environmental resources. Spearheading this vital coalition effort for the Milwaukee Estuary RAP is the CAC, which is comprised of representatives from local government, the University of Wisconsin - Milwaukee, organized labor, SEWRPC, business organizations, civic organizations, environmental and citizen groups, and other key constituencies.

The CAC advises the WDNR on environmental restoration of the Milwaukee Estuary, specifically by:

1. Representing the interests of key organizations and constituencies in the development of the Milwaukee Estuary RAP.

2. Developing a vision for the AOC, setting RAP goals and objectives, and reviewing and approving recommendations.

3. Reviewing chapters of the RAP and reports from the TAC.

4. Establishing a strategy for timely implementation of recommendations.

5. Encouraging unity among the diverse interests enabling successful implementation.

6. Initiating public education programs which:

   a. develop widespread recognition of the causes of poor water quality and habitat loss which result in impaired uses, reduced economic opportunities and lowered environmental value in the Milwaukee AOC.

   b. promote a sense of responsibility and generate motivation to restore the AOC and entire river basin, accepting the remedial measures necessary to correct pollution problems and restore habitat.

7. Encouraging the public's participation in the RAP process.

The CAC seeks to build consensus from divergent views, striving for the ultimate goal of community-wide unity and enthusiasm for the RAP. The CAC carries out its responsibilities for public participation and education through activities recommended by the CEPS.

As a starting point for its efforts, the CAC developed and unanimously adopted the "Desired Future State" - a statement of the vision the CAC holds for the future of the estuary after successful implementation of RAP recommendations. In conjunction with the TAC, the CAC defined goals and objectives for the RAP. The "Desired Future State" and goals and objectives are included in Chapter Seven - Goals and Objectives.

The TAC consists of technical experts familiar with the AOC. The TAC:

- identifies problems, i.e., the causes and sources of impaired uses such as pollution, poor physical habitat, riparian land use activities, eutrophication;

- analyzes problems and assists the CAC in defining preliminary goals and objectives for management and restoration of the resource;

- identifies and evaluates alternative solutions for managing and restoring the resource;

- together with the CAC, the TAC recommends a plan of action to implement preferred alternatives.

The TAC has identified problems and is developing management alternatives to control toxic substances, nutrient loading and excessive sedimentation, and to improve aquatic fish and wildlife populations and habitat. TAC work groups analyzed pollution causes and sources of impaired uses from point sources and combined sewer overflows (CSOs), nonpoint sources, contaminated sediments, contaminated biota and human health concerns, atmospheric deposition, and leachate from landfills, surface water spills, and contaminated groundwater. The TAC is also developing a monitoring strategy which details a method for gathering additional information needed to refine RAP recommendations, and establishes a format to use to assess progress made toward attaining RAP goals. This monitoring strategy will be found in Appendix VIII to this plan.

In the RAP planning process, public awareness is generated through several activities. Monthly CAC and TAC meetings are open to the public. Public meetings were held in February 1989 and June 1990, and will be scheduled in the future to obtain citizen input on various parts of the RAP.

Media coverage is generated through meetings with editorial boards, press briefings, and other media events. Similarly, regular briefings are scheduled for local public officials and business leaders. On August 21, 1989 the CAC toured the AOC with local officials to review pollution problems. As part of information and education activities, a newsletter is being developed as are periodic brochures and fact sheets. Chapter Nine, Programs and Participants, will elaborate on education and participation activities used during RAP development and implementation.

INTENDED USE OF THE REMEDIAL ACTION PLAN

RAPs are site specific elements of Wisconsin's areawide water quality management plans which WDNR prepares for EPA under section 208 of the Clean Water Act. When these plans are complete, the governor certifies the plans to EPA. Under Wisconsin law, WPDES discharge permits and wastewater treatment plant construction must be consistent with these certified plans. In addition, WDNR uses these plans to drive work planning efforts for water quality monitoring, evaluation and management activities.

The entire process of developing and implementing the Milwaukee Estuary RAP and then confirming the restoration of beneficial uses may take several decades. The RAP can succeed only through the continued involvement of citizens, state and local governments, the business community, and resource agencies throughout its development and implementation. This plan is intended for use by the public as well as local, state and federal environmental agencies as a guide for the restoration and protection of the AOC. For all parties involved in the RAP's development, this plan serves as a symbol of ongoing commitment to implement crucial pollution abatement and management recommendations.

CHAPTER THREE - HISTORICAL RECORD OF MANAGEMENT ACTIONS

INTRODUCTION

This chapter presents an overview of the history of water quality management in the Milwaukee Harbor estuary. Actions taken since 1970 such as harbor dredging activities, water quality management plans, MMSD's water pollution abatement program, fish consumption advisories, flushing tunnel and surface skimming operations, and remedial action planning efforts are emphasized.

EARLY HISTORY OF THE MILWAUKEE AREA OF CONCERN

Founded as a trading post on Lake Michigan in 1795, the City of Milwaukee has always relied upon Lake Michigan for transportation, food and water, and waste treatment. Initially, untreated sewage discharged directly into surface waters, creating offensive odors and contaminating streams. Milwaukee developed a sewerage system in 1869. In 1888, the city constructed a flushing tunnel to pump water from the lake into the Milwaukee River just downstream of the North Avenue dam. A similar flushing tunnel was built on the Kinnickinnic River in 1907 which discharged just downstream of Chase Avenue. Operated during low flow periods, the tunnels were used to dilute contaminated river water and to flush solids from the system. Both flushing tunnels still operate today. By 1910, 410 miles of combined sewers were constructed to serve the city. A total of 567 miles of combined sewers were constructed and remain in use.

In 1913, state law (Chapter 608, Wisconsin Statutes) established a sewerage commission for Milwaukee. The commission was charged with collecting, transmitting, and disposing of the city's sewage. By 1920, it was evident the rapidly expanding service area could not continue to be administered solely by the city sewerage commission. Therefore, in 1921, the Milwaukee County Metropolitan Sewerage Commission was created (Chapter 554, Wisconsin Statutes). The commission's charge was to construct trunk sewers outside the city to transport sewage from various suburban communities to the intercepting sewer system of the city.

Pilot testing of new sewage treatment processes began in 1918 and, after extensive study, the first full-scale activated sludge wastewater treatment plant in the United States was built at Jones Island by the city sewerage commission. The plant began operation in 1925 and the facilities have since been expanded and upgraded several times.

In 1951, the two sewerage commissions initiated a joint study to develop a strategy for future sewerage facility construction. The "master plan" was adopted by both commissions in November 1959. This plan recommended construction of a new wastewater treatment facility and expansion of the trunk sewer system. Construction of the South Shore wastewater treatment plant was completed in 1968. Additional trunk sewers were constructed to convey wastewater to the new facility. In 1960, the city sewerage commission and the Metropolitan Sewerage Commission for the county were combined to form today's Milwaukee Metropolitan Sewerage Commission.

Development and maintenance of harbor facilities in the Milwaukee estuary has also affected water quality conditions in the estuary. Maintenance of the harbor for navigation has changed the physical character and hydraulic structure of the area, and also altered the character and depth of sediments through dredging operations. Construction of harbor facilities began in the 1840s. (Further information on Milwaukee's harbor and port facilities can be found in SEWRPC Technical Report, Volume 4, No. 5, 1989.)

Surface skimming is another tool which improves water quality in the Milwaukee AOC. In 1962, the Port of Milwaukee began using a skimmer vessel called *M.V. Harbor Seagull* to remove surface debris from the Inner and Outer Harbors, flush out tunnel intakes clogged by debris, remove dead fish (especially the enormous numbers of alewives which died in the Inner Harbor in the 1960s), and remove sunken debris or abandoned watercraft. Skimming responsibilities were transferred to MMSD in 1989.

WATER QUALITY MANAGEMENT ACTIONS: 1970-1989

Water quality management actions taken since 1970 include implementation programs, fish consumption advisories, court decisions, and specific public works construction programs which have improved water quality conditions. Table III-1 presents a chronological listing of important water quality management actions taken since 1970 to improve water quality conditions in the AOC. Table III-2 lists numerous plans and studies that have been completed. These documents highlight recommendations to improve water quality.

In addition to making recommendations to improve water quality, recent studies listed in Table III-3 highlight land use and development along the shores of the AOC. These plans recognize that revitalization of the AOC through aesthetic improvements, economic incentives for business relocation and development in downtown Milwaukee will encourage improved water quality. Specific water quality management actions are discussed below.

Harbor Dredging Operations

Prior to 1970, adequate water depths were maintained in the Milwaukee Harbor by dredging bottom sediments, loading the dredged materials onto scows, and towing the scows to a deep water area of Lake Michigan and dumping the dredge materials. In the mid-1960s, however, dredge spoils disposal in open waters of Lake Michigan came under scrutiny. In 1970, federal law 92-500 was passed creating the confined disposal facility program. This law was the catalyst which EPA used to recommend that all polluted dredge spoils be placed in a confined disposal facility and separated from open waters. The law provided the funding mechanism for the COE 10-year program to construct confined disposal facilities in harbors around the Great Lakes.

In 1975, the WDNR began enforcing existing regulations that prohibited the dumping of any dredge spoils in State waters. In 1975, the COE constructed a confined disposal facility along the shoreline in the southern portion of the Milwaukee Outer Harbor. The disposal facility covers 53 acres and has an estimated capacity of 1.6 million cubic yards, enough space to hold dredge material collected from the Milwaukee Harbor for over 20 years. The disposal facility is expected to be filled and capped in the mid-1990s.

Table III-1 MANAGEMENT ACTIONS IN THE MILWAUKEE AREA OF CONCERN: 1970-1989

Year	Management Action	Related Use Impairments: Fish and Wildlife Damage	Restrictions on Human Consumption of Fish	Benthic Degradation	Dredging Restrictions	Eutrophication	Beach Closings	Recreation and Aesthetic Impacts
1970	WDNR begins enforcing prohibition of dumping Milwaukee's dredge spoils into Lake Michigan waters.	X	--	X	X	--	--	--
1970-1990	Intermittent operations of flushing tunnels on the Milwaukee and Kinnickinnic Rivers to improve water quality.		--	X	--	X	X	X
1970-1990	Intermittent surface skimming of debris in the estuary.	--	--	--	--	--	--	X
1971	Illinois and Michigan file suit in federal court alleging pollution of Lake Michigan by Milwaukee wastewater discharges.	--	--	--	--		--	--
1974	WPDES permit issued by the WDNR to the MMSD requires that secondary treatment standards be met at Jones Island wastewater treatment plant.	--	--	--	--	X	--	--
1975	WDNR begins enforcing prohibition of open water disposal of dredge materials as stated in Ch. 30, Wis. Stats.	X	X	X	X	--	--	--
1975	COE constructs confined disposal facility to hold dredge spoils in Milwaukee Outer Harbor.	--	--	X	X	--	--	--
1975-1978, 1981, 1987, 1990	Maintenance dredging by COE in federal project areas.	--	--		X	--	--	--
1976-1990	Fish consumption advisories issued for the Milwaukee Harbor estuary and Lake Michigan by the WDNR due to PCB contamination.	--	X	--	--	--	--	X
1977	Dane County Circuit Court issues judgment order requiring MMSD to comply with secondary treatment standards, construct additional interceptor sewers, and abate pollution from combined sewers.	X	--	X	X	X	X	X

Table III-1 MANAGEMENT ACTIONS IN THE MILWAUKEE AREA OF CONCERN: 1970-1989

		Related Use Impairments						
Year	Management Action	Fish and Wildlife Damage	Restrictions on Human Consumption of Fish	Benthic Degradation	Dredging Restrictions	Eutrophication	Beach Closings	Recreation and Aesthetic Impacts
1977	Federal Judge John J. Grady rules Milwaukee must eliminate its combined sewer overflow problems and meet specified sewage treatment levels based on standards more stringent than required by federal and state law. This ruling was overturned in 1981 by the U.S. Supreme Court.	X	--	X	X	X	X	X
1978-1979, 1982-1984	Maintenance dredging conducted under city of Milwaukee contract.	--	--	--	X	--	--	--
1979-1990	Sewage treatment plants upgraded and expanded as recommended in the regional water quality management plan for Cedarburg, Fredonia, Grafton, Saukville, Newburg, and West Bend.	X	--	--	--	X	--	X
1980	Work initiated on construction of sanitary relief and intercepting sewers within the MMSD.	X	--	X	--	X	X	X
1982	Work initiated on upgrading Jones Island sewage treatment plant.	X	--	X	--	X	--	--
1984	Five watersheds within the Milwaukee River basin are designated as priority watersheds under the Wisconsin Nonpoint Source Pollution Abatement Program.	X	X	X	X	X	X	X
1984	Construction initiated on the Milwaukee deep tunnel inline system for storage of infiltration inflow and separate and combined sewer system overflows.	X	--	X	X	X	X	X
1987-1988	MMSD sewer service extended to Germantown and Thiensville to allow abandonment of local sewage treatment plants as recommended in the regional water quality management plan.	X	--	--	--	X	--	X
1989	WDNR creates citizens advisory committee and technical advisory committee to guide development of Milwaukee Estuary RAP.	--	--	--	--	--	--	--
1990	Wisconsin State legislature designates Kinnickinnic River watershed as a priority watershed under the Wisconsin Nonpoint Source Pollution Abatement Program.	X	X	X	X	X	X	X

Table III-2 WATER QUALITY PLANS AND STUDIES DEVELOPED IN THE MILWAUKEE AREA OF CONCERN: 1970-1989

		Related Use Impairments						
Year	Management Action	Fish and Wildlife Damage	Restrictions on Human Consumption of Fish	Benthic Degradation	Dredging Restrictions	Eutrophication	Beach Closings	Recreation and Aesthetic Impacts
1971	SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed. Volume One, Inventory Findings and Forecasts, December 1970; and Volume Two, Alternative Plans and Recommended Plan. October 1971.	X	--	X	--	X	X	X
1976	SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecast, October 1976; and Volume Two, Alternative Plans and Recommended Plan, October 1976.	X	--	X	--	X	X	X
1978	SEWRPC Planning Report No. 32, A Comprehensive Plan for the Kinnickinnic River Watershed. December 1978.	X	--	X	--	X	X	X
1979	SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; and Volume Three, Recommended Plan, June 1979.	X	--	X	--	X	X	X
1979-1989	Detailed refinement of sewer service areas as recommended in the regional water quality management plan for Butler, Germantown, Cedarburg, Grafton, Saukville, Waubeka, Fredonia, Jackson, West Bend, and Kewaskum.	--	--	--	--	--	--	--
1980	Milwaukee Harbor identified as an Area of Concern by the International Joint Commission.	--	--	--	--	--	--	--
1980	MMSD completes wastewater system facilities plan.	X	--	X	X	X	X	X
1981	Environmental Impact Statement on Milwaukee Water Pollution Abatement Program prepared by U.S. EPA and WDNR.	--	--	--	--	--	--	--

Table III-2 WATER QUALITY PLANS AND STUDIES DEVELOPED IN THE MILWAUKEE AREA OF CONCERN: 1970-1989

		Related Use Impairments						
Year	Management Action	Fish and Wildlife Damage	Restrictions on Human Consumption of Fish	Benthic Degradation	Dredging Restrictions	Eutrophication	Beach Closings	Recreation and Aesthetic Impacts
1981	SEWRPC Community Assistance Planning Report No. 68, Upland Disposal Area Siting Study for Dredge Material From the Port of Milwaukee, December 1981.	--	--	--	X	--	--	--
1983	Dredge Material Disposal Planning Study, by Camp, Dresser, and McKee, Inc., July 1983.	--	--	--	X	--	--	--
1983	MMSD completes advanced facility plan for combined sewer overflow abatement.	X	--	X	--	X	X	X
1987	SEWRPC Planning Report No. 37, A Water Resources Management Plan for the Milwaukee Harbor Estuary, Volume One, Inventory Findings, March 1987; and Volume Two, Alternative and Recommended Plans, December 1987.	X	--	X	--	X	X	X
1988	Milwaukee River Remedial Action Plan Status Report and Scope of Study, published by the Wisconsin Department of Natural Resources, 1988.	--	--	--	--	--	--	--
1990	Nonpoint Source Control Plans and Integrated Resource Management Plans completed for five priority watersheds in the Milwaukee River basin.	X	X	X	X	X	X	X

Table III-3 STRATEGIC PLANS AND LAND USE PLANS FOR THE AOC

City of Milwaukee Plans:

A Planning Guide for the Middle and Upper Portions of the Milwaukee River, Department of City Development, June 1989.

A Plan for the Menomonee Valley, Department of City Development, March 1990.

Riverlink, draft, 1989.

Strategic Plan, Port of Milwaukee, October 1988.

Milwaukee County Plans:

An Inventory of Vacant or Underutilized Lands in the Riverine Areas of Central Milwaukee County, May, 1989.

Lakefront Master Plan, November, 1989.

Guide for Growth, June, 1979.

Park and Open Space Plan for Milwaukee County (draft), April, 1991.

Park Department 1990-1994 Capital Program, June 1989.

Other Plans:

Milwaukee Harbor Strategic Plan, University of Wisconsin - Milwaukee, 1989.

The federal government, the city, MMSD and private riparian property owners conduct maintenance dredging in the Milwaukee estuary. Figure III-1 shows the federal channels where navigational depths are maintained in the estuary. The COE maintains federal channels at project depths ranging from 21 to 30 feet below established low-water datum, or 578.14 feet above National Geodetic Vertical Datum.

After 1975, no significant dredging activity took place within the Milwaukee Harbor estuary due to the ban on open water disposal. Dredge quantities removed from the Milwaukee Harbor under federal projects over the period of 1975 through 1989 are presented in Table III-4. Quantities of dredge material removed under city contract from 1975 through 1989 are presented in Table III-5. In addition, an indeterminate, relatively minor amount of dredging occurred under private contract. No records are available which detail the means of disposal of the spoils from the private dredging operations.

Based upon the most recent evaluation, the disposal facility is projected to be at or near capacity by the end of 1993. The COE is considering options to extend the life of the facility. One option being considered is to mound material to elevations higher than originally anticipated.

Maintenance dredging operations from 1970 to 1990 removed pollutants associated with the sediments in addition to maintaining navigational depths. Polluted sediments will continue to be removed in federal channels by maintenance dredging.

Regional Water Quality Management Plans

The Southeastern Wisconsin Regional Planning Commission was created in August 1960 under statutory provisions to assist the local, state, and federal governments in planning for development of southeastern Wisconsin. Since 1963 the commission, in cooperation with its constituent county and local units of government, has engaged in a comprehensive regional planning program. Several water quality related plans have been developed as a part of this program. These plans include detailed watershed studies, a regional water quality management plan, and the Milwaukee Harbor estuary study (which is being carried out cooperatively with the MMSD, the U.S. Geologic Survey, and the WDNR).

Comprehensive Watershed Studies

Watershed studies were conducted for the Milwaukee, Menomonee, and Kinnickinnic River watersheds, which drain to the Milwaukee estuary. Each of these studies contains a thorough plan, including land use, park and open space, water quality, and floodland management elements.

Regional Water Quality Management Planning Program

In July 1979, the commission completed a regional water quality management plan which has important implications for the Milwaukee estuary. The regional plan updated previous water quality plans and extended them to the year 2000. In 1979, this plan was adopted as the Areawide Water Quality Management Plan for Southeastern Wisconsin (Section 208 basin plan).

Areawide or regional water quality management plans (also called basin plans) are prepared for 22 drainage basins. SEWRPC is currently updating the regional plan for southeastern Wisconsin. The Milwaukee River Integrated Basin Management Plan updates the Milwaukee basin portion of the regional plan for southeastern Wisconsin. The Milwaukee Estuary RAP is a site specific element of the water quality management plan.

Basin plans are certified by the governor to EPA. They then become regulatory documents because Wisconsin laws require that grants or loans, wastewater treatment plant facility plan approvals and WPDES permitting actions be consistent with approved areawide water quality management plans. WDNR also uses these plans to direct internal work planning efforts regarding monitoring, evaluation and management activities.

The areawide water quality management plan for southeastern Wisconsin consists of five major plan elements: land use, point source pollution abatement, nonpoint source pollution, sludge management, and water quality monitoring. The land use element is the adopted regional land use plan for the year 2000. The point source pollution abatement element includes recommendations for the location and extent of sanitary sewer service areas; the location, type, and capacity of sewage treatment facilities; the level of treatment required to meet water use objectives; the location and size of trunk sewers; the abatement of pollution from separate and combined sewer overflows; and the abatement of pollution from industrial waste discharges. The nonpoint source pollution abatement element includes recommendation to control stormwater runoff from both urban land and rural land, livestock waste runoff, construction site erosion, and malfunctioning septic tank systems. The sludge management element lists specific processes for each individual major public sewage treatment facility in the Region. The water quality monitoring element sets forth recommendations for establishing of a sound water quality monitoring program within the Region to determine the extent to which recommended water use objectives are met over time.

Considerable progress was achieved between 1979 and 1989 in implementing the areawide water quality management plan and the comprehensive watershed studies. The most important component of the land use element of the plan relates to the significant progress made in protecting environmental corridors and prime agricultural lands. By 1985, about 350 square miles, or 75 percent of environmental corridors in the region, were protected under public ownership, zoning, and state regulation. However, certain environmental corridors decreased by eight square miles, almost 2 percent, between 1970 and 1985. Most of this loss occurred prior to 1980--before many of the current protective measures were in place.

All public sewage treatment plants within the MMSD service area were abandoned by July 1988. These plants included two facilities operated by Menomonee Falls, the Germantown treatment plant, and the Thiensville treatment plant. Implementation of the point source element of the areawide water quality management plan is nearly complete. Table III-6 details the status of recommendations for public and private wastewater treatment facilities which discharged to watercourses tributary to the Milwaukee estuary. Figure III-2 shows the location of these facilities.

The regional plan recommended reductions in the pollutant concentrations in industrial wastewater treatment discharges which are consistent with the effluent characteristics for public or private wastewater treatment facilities discharging to the same or similar watercourses. During the early 1980s, increased surveillance and reporting requirements identified known industrial wastewater sources. During the late 1980s, the number of such discharge sources

Table III-4
SUMMARY OF QUANTITIES OF MATERIALS DREDGED FROM
THE MILWAUKEE HARBOR UNDER FEDERAL PROJECTS: 1975-1989

	Entrance Channel and Outer Harbor		Milwaukee River		Menomonee River		Kinnickinnic River		Burnham Channel		South Milwaukee Canal		Total	
Year	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total	Volume (cubic yards)	Percent of Total
1975	93,100	7.6	--	--	--	--	65,900	5.4	--	--	--	--	159,000	13.0
1976	--	--	--	--	--	14.1	100,500	8.2	25,100	2.0	8,100	0.6	306,800	24.9
1977	56,700	4.6	--	--	--	--	--	--	--	--	--	--	56,700	4.6
1978	44,200	3.6	85,200	7.9	43,000	3.5	22,300	1.8	13,700	1.1	--	--	208,400	16.9
1979	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1980	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1981	12,900	1.1	64,700	5.3	80,900	6.6	21,800	1.8	6,800	0.6	1,300	0.1	188,400	15.5
1981-1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	29,500													
1988-1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	236,400	19.3	221,100	18.0	404,700	33.0	276,800	22.6	52,900	4.3	35,000	2.8	1,226,900	100.0

NOTES: • Quantities estimated based upon bottom depth sounding records.
• No significant dredging was carried out from 1970 through 1974.

Source: Port of Milwaukee.

Table III-5

SUMMARY OF QUANTITIES OF MATERIAL DREDGED FROM THE MILWAUKEE HARBOR UNDER CITY OF MILWAUKEE CONTRACT: 1975-1989

Date	Location	Volume (cubic yards)	Percent of Total
1975-1977	--	--	--
October 1978	Municipal Mooring Basin	9,600	4.1
December 1979	Kinnickinnic River downstream from Becher Street-Right Bank	5,000	2.2
May 1982	Municipal Mooring Basin and Outer Slips of Piers	115,000	49.6
June 1982	Municipal Mooring Basin and Liquid Cargo Pier	49,500	21.4
December 1983	Kinnickinnic River downstream from Becher Street-Left Bank	12,200	5.3
December 1983	Kinnickinnic River at 401 E. Greenfield Dock	3,000	1.3
December 1984	Kinnickinnic River at 401 E. Greenfield Dock	37,300	16.0
1985-1989	--	--	--
	Total	231,600	100.0

NOTE: Quantities estimated based upon bottom depth sounding records.

Source: Port of Milwaukee.

decreased as many sources discharged to municipal treatment facilities. A detailed inventory of these industrial sources in the Milwaukee and Menomonee river watersheds is in the WDNR integrated resource management plans completed in 1990. A similar inventory will be compiled for the Kinnickinnic River watershed early in 1991.

The areawide water quality management plan also recommended construction of several intercommunity trunk sewers to extend centralized sanitary sewer service throughout proposed sewer service areas and enable the abandonment of certain wastewater treatment facilities. As of 1989, all intercommunity trunk sewers in the area tributary to the Milwaukee estuary were completed, except for the Waubeka-Fredonia trunk sewer.

The plan delineated sanitary sewer service areas on a preliminary basis, recommending planning efforts to refine and detail each service area in cooperation with the local government. By the end of 1989, sewer service areas for Butler, Germantown, Cedarburg, Grafton, Saukville, Waubeka, Fredonia, Jackson, West Bend, and Kewaskum were revised. Local refinement is still needed for the MMSD, South Milwaukee, Elm Grove, Brookfield East, Menomonee Falls, Mequon, Thiensville, and Newburg sewer service areas.

The areawide water quality management plan recommended urban and rural control and construction site erosion control measures to achieve a 25-50 percent reduction in nonpoint source pollutant loadings, with higher phosphorus loading reductions in part of Washington County. Incorporating special provisions into existing local zoning, building, and subdivision regulations should control construction site erosion. These provisions require the installation of erosion control measures and also limit the area and duration of land disturbance activities. SEWPRC provides ordinance drafting assistance to many of the communities in the region and promotes inclusion of construction erosion control in local ordinances. In 1988, the League of Wisconsin Municipalities and the WDNR prepared a model construction erosion control ordinance which could reduce construction site sediment loadings by up to 75 percent. By 1989 Construction erosion control plans or ordinances were adopted in Washington and Waukesha counties; the cities of Cedarburg, Greenfield, Milwaukee, West Allis, and West Bend; the villages of Butler, Elm Grove, Glendale, Germantown, Kewaskum, River Hills, Saukville, West Milwaukee, and Whitefish Bay; and the town of Cedarburg. In addition, as of 1989, the WDNR priority watershed program was underway within the Milwaukee and Menomonee River watersheds. Furthermore, all counties completed soil erosion control plans required by state law.

<u>Milwaukee Harbor Estuary Study</u>: SEWRPC's Planning Report No. 37, <u>A Water Resources Management Plan for the Milwaukee Harbor Estuary</u>, addresses the following issues: 1) What are the desired and achievable water use objectives for the Milwaukee Harbor estuary? 2) What level of protection for combined sewer overflow abatement meets those objectives? 3) Is it necessary to abate in-place pollution and what are the recommended methods? 4) What reductions in pollutant discharges will be required from nonpoint and point sources upstream of the estuary? and 5) Are toxic conditions affecting the beneficial uses of the Milwaukee estuary?

The Milwaukee Harbor estuary water resources management plan included a water quality management element, a dredging and dredge materials disposal element, a shoreline storm damage and flood protection element, and a toxic substances management element.

Table III-6

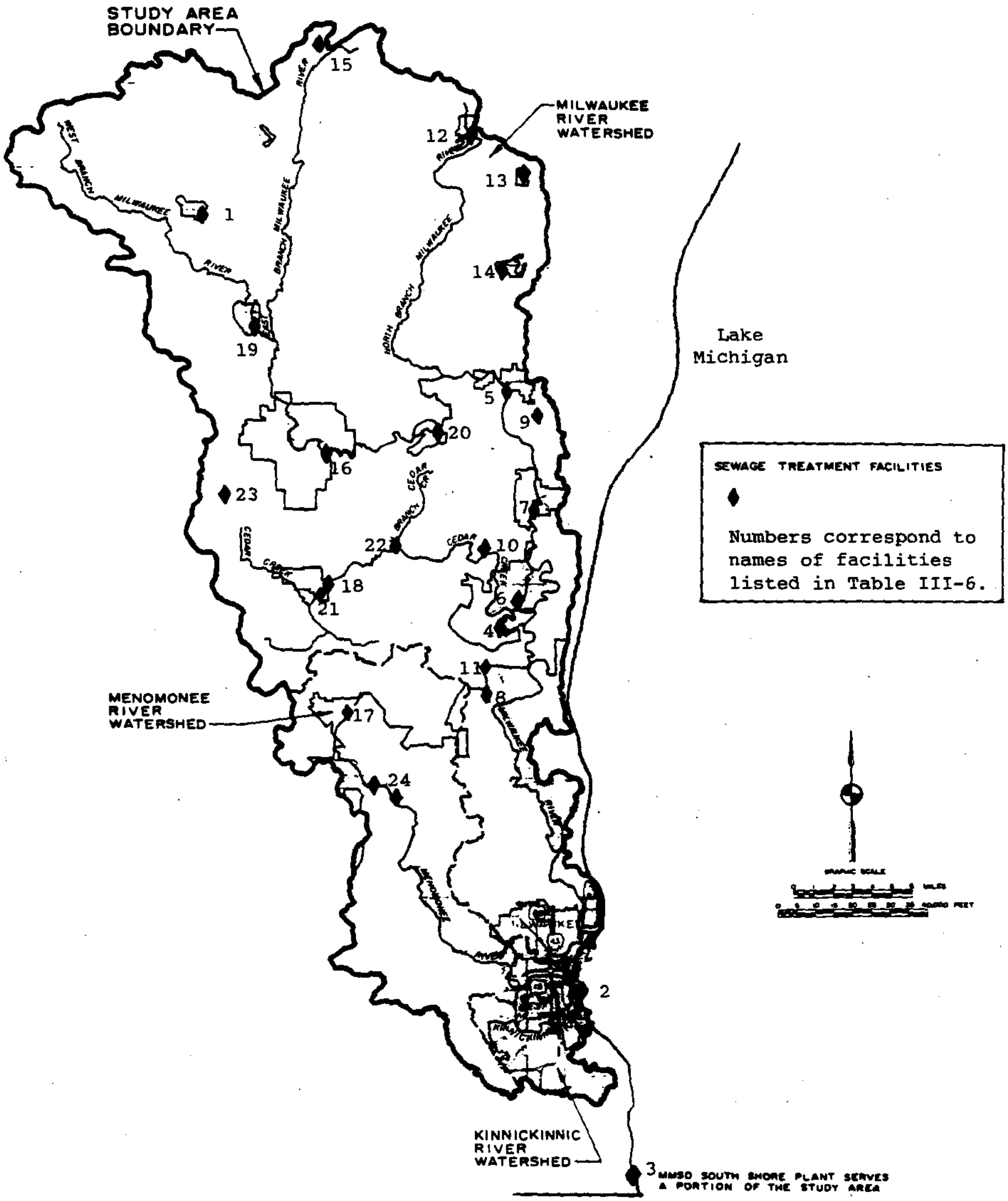
IMPLEMENTATION STATUS FOR REGIONAL WATER QUALITY MANAGEMENT PLAN RECOMMENDATIONS FOR PUBLIC AND PRIVATE WASTEWATER TREATMENT FACILITIES TRIBUTARY TO THE MILWAUKEE HARBOR ESTUARY: 1989

Public Wastewater Treatment Facility	Regional Plan Recommendation	1989 Status of Implementation
Fond du Lac County		
1. Village of Campbellsport	Upgrade	Completed
Milwaukee County		
Milwaukee Metropolitan Severage District		
2. Jones Island Plant	Upgrade	Construction Underway
3. South Shore Plant	Upgrade	Construction Underway
Ozaukee County		
4. City of Cedarburg	Upgrade and Expand	Completed
5. Village of Fredonia	Upgrade and Expand	Completed
6. Village of Grafton	Upgrade and Expand	Completed
7. Village of Saukville	Upgrade and Expand	Completed
8. Village of Thiensville	Abandon Facility	Facility Abandoned
9. S & R Cheese	Maintain Facility	--
10. Justro Feed Corporation	Maintain Facility	--
11. Federal Foods Company	Abandon Facility	Abandoned
Sheboygan County		
12. Village of Cascade	Upgrade	Completed
13. Village of Adell	Upgrade	Completed
14. Village of Random Lake	Upgrade	Completed
15. Kettle Moraine Institute	Maintain Facility	--
Washington County		
16. City of West Bend	Upgrade and Expand	Completed
17. Village of Germantown	Abandon Facility	Facility Abandoned
18. Village of Jackson	Construct New Facility	Completed; New upgrade required; Facility planning underway
19. Village of Kewaskum	Upgrade	Facility Planning Underway
20. Village of Newburg	Upgrade and Expand	Partially Completed
21. Seneca Foods Corp.	Abandon Facility	Intermittent Use--Most flows tributary to Village of Jackson sewage treatment plant
22. Level Valley Dairy	Maintain Facility	--
23. Cedar Lake Rest Home	Abandon Facility	Facility Abandoned
Waukesha County		
24. Village of Menomonee Falls (2)	Abandon Facilities	Facilities Abandoned

Source: SEWRPC.

Figure III-2

WASTEWATER TREATMENT FACILITIES IN THE MILWAUKEE RIVER BASIN



The MMSD Water Pollution Abatement Program

In December 1974, a WPDES Permit issued to the MMSD, required that the Jones Island wastewater treatment plant meet secondary treatment standards. MMSD challenged these requirements in Dane County Circuit Court, arguing that federal deadlines were more lenient than those ordered by the WDNR. In May of 1977, the Dane County Circuit Court issued a judgment order requiring MMSD to comply with secondary treatment standards, construct additional interceptor sewers, and abate pollution from combined sewers.

In a federal lawsuit filed in 1971, Illinois and Michigan alleged that wastewater discharged into Lake Michigan by the city and the sewerage district endangered the health of their citizens and caused accelerated eutrophication of the lake. On July 29, 1977, Federal Judge John F. Grady ruled that Milwaukee must eliminate its combined sewer overflow problem and meet wastewater treatment standards more stringent than the secondary treatment limitations imposed by federal legislation. Subsequent court appeals rejected or overruled these stringent effluent limitations but reaffirmed the district court stipulation that all overflows and bypasses be abated.

In order to comply with the 1977 Federal Clean Water Act and the court orders, MMSD undertook a series of interrelated projects collectively called the Milwaukee water pollution abatement program. The principal elements of this program are: 1) a sewer system evaluation and rehabilitation; 2) relief sewers constructed to reduce wet weather bypassing of the sanitary sewer system; 3) abatement of combined sewer overflows; 4) rehabilitation and expansion of the Jones Island plant and expansion of the South Shore plant; 5) construction of storage facilities that temporarily hold peak flows until the sewage treatment plants can treat them; 6) development of a sludge management program; and 7) extension of trunk sewers to serve other communities in the district's planning area.

Between 1980 and 1990 MMSD has made considerable progress in implementing its facility plan. All wastewater treatment plants recommended for abandonment in the plan were abandoned. The last plant, in Thiensville, was abandoned in July 1988. As of 1990, most local community sewer system rehabilitation programs were completed, resulting in a significant reduction of sanitary sewer system overflows, and in the frequency of remaining overflows. Many of the sanitary sewer overflow systems that remain are inactive and remain in place as a precaution against extreme flow conditions. In some cases, overflow devices cannot be eliminated and remain in use pending completion of the district's water pollution abatement program.

When MMSD's projects are complete and in operation, water quality in the AOC will improve significantly. Overflows from the separate sanitary sewer system will be eliminated, while combined sewer overflow events will be reduced from an average of 50 times per year to less than 2 times per year. Completion of all MMSD construction projects is anticipated by 1996.

Over 500 industries discharge their wastewater into MMSD's plants. Remaining industrial wastewater discharges to surface waters or storm sewers are currently regulated by WDNR under the WPDES permit program. These discharges require either a specific permit which requires treatment to meet effluent limits and requires monitoring to ensure that limits are met or a general permit which requires minimal or no treatment. General permits are issued for the following types of wastewater: noncontact cooling water and boiler blowdown, concrete products, stormwater, sand and gravel, swimming pools, water treatment plants, dredging, subsurface absorption field systems, and land spreading of liquid wastes. General permits are also issued for treated groundwater from projects which pump and treat contaminated groundwater to protect human health and welfare.

WDNR is currently evaluating the reissuance of general permits and determining how to apply water quality standards for toxic substances (discussed in chapter four) to the new permits. Historically, general permit discharges have contained oil and grease, total suspended solids and unknown toxic chemicals in cooling water (such as slimicides and biocides) which may be toxic. In addition, the contribution of industrial wastewater to CSOs, unregistered bypasses because an industry's system cannot handle the amount of waste, and spills add to the water quality impacts in the AOC.

The Greater Milwaukee Toxics Minimization Task Force

In addition to the water pollution abatement program, MMSD is sponsoring and staffing a community-wide group, the Greater Milwaukee Area Toxics Minimization Task Force, to assist MMSD in developing a toxics reduction strategy. The goal of the task force is to "minimize toxic waste discharged to the MMSD system and to the environment with consideration of financial, social, and public health impacts".

Task force members represent the following constituencies: industries, consulting engineers, education institutions, environmental advocacy groups, economic development, environmental law, trade associations, and support staff from MMSD and DNR.

The task force has proposed the following objectives for developing a toxics minimization strategy.

1. To quantify, to the extent possible, a mass balance of toxic substances in the MMSD system. Major inputs to be characterized are: domestic, permitted industries, other industries and commercial activities, and stormwater. Major outputs to be characterized are: effluent, sludge, and air emissions.

2. To assess the existing and future regulatory environment for effluent, sludge, and air emissions and potential implications for MMSD.

3. To determine priority areas for toxics minimization initiatives.

4. To evaluate waste minimization strategies for each priority area.

5. To develop an implementation plan which identifies recommended actions, timetables, and lead roles

6. To generate a report containing Task Force recommendations for presentation to the Milwaukee Metropolitan Sewerage commission, other appropriate agencies, and the community.

The task force anticipates completion of its work in 1991.

Milwaukee River Priority Watershed Program and Integrated Resource Management Program

In 1984, five of the six drainage areas within the Milwaukee River basin were designated as priority watersheds under the WDNR Nonpoint Source Pollution Abatement Program: the East-West Branch of the Milwaukee River, the North Branch of the Milwaukee River, the Cedar Creek, the Milwaukee River-South, and the Menomonee River watersheds. In 1990, the state legislature also designated the Kinnickinnic River watershed as a priority watershed. The entire Milwaukee River basin has now been designated. Created in 1978 by the state legislature, the nonpoint source program is designed to improve and protect the quality of streams, lakes, wetlands, and groundwater by reducing pollution from urban and rural nonpoint sources. Priority watershed projects are guided by plans prepared by the WDNR with the advice of the Wisconsin Department of Agriculture, Trade and Consumer Protection, local units of government, and citizen's advisory committees.

As of March 1990, priority watershed plans have been completed and adopted for the North Branch and for East-West Branch watersheds. Plans are complete but not yet adopted for the Menomonee River and Milwaukee River-South watersheds. Planning is nearly complete for the Cedar Creek watershed and has not yet begun for the Kinnickinnic watershed. The plans provide the basis for the WDNR to enter into cost-share and local assistance grants and are used to guide implementation measures. The plans recommend control of both urban and rural nonpoint sources. Implementation of the plans will reduce nonpoint source pollution such as excessive sediment and nutrient loads originating in the upstream watersheds and ending up in the AOC and Lake Michigan. Following adoption, the plans become an amendment to the areawide water quality management plan.

Related to the priority watershed planning program is a new approach to natural resource management developed by the WDNR, the integrated resource management planning program. The nonpoint source water pollution control program is used as the foundation for coordinating other department environmental protection and resource management efforts. This program is documented in a seven-volume report by the department entitled "Milwaukee River Integrated Basin Management Plan: 2000." The integrated resource management strategy is to protect or enhance fish and wildlife habitat, aesthetics, and other natural resources within priority watersheds. The integrated resource management plan for the Milwaukee River basin also updates the areawide water quality management plan for the basin.

Fish Consumption Advisories

In the Milwaukee AOC, fish consumption advisories have been issued by the state since 1976. Fish have been sampled and found to contain levels of polychlorinated biphenyls (PCBs) and pesticides that exceed uniformly acceptable levels. Issued jointly by the Wisconsin Department of Health and Social Services and the WDNR, these advisories identify areas around the state where selected fish contain unacceptable levels of mercury, PCBs and pesticides.

Flushing Tunnel Operation

Flushing tunnels built in 1888 and 1907 are still used for water quality management in the AOC. The capacity of the Milwaukee flushing tunnel is about 600 cubic feet per second (cfs), increased in the summer of 1985 from 400 cfs. The Kinnickinnic flushing tunnel has a capacity of about 350 cfs. MMSD assumed responsibility for the operation and maintenance of the Milwaukee flushing tunnel in 1964 and the Kinnickinnic flushing tunnel in 1980.

Prior to 1987, the flushing tunnels were operated only during warm weather periods of low flows and during times when dissolved oxygen levels were below 2 ppm. These conditions result in flushing tunnel operation of about 500 hours per year. More recently, the tunnels are operated more frequently to improve overall water quality and enhance aesthetics. In 1988, during severe drought conditions, the tunnels were operated continuously during the summer months. In 1989, the tunnels operated 12 hours each day in the evenings when dissolved oxygen levels were lowest. Studies conducted by the MMSD in 1982 and 1984, and documented in Volume One of SEWRPC Planning Report No. 37, A Water Resources Management Plan for the Milwaukee Harbor Estuary, 1987, indicate that operation of the tunnels substantially improves dissolved oxygen levels within the Milwaukee and Kinnickinnic Rivers, increases water clarity and flushes floating debris out of the Inner Harbor.

Surface Water Skimming Operations

The Port of Milwaukee carried out all skimming and debris removal operations up to 1989 when responsibilities were divided with MMSD. The Port maintains responsibility for removing heavy objects and sunken debris from the rivers, harbor and lake, using the *M.V. Seagull*. The Port also continues to remove surface debris from the Outer Harbor. In 1989 MMSD took over responsibility of removing surface debris from the rivers. MMSD uses the skimmer, *The River Clean* which can collect 1,200 cubic yards of debris annually from the rivers.

Remedial Action Plan (RAP)

In 1985, the eight Great Lakes states and the Province of Ontario committed to developing RAPs to restore beneficial uses in each AOC. Wisconsin is developing RAPs for four Areas of Concern--Lower Green Bay and Fox River, Sheboygan River and harbor, the Milwaukee Harbor estuary, and the Menomonee River, and is also assisting Minnesota in developing a RAP for the St. Louis River AOC.

The development of RAPs represents a challenging departure from most historical pollution control efforts. Previously, separate programs for regulation of municipal and industrial discharges, urban runoff, and agricultural runoff were implemented without considering overlapping responsibilities or whether the programs were adequate to restore all beneficial uses. This new process calls upon a wide array of programs, including the involvement of local communities and a wide range of government agencies at all levels. For example, cooperation between the University of Wisconsin-Milwaukee and MMSD has resulted in the start up of a sediment study which will identify contaminants in the sediment and the hotspots where those contaminants are located. All programs, agencies, and communities influencing an AOC must develop common goals and objectives and clean up recommendations in the RAP to assure its successful implementation (IJC, 1987).

CHAPTER FOUR - ENVIRONMENTAL SETTING

This chapter describes the characteristics of the AOC pertinent to existing water quality pollution problems. The chapter is divided into five sections which focus on natural and political features of the AOC. Much of the information is taken from A Water Resources Management Plan for the Milwaukee Harbor Estuary (SEWRPC, 1987). For more detail, refer to this document and the documents listed in the reference section at the back of this document. The glossary, also located in the back of this plan, identifies terms used throughout this report.

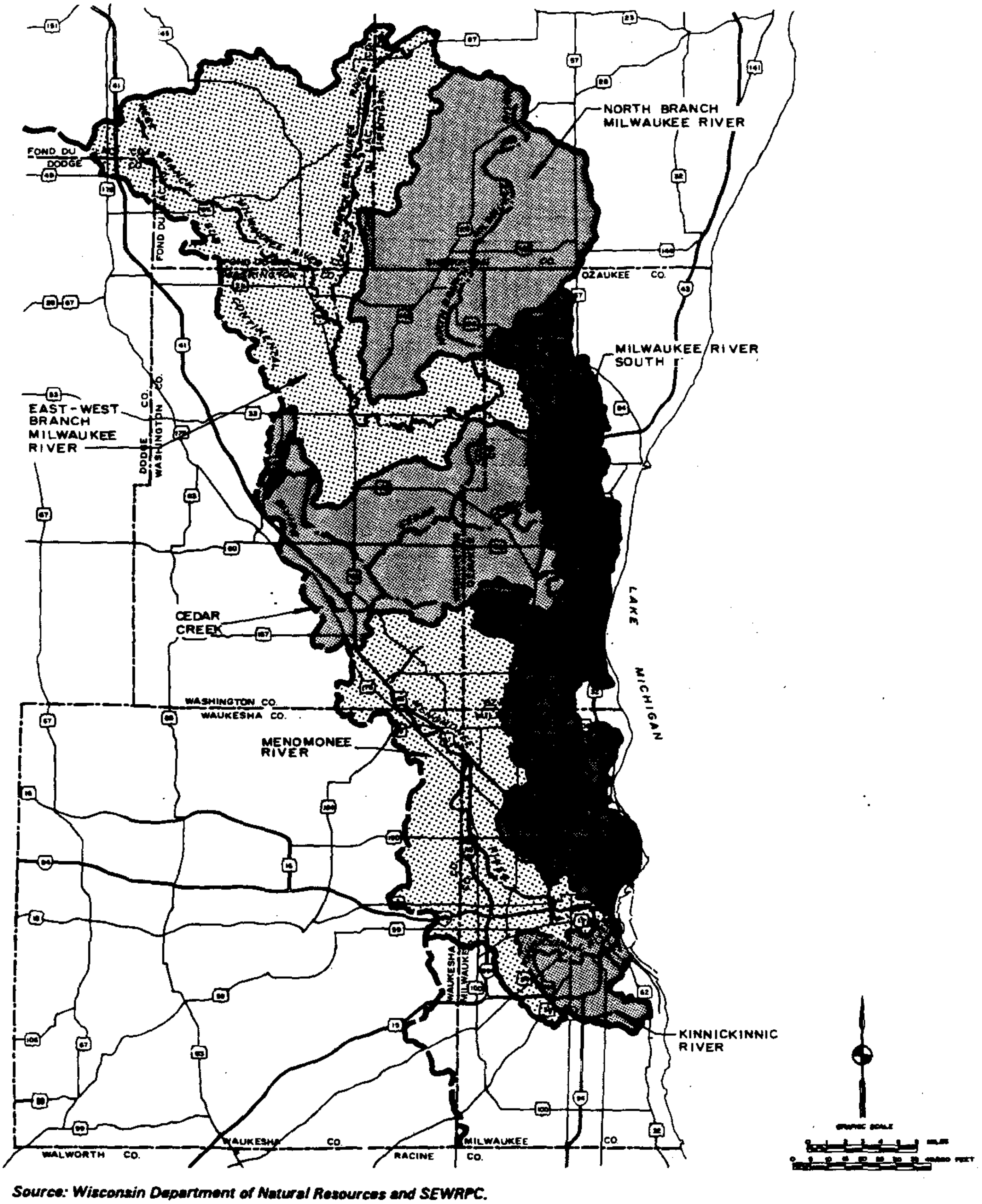
LOCATION

The Milwaukee AOC is severely affected physically, chemically and biologically by human use. The AOC is the lower portion of the three watersheds in the Milwaukee River surface water drainage basin plus the Outer Harbor and near shore areas of Lake Michigan as defined below.

* The Milwaukee River Surface Water Drainage Basin includes (Figure IV.1):
  - The Milwaukee River Watershed[1]
    - The Milwaukee River East and West Branches Watershed
    - The Milwaukee River North Branch Watershed
    - Cedar Creek Watershed
    - Milwaukee River South Watershed
  - The Menomonee River Watershed[2]
  - The Kinnickinnic River Watershed[3]
* The Milwaukee Estuary AOC includes (Figure IV.2):
  - The Milwaukee Estuary
    - the lower Milwaukee River downstream of North Avenue Dam (3.1 miles/5.0 km)
    - the lower Menomonee River downstream of 35th Street (3.0 miles/4.8 km)
    - the lower Kinnickinnic River downstream of Chase Avenue (2.5 miles/4.0 km)
    - the Outer Harbor, that part of Lake Michigan enclosed within the breakwalls (approximately 1.5 square miles/389 hectares)
  - The near shore areas of Lake Michigan, outside the Outer Harbor, bounded by a line extending north from Sheridan Park northwest to the city of Milwaukee's Linnwood water intake (approximately 5 square miles/1,295 hectares)

Figure IV.1

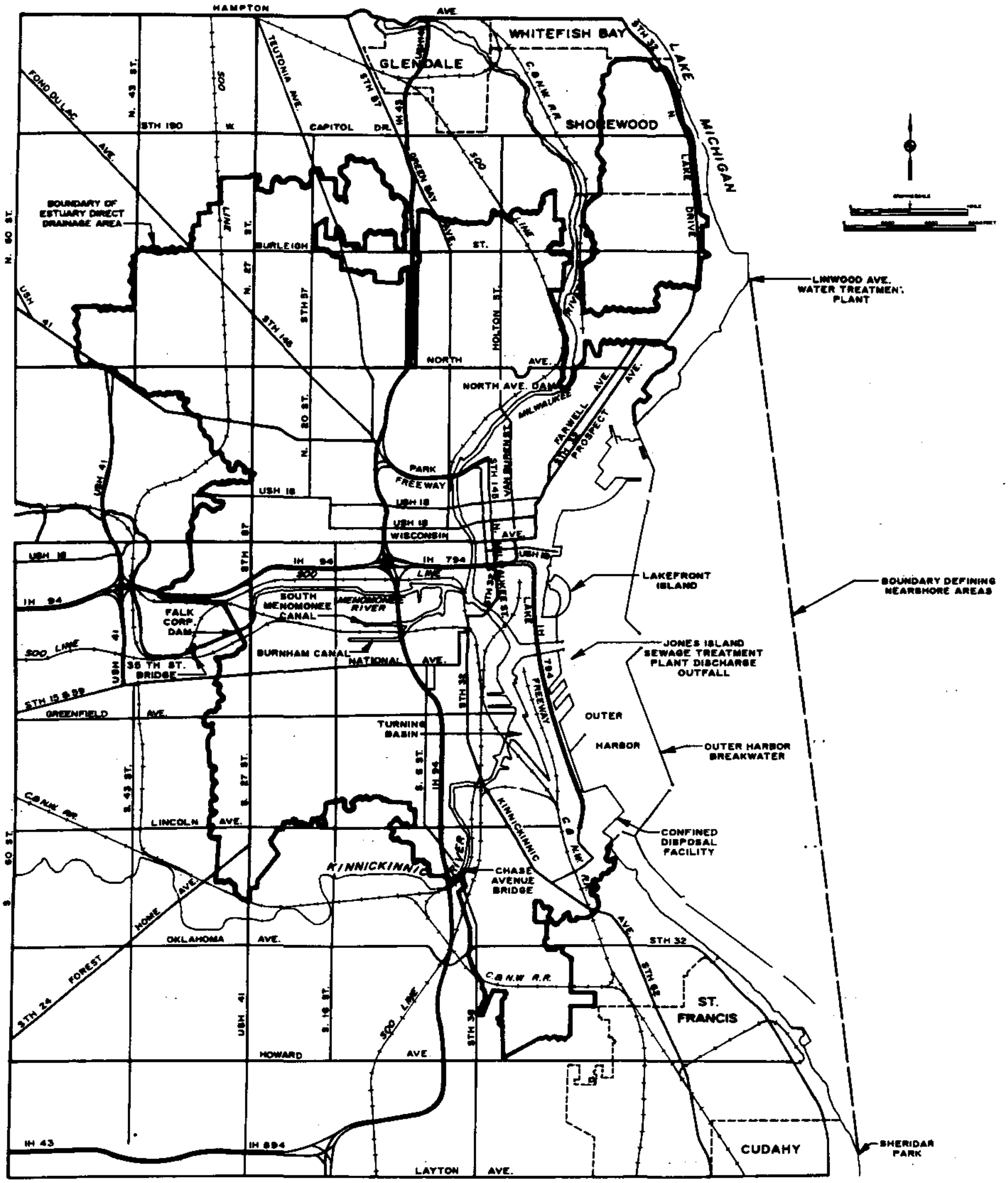
Milwaukee River Surface Water Drainage Basin—WATERSHEDS AND SUBWATERSHEDS TRIBUTARY TO THE MILWAUKEE HARBOR ESTUARY



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure IV.2

MILWAUKEE ESTUARY AREA OF CONCERN AND DIRECT DRAINAGE AREA



Source: Wisconsin Department of Natural Resources and SEWRPC.

NOTE: MMSD SOUTH SHORE AND CITY OF SOUTH MILWAUKEE SEWAGE TREATMENT PLANTS AND OUTFALLS ARE LOCATED ABOUT 5 MILES SOUTH OF SHERIDAN PARK

The AOC includes the portion of the lower rivers and harbor affected by Lake Michigan's flow reversals, stage fluctuations (seasonal and annual changes in water levels), seiches (waves that oscillate in lakes, bays, or gulfs as a result of atmospheric disturbances), wave action, wind action, thermal stratification and the flushing tunnels on the Milwaukee and Kinnickinnic rivers. The upstream boundaries of the AOC are the points where lake effects end. Although the emphasis is on problems in the AOC, the RAP also identifies pollution problems, pollution sources and clean up actions necessary in the upstream portions of the Milwaukee River drainage basin. Besides being a source of Lake Michigan pollution, the AOC acts as a sink for pollutants generated upstream. Table IV.1 - Watershed Comparison shows stream length, drainage area and population density for the basin, each watershed and the AOC.

Table IV.1, Milwaukee Basin Watershed Comparisons

	Milwaukee River Basin	Milwaukee	Menomonee	Kinnickinnic	AOC
Length[1] (miles)	411 mi (658 km)	329 mi (526 km)	65 mi (104 km)	8 mi (13 km)	9 mi (14 km)
Drainage Area[2]	860 sq mi (222,740 HA)	700 sq mi (181,300 HA)	136 sq mi (35,224 HA)	20 sq mi (5,180 HA)	28 sq mi[3] (7,252 HA)
Population Density (persons per square mile)	NA[4]	478	2,036	4,984	11,600

1 Length of river plus major tributaries. For the Milwaukee, Menomonee and Kinnickinnic Rivers, length refers to the portions of the rivers above the AOC.

2 Area in square miles (sq. mi.) and hectares (HA).

3 Made up of the lower portions of the Milwaukee, Menomonee and Kinnickinnic watersheds plus about four square miles that drain directly to Lake Michigan.

4 Not available for the basin.

The AOC is within the political jurisdictions of the city of Milwaukee and Milwaukee County and the statutory jurisdictions of MMSD and SEWRPC.

NATURAL FEATURES

Geology, Topography and Soil Types

The AOC and its tributaries are within the Eastern Ridges and Lowlands regions of Wisconsin. The Paleozoic era sedimentary rock which parallels the Lake Michigan shoreline influenced deposition of glacial materials during the Pleistocene epoch of geologic history. As a result of this glaciation, ground moraine, end moraine, and outwash glacial deposits are found in the

Milwaukee River drainage basin. Within the AOC, the predominant glacial features are ground and end moraines. These glacial deposits consist of clay tills interspersed with sand and gravel layers. The thickness of these deposits ranges from 0 to 150 feet (46 m.) in the AOC.

Holocene age (recent) deposits of alluvial material lies in stream valleys and Holocene marsh material exists in low lying areas. These deposits are primarily organic-rich muck, silt, sand and gravel. For details on rock formations, see Appendix IV.A.

Elevations in the Milwaukee River watershed range from a high of 1,310 feet (399 m.) above sea level at the Parnell Lookout tower in the town of Mitchell, Sheboygan County to a low of about 580 feet (177 m.) above sea level in the AOC. In the Menomonee River watershed, the highest elevation is 1,090 ft. (332 m.) above sea level in the Town of Richfield in Washington County. The Kettle Moraine, where the headwaters of the Eastern Branch of the Milwaukee River originate, has the greatest variation in elevation. Dominant features in the basin are rolling to gently sloping ground moraine composed of heterogeneous glacial material. However, significant variations in topography range from steep slopes in the Kettle Moraine area to fairly flat or gradual slopes in the lower portions of the watersheds and the AOC.

Soil types in the AOC were determined from a generalized soil survey map prepared by the Soil Conservation Service. Detailed soil survey information is not available for this area. Dominant soil associations or soil groupings, are the Ozaukee-Morley-Mequon association and the Kewaunee-Manawa association.

Soils in the Ozaukee-Morley-Mequon association are typically well-drained to somewhat poorly drained soils with a subsoil of silty clay loam and silty clay. According to the soil survey, these soils are well suited to farming, but erosion control is needed on slopes. These soils are not well-suited for use as disposal sites of septic system effluent. There are no septic systems in use in the AOC.

Soils in the Kewaunee-Manawa association are typically well-drained to somewhat poorly drained soils with a subsoil of clay and silty clay. According to the soil survey, these soils are well suited to farming, but almost the entire area is committed to commercial, industrial and residential development. Soils in low areas are water saturated during wet seasons and are not suitable as disposal sites for septic system effluent.

The soil associations in the watersheds upstream of the AOC vary from well drained soils in the upper portions of the Milwaukee River watershed to somewhat poorly drained soils in the Menomonee and Kinnickinnic River watersheds.

Due to modifications such as channelization and streambank development, streambank erosion is severe in some areas of the Milwaukee River basin. Erosion along the tributaries causes water quality problems within the AOC as sediment is washed downstream and settles out. Increased turbidity in the AOC interferes with algal productivity and sediment loading impairs habitat for macrophytes, benthic organisms, and fish forage and spawning.

Human activity has significantly modified the AOC. In the late 1800's, natural marshes along the lower rivers were filled for commercial development. More recently, excavated materials from freeway and "deep tunnel" construction were used to create an extensive landfill area within the Outer Harbor. Dredge spoils continue to be deposited in the confined disposal facility in the Outer Harbor.

Surface Waters of the Milwaukee River Drainage Basin

The problems addressed in the RAP result in part from hydrologic, hydraulic and land use characteristics of the AOC and its tributary watersheds. Characteristics of the upstream portions of the three rivers vary distinctly from the estuary. The rivers in the upstream portions of the basin consist of surface water runoff and groundwater infiltration. As the rivers pass through urban areas upstream of the AOC, CSO events become part of the flow during wet weather. The upstream river flows, surface water runoff, groundwater infiltration (a small percentage of total flow), Lake Michigan water pumped into the AOC through the flushing tunnels and Lake Michigan inflows (flow reversals, seiches, etc.) make up the flow in the AOC. While the rivers above the AOC move downstream, flows may enter the AOC from Lake Michigan at the same time as water flows out of the AOC into Lake Michigan. Table IV.2 summarizes some of the hydrologic characteristics of rivers above the AOC. There are no monitoring stations at the AOC boundaries or in the AOC.

The headwaters of the West Branch and the mainstem of the Milwaukee River originate in Fond du Lac County near Eden. The East Branch originates in Sheboygan County and joins the Milwaukee River downstream of Kewaskum. The North Branch originates in Sheboygan County and joins the river between the village of Newburg and the town of Fredonia. Cedar Creek originates in Washington County and joins the Milwaukee River between the village of Grafton and the city of Cedarburg. In the Milwaukee River watershed, toxic contaminants in sediment in Cedar Creek as well as contaminated sediments and poor water quality in the Lincoln Creek subwatershed move downstream and affect the water quality of the AOC.

The Menomonee River originates in a large wetland area in the northeast corner of the Village of Germantown in Washington County. It has four noteworthy tributaries. The Little Menomonee River is 10.6 miles long, originates in Ozaukee County and joins the Menomonee downstream of Butler. Underwood Creek is about 10.7 miles long, originates in Waukesha County, and enters the Menomonee in the City of Milwaukee. Honey Creek, is 7.5 miles long, originates in Milwaukee County, and joins the Menomonee in the City of Milwaukee. Sections of the Menomonee River above the AOC are concrete lined channels. A mix of Menomonee River and Lake Michigan waters make up the flows in the Burnham Canal and the South Menomonee Canal, man-made channels that lie parallel to each other and join the Menomonee River near 3rd Street in Milwaukee. In the Menomonee River watershed, contaminated sediments and poor water quality from the Little Menomonee River, the lower Menomonee River and the Burnham and South Menomonee Canals affect water quality in the AOC and Lake Michigan.

Table IV.2, Hydrologic Characteristics of Streams Tributary to the AOC[1]
Source: Water Resources Data Wisconsin Water Year 1989, Holmstrom, USGS, 1990

Monitoring Stations	$Q_{7,10}$[2] cfs (m^3/s)	Ave. annual flows cfs (m^3/s)	100 yr flood cfs (m^3/s)	Max. discharge - cfs (m^3/s) (date recorded)	Min. discharge - cfs (m^3/s) (date recorded)
Milwaukee River near Cedarburg	21 (0.59)	513 (14.5) (7 yrs data)	not enough record	4,860 (137.6) 9/11/86	42 (1.2) 7/9/88
Milwaukee River at Estabrook Park	26 (0.7)	426 (2.1) (75 yrs data)	13,900 (393.4)	15,100 (427.6) 3/20/18 & 8/6/24	0 9/8/43
Menomonee River at Menomonee Falls	1.3 (0.04)	30.0 (0.9)[4] (12 yrs. data)	1,840 (52.1)	1,440 (41) 9/11/86	0.52 (0.01) 8/18/88
Menomonee River at Wauwatosa	5.6 (0.2)	97.9 (2.8) (28 yrs. data)	14,100 (399)[5]	13,500 (382.3) 4/21/73	2.8 (0.08) 1/18/64
Kinnickinnic River at South 11th St.	5 (0.14)	26.0 (0.7) (7 yrs data)	4,350 (123.1)	10,600 (300.2) 8/6/86	1.3 (0.04) 1/26/86 1/27/86

1 Information provided in cubic feet per second (cfs) and cubic meters per second (m^3/s).

2 Barry Holmstrom, USGS, 10/24/90 and 10/26/90. Used gauging station records. $Q_{7,10}$ is the seven day average low flow expected to occur once in 10 years.

3 Data provided by Bill Krug, USGS, 2/28/90.

4 Years are 1976-77 and 1980-1989.

5 Previous 100 year flood was published as 11,300 cfs in 1981.

The Kinnickinnic River originates in Milwaukee County from a storm sewer outfall at 60th Street. The river drains high density residential areas, industrial and commercial areas, and county parks. Sections of the stream channel have been extensively modified to reduce flooding in the watershed. About 3.5 miles of the stream channel above the AOC are concrete lined. Drop structures in the concrete channel prevent fish migration upstream during low flows. Habitat is severely limited in the concrete lined portions of the Kinnickinnic River.

Airshed

The Milwaukee AOC is in the Southeastern Wisconsin Intrastate Air Quality Control Region which is managed by WDNR for ambient air quality. Ambient air quality standards are set for six criteria pollutants [ozone, lead, particulates (made up of total suspended particulates and particulate matter), carbon monoxide (CO), nitrogen dioxides (NO_2) and sulfur dioxides (SO_2)]. Primary standards apply to human health and secondary standards apply to welfare (property and crop damage). Standards are listed in Appendix IV.B. If an area does not meet primary or secondary standards, it is considered a nonattainment area. The Milwaukee AOC is classified as follows:

Primary nonattainment	SO_2[1] Ozone[2]
Secondary nonattainment (Waukesha area)	Total suspended particulates[3]
Attainment	CO NO_2 lead

1 Milwaukee is a federally designated nonattainment area although the SO_2 standard has not been exceeded since 1979. In 1986 WDNR furnished EPA with information justifying attainment with the SO_2 air quality standard. EPA is reviewing this information.

2 The AOC has been designated as not meeting primary ozone standards since the early 1970s. An area becomes primary nonattainment when the ozone standard is exceeded more than four times over a three year period.

3 The Sussex quarries west of the city of Milwaukee have total suspended particulates violations.

Appendix IV.C contains a map showing the nonattainment areas.

In Milwaukee, monitoring of ambient air quality takes place at 17 sites. Appendix IV.D contains information on these sites.

Regulations to protect Wisconsin residents from hazardous air pollutants are being implemented. Facilities which emit any of the regulated hazardous pollutants must detail these emissions to WDNR and develop a compliance plan to meet acceptable ambient concentrations. Potential sources of toxic air emissions which may impact the water quality of the AOC are discussed in chapter six.

POPULATION AND LAND USES

Population

According to the 1980 census 970,300 people live in the Milwaukee River drainage basin. About 255,200 people live in areas adjacent to the AOC where surface water runoff drains to the AOC Table IV.1 summarizes population density.

Appendix IV.E and Figure IV.3 highlight land uses in the basin and the AOC. About 93 percent of the 28-square mile area that drains to the AOC is urban. Predominant land uses are transportation, utilities and residential uses on about 16 square miles or 72 percent of the land area around the AOC. About 74 percent or 639 square miles of the total basin (square miles total area) is rural predominantly agriculture. The largest urban land use in the drainage basin is residential and about 101 square miles or 12% of the drainage basin is used for residential purposes. Transportation and utilities account for approximately 76 square miles or 9 percent; other urban land uses total less than 15 square miles or 4 percent of the study area.

Sewer Service Areas

Eleven municipally owned wastewater treatment plants operate in the upstream portions of the basin. In the AOC, the MMSD treats wastewater and discharges effluent to Lake Michigan. In MMSD's sewer service area, individual municipalities (such as Milwaukee) construct, operate and maintain collector sewers which carry wastewater from industries, residents and commercial businesses. MMSD owns and operates the sewers that transport sewage to the two wastewater treatment plants, Jones Island and South Shore. The Jones Island plant discharges to Lake Michigan in the Outer Harbor. The South Shore plant discharges to Lake Michigan about four miles south of the AOC. Sewers that serve the urban areas around the AOC are either combined sewers which combine both stormwater and sewage flows or sanitary sewers that carry only sewage. These sewers were originally built with pressure relief devices designed to overflow when the sewer system was unable to handle high flows. These devices are referred to as combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs).

Along the urban portion of the Milwaukee River, there are a total of 61 CSOs and 127 known SSOs. In addition to overflows, 18 industries have WPDES permits with specific discharge limits and 66 industries discharge primarily noncontact cooling water under general WPDES permits to the river directly or via tributaries and storm sewers. Within the AOC, there are six industries with specific permits that must provide treatment as necessary, and nine industries that discharge wastewater under general permits which require little or no treatment.

Along the urban portion of the Menomonee River, SEWRPC identified 171 point sources: 25 CSOs, 102 SSOs, 31 discharges with specific WPDES permits and 56 industrial cooling and process water discharges. Two CSOs discharge to the South Menomonee Canal and five CSOs discharge to the Burnham Canal. Within the AOC, there are 21 dischargers of which 11 discharge process or cooling water. One of the largest dischargers, the Wisconsin Electric Power Company Valley Power Plant, draws cooling water from the Menomonee River and discharges to the South Menomonee Canal.

Along the Kinnickinnic River in the AOC, there are 22 CSOs located downstream of the Chase Avenue Bridge. An additional 29 known SSOs and 47 known industries discharge primarily non-contact cooling water to the stream or via tributaries and storm sewers to the entire Kinnickinnic River. Within the AOC, there are four discharges under general permits.

In the Outer Harbor, there are two CSOs which discharge north and south of the confined dredge spoil disposal facility. Along the near shore areas of Lake Michigan, there are five industrial cooling and process water discharges.

MMSD's Water Pollution Abatement Program has corrected several of the overflow devices and will completely eliminate SSO events and, on average, all but two CSO events per year by 1996.

Solid and Hazardous Waste

Wastes are classified as hazardous based upon four characteristics: ignitability, corrosivity, reactivity and toxicity. Toxicity usually results from heavy metals or certain pesticides. From July 1, 1988 to July 1, 1989, 610 known facilities generated hazardous waste in Milwaukee County. Appendix IV.F lists poundage and types of waste materials generated. WDNR manages hazardous waste under authorization from the federal Resource Conservation and Recovery Act.

In Wisconsin, there are no active landfills licensed to accept commercial or industrial hazardous waste; however, they may accept household hazardous waste. There are abandoned or closed landfills in the AOC that accepted hazardous waste prior to the development of regulations which restrict disposal, require siting evaluations and regulate construction and operation of landfills. Landfills pose potential water quality problems because leachate draining from landfills may contaminate surface water or groundwater. As of April 1988, there were 10 active landfills in Milwaukee County. Ninety abandoned or inactive waste disposal sites which may contain hazardous waste are located within one mile of streams in the Milwaukee County portion of the Milwaukee Basin. Table IV. 3 lists waste disposal sites identified within 400 meters of a stream in the AOC.

TABLE IV.3, Waste Disposal Sites Identified in the AOC

Stream	Facility
Milwaukee River	J. G. Milligan & Co., Inc.
Menomonee River	Milwaukee Road Dump Yard
South Menomonee Canal	WEPCo.
South Menomonee Canal	Framitized Steel Co.
South Menomonee Canal	International Harvesters
Burnham Canal	Try Chem Corporation
Kinnickinnic Turning Basin	Jones Island WWTP
Kinnickinnic Turning Basin	Magnus Co.
Kinnickinnic Turning Basin	Milwaukee Sales Term
Kinnickinnic River	Baran Park
Kinnickinnic River	Center City Industrial Park

Appendix IV.G lists all of the sites in the Milwaukee County portion of the basin. Some of these sites and the sites upstream of the AOC may be impacting the AOC. WDNR has limited pollutant data on some of the sites. Investigations are underway at some of the sites such as the Hawley Road dump, Havenwoods and Whitefish Bay dump. As part of the monitoring strategy, all sites need to be screened to determined their environmental impacts and what contaminants may be leaching to nearby streams or groundwater.

As sites are identified as causing or threatening to cause environmental pollution, the WDNR uses its Environmental Response Program and the federal Superfund program to pursue site clean up.

Through the Wisconsin Environmental Response Program, WDNR investigates and cleans up disposal or spill sites which can harm public health. The program seeks reimbursement for all costs from responsible parties. The program can also assist in clean up of federal Superfund sites. Sites are inventoried, then evaluated and ranked. Sites which present a substantial danger to the public health and welfare, or to the environment, rank highest. The higher-ranked projects in the state may also be recommended for the federal Superfund program. There are several sites in the Milwaukee River Basin under investigation by WDNR or WDNR and EPA. In addition to the Environmental Response Program and Superfund investigations, WDNR is ordering corrective or enforcement actions on more than 500 underground gasoline storage tanks in Milwaukee County.

The Moss-American Superfund site is about 15 miles upstream of the AOC on the Little Menomonee River. The 88-acre site is located in northwestern Milwaukee at the southeast corner of the intersection of Brown Deer Road and Granville Road. Milwaukee County owns 65 acres of the site and the remaining 23 acres are owned by the Chicago & North Western Railroad and used as an automobile loading and storage area.

The Moss-American site was a former wood preserving facility where railroad ties were treated with a creosote and fuel oil mixture. The site operated from 1921 until 1976 when it was closed by Kerr-McGee. During operation, liquid wastes were discharged to settling ponds which drained into the Little Menomonee River. Environmental problems observed at the site are related to the use and disposal of creosote, which results in the release of PAHs to the environment. The site may be a source of PAH contamination to the AOC.

In Cedarburg, a city upstream of the AOC, the WDNR is investigating PCB contamination in Ruck Pond and Cedar Creek. One sediment core showed a mix of Aroclor 1242 and 1260 with concentrations of 18,000 ppm. Others showed concentrations of Aroclor 1260 alone at 41,000 ppm. Aroclor refers to the trade name used by Monsanto Chemical Company, one of the major PCB manufacturers, for various mixtures of PCBs. Aroclor 1260 is one of the more toxic mixes of PCB. PCBs from Cedar Creek are suspected to be a significant source of PCBs to the AOC.

Similarly, Lincoln Creek is a suspected source of bacteria, nutrients, heavy metals (lead, copper, zinc, chromium and nickel), sediment and PCBs to the AOC. Industrial spills, landfill leachate, urban runoff and CSOs from the Lincoln Creek area may be impacting the AOC.

WATER USES

Navigation

Commercial shipping and development of the port has encouraged Milwaukee's growth. Nearly 180 commercial vessels arrived in Milwaukee annually by 1839. Until 1850, the principal link to other areas of the nation was through the Great Lakes, and commerce depended upon safe harbors and port facilities like those at Milwaukee. In the 1860s and 1870s, Milwaukee served as the nation's largest wheat market with several mills located along the banks of the Milwaukee River.

The Milwaukee River discharged south of its present location and changed course several times so the mouth of the river constantly shifted. From 1835 to 1837, the COE conducted a harbor survey and recommended the entrance to the harbor be moved north to its present location which was constructed in 1857. The natural outlet was filled to form a protected Inner Harbor. The original four mile long breakwater enclosing the Outer Harbor was built in 1888 followed by large, cargo-handling facilities in the 1920s and 1930s. Piers were built in the Outer Harbor in 1933. Commercial navigation on the rivers declined because of competition from railroads and overland transportation. Navigation on the Milwaukee River ended in 1959 but continues in the lower Kinnickinnic River, the lower Menomonee River and its canals, the turning basin and southern half of the Outer Harbor. Recreational and pleasure craft navigate the AOC during ice free periods.

Major port facilities on Jones Island, a 300 acre peninsula, include cargo docks, a municipal mooring basin, piers, terminals, an internodal terminal, storage facilities for dry and liquid bulk materials, and a container yard. Grain and cement elevators, scrap metals facilities and coal docks are found in other areas of the harbor. Today, the harbor facilities service ocean freighters, car ferries, passenger ships, tanker vessels, barges, and large cargo freighters. The facilities handle the loading and unloading of bulk materials such as coal and salt, heavy liquid and general cargo. From 1968 to 1982 approximately two to four million tons of cargo came through the port facilities annually. More than 683,000 tons of coal, 449,000 tons of grain, 408,000 tons of salt, and 339,000 tons of cement were handled in 1982. Storage of these materials on Jones Island and surrounding land may contribute to surface water contamination runoff from these sites during rain storms.

The COE maintains federal navigation channels within the AOC and periodically dredges the harbor and river portions to maintain navigability. The Kinnickinnic River ranges in depth from five feet by Chase Avenue to about 15 feet near Kinnickinnic Avenue. Downstream from Kinnickinnic Avenue into the turning basin, the COE maintains depths at 25 feet. The Menomonee River, Burnham and South Menomonee canals are also kept at navigation depths of 25 or more feet. The southern half of the Outer Harbor is maintained at 25 to 27 feet. In addition, the Port of Milwaukee, MMSD or private industries occasionally dredge portions of the AOC. The Milwaukee River is no longer dredged.

In Wisconsin, because it is illegal to dispose of dredged material in the open lake, dredge spoils must go to a confined disposal facility (CDF) or an upland site. Sediment in the Milwaukee AOC is contaminated according to EPA guidelines and is disposed of in the CDF. Confined disposal facilities allow water to leak out leaving the contaminated sediments inside. As discussed in chapter three, the CDF will be filled and capped in the mid-1990s. Future sediment disposal options are being reviewed by the port authority. The COE has full responsibility for maintaining the existing CDF until it is filled. The City of Milwaukee then assumes maintenance responsibility. If another is built when the present one reaches capacity, the COE will build it and the Port of Milwaukee will be responsible for maintenance. COE maintenance includes periodic repair of the dike walls. Wave action in the Outer Harbor warrants occasional replacement and reinforcement.

Decisions to deposit dredge spoils in a CDF are based on chemical sampling of bottom sediment before dredging occurs. Chemical analyses are used to classify sediments as heavily polluted, moderately polluted or nonpolluted depending on the levels of volatile solids, chemical oxygen demand, nitrogen, oil and grease, and heavy metals. Levels of PCBs and mercury greater than 1 mg/kg or 1 ppm are classified as polluted because of their toxicity and ability to bioaccumulate (EPA Region V, 1990 correspondence).

The COE analyzes sediment in Milwaukee's navigational channel every five years to determine whether options for disposal of dredge spoils have changed. Samples collected by the COE in 1989 indicated PCB levels range from 1 ppm to 6 ppm for 25 sediment samples. Each sample was classified as moderately or heavily polluted for cadmium, arsenic, copper, iron, lead, zinc, mercury, chromium, polynuclear aromatic compounds, conventional pollutants such as BOD and excessive phosphorus and oil and grease. All materials dredged in 1990 were disposed of in the CDF.

Water Supply

The city of Milwaukee draws its drinking water supply from Lake Michigan through a distribution system built in 1873. The Linnwood Plant began operation in 1939 and the Howard Avenue Plant was installed in 1962. The Linnwood plant has a design capacity of 275 million gallons per day (MGD) while the Howard plant can treat and distribute 100 MGD. Intakes for both plants are located 6,565 feet out into Lake Michigan. The plants provide chlorine gas disinfection, coagulation and softening, flocculation and settling, taste and odor control when necessary, and filtration.

Wildlife Habitat

About 26 percent of the Milwaukee basin land area is considered an environmental corridor or open land (such as parkland), 25 percent is in urban land use, 47 percent is agricultural, and 2 percent represents surface water. Very little open land (1.2 square miles) drains to the AOC. About 4.5 square miles of open land lies along the near shore areas of Lake Michigan within the AOC. Available wildlife habitat is limited and often of poor quality. It is used by animals such as cottontail rabbits, raccoons, rats, songbirds, gulls, ducks and geese. Amphibians found in the area include salamanders, toads, and frogs. Reptiles include snapping turtles, musk turtles, midland painted turtles, western painted turtles, the brown snake, the northern red-bellied snake and Butler's garter snake.

The confined disposal facility provides nesting, loafing and feeding habitat for migratory waterfowl during the spring and summer months. It also attracts local duck and geese flocks during the winter. Appendix IV.H lists avian species observed on the CDF during the summer of 1990. Waterfowl in the area may be ingesting contaminants from the CDF but further study is necessary to determine whether the CDF contributes to waterfowl contamination. Initial studies are underway. During the summer of 1990, game farm mallards were released on the CDF and collected after 2 months. The birds are being analyzed to determine if they have picked up harmful concentrations of chemicals.

Additional wildlife habitat is available in parks along the near shore areas around the harbor. There are small patches of upland hardwoods in the county park system and on the University of Wisconsin-Milwaukee campus. Portions of the Milwaukee and Menomonee Rivers and adjacent land upstream of the AOC provide significant habitat for deer, coyote, rabbits, squirrels, waterfowl, and song birds. The city and Milwaukee County operate an extensive park system in the lower portions of the Milwaukee basin which also provides some wildlife and aquatic habitat.

Fish Habitat

Within the AOC, the lower reaches of the Milwaukee, Menomonee and Kinnickinnic rivers are severely degraded where the existing aquatic habitat supports mostly rough fish and pollution-tolerant species. On the Milwaukee River, habitat diversity and quality is limited by CSOs, nonpoint source pollution, sediment and silt deposition, and the composition of bottom substrate. Above the North Avenue Dam silt may be as much as 10 feet deep and may contain toxic substances discharged from upstream sites. Silt deposition below the North Avenue Dam is also significant because the river flows slow and silt accumulates below the dam. On the Menomonee River, streambank erosion, channelization and urban runoff impact habitat quality. Above the AOC, the Menomonee River passes railroad yards and material storage areas where occasional spills occur. In the Burnham and South Menomonee canals, channel sides are made of wood, steel sheet pilings or concrete. Portions of the Kinnickinnic River above the AOC are concrete channels which incur high velocity flows during storm events. Concrete channels provide very poor habitat which supports temporary populations of very pollution-tolerant macroinvertebrates and an occasional fish. Within the AOC, the bottom sediments of the Kinnickinnic River are dominated by thick deposits of muck over sand and clay. Streambank erosion is minimal between Chase and Becher streets but downstream of Becher Street, the natural banks have been replaced by steel sheet pilings. In addition, urbanization of the Lake Michigan coastline has contributed to declining water quality and destruction of aquatic and wildlife habitat and spawning areas in the AOC.

Endangered and Threatened Species

There are several threatened or endangered species in the AOC. Endangered species observed in the last 10 years in or near the AOC are the greater redhorse, the black-crowned night heron, and such plants as blue-stemmed goldenrod, heart-leaved plantain, forked aster, american gromwell, yellowish gentian, and false asphodel (Hill Mochen, WDNR, 1989).

Commercial and Sport Fishing

A decline in Lake Michigan fish populations and species diversity has occurred due to significant ecosystem changes such as altered water quality, the invasion of the sea lamprey and alewife, and the effects of commercial fishing. These combined impacts severely hamper whitefish, large herring, sturgeon and lake trout populations. Unchecked by predators, the alewife population had increased to an estimated 90 percent of the total Lake Michigan fish population by 1955. More recently, a severe decline in the alewife population has reduced salmon harvests.

Fish have been stocked in Lake Michigan since 1963 when 9,000 rainbow trout were released. Since 1969 WDNR has stocked rainbow, brown, brook and lake trout and coho and chinook salmon as well as hybrids (tiger or splake). Estimates of released and proposed releases for 1988 and 1989 are shown in Table IV.4.

Table IV.4, Estimated Stocking from the Milwaukee Area Hatchery and Lake Michigan

	1988[1]		1989[2]	
	Grid #1901	Lakewide	Grid #1901	Lakewide
Rainbow	-0-	291,000	NA	500,000
Brown	63,340	1,021,000	NA	1,000,000
Brook	20,850	466,000	NA	245,000
CoHo	112,515	995,000	NA	150,000
Chinook	110,635	1,409,000	NA	2,500,000
Lake	-0-	736,000	NA	828,000
Splake	-0-	29,000	NA	-0-

Note: NA = Not Available
Source: Wisconsin's Great Lakes Planting Program, Michael J. Hansen, 1989

[1] Estimates from stocking receipts completed after hatchery fish are released into the wild.

[2] Anticipated estimates of stocking for 1989. Estimates from stocking receipts from individual hatcheries are not available yet.

However, sport fishing in the AOC is restricted because spawning areas are polluted and channel modifications such as dams and concrete lining have degraded habitat. Resident fish are pollution tolerant species such as carp and black bullheads. Salmon, walleye, bass, pike and trout are found in the AOC, but are unable to spawn. The harbor provides habitat for perch, northern pike, suckers and carp. Some of the naturally occurring perch spawning beds were altered in 1989 when the new landfill island, Lakefront Island, was built in the Outer Harbor. However, habitat was also created in the installed rip rap which may replace some of the perch habitat lost by construction.

On Lake Michigan, large-scale stocking of salmon and trout continues to sustain Wisconsin's Lake Michigan sport fishery, estimated to be worth $60 million per year (1981-1983 numbers) despite recent reductions and anticipated future reductions. WDNR stocks about 7 million chinook and coho salmon, and lake, brown, rainbow and brook trout annually. Alewife populations have become a food source for stocked fish. Recent crashes or declines in alewife populations will affect future stocking programs. The hatchery in the Milwaukee area reduced its stocking quotas in 1988 by 10 percent. Another reduction is being discussed for future stocking. The chinook stocking program has shown decreased successes perhaps because of the decline in alewife populations as forage food and/or perhaps because of recent incidences of bacterial kidney disease.

From 1982 to 1984, sport anglers harvested an average of about 650,000 of these game fish from Wisconsin's Lake Michigan waters annually. Lake Michigan anglers include pier, shore and stream anglers, and trollers who charter, moor or trailer their boats. Estimated 1988 angler harvest is summarized in Table IV.5. These numbers are calculated from creel surveys taken from Whitefish Bay, Milwaukee and South Milwaukee.

TABLE IV.5
1988 Creel Survey Estimates of Angler Fishing, Milwaukee County[1]

Species	Total Harvest Estimates (No. of Fish)
Coho Salmon	29,300
Chinook Salmon	17,100
Rainbow Trout	2,700
Brown Trout	8,600
Brook Trout	1,400
Lake Trout	1,500
Yellow Perch	407,800

[1]Creel Surveys estimate the fishing done by ramp, pier, from shore and along rivers.
Source: Mike Staggs, WDNR, 1990.

Commercial fishing is limited by WDNR generated biological quotas. The quotas are used to try to prevent over harvesting and are subject to continual revisions. In 1988, Wisconsin's commercial fishers harvested approximately 13 million pounds of fish from Zone 3, which is the open water of Lake Michigan from Kewaunee to Racine and includes the Milwaukee Harbor. Harvest numbers from 1989 are not yet available. The most recent quotas for Zone 3 compared with 1988-89 harvests are listed in Table IV.6.

TABLE IV.6
Commercial Fish Quotas for Zone 3 Compared with 1988-89 Harvests

Species	Quotas (lbs)	1988-89 Harvests
Chubs	3,000,000	1,698,906
Perch	306,700	267,000
White Fish	100,000[1]	1,133,441
Menominees	28,000[1]	--
Forage	18,500,000	15,300,000[2]
Alewives		7,500,000[2]
Smelt		2,600,000[2]
Chub		5,100,000[2,3]

[1]New quotas established for the 1989-90 season. Harvests include pre-quota numbers.

[2]Estimate based on intensive monitoring efforts.

[3]Forage fish trawling is primarily for alewives; however, the catch is also composed of smelt and chubs.

Source: Baumgartner, et al., WDNR, 1990, and Mike Talbot, WDNR, 1990.

The charter boat industry has grown in recent years as it continues to attract more out-of-state anglers. However, the 1989 Lake Michigan charter fishery experienced its first decline, perhaps due to the decline in alewife. Table IV.7 summarizes the charter fishing history for the Port Washington - Milwaukee area.

WDNR and the DHSS jointly determine fish consumption advisories for PCBs, pesticides and mercury contamination. There are no consumption advisories due to mercury in the Milwaukee AOC or river basin. However, there are advisories due to PCB and pesticide concentrations found in fish sampled in the AOC and in the Milwaukee and Cedar rivers upstream of the AOC. WDNR has also issued wildlife consumption advisories for mallard ducks from the Milwaukee River and Cedar Creek upstream of the AOC and for black ducks, mallards, scaup and ruddy ducks in the Milwaukee harbor.

Recreation

Wading and swimming are restricted due to physical barriers and water quality problems in the waterways in some portions of the AOC.

The Milwaukee River is navigable up to the North Avenue dam for pleasure craft during the ice-free portion of the year. In the AOC, there are private docking facilities for recreational watercraft. In Milwaukee County parks along Lake Michigan, public access and launch facilities are provided.

TABLE IV.7
Port Washington-Milwaukee Charter Fishery Efforts
and Catch: 1976-1989

Year	Brown Trout	Rainbow Trout	Coho Salmon	Lake Trout	Chinook Salmon	Total Fish Caught
1976	50	310	1,165	341	828	2,694
1977	108	241	2,419	386	1,874	5,038
1978	74	141	723	190	1,699	2,827
1979	206	214	1,255	750	2,935	5,360
1980	221	139	3,086	325	3,120	6,891
1981	275	307	2,639	976	4,604	8,801
1982	300	155	4,152	1,500	6,303	12,413
1983	388	236	1,650	3,379	7,798	13,451
1984	470	298	5,121	1,223	10,624	17,841
1985	956	238	6,882	834	12,569	21,495
1986	849	309	7,736	1,428	13,670	23,992
1987	919	1,816	8,126	1,870	14,060	26,820
1988	1,902	1,814	13,701	1,360	9,002	27,855
1989	1,183	2,560	11,046	2,747	6,100	23,954

Anglers fish along the Milwaukee River and off the breakwall in the Outer Harbor and the walls of the CDF. Many anglers fish below the North Avenue Dam during the annual spring and fall run of salmonids. Boats troll the mouth of the Milwaukee River and Outer Harbor during these spring and fall runs.

Milwaukee County operates an extensive park system along the Milwaukee River. The Milwaukee River upstream of the Milwaukee County line has water quality adequate to support full body contact while the river downstream of the county line is restricted to partial body contact.

On the Menomonee River, flow is adequate to support canoeing and full-body contact uses in reaches of the river well above the AOC (above 45th Street). However, high bacteria levels limit uses such as swimming and wading, in much of the Menomonee River, including the AOC. Recreation in the Burnham and South Menomonee Canals is limited to boating.

The fishery on the Menomonee River is affected by accidental or intentional spills, fish kills and consumption advisories. The extent of public use of the Menomonee River for fishing is unknown, but access is abundant in the parkways upstream of 45th Street.

On the Kinnickinnic River above the AOC, extensive channel modifications such as concrete lining, detract from recreational use. Above the concrete lined channels, the Kinnickinnic flows through a county park and wooded area. Here, the river is not used for recreation because river flows are low throughout the year. The upper end of the river within the AOC is used by anglers during the spring and fall trout and salmon runs. The Kinnickinnic River within the AOC is classified as supporting partial body contact.

WATER QUALITY STANDARDS, GUIDELINES, OBJECTIVES AND APPLICABLE BENEFICIAL USES

Water Quality Standards for Surface Waters

Water quality standards apply to the use(s) to be made of a particular waterbody and the water quality criteria necessary to protect the use(s). Standards are developed by all levels of government and are continuously reviewed and changed. Water quality standards form the basis for deriving water quality based effluent limitations. They are also used to make management decisions related to discharge permitting, sewage treatment plant construction and funding, and resource management. Water quality standards for recreational use and public health and welfare apply to all the classified waters and designated uses. WDNR classifies surface waters into the following classification systems:

Great Lakes Waters, (Lake Michigan and Lake Superior)
Outstanding Resource Waters, see NR 102.10
Exceptional Resource Waters, see NR 102.11
Fish & Aquatic Life Waters are use categories for purposes of setting standards, see NR 102.4(3)a - f.

Fish and Aquatic Uses are categorized into subcategories which include:

a) Great Lakes communities (NR 102.12)
b) cold water communities
c) warm water sport fish communities
d) warm water forage fish communities
e) limited forage fish communities (intermediate surface waters)
f) limited aquatic life (marginal surface waters)

If streams are classified as supporting the last two subcategories, they are considered variance streams which are allowed to meet lower criteria for dissolved oxygen, BOD, ammonia and suspended solids and in special cases, temperature and fecal coliform bacteria.

"Variance" classifications have been established by WDNR to identify different standards for waters that, due to natural conditions or human activities are unable to support a fishery or a balanced community of aquatic organisms. An example is an intermittent stream that has no flow for part of the year, or a concrete line channel. A stream has a variance classification because of naturally poor water quality or habitat or permanently altered water quality or habitat. Streams which have been channelized or streams with intermittent flow are generally able to support few if any aquatic organisms because of scouring, periodic high flows or no flows. In the AOC, portions of the channels and rivers have variance classifications because they have been physically altered. If dissolved oxygen levels increase due to significant water quality improvements, and habitat becomes available and fish are documented as breeding and surviving, these sections of the river could be reclassified to support higher uses such as a warm water fishery.

The Milwaukee AOC is classified as a Great Lakes water in NR 102. Various reaches of the streams that feed into the AOC have different fish and aquatic use classifications as listed in NR 102. Appendix IV.I identifies the use classification for all of the streams in the urban area of Milwaukee (above the AOC and within the AOC).

A warm water fishery classification requires the following based on WDNR regulations in chapter NR 102:

- *dissolved oxygen levels must remain greater than or equal to 5 mg/L;
- *temperature changes shall not adversely affect aquatic life;
- *natural daily and seasonal temperature fluctuations shall be maintained;
- *maximum temperature increases at the edge of the mixing zone shall not exceed 5 degrees F for streams and 3 degrees F for lakes;
- *temperature shall not exceed 89 degrees F for warm water fish;
- *unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life;
- *surface waters must meet acute and chronic criteria as set forth in Chapter NR 105.05 and 105.06, Wisconsin Administrative Code.

For those areas of the Milwaukee AOC classified as supporting limited forage fish and limited aquatic life classifications, the dissolved oxygen levels, temperature limits and bacteria levels are less stringent. In the Burnham and South Menomonee canals, a variance allows lower standards for dissolved oxygen (2 mg/L) and fecal coliform bacteria (1,000 counts/100 ml monthly geometric mean). In addition, temperatures in the Milwaukee River downstream of the North Avenue Dam and within the South Menomonee and Burnham canals may not exceed 89 degrees Fahrenheit at the edge of a discharge mixing zone.

Antidegradation

In March 1989, the WDNR revised its water quality antidegradation policy. Revised regulations establish an antidegradation classification system for all surface waters in Wisconsin. Procedures are established for determining if a proposed new or increased discharge is subject to antidegradation policy and for determining limits for those discharges.

The antidegradation policy listed in Chapter NR 102, Wisconsin Administrative Code, states: "No waters of the state shall be lowered in quality unless it has been affirmatively demonstrated to the Department that such a change is justified as a result of necessary economic and social development, provided that no new or increased effluent interferes with or becomes injurious to any assigned uses made of or presently possible in such waters."

In the past, water quality standards were not as stringent. For example, the interpretation of the 1973 antidegradation policy was that water quality standards were set to protect only designated uses and degradation of surface waters was allowed as long as the current uses were maintained. The new antidegradation policy allows only a certain minimal amount of degradation or none at all, depending on how a water body is classified. For all classifications, the impacts of new or increased discharges are evaluated against background water quality conditions, not current uses. As a result of antidegradation policy, only one-third of the assimilative capacity of a stream can be used for a discharge to a fish and aquatic life waters, unless there are socio-economic justifications and no cost-effective control alternatives. The old policy allowed use of the full assimilative capacity.

The antidegradation rules contain a "Great Lakes Initiative" which protects the Great Lakes and their tributaries from the impacts of persistent, bioaccumulating toxic substances. Effluent limits for dischargers to the Great Lakes will be determined such that any increase in mass loading of a substance with a bioaccumulation factor greater than 250 will be considered a significant lowering of water quality. There are 21 substances that are regulated for bioaccumulation which can be found in Appendix IV.J.

EPA is developing antidegradation guidelines which may result in revised Wisconsin policy in the future.

Water Quality Standards for Toxic Substances

WDNR developed water quality criteria standards and procedures for calculating point source discharge limits for toxic substances discharged to surface waters. Chapter NR 105 establishes numerical standards for fish and aquatic life, wildlife and human health for about 100 toxic substances. Chapter NR 106 establishes the methods to calculate effluent limits for point source dischargers that ensure water quality standards for toxic substances are met in surface waters. Appendix IV.K lists Warm Water criteria and Appendix IV.L lists the Great Lakes criteria which apply for point source discharge permits in the AOC.

CHAPTER FIVE - DEFINITION OF THE PROBLEMS

Chapter Five identifies problems in the Milwaukee AOC that result in impaired beneficial uses. The first section identifies all impaired uses that occur in the AOC. The second section identifies the major water quality problems and the chemicals and their distribution in the water, biota and sediment that cause the impaired uses in the AOC.

IMPAIRED USES IN THE MILWAUKEE AOC

IJC has developed criteria to determine if a harbor or river system that enters a Great Lake has water quality or toxic contamination problems. These criteria or impaired uses signify that beneficial uses are restricted in an AOC and are used to "list" an AOC and require preparation and implementation of a remedial action plan. Fourteen impaired uses have been identified by the IJC as occurring in many of the AOCs around the Great Lakes. For each AOC, the RAP must examine and document if any of these 14 impaired uses, caused by poor water quality or toxic contamination, occur. Recommendations in the RAP must show that the impaired uses will be eliminated so that the AOC can be "delisted" once the water quality and toxic contamination problems are resolved. In the Milwaukee AOC, 10 of the IJC 14 impaired uses have been identified after evaluating existing information and data. Each impaired use is discussed below and then Table V.4 summarizes the impaired uses for the Milwaukee AOC.

A) Restrictions on Fish and Wildlife Consumption

There are fish consumption advisories for both resident and migratory fish species in the AOC. Health advisories exist for consumption of resident fish such as carp, suggesting contamination is coming from the AOC or upstream. Waterfowl contamination has led to consumption advisories in the AOC. Because waterfowl migrate through the Great Lakes region and along flyways from Canada to the Gulf of Mexico and the Atlantic Ocean, more research could identify the extent of contamination waterfowl pick up in the AOC and the role the AOC has as a source of contaminants to the region.

WDNR uses U.S. Food and Drug Administration (FDA) action levels and DHSS criteria to determine advisories. FDA establishes "action levels" and "tolerance levels" to limit the concentration of contaminants in food sold for human or animal consumption. FDA will take legal action to remove products from the market that contain concentrations exceeding action levels or tolerance levels. Table V.1 identifies action level and criteria used for the fish and waterfowl advisories.

Fish

WDNR health advisories warn the public to limit exposure to toxic chemicals found in certain sport fish. They do not directly link a given exposure to a certain level of health risk. The advisories are based upon the results of chemical analyses of fish taken from harbors and waters around the state that, along with associated sediments, are believed to contain high levels of contaminants. Advisories have been issued over the past 10 years and, since 1987, in April and October each year.

A PCB advisory exists for the entire Milwaukee AOC, for the Milwaukee River upstream of the AOC and for Cedar Creek also above the AOC, from its junction with the Milwaukee River to Bridge Road in the Village of Cedarburg. Two pesticides, chlordane and dieldrin, also exceed consumption advisory levels in lake trout. Appendix V.A details the PCB advisory for the Milwaukee AOC. Based upon the species, size and percentage of tested fish that exceed action levels, the advisory suggests that women who intend to have children or are pregnant and children 18 years or younger should take the greatest precaution when consuming fish.

Other states issue consumption advisories for their territory on Lake Michigan and the National Wildlife Federation published a consumption advisory for Lake Michigan. While the advisories differ, they all stress consumer awareness against consuming fish with high levels of PCBs and pesticides. An objective of the Milwaukee RAP is to alleviate the need for consumption advisories. WDNR fish contaminant data is in Appendix V.B.

Table V.1
Contaminant Concentrations
Used to Determine Consumption Advisories

Compound	Fish	Waterfowl
PCBs	2 ppm	3 ppm (3)
DDT	5 ppm	5 ppm (4)
Toxaphene	5 ppm	5 ppm (4)
Chlordane	0.3 ppm	0.3 ppm
Dieldrin	0.3 ppm	0.3 ppm
Mercury	0.5 ppm (1)	1 ppm (5)
Dioxin	10 ppt (2)	---

Note: Values are expressed in parts per million (ppm) and parts per trillion (ppt)

(1) WDNR and DHSS use 0.5 ppm, the FDA action level is 1.0 ppm.
(2) FDA action level is 50 ppt; WDNR and DHSS use 10 ppt as cause for concern warranting an advisory.
(3) This is FDA's tolerance level (more stringent action can be taken for exceedances) for red meat and USDA's action level for poultry.
(4) For these compounds the action level for fish is used because poultry action levels are undetermined.
(5) The action level is 1 ppm for methyl mercury. When total mercury is measured, 80 percent is estimated to be in the methyl mercury form.

Wildlife

A waterfowl advisory issued for certain species harvested in the Milwaukee AOC suggests no one should eat mallard, black ducks, scaup, and ruddy ducks from the Milwaukee area. Waterfowl harvested from the Milwaukee River and harbor contain PCB concentrations exceeding FDA tolerance levels. The FDA "tolerance level" for PCBs in poultry is 3 ppm on a fat basis, ppm wet weight multiplied by 100 percent then divided by the percentage of fat. The Federal Register states poultry may not be sold commercially or used in interstate commerce with levels higher than 3 ppm PCBs on a fat basis.

The waterfowl consumption advisories demonstrate that bioaccumulation occurs in waterfowl harvested from the AOC. While specific sources are unknown, a suspected source of this contamination in the Milwaukee AOC is the confined disposal facility. The CDF provides forage habitat for resident species of ducks and Canadian geese. Migratory ducks use it when they pass through in the spring and fall. The CDF's polluted sediment contains heavy metals, PCBs, oil and grease, PAHs and pesticides. The CDF is known to leak into the Outer Harbor waters and surrounding sediments.

A U.S. Fish and Wildlife study (Miller, 1984) documented that ducks pick up contaminants in a two to three month period from the Saginaw Bay CDF. Similarly, a sentinal duck study was initiated in the summer of 1990 to determine if waterfowl are picking up contaminants from the Milwaukee CDF. Game farm mallards were released on the Milwaukee CDF and collected 70 days later. Analyses are underway to look for total PCBs, metals, pesticides and PAHs. WDNR wildlife contaminant data is in Appendix V.C.

B. Tainting of Fish and Wildlife Flavor

In other areas of Wisconsin, fish tainting is associated with paper mill discharges. No paper mills discharge in the AOC or the basin. WDNR fish managers have not received complaints about fish or wildlife flavor tainting in the Milwaukee AOC and it is not considered an impaired use in the AOC. However, when water quality improves and the fishery is restored, a study or survey of anglers may be warranted to verify that tainting is not a problem.

C. Degradation of Fish and Wildlife Populations (diversity and abundance)

Fish populations in the AOC are severely degraded. Resident fish species (carp, suckers, bullheads, mudminnows and goldfish), are pollution tolerant species that survive in poor water quality conditions. In addition, poor water quality due to low dissolved oxygen levels and contaminant spills results in periodic fish kills.

Evidence of wildlife population degradation from water quality or chemical contamination has not been documented in the AOC. However, the AOC is an urban area which supports residential, commercial and industrial land uses. Wildlife populations do not prosper in the AOC because the limited, poor quality habitat does not support large and diverse populations.

Fish

WDNR classifications for fish species are sport fish, including cold water species such as trout and salmon, warm water species such as bass and walleye, intolerant forage fish such as the fantail darter, tolerant forage fish like the white sucker, and very tolerant forage fish such as carp. Sport fish and intolerant forage fish need good water quality to survive while tolerant and very tolerant species can live in more polluted conditions.

Surveys were conducted in the lower reaches of the Milwaukee, Menomonee and Kinnickinnic rivers by WDNR in 1983 as part of SEWRPC's Milwaukee Harbor estuary study. The Milwaukee River survey identified 35 species. Carp and white suckers were most abundant followed by redhorse, alewife, bluegills, rainbow trout, black crappie, black bullhead, rock bass, and goldfish. Twenty-three species were sport fish, including six species of cold water sport fish. In 1984, a survey conducted upstream of the North Avenue Dam to Pioneer Road identified 29 species, including 12 sport fish and 10 pollution intolerant species.

In the Menomonee River, comprehensive surveys were conducted in 1973, 1983, and 1984. The 1973 survey showed a fishery almost entirely composed of green sunfish. In 1983, 20 fish species were collected in the Menomonee River from the 29th Street bridge to the junction with the Milwaukee River. Cold water salmonids, other sport fish, intolerant and very tolerant forage species were present and carp were most abundant. In 1984, a total of 21 species were surveyed and the most abundant species was the central mudminnow. Seven sport fish species were also identified dominated by green sunfish and black bullheads. Both of these sport fish are very pollution tolerant. Three species which need good water quality, the blacknose dace, fantail darter and hornyhead chub were also surveyed. Seven species of tolerant fish were collected of which the common shiner predominated. The central mudminnow was the most dominant of the four very tolerant fish species collected.

In the Kinnickinnic River, a comprehensive survey was conducted by WDNR in 1983. The river was sampled from its confluence with Lake Michigan upstream to the beginning of the concrete channel at 6th Street, just above the AOC. Twenty-three fish species were caught; most abundant were white suckers, then black bullheads, rainbow trout and carp. Fourteen of the species collected are classified as sport fish, including five cold water sport fish. No fish were caught or observed above the concrete channel. Wilson Park Creek is the only tributary to the Kinnickinnic River capable of supporting fish.

Of the variety of fish identified in the AOC, several species are transient and nonresident. Resident species are the more pollutant tolerant species, such as suckers, black bullheads and carp, and also the most numerous.

Appendix V.D lists information on WDNR fish surveys. A comprehensive survey of the Menomonee River above the AOC is underway, but results are not yet available. A comprehensive survey of the AOC is necessary to document current conditions, determine relative abundance and reflect seasonal changes. A survey is recommended in the monitoring strategy which will be used as baseline information for trend analysis.

The perch populations that live and spawn in the Outer Harbor are surviving without problems (Coshun, WDNR, 1990), but lake trout have reproduction problems lakewide which may be related to chemicals such as PCBs in the lake and lack of suitable spawning habitat. Information is needed to determine what significance pollutants from the Milwaukee estuary have on Lake Michigan fish populations.

Fish kills occur periodically in the AOC from poor water quality conditions or contaminant spills. Poor water quality due to low dissolved oxygen levels is caused by the combined effects of nutrient enrichment, high levels of suspended solids, sediment oxygen demand, and high water temperatures. Table V.2 lists major fish kills reported to the WDNR since 1979. These results reflect only the kills reported, but they indicate that poor water quality continues to impair fish and aquatic populations in the AOC.

Fish populations are also affected by poor quality habitat in the estuary. The lack of natural features coupled with installation of steel pilings, concrete channelization, runoff from upstream sources and adjacent land and high input of suspended solids interfere with foraging and spawning. The North Avenue Dam inhibits migration and spawning of salmon, trout, walleye and suckers. The Falk Dam, which is really a drop structure, restricts migration during low flow periods. Physical and chemical degradation of the sediments impact the benthos and contribute to bioaccumulation in the food chain, as indicated by higher concentrations of chemicals in fish tissue. Additional data will be required to assess impairments caused by bioaccumulation or physical habitat alterations.

Wildlife

Degraded wildlife populations is not an impaired use in the AOC as no evidence exists to show that chemical contamination or water quality problems have diminished abundance and diversity of wildlife populations. However, further research may be warranted to determine if water quality or chemical contamination is degrading wildlife populations. Irregardless of water quality problems, the declines in wildlife populations and decreases in species diversity can be attributed to the urban and physical development of Milwaukee. No wetlands and very little habitat exists along the streambanks within the AOC. All wetlands were filled as development occurred.

Table V.2
Major Fish Kills Reported to the WDNR in the Milwaukee AOC

Date	Location	# of Fish and Species	Cause
8/10/90	Milwaukee River, North Ave. Dam Impoundment	2,000 - 5,000 White sucker, carp, redhorse, green sunfish, bullhead	Unknown
1/10/90	South Menomonee Canal, Menomonee River at WEPCo Valley Plant	Unknown	Unknown
10/24/89	Burnham Canal, Menomonee River	100,000 catfish, walleye, northern pike, gizzard shad, others	Unknown
9/7/85	Lake Michigan, Milwaukee, Milwaukee County	approx. 200 fish, 90% game	Construction, temperature
8/9/84	Burnham Canal, Menomonee River	100-200 fish, 50-75 gizzard shad, 10-20 bluegills, 5-10 black bullheads, 3 carp, 2 smelt	Suspect summerkill
5/21/80	Burnham Canal, Menomonee River	Unknown	Pickel liquor
2/26/79	Burnham Canal	1,000, 10% game fish	Unknown (low DO, thermal discharge plus lake seiches

Source: WDNR SED Headquarters

D. Fish Tumors or Other Deformities

There has been no systematic study to determine if neoplastic (liver) tumors or other deformities exist in fish from the Milwaukee AOC. WDNR has conducted 10-day annual fyke net surveys in the Outer Harbor since 1984 to quantify the abundance of two year old (age II) yellow perch. During this six year period, thousands of yellow perch were examined superficially, as well as hundreds of non-target species such as white sucker, carp, small mouth bass and bullheads. No evidence of external tumors were observed during this period.

However, PAHs heavily contaminate sediments in sites sampled in the Inner Harbor and the Kinnickinnic, Menomonee and Milwaukee rivers. Concentrations of fluoranthene and pyrene, two carcinogens, correspond to concentrations found in sites where fish have high cancer rates (Bauman, 1990). These concentrations are sufficient to cause cancer if adequate numbers of the susceptible fish species such as brown bullhead were found. Sediment concentrations of benzo(a)anthracene and benzo(a)pyrene, known human carcinogens, range from 1.6 to 28 mg/kg (ppm) and 1.5 to 15 mg/kg (ppm) respectively. These also correspond to concentrations found in sites where tumors are found. Because these concentrations correspond to dose/response tables provided by Baumann, fish tumors is considered an impaired use in the AOC. The poor water quality in the AOC does not support sufficient numbers of resident fish to conduct a tumor study. Once fish populations return to the AOC and stabilize, a tumor study may be warranted to examine consumer risks from eating PAH-laden fish. Appendix V.E summarizes PAH concentrations in the AOC in comparison to sites with fish tumors.

E. Bird or Animal Deformities or Reproductive Problems

Bird or animal deformities or reproductive problems is not considered an impaired use as there is no evidence that levels of contaminants are causing these problems in the AOC. There are no recorded incidences of deformities or reproductive problems, perhaps because insufficient habitat exists for breeding and foraging. Further studies must be conducted to determine if contaminants cause deformities or reproductive failure.

F. Degradation of Benthos

The degradation of benthos is considered an impaired use in the AOC. The results of a benthic organism survey conducted in 1984 along the Menomonee River from Menomonee Falls downstream to Interstate Highway 94 (I-94) revealed that benthos were dominated by pollution tolerant species. The I-94 site had an undiversified benthic community dominated by Asellus intermedius, a type of isopod which is very tolerant. Other species identified included midge and caddis fly larvae. A 1979 seasonal study sampled 12 sites on the Menomonee River. The spring results showed water quality decreased from upstream sites to downstream sites and insects collected downstream were more pollution tolerant than those collected at upstream sites. The fall survey indicated that at all sites insects were tolerant of poor to very poor water quality. On the Kinnickinnic River, benthos were collected from a riffle area downstream of the concrete channel near 6th Street in November 1977 and October 1978. Both samples lacked diversity and were dominated by oligochaeta, very pollution tolerant organisms.

Macroinvertebrate samples collected from the Milwaukee River in June, 1980 showed large populations of oligochaeta, indicating organically enriched and silty substrate. Appendix V.F identifies the taxa composition collected and the location of the samples.

Future bioassay work using benthic organisms is necessary to determine the impact of contaminated sediments upon the benthic community. Further study is also needed to determine what impact physical habitat restraints have upon benthic populations.

G. Restrictions on Dredging Activities

The levels of toxic contaminants, combined with sediment and nutrient loadings, restrict the disposal of dredged materials. The quiescent waters of the AOC encourage increased sedimentation resulting in constant shoaling. Dredging is continually required to maintain sufficient water depth to accommodate the 27-foot draft of larger seagoing commercial ships.

Prior to 1970, required water depths were maintained in the Milwaukee Harbor by dredging and depositing dredge spoils in a deep-water location in Lake Michigan. In the early 1970s, WDNR began enforcing s. 30.12, Wisconsin Statutes., which prohibits the placement of dredged material, whether polluted or not, in navigable waters.

After federal funds became available to construct facilities to confine polluted dredge materials, the COE constructed a confined disposal facility along the shoreline in the southern portion of the Outer Harbor and began using it in 1975. (See chapter three for further details).

Since 1980, the COE has conducted extensive sediment sampling in the Milwaukee AOC to evaluate dredging disposal alternatives. The AOC contains sediment which is considered moderately to heavily polluted with volatile solids, chemical oxygen demand (COD), phosphorus, total nitrogen, ammonia nitrogen, lead, zinc, cadmium, arsenic, copper, PCBs, PAHs and oil and grease. Sediment contamination will likely continue to cause dredge disposal restrictions until all major sources of contamination are brought under control. Appendix V.G discusses sediment quality in the AOC.

H. Eutrophication and Undesirable Algal Blooms

The AOC is considered excessively eutrophic as a result of high nutrient levels of phosphorus and nitrogen. Phosphorus and nitrogen are important indicators of river and estuary water quality because of their effect on algal productivity. High levels of these two nutrients can lead to nuisance algal blooms and oxygen depletion. Phosphorus is usually the least abundant nutrient in most Wisconsin waterbodies and therefore, the controlling nutrient that can limit algae and weed growth. Excessive amounts of phosphorus can trigger eutrophication by dramatically increasing algae and weed growth. Phosphorus measurements include both soluble reactive phosphorus, which is dissolved in the water and readily available for plant growth, and total phosphorus, which includes soluble phosphorus plus all phosphorus contained in plant and animal matter suspended in the water and attached to sediments. Total phosphorus in the Milwaukee AOC exceeded concentrations suggestive of eutrophic conditions (0.1 mg/l) in 40-75 percent of the samples taken from the Inner Harbor and 10-25 percent of the samples taken from the Outer Harbor.

After phosphorus, nitrogen is most important in controlling algae growth. In water, nitrogen occurs in many forms. Total Kjeldahl nitrogen (TKN) is a measurement of ionized ammonia (NH-N_4) and organic nitrogen in amino acids. TKN is converted to nitrites (NO_2) and nitrates (NO_3) when oxygen is present. Nitrates are most readily available for uptake by aquatic plants and algae. While there are no standards or guidelines to determine when nitrogen levels indicate eutrophic conditions, Shaw (1989) suggest that concentrations of ionized ammonia, nitrites and nitrates that exceed 0.3 mg/L (ppm) will support algal blooms.

Another characteristic of water quality, chlorophyll *a*, is a measure of the amount of algae present. Low levels of phosphorus are associated with low levels of algae. The mean values of chlorophyll *a* from samples collected by MMSD in the AOC have exceeded the level associated with eutrophic conditions (10 mg/m^3) at sites on the Milwaukee River and in the Outer Harbor. Table V.3 summarizes mean concentrations of phosphorus, nitrates, TKN and chlorophyll *a* at certain sites in the AOC. Appendix V.H details information on these and other parameters measured in MMSD's water quality surveys.

Undesirable algal blooms occur in response to nutrient loading from combined sewer overflows, sanitary sewer overflows, upstream non-point pollution and urban non-point pollution such as runoff from streets, storm sewers, and construction sites. After CSO and SSO events, bluegreen algal blooms occur causing fluctuating dissolved oxygen levels and increased turbidity.

Table V.3, Chemical Concentrations of Variables in the AOC
Used to Assess Water Quality
Source: MMSD River and Outer Harbor Data Collected Monthly for 1979-1988.
Numbers shown are mean values.

Site	Total Phosphorus[1]	NO_3	Total Kjeldahl Nitrogen	Chlorophyl *a*[2]
North Ave. Dam. Milw. River	0.15	0.70	1.2	40.0
Muskego Ave. Menomonee R.	0.13	0.65	1.16	9.22
S. 1st St. Kinnickinnic R.	0.14	0.52	1.13	8.05
Outer Harbor #1	0.09	0.59	1.28	10.32
Outer Harbor #7	0.05	0.43	0.82	8.16
Outer Harbor #14	0.01	0.3	0.42	4.11

NOTE: Values in mg/L (ppm) except for chlorophyll *a* which is in mg/m^3 (ppb).

1 Total phosphorus should not exceed 0.05 mg/L (ppm) at the point where a stream enters a lake (EPA, 1976) and 0.03 mg/L (ppm) within lakes.

2 Chlorophyll *a* levels above 10 mg/m^3 are generally associated with eutrophic conditions in lakes.

I. Restrictions on Drinking Water Consumption or Taste and Odor Problems

Milwaukee's water treatment facilities meet all drinking water standards for health and taste and odor. The Milwaukee AOC is not a water supply source for the city of Milwaukee. Drinking water is withdrawn from Lake Michigan from two sources, the Linnwood treatment plant and the Howard Avenue treatment plant. Both have intakes which extend 6,565 feet into Lake Michigan. The plants provide coagulation, settling and filtration to remove suspended particles. They also provide chlorinated disinfection and fluoridation. Both plants provide additional water treatment during periods of high algal production to control taste and odor problems with activated carbon. This additional treatment can be attributed to natural phenomenons such as lake turnover, nearshore current upwellings and daily changing weather conditions.

The treatment facilities meet all drinking water standards. No additional treatment is necessary to meet primary (health) and secondary (aesthetic) standards and this is not considered an impaired use.

J. Beach Closings/Recreational Restrictions

Beach closings and recreation restrictions are considered an impaired use in the AOC. There are no swimming beaches along the lower Milwaukee, Menomonee and Kinnickinnic Rivers. However, beaches along Lake Michigan within the AOC close periodically when high bacteria counts occur after CSO events. Beach closings occur for 48 to 96 hours after rainfalls of 0.3 inches or greater occur.

Closing criteria are determined from an established correlation between rainfall levels and increased bacteria counts resulting from CSO/SSO events. In addition to closing beaches after rainfall events, the city of Milwaukee Department of Health also samples beaches for bacterial counts periodically between June and August each year. South Shore Park Beach closed three times during the summer of 1989 and four times during 1990.

Some of the bacteria loading comes from above the boundaries of AOC. Appendix V.I summarizes bacteria counts at stations within the AOC taken by the Milwaukee Health Department and MMSD. Bacteria levels in the lower rivers exceed recreation standards so water is classified as supporting partial body contact rather than full body contact. The partial body contact classification suggests people should not swim in the lower reaches of the Milwaukee, Menomonee and Kinnickinnic rivers for health reasons. Full recreation potential is not being realized within the AOC.

K. Degradation of Aesthetics

The aesthetics of the AOC are impaired because of poor water quality. After storms considerable debris can be seen near all of the combined sewer overflow outfalls. MMSD operates a skimmer on the rivers throughout the summer. In addition, flushing tunnels on the Kinnickinnic and the Milwaukee rivers flush debris from the river system as well as introduce higher quality lake water into the AOC. The Milwaukee flushing tunnel pumps about 58,800 million gallons per year and the Kinnickinnic flushing tunnel pumps about 25,500 million gallons per year.

L. Added Costs to Agriculture or Industry

This is not an impaired use in the Milwaukee AOC. There is no agriculture in the Milwaukee estuary. The direct drainage area which surrounds the AOC is used for industrial, municipal or residential purposes.

In a survey of more than 200 industries conducted by the Metropolitan Milwaukee Association of Commerce during early 1990, only two indicated they pretreat intake water from the AOC. The Wisconsin Electric Power Company draws water from the Menomonee River, chlorinates it prior to use in its condenser cooling system and dechlorinates the water before it is returned to the river. This treatment is a standard procedure to guard against the bio-fouling of equipment. Similarly, the Eaton Corporation pretreats water drawn from Milwaukee harbor as a standard procedure for water softening purposes. The frequency of chlorination/dechlorination might be less if water quality were to improve significantly, but it would not be eliminated.

M. Degradation of Zooplankton and Phytoplankton

Phytoplankton

Phytoplankton populations, microscopic aquatic plant life, are impaired in the Milwaukee AOC due to poor water quality resulting from nonpoint source and point source perturbations which affect growth conditions such as temperature, chloride, nutrients, silt, light penetration, and zooplankton communities. Additionally, rain events which cause scouring of river substrates and banks displaces a portion of the periphytic community (attached microscopic plants) into the phytoplankton community suspended in the water column.

Phytoplankton collected by the MMSD within the AOC in 1980, 1981, and 1982 indicate that more pollution tolerant (eutrophic) species exist in greater numbers in the Outer Harbor than in the nearshore waters (one mile outside the breakwall). Total cells of phytoplankton per milliliter are higher inside the Harbor than one mile outside of the breakwall. Water quality variables including ammonia, total phosphorus, specific conductivity and temperature have higher values in the Outer Harbor than in the open lake, while dissolved oxygen is slightly lower in the Outer Harbor. The greater concentrations of nutrients within the Harbor allows more pollution tolerant organisms to gain the competitive advantage over other organisms and dominate the types and quantity of organisms found. Eutrophic (nutrient rich) conditions generally lead to quantity (numbers)-rich, species (diversity)-poor biological communities. Conversely, oligotrophic conditions (nutrient poor) generally lead to quantity poor, species-rich communities.

At two locations within the Outer Harbor breakwall, diatoms dominated the species collected followed by greens and bluegreens. These two locations tended to display more peaks and crashes in populations and diatoms showed more pronounced spring and fall peaks (this is usually the case in a perturbed system). Outside the breakwall, diatoms were a less significant portion of the species collected and the phytoplankton displayed a more stable community. At these locations, Chrysophytes and Cryptophytes became a more important component of flora. These groups of organisms, are generally considered indicators of oligotrophic, non-polluted conditions.

Diatoms and other phytoplankton species can be used as indicators of trophic status and long-term eutrophication trend analysis. The Outer Harbor phytoplankton populations are more representative of a river system rather than resembling open lake populations. Research has shown that in Saginaw Bay, the Saginaw River actually acts as a "seed" mechanism contributing to the phytoplankton community within the bay. The predominance of periphytic species of diatoms in the Outer Harbor, various spectral analyses, and water chemistry data indicates that the three rivers have a significant influence on the phytoplankton community of the Outer Harbor. The nearshore waters in the area of concern are also affected by the rivers and the Outer Harbor, although to a lessor extent.

In Milwaukee, present phytoplankton populations are surviving in the Outer Harbor because of nutrient loading from the three rivers, the Jones Island wastewater treatment facility discharge and other non-point and point-source discharges. Research has suggested that the increase in some phytoplankton species indicative of eutrophication is due to degradations in water quality parameters. The incidence of brackish water species found in the Outer Harbor tend to indicate that this segment of the phytoplankton community could be influenced by chloride concentrations (generally controlled by manmade activities). These types of organisms were found on 38 occasions over the three year study in the Harbor while only 4 occurrences were noted outside the Harbor's breakwall.

These factors and variables separately and/or in combination affect the phytoplankton population dynamics.

<u>Zooplankton</u>

Zooplankton populations are also impaired in the AOC. In studies conducted from 1980-1988, MMSD identified and quantified zooplankton species (planktonic invertebrate animal life) in the Outer Harbor and nearshore areas of Lake Michigan. These studies indicate a decline of species richness and a dominance of pollutant tolerant species in the Harbor as compared with the community structure of the open lake. This trend is most evident from late spring through early fall, when the zooplankton are most active.

The zooplankton community can be divided into three groups Cladocerans, Copepods and Rotifers. In the Outer Harbor the Cladoceran population is dominated by Bosmina longirostris which can reach densities of 20,000 - 100,000/m^3 during the summer. The large Daphnia spp. and large predator species found in the open lake are rare in samples from the Harbor. The Copepod community follows a similar pattern with Diacyclops thomasi dominating the Harbor and the species from the open lake being rare. The Rotifer community is dominated by Keratella spp., Brachionus spp., Synchaeta spp. and Polyarthra spp.. The high densities of these species found in the Harbor throughout the summer in comparison with the open lake are good indications of high nutrient loading (Gannon, 1982). Species from the open waters do appear in the Harbor but only for short periods and in low numbers throughout the summer.

The contribution of zooplankton species originating from the Jones Island wastewater treatment plant (discharged via the outfall) to the Outer Harbor's overall plankton community is minimal. Two types of rotifers Philodina spp. and Rotaria spp. make up 80-90 percent of the animals in the discharge. Both are periphytic (attached) and do not survive long in the planktonic environment in the Outer Harbor and lake.

While water quality may have a significant effect on the zooplankton community, other factors also play a role. Fish predation on Cladocerans and Copepods, food availability, and physical structures (breakwalls) can help determine population densities and community structure. Nutrient loading from the Jones Island wastewater treatment plant and discharge from the Milwaukee River play a large part in the Harbor ecology, particularly in the rotifer community structure.

N. Loss of Fish and Wildlife Habitat

Habitat loss is apparent in the Milwaukee AOC. From a water quality perspective, fish and aquatic habitat is impaired because sediments are contaminated and provide an avenue for bioaccumulation. The types and numbers of benthic invertebrates dominated by pollutant tolerant oligochaetes suggests that aquatic habitat quality is also impaired because of ambient water quality. Continual nutrient and sediment loading from CSOs and SSOs and upstream urban and rural nonpoint sources further degrades habitat available for fish forage and spawning.

From a water quality perspective, there is no evidence that wildlife habitat is impaired. However, water quality-related alterations of the benthic community may impose restrictions on wildlife species using the AOC. Seasonally, large flocks of waterfowl and other migratory birds use the AOC, and a restricted food supply in the aquatic environment may be affecting these species. During the winter, the rivers in the AOC provide open water for wintering waterfowl as the result of thermal discharges from industries, particularly the power plant on the Menomonee River.

While its impacts are uncertain, the CDF provides forage and feeding habitat for fish and migratory birds. Contaminants stored in CDF sediments may be available for bioaccumulation in waterfowl. A variety of waterfowl species are contaminated and unfit for human consumption. No attempt to completely characterize the extent of wildlife contamination in the AOC has been made. Given the extensive list of contaminated species, it is likely that most of the wildlife inhabiting the AOC are contaminated to some degree. Further data is necessary to fully specify the extent of contamination and to determine how much contamination in these highly mobile species is obtained from the AOC. The extensive list of affected species suggests that local sources may provide an important contribution to wildlife contamination.

The physical development of the estuary area has greatly diminished aquatic and wildlife habitat. Replaced by steel pilings, streambanks do not exist below the North Avenue Dam on the Milwaukee River. The mouth of the Milwaukee River was relocated one-half mile north of its original discharge point, and the original outlet closed off. Almost no natural areas exist on adjacent streambanks in the harbor or along the rivers. Abandoned land in the Menomonee River valley exists where plant communities are reestablishing. However, the physical habitat is not of high quality for birds and wildlife. The only significant habitat in the AOC are the parks along near shore areas of Lake Michigan.

Table V.4. summarizes the IJC impaired uses and acknowledges the impaired uses found in the Milwaukee AOC.

Table V.4 Impaired Uses IJC Impaired Uses

(If identified in the AOC, these problems need to be corrected)	Impaired Use Identified in the AOC	Use is Unimpaired
A) Restrictions on Fish and Wildlife Consumption		
Fish	X	
Wildlife	X	
B) Tainting of Fish and Wildlife Flavor		X[1]
C) Degraded Fish and Wildlife Populations (diversity and abundance, including reproduction problems)		
Fish	X	
Wildlife		X[1,2]
D) Fish Tumors or Other Deformities	X[3]	
E) Bird or Animal Deformities or Reproductive Problems		X[1,4]
F) Degradation of Benthos	X	
G) Restrictions on Dredging Activities	X	
H) Eutrophication or Undesirable Algae	X	
I) Restrictions on Drinking Water Consumption or Taste and Odor Problems		X
J) Beach Closings/Recreational Restrictions	X	
K) Degraded Aesthetics	X	
L) Added Costs to Industry		X
M) Degradation of Phytoplankton and Zooplankton Populations		
Phytoplankton	X	
Zooplankton	X	
N) Loss of Fish and Wildlife Habitat		
Fish Habitat	X	
Wildlife Habitat		X[1,2]

[1] These IJC impaired uses are not known to be caused by water quality or toxic contaminant problems in the AOC. However, because they have not been sufficiently studied further research may be necessary.
[2] These impaired uses may have been caused by urban development over the past 150 years. The AOC is completely urban, serving residential, commercial and industrial uses. Improvement of habitat may restore some of these uses. Goals and objectives for this RAP do address problems resulting from poor physical habitat.
[3] The existence or *possibility* of fish tumors occurring in the AOC is inferred by comparing sediment concentrations found in the Milwaukee AOC to concentrations found in other sites where tumors occur. See text on p. V-5.
[4] Refer to text on p. V-6.

CONTAMINANTS OF CONCERN BY MEDIA

This section evaluates the quality of the ecosystem by media - water, biota and sediment. The quality of each medium is summarized, and major contaminants of concern identified. Overall water quality is poor as a result of excessive nutrients, high bacteria levels and excessive sediment loading resulting in high levels of algae and low dissolved oxygen. Each medium also acts as a sink for chemical contaminants. Significant chemicals identified in the environment include:

- Organic toxic substances

    * PCBs in fish, waterfowl and sediment
    * PAHs - benzo(a)anthracene, benzo(a)pyrene, pyrene and fluoranthene in the sediment
    * Dioxin in fish
    * Pesticides - DDT and metabolites, chlordane, toxaphene in sediment; chlordane and dieldrin in fish

- Metals - arsenic, barium, cadmium, chromium, copper, cyanide, iron, lead, manganese, mercury and zinc in sediments

- Conventional organic materials - total Kjeldahl nitrogen, phosphorus, chemical oxygen demand, volatile solids, total organic carbon, unionized ammonia (NH_3-N) and oil and grease in sediments; phosphorus, total Kjeldahl nitrogen, nitrates, chlorophyll *a* and bacteria in the water column

WATER QUALITY

As noted earlier, the water quality in the AOC reflects eutrophic conditions. New studies and existing data indicate that high levels of chemical contaminants, both organics and metals, are in the water column.

MMSD conducts periodic water quality surveys of the rivers and harbors. Data collected from 1979-1985 shows that average concentrations at stations throughout the AOC exceed chronic ambient water quality standards for cadmium and lead. Appendix V.H summarizes MMSD's data.

A 1989-1990 urban stormwater runoff study on the Menomonee River upstream of the AOC is near completion. Preliminary results identify several problem pollutants. Chemical analysis of runoff from 10 storm events shows that concentrations of lead, zinc and copper exceed acute and/or chronic standards. The analysis also shows detects of: urban pesticides and insecticides such as dicamba, 2,4-D and others; nine PAHs including benzo(a) pyrene, anthracene and others; PCBs; phosphorus; bacteria and sediment. Final results will be available in early 1991. Further studies are needed to determine the quality of stormwater runoff within the AOC.

The levels of nutrients and pollutants in the water result from runoff and discharges to the AOC. The pollutants in the water then settle out into the bottom sediment. Once in the sediments, in-place pollutants can resuspend into the water and remain as a continuing source to the water.

Pollutants in the water also are a source of contamination to the biota.

BIOTA QUALITY

The biota - benthos, plankton, fish, waterfowl and other wildlife - are all affected by poor water quality and/or toxic contamination. Chemical concentrations in the water and sediment are available to all forms of life. Bioaccumulation is taking place but the exact avenues of transfer need to be identified.

Benthos

A number of factors contribute to the relative abundance and diversity of the benthic organism community including type of substrates, water column chemistry, sediment chemistry, availability of food resources, and stream currents. During the SEWRPC estuary study, benthic macroinvertebrate sampling was conducted at 15 sites in the three rivers and Outer Harbor. The dominant group of organisms found were oligochaetes, which comprised the following percentages of the total benthic fauna:

Milwaukee River	87%
Menomonee River	92%
Kinnickinnic River	63%
Outer Harbor	87%

The relationship between oligochaete species and degree of enrichment has been used to indicate pollution (Krieger, 1984; Lauritsen, et. al., 1985). Goodnight and Whitley (1961) used the relative abundance of oligochaetes as a measure of the organic enrichment in sediments. They determined that a population of oligochaetes comprising 80 percent or more of the total benthic macroinvertebrate population indicates a high degree of either organic enrichment or industrial pollution. Oligochaete representation below 60 percent indicates the stream is probably in good condition. Other studies have used the number of tubificids, a type of oligochaete worm, per square meter to establish the degree of organic enrichment. Tubificid numbers of 5,000 to 10,000 per square meter have been used to indicate heavy pollution. The number of tubificids found during the SEWRPC estuary study in each of the 15 sediment samples taken from the Inner and Outer Harbor is approximately 10,000 tubificids per square meter. These numbers represent a very minimal number collected at each site because the numbers of oligochaetes were so high only a small number of individual oligochaetes were counted in each sample to provide a representative distribution of species. The limited number counted represents approximately 10-20 percent of the total number of tubificids present; the actual number present could range between 50,000 to 100,000 per square meter.

Hawmiller and Scott (1977) looked at the presence of specific oligochaete species and correlated their presence with various degrees of organic enrichment. The dominant oligochaetes typically found in the benthic samples from the Milwaukee estuary are usually restricted to areas of gross organic pollution according to the Hawmiller and Scott pollution classification system. The species include Limnodrilus hoffmeisteri, Quistadrilus multisetosus, Tubifex tubifex, and Limnodrilus cervis. Tubificids thrive in habitats where the water column is polluted with heavy metals (Winner et. al., 1980; King and Ball, 1964). Some portion of metals in the water column are deposited on the bottom sediments and impact benthic organisms through sediment and pore water interactions. Tubificids are also tolerant of anaerobic sediment conditions.

Studies to identify contaminants in benthic organisms have not been conducted in the AOC. Sediment bioassays utilizing benthic organisms and field studies are needed to determine the impact that toxic agents have on the benthos, benthic organism community structure and function, and the bioaccumulation of toxicants in the food chain.

Plankton Communities

As described earlier, plytoplankton and zooplankton are affected by the poor water quality in the AOC. Higher nutrient levels in the rivers and harbor support diatoms, bosmina and rotifers tolerant to eutrophic conditions.

In addition to the effects of higher nutrient levels from point and nonpoint discharges, the zooplankton and fish populations may be stressed by the introduction of an exotic zooplankton species. The Bythotrephes cederstroemi, also called the spiny water flea, was collected in Lake Michigan and in the Milwaukee harbor area in the early 1980s. This zooplankton species is native to freshwater tributaries of the Baltic Sea and likely was transported to the Great Lakes on cargo ships. This species may prey on other zooplankton species valuable as fish food and are themselves less valuable and available as fish food. There is some indication that as the bythotrephes is eaten by forage fish such as the alewife, and the alewife is in turn eaten by game fish, that the spiny tail does not break down. As it is passed through the intestines of game fish such as coho, it may induce hemorrhaging in the fish's intestines.

Fish

Information on the fish collected and analyzed from the AOC and upstream reaches of the Kinnickinnic, Menomonee and Milwaukee rivers is shown in Appendix V.D.

The primary pollutants of concern include PCBs, dioxins and furans, and the pesticides chlordane and dieldrin. Other chemical contaminants have shown up in analyses: mirex, DDE, hexachlorobenzene, biphenyl, mercury, copper, chromium and lead. However, the levels are below human health concerns as defined by FDA. Studies are needed to determine how these concentrations affect fish survival and reproduction.

Wildlife

Throughout the Great Lakes region, bioaccumulation of contaminants occurs in waterfowl and wildlife. In the Milwaukee AOC, a snapping turtle caught in 1983 contained 0.2 ppb dioxin and 0.1 ppb furans. A racoon caught in Milwaukee County in 1984 contained 1.4 ppm DDT, 6.4 ppm DDE and 0.2 ppm DDD. Ducks from 1984 through 1988 in the harbor and CDF were found with PCBs, DDT, DDD, DDE, dieldrin, chlordane, mercury, cadmium and selenium. Only the PCBs were in concentrations to warrant consumption advisories. However, there is no evidence that existing levels of contaminants negatively affect abundance or diversity of wildlife species because wildlife populations are severely limited by physical alterations of the estuary. Further study is needed to document the effect of these chemicals on wildlife species diversity and population numbers.

SEDIMENT QUALITY

Introduction

As flow velocities of the Milwaukee, Kinnickinnic and Menomonee Rivers decrease as they enter the Milwaukee estuary at their confluence, suspended particulates settle out and accumulate on the bottom. These suspended particulates tend to adsorb toxic metals and organic compounds. Over time, the estuary bottom sediment has become a repository or sink of highly polluted material. These so called "in-place pollutants" that have accumulated in bottom sediment also serve as a major source of contaminants back to the water column when the sediment is disturbed by biological, chemical, or physical processes. The highly polluted sediment in the Milwaukee AOC has serious detrimental effects on:

1) ambient water quality.

2) the health, diversity and abundance of benthic and aquatic organisms.

3) human health because of heavy metals and the bioaccumulation of organic compounds in the food chain.

4) disposal of dredge spoils from harbor maintenance projects.

Considerable data is available regarding sediment quality (sediment bulk chemistry) in the Milwaukee AOC (Kizlaukas, 1982; SEWRPC, 1987; MMSD, 1987; and Willis (USA COE); 1990. Full references and a detailed discussion of the data are present in Appendix V.G.

Suspended Particulate Organic Carbon Loading to Milwaukee Estuary

Table V.5 is adopted from SEWRPC (1987) and summarizes the estimated average annual Inner Harbor particulate organic carbon loadings from upstream and direct sources to each river. Overall, SEWRPC estimated the combined sewer overflow inputs account for 60, 72, and 93 percent of the particulate organic carbon loadings to the estuary portions of the Milwaukee, Menomonee, and Kinnickinnic Rivers, respectively. Combined sewer overflows accounted for two-thirds of the total particulate organic carbon loading to the Inner Harbor.

Table V.5
AVERAGE ANNUAL CARBON LOADING ESTIMATES
TO THE INNER HARBOR: 1981-1983

Particulate Organic Carbon Loading (1,000) pounds/day)

River	Non-CSO	Percent of Total	Upstream CSO	Percent of Total	Direct CSO to Inner Harbor	Percent of Total	Total CSO	Percent of Total	Total Loading
Milwaukee	5.95	40	3.97	27	4.86	33	8.83	60	14.78
Menomonee	1.85	28	1.33	21	3.34	51	4.67	72	6.52
Kinnickinnic	0.23	7	0.45	13	2.82	80	3.27	93	3.50
Total	8.03	32	5.75	23	11.02	44	16.77	67	24.80

Source: HydroQual, Inc.

Based on sediment trap data, particle settling rates, and sounding records, the SEWRPC estuary study estimated the sedimentation rates for various river segments in the estuary. Sedimentation rates partially determine whether the organic carbon particulate loading will settle out of the water column in the Inner Harbor and river segments or be transported through the system to the Outer Harbor and Lake Michigan. SEWRPC concluded that in general, the combined sewer overflows may be responsible for 40-50% of the sedimentation of the Inner Harbor. Estimated sedimentation rates for different segments of the estuary range from 1.8 to 7.9 inches per year in the Milwaukee River, from 4.3 to 19 inches per year in the Menomonee River and from 3.4 to 8.5 inches per year in the Kinnickinnic portions of the estuary. The highest net sedimentation rate found at an individual station was 43 inches per year in the Menomonee River near N. 25th Street.

Sediment Gas Production and Sediment Oxygen Demand

Organic matter in bottom sediment is anaerobically metabolized by microbes, resulting in the production of methane and nitrogen gas which bubbles to the surface. The gas released by the bottom sediments in the Inner Harbor was found to be composed primarily of methane (86-92%) and nitrogen (4-12%). Gas release rates in excess of 132 liters/m^2/day were observed at N. 25th Street on the Menomonee River. In the Milwaukee River, methane gas release rates were always less than 6.4 l/m^2/day. In the Kinnickinnic River, gas release rates were always less than 5.7 l/m^2/day. For comparison, in secondary wastewater treatment plants, sludge gas collected from settled solids yields an average of 28 liters/m^2/day of methane. (American Society of Civil Engineers, 1977). Highest rates of gas production occurred in the summer months when sediment and water temperatures were highest. No hydrogen sulfide was detected in any of the gas samples.

The consumption of dissolved oxygen by sediment reactions is an important factor affecting dissolved oxygen levels in the Inner Harbor. Sediment oxygen demand (SOD) can have a significant influence on the water column and the relationships between the overlying water quality and the sediment chemical, physical and biological characteristics (Davis and Lathnap-Davis, 1988).

The primary reaction that results in SOD is the bacterial decomposition of particulate sedimentary organic matter under anaerobic conditions. Carbon and nitrogen are liberated with their potential oxygen demand to the interstitial water of sediments. Sediment oxygen demands measured in the SEWRPC estuary study ranged from 0.59 to 5.22 grams of oxygen per square meter per day (gO_2/m^2/day) with the highest demand measured at N. 25th Street on the Menomonee River. The median oxygen demand level was less than 2 g of O_2/m^2/day. The SEWRPC study indicates that the primary cause of dissolved oxygen depletions that occur in the inner harbor is SOD. Seventy percent of the SOD in the Inner Harbor is attributed to the organic loading from the separate and combined sewer overflows.

Nutrients and Conventional Pollutants

A number of chemical parameters are used to measure the enrichment of sediment with organic materials and nutrients. These parameters include total volatile solids (TVS), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), total phosphorus, ammonia nitrogen (NH_3-N), total organic carbon (TOC), biological oxygen demand (BOD), and oil and grease (O&G). Tables A-E in Appendix V.G compare the sediment data generated for the parameters listed above to the U.S. EPA Sediment Quality guidelines and list enrichment factors (EF) for each parameter. The average enrichment factors for the conventional pollutants and nutrients is generally 2 or greater for all sites samples in the AOC. This means that the concentrations of pollutants are approximately 2 times greater than the upper threshold limit for unpolluted sediment. Therefore, Milwaukee AOC sediment can be classified as heavily polluted using USEPA's sediment quality guidelines, based on nutrients and conventional pollutants.

Metals

Using the same assessment technique as for conventional pollutants, the EPA Pollutional Classification Guidelines for Great Lakes Harbor Sediments were used to assign a pollutional category and an enrichment factor for each metal and cyanide contaminant (Tables A-E and H-I, Appendix V.G). Enrichment Factors were derived based on both mean concentrations and/or maximum concentrations for pollutants at sampling sites in each river or harbor segment.

Based on Tables A-E and H-I (Appendix V.G), the majority of metals at the sediment sampling sites within each of the river or harbor segments are in the Heavily Polluted Classification using the EPA pollutional classification scheme.

In order to get an idea of the possible biological effects related to the concentrations of metals in the Milwaukee Harbor Estuary sediments, the Provincial Sediment Quality Guidelines (PSQGs) developed by the Ontario Ministry of Environment were used as a preliminary evaluation tool. The PSQGs establish three levels of ecotoxic effects:

1. No effect level - essentially background level. No toxic effects observed on aquatic organisms.

2. Lowest Effect Level - indicating a level of sediment contamination that can be tolerated by the majority of benthic organisms.

3. Limit of Tolerance - indicating the level of which pronounced disturbance of the sediment - dwelling community can be expected. This concentration would be detrimental to the majority of benthic species.

Table V.6 contains the PSQG values for metals and the three effect levels. Table V.6 also contains an enrichment factor, the number of times greater the level of concentration is when compared to the upper nonpolluted threshold value of EPA's Pollutional Classification guideline for Great Lakes Harbor Sediments.

The normalized enrichment factors derived in Table V.6 related to the Lowest Effect Level and Limit of Tolerance can be directly compared with the normalized enrichment factors in Tables A-E and H-J (Appendix V.G) to assess the relative impact of metals concentrations in the Milwaukee Estuary sediments on benthic organisms and the benthic community.

For example, if the enrichment factor for arsenic exceeds 2 in any river or harbor segment of the Milwaukee Estuary, a proportion of the benthic species that can potentially tolerate the increasing concentrations becomes less. At an enrichment factor of 10 for arsenic, severe disturbance of the sediment dwelling community can be expected.

Table V.6: Sediment Guidelines for Metals (values in $\mu g/g$ (ppm) dry weight unless otherwise noted)

Metals	No Effect Level	Lowest Effect Level	Enrichment Factor	Limit of Tolerance	Enrichment Factor
As	4	6	2	33	10
Cd	1	*1	1.0	10[1]	10
Cr	31	*31	1.2	110	4.4
Cu	25	*25	1.0	110	4.4
Fe(%)	3	*3	1.8	4	2.4
Pb	23	31	--	250	6.3
Mn	400	460	1.5	1200	30
Hg	0.1	0.2	2	2[2]	20
Ni	31	*31	1.6	90	4.5
Zn	65	120	1.3	820	9.0

* - values less than 10 have been rounded to 1 significant digit. Values greater than 10 have been rounded to two significant digits except for round numbers which remain unchanged (e.g., 400).

1. For Cadmium, a 1.0 ug/g value is used as the upper nonpolluted threshold value.

2. For Mercury, a 0.1 ug/g value is used as the upper nonpolluted threshold value.

Based on tables A-E and H-J (Appendix V.G), the enrichment factors for most metals and cyanide are very high in several estuary segments. Milwaukee AOC sediments are heavily contaminated with toxic metals, and these metals are probably having an adverse effect on biota.

Organic Compounds

The Equilibrium Partitioning (EQP) approach was used to assess sediment quality in terms of the nonpolar chlororganic compounds such as PCB, PAH, and the chlorinated pesticides. A thorough discussion of this approach is presented in Appendix V.G.

PAHs

Tables O-T (Appendix V.G) show the total PAH concentration and total carcinogenic PAH (CPAH) concentration at individual sampling sites in the AOC and Little Menomonee River. Based on a literature review, the levels of PAHs found in the Milwaukee AOC are some of the highest values found in any Great Lakes Harbor.

Table U (Appendix V.G) contains the predicted interstitial and possibly interfacial water concentrations of Benzo (A) Pyrene and the class of 9 PAH compounds that have been designated carcinogenic PAHs.

The ambient water quality criteria for Benzo(a)Pyrene and CPAHs in the Outer Harbor based on NR 105 is 0.023 $\mu g/L$. In the Inner Harbor, the water quality criteria to maintain a warm water sports fishery for Benzo(a)pyrene and CPAHs is 0.1 mg/L.

The Benzo(a)Pyrene interstitial water concentrations exceed the water quality criteria at 18 of the 30 sites. Concentrations of CPAHs in interstitial waters at all of the sites exceed the water quality criteria.

PAH contamination of the Milwaukee AOC is a serious problem. Concentrations in most of the AOC are in the range that has caused documented biological effects elsewhere in the Great Lakes Region

PCBs

PCB contamination of Milwaukee AOC sediment was evaluated using the U.S. EPA sediment quality guidelines, the Ontario Province Sediment Quality Guideline (PSQG), and the Equilibrium Partitioning (EQP) approach. A detailed evaluation is presented in Appendix V.G.

U.S. EPA Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments (1977) establishes a threshold of 10 mg/kg of total PCBs for a determination that sediments are polluted. EPA has since corresponded with DNR (Sutfin letter to Hockmuth, 1987 and 1988) indicating that the 10 mg/kg total PCB guideline is not restrictive enough. Additional preliminary data suggests that a concentration of 1 mg/kg may not be restrictive enough to address human health concerns.

The Ontario Ministry of the Environment Provincial Sediment Quality Guidelines contain Lowest Effect Levels and Limit of Tolerance values for total PCBs and four Aroclors based on their water quality criteria. Values are listed in Table X Appendix V.G. The Lowest Effect Level of .07 mg/kg is based on prevention of unacceptable tissue residues of PCBs in fish.

Sediment Quality standards for PCB generated from the EQP approach are shown in Table Y, Appendix V.G.

The COE sample results generally show total PCBs concentrations in the estuary in the 2-5 mg/kg range. The only two Aroclors found above detection were 1248 and 1254.

Kizlaukas (1982) also found PCB concentrations in the estuary typically in the 2-5 mg/kg range. Kizlaukas found the highest PCB concentrations off the Jones Island Wastewater Treatment Facility (47 mg/kg total PCBs) and at St. Paul Avenue on the Milwaukee River (32 mg/kg total PCBs). Kizlaukas references surface grab samples taken in the Kinnickinnic turning basin in 1980 (Raltech 1982) that showed high levels of PCBs (55.6 mg/kg and 73.3 mg/kg). One sample in the referenced study from a mooring slip in the Outer Harbor had a PCB concentration of 38 mg/kg. MMSD obtained sediment core samples at 8 locations in the vicinity of the Jones Island sewage treatment plant in 1980. Concentrations of 10 to 25 mg/kg were found. The highest concentration, 79.2 mg/kg was found in a core off a Outer Harbor mooring slip.

Wawrzyn and Wakeman (1986) have investigated PCB contamination in a series of impoundments on Cedar Creek upstream of the estuary. Locations within the impoundments have PCB concentrations between 2.5 and 1,180 mg/kg. Recent sediment core samples found concentrations of Aroclor 1260 as high as 41,000 ppm (4.1 percent).

A comparison of the total PCB concentrations in Milwaukee AOC sediment with the sediment quality values in Table Y, which are designed to protect aquatic organisms from chronic toxicity, shows that at the average concentration of TOC in the Milwaukee harbor sediments (7.9%), the sediment quality value (1.5 mg/kg) is consistently exceeded. This would indicate potential long term adverse impacts to benthic organisms and bioaccumulation in fish which will result in consumption advisories.

The PCB (Arochlor 1254) sediment quality standards generated by the EQP approach, using the human cancer criteria in Wis. Adm. Code NR 105, are exceeded by two orders of magnitude in Milwaukee AOC sediment.

PCB contamination of Milwaukee AOC sediments is a widespread and serious problem. Adverse effects on aquatic organisms and fish consumption advisories will continue if the current levels of PCB in the sediment are not reduced.

Pesticides

Using the EQP approach, sediment quality standards were generated for ten pesticides: Lindane, Dieldrin, DDT, Endrin, Heptachlor, Parathion, Aldrin, Chlordane, Toxaphene, and Endosulfan (Tables AA & BB, Appendix V.G).

When the sediment concentrations in the surficial sediments (0-30 cm) in Table CC, Appendix V.G are compared with the sediment quality values in Table BB, the sediment quality values to protect human health are generally exceeded even at the highest TOC levels and K_{oc} values. With the exception of toxaphene, the sediment concentrations are below the sediment quality value in Table AA which are based on the protection of aquatic life. Since some of the sediment quality values are based on acute criteria, the aquatic organisms could still be chronically impacted by the low levels of the pesticides present.

Most of the uses of the above discussed pesticides have been banned or restricted beginning in the early 1970s. However, their characteristic long persistence in soils and sediments is measured in years. Some of the pesticides such as Chlordane, Aldrin, Heptaclor, and Endrin yield degradation products as toxic or more toxic than the original compounds that are more readily desorbed from the soil complex.

<u>Summary</u>

Sediment contamination in the Milwaukee AOC is a serious problem. Sediment is highly enriched with organic material and nutrients, which upon bacterial decomposition, generates large amounts of methane gas, and consumes large amounts of oxygen from the water column. Oxygen depletion of the water column has obvious adverse effects on biota.

The organically enriched sediments serve as a sink for a variety of toxic metals and chlorinated organic compounds. The pollutants of greatest concern are arsenic, cadmium, chromium, cyanide, lead, mercury, zinc, PAH, PCB, chlordane, and toxaphene. The sediment sink also serves as a major source of the toxic substance back to sediment pore water, the water column, and biota. If this sediment source of SOD and toxic substances is not removed or isolated, the present effects on biota and human health will continue.

CHAPTER SIX - POLLUTANT SOURCES

INTRODUCTION

Poor water quality and chemical contamination in the Milwaukee estuary AOC is caused by many diverse sources. Table VI.1. links the impaired uses identified in Chapter Five with their likely causes and sources. This chapter discusses pollution sources within and upstream from the AOC and estimates pollution loadings to the AOC and Lake Michigan using the most current data available.

Table VI.1. Summary of Sources and Causes of Impaired Uses

Impaired Use	Likely Cause	Likely Sources of Pollution or Problem
Restrictions on Fish Consumption	High concentrations of PCB and chlordane	Upstream sources of PCB and other toxic substances; contaminated sediment, historic point sources and nonpoint source pollution and atmospheric deposition
Restrictions on Waterfowl Consumption	High concentrations of PCB	Regional sources such as those listed for fish above found throughout the regional flyways
Fish Tumors or Other Deformities	Sediments heavily contaminated with PAHs (fluoranthene, pyrene, benzo(a)anthracene, benzo(a)pyrene)	Contaminated sediments, spills, nonpoint sources, combined sewer overflows and other point source pollution, atmospheric deposition.
Degraded Fish Populations (diversity and abundance)	Poor ambient water quality (low dissolved oxygen), poor quality habitat resulting from excessive sedimentation and anthropogenic development along the rivers in the AOC and the basin	Nonpoint source pollution, combined sewer overflows, physical habitat restraints

Degradation of Benthos	Contaminated sediment containing PCB, PAHs, heavy metals, oil and grease, organic matter and nutrients, poor ambient water quality (low dissolved oxygen), and poor quality habitat (excessive sedimentation, concrete channelization above the AOC and other human made restrictions)	Nonpoint source pollution, combined sewer overflows
Restrictions on Dredging Activities	Elevated levels of oil and grease, zinc, lead, iron, chromium, mercury, arsenic, cadmium, PAHs, PCBs, excessive organic matter and nutrients	Combined sewer overflows and other point source pollution, nonpoint source pollution, atmospheric deposition, spills
Eutrophication or Undesirable Algae	Excessive phosphorus and nitrogen loading and increased temperatures	Combined sewer overflows and point source pollution, nonpoint source pollution, dams
Beach Closings and Body Contact Restrictions	Elevated bacteria levels	Combined sewer overflows and nonpoint source pollution
Degraded Aesthetics	Surface water debris and unregulated development	Combined sewer overflows, nonpoint source pollution, trash and debris
Degraded Phytoplankton and Zooplankton Populations	Eutrophication and physical habitat constraints (concrete channelization above the AOC, migration restrictions and other restrictions)	Combined sewer overflows, nonpoint source pollution and habitat loss
Loss of Fish Habitat	Contaminated sediment, poor water quality, poor quality habitat	Combined sewer overflows, nonpoint source pollution, in-place pollutants concrete channelization, migration restrictions and other human-made physical constraints

SOURCES WITHIN THE AOC

Point Source Discharges

A major point source discharge within the AOC is the Milwaukee Metropolitan Sewerage Districts' Jones Island wastewater treatment facility. The Jones Island wastewater treatment plant began operating in 1925. It currently is designed to treat 200 million gallons of wastewater per day (MGD). The plant discharges effluent directly to Milwaukee's Outer Harbor. Annual pollutant loadings discharged into the Outer Harbor from Jones Island treatment plant are shown in Table VI.2. Another major point source, although technically not discharging within the AOC, is the South Shore treatment plant. The South Shore treatment plant began operating in 1968 and is designed to treat 120 MGD. The plant discharges effluent directly to Lake Michigan, eleven miles south of the Milwaukee Outer Harbor. Both facilities provide secondary treatment with phosphorus controls.

Table VI.2.

ESTIMATED ANNUAL POLLUTANT LOADINGS DISCHARGED INTO THE OUTER HARBOR FROM THE JONES ISLAND WASTEWATER TREATMENT PLANT: 1984

Pollutant	Estimated Annual Loading (pounds unless noted)
Suspended Solids.	7,060,100
Biochemical Oxygen Demand . . .	4,569,000
Fecal Coliform	1.27×10^{15} counts
Total Phosphorus	169,500
Soluble Phosphorus	85,900
Ammonia Nitrogen	2,561,000
Nitrate Nitrogen	410,500
Nitrite Nitrogen	205,000
Total Kjeldahl Nitrogen	3,956,000
Total Residual Chlorine	470,100

Source: Milwaukee Metropolitan Sewerage District.

In 1977 the DNR and MMSD agreed to a court ordered stipulation which determined actions and the time schedule which MMSD would take to meet secondary standards and applicable water quality standards for pathogenic or disease carrying organisms, biochemical oxygen demand, nutrients and suspended solids. The Milwaukee Water Pollution Abatement Program is designed to meet the agreed upon requirements. The entire project will cost about $2.2 billion and is scheduled for completion by 1996. The components include upgrading the Jones Island plant from 200 MGD to 300 MGD by 1994, upgrading the South Shore plant from 120 MGD to 200 MGD by 1992, constructing the inline storage system or "deep tunnel" by 1992, plus completing a solids management program and sewer rehabilitation, constructing additional interceptor and relief sewers and installing flow meters and hydraulic controls. The upgraded system will reduce waste overflows by more than 3.1 billion gallons per year. The inline storage system will be able to store 365 million gallons of waste water for treatment at the Jones Island facility.

Both of these treatment plants have recently received revised WPDES discharge permits. On a monthly basis, both facilities monitor for cadmium, trivalent chromium (+3), total chromium, total copper, total lead, total mercury, total nickel, total zinc, total phosphorus, total silver and total cyanide. Beginning in 1992, Jones Island will have limits for hexavalent chromium, total recoverable copper, lead and silver, cyanide, mercury, phenanthrene and pyrene. South Shore will have limits for hexavalent chromium, total recoverable copper, lead and silver, cyanide, benzo(a)anthracene, bromoform, bromodichloromethane, 2,4,6-trichlorophenol, methyl bromide, methyl chloride and pyrene. Also starting in 1992, both Jones Island and South Shore will have limits to prevent increased discharges of 21 bioaccumulating substances as part of antidegradation regulations. Appendix VI.A lists the 1992 limits for both plants. Sludge monitoring takes place at both plants for three lists of parameters identified in MMSD's permits. Limits may be required for sludge constituents if warranted based upon reviews of monitoring data.

Both of MMSD's facilities conduct priority pollutant scans on influent, effluent and sludge on an annual basis. The results of the scans are listed in Appendix VI.B. Information from the scans is used to estimate quantities of pollutants being discharged to Lake Michigan.

MMSD also is required to operate a pretreatment program to control pollution in the industrial wastewater entering the Jones Island and South Shore plants. Through its sewer use ordinance and local discharge control permits, MMSD regulates over 500 industries, 150 of which must meet pretreatment requirements. All but 15 of these 150 facilities have federal categorical limits which they must meet based upon the type of waste generated, and each facility has a standard industrial classification code which is used to determine what limits apply. The remaining 15 facilities are regulated under local limits. Industries that have pretreatment limits for discharges to MMSD are listed in Appendix VI.C. The pollutants regulated under MMSD's pretreatment program are listed in Appendix VI.D.

MMSD will be issuing permits to approximately 80 additional industrial discharges in response to the results of the federal domestic sewage study. Under RCRA, EPA was required to estimate hazardous waste discharged to sewers. The results indicate a need to regulate additional discharges under the industrial wastewater pretreatment program.

In the AOC, there are 15 industries that directly discharge into the Milwaukee River, of which nine discharge process and cooling water. On the Menomonee River, there are 21 dischargers with 11 process water discharges, and on the Kinnickinnic River, there are four process water dischargers. Along the near shore areas, there are five process water discharges. Process water and cooling water discharges are reviewed as general WPDES permits when reissued. Some of these industrial discharges may require specific WPDES permits with effluent limits.

Another significant point source is the Wisconsin Electric Power Company's Menomonee Valley Plant which draws water from the Menomonee River and discharges approximately 73 MGD of cooling water to the Menomonee River's South Canal just upstream from its confluence with the Milwaukee River. This discharge can contribute to fish kills by drawing fish into the relatively warmer water near the cooling water discharge when low dissolved oxygen levels and other adverse conditions are present in the canal. The draw of water from the Menomonee River can also contribute to relatively low flow conditions in the river.

Combined Sewer Overflows

A very significant amount of conventional pollution to the Milwaukee estuary results from combined sewer overflows to the AOC. The combined sewer service area totals about 25 square miles in area, and 111 combined sewer outfalls are located along the watercourses of this area. CSO discharges between 1981 and 1983 were estimated to be 8.6 billion gallons per year. Table VI.3. lists concentrations and estimated loadings of pollutants from CSOs. About 33 percent of the total pollutant loadings from CSOs is discharged to the rivers upstream of the estuary, 61 percent is discharged directly to the Inner Harbor and the remaining 6 percent is discharged to the Outer Harbor. This source of pollution will be drastically reduced from 50-70 events to only 1-2 overflow events per year after the MMSD "deep tunnel" storage system goes on line in 1993. Loadings directly to the rivers and harbor will be greatly decreased. Flows will be held temporarily, treated by Jones Island and South Shore plants and discharged to Lake Michigan.

Table VI.3. **SUMMARY OF ESTIMATED QUALITY OF COMBINED SEWER OVERFLOW DISCHARGES AND ANNUAL POLLUTANT LOADINGS: 1981-1983**

Pollutant	Mean Concentration (mg/l unless noted)	Annual Loadings: 1981-1983[a] (pounds, except fecal coliform in number of organisms)			
		Upstream of Inner Harbor	Directly to Inner Harbor	Directly to Outer Harbor[b]	Total
Total Solids	643	15,284,000	28,252,000	2,778,000	46,314,000
Total Suspended Solids	258	6,132,000	11,336,000	1,115,000	18,583,000
Volatile Suspended Solids	138	3,280,000	6,064,000	596,000	9,940,000
Biochemical Oxygen Demand	86	2,044,000	3,778,000	372,000	6,194,000
Chemical Oxygen Demand	265	6,299,000	11,644,000	1,145,000	19,088,000
Total Phosphorus	2.02	48,000	88,000	9,000	145,000
Soluble Phosphorus	0.24	6,000	10,000	1,000	17,000
Ammonia Nitrogen	1.73	41,000	76,000	8,000	125,000
Nitrate Nitrogen	1.21	29,000	53,000	5,000	87,000
Total Kjeldahl Nitrogen	10.9	259,000	479,000	47,000	785,000
Chloride	303	7,202,000	13,313,000	1,310,000	21,825,000
Cadmium	0.01	230	430	40	700
Chromium	0.08	1,900	3,500	400	5,800
Copper	0.08	1,900	3,500	400	5,800
Lead	1.07	25,500	47,000	4,600	77,100
Zinc	0.67	15,900	29,500	2,900	48,300
Fecal Coliform	7.0×10^5 no./100 ml	0.75×10^{17}	1.39×10^{17}	0.14×10^{17}	2.28×10^{17}

[a] *Based on an estimated average annual discharge of* 8,600 million gallons.

[b] *Includes South Shore harbor.*

Source: Milwaukee Metropolitan Sewerage District, U. S. Environmental Protection Agency, and SEWRPC.

Nonpoint Sources

Pollutant loadings from nonpoint sources include both particulate pollutants, some of which settle to the bottom of the waterways, and dissolved pollutants. These loadings are important determinants of water quality conditions within the waterways, as well as the physical, biological, and chemical characteristics of the harbor bottom sediments. Nonpoint loadings result from rural nonpoint sources upstream of the estuary as well as urban sources upstream and within the estuary. Rural sources are primarily barnyard and livestock area runoff, eroding croplands, eroding, slumping or trampled stream banks and areas contributing runoff from winter spread livestock manure. Urban nonpoint sources include construction site erosion runoff, runoff from paved or other impermeable surfaces such as parking lots, leaking underground gasoline storage tanks, bulk storage piles, eroding streambanks, home and garden fertilizers and pesticides, and improper disposal of domestic animal waste, used motor oil, antifreeze, paint and other household chemicals. Rural and urban sources of pollutants have been identified in the Menomonee River Priority Watershed and the Milwaukee River South Priority Watershed Nonpoint Source Control Plans as well as in SEWRPC studies.

Analyses of the inventory data collected for SEWRPC studies indicate that within the area of concern, nonpoint sources of pollution have the greatest impact on the Inner Harbor portion of the estuary. Nonpoint source pollutants also have a significant impact on the tributary rivers upstream of the estuary. Nonpoint sources have a lesser impact on the Outer Harbor because sediment deposition occurs in the lower reaches of the rivers upstream of the Outer Harbor and because relatively clean Lake Michigan water dilutes the runoff to the Outer Harbor. Nonpoint source impacts on the nearshore are of Lake Michigan have not been thoroughly investigated but are suspected to be minor (SEWRPC, 1990).

Estimated annual loadings of total suspended solids, volatile suspended solids, biochemical oxygen demand, total phosphorus, ammonia nitrogen and lead are set forth in Tables VI.4., 5., and 6., for the tributary rivers, the Inner Harbor and the Outer Harbor. These pollutant loadings were estimated in the SEWRPC Milwaukee Harbor Estuary Study using dry-weather and wet-weather water quality data obtained over the period of 1981 through 1983, and mathematical water quality simulation modeling. The relative contribution of pollutant loadings to the Inner Harbor is shown in Figure VI.1. The two largest sources of pollutant loadings to the Inner harbor are nonpoint sources of pollution and combined sewer overflows. Nonpoint sources of pollution are estimated to account for over 90 percent of the total Inner Harbor loadings of total solids, nitrate nitrogen, and copper; and for over 50 percent of the loadings of total suspended solids, chemical oxygen demand, phosphorus, ammonia nitrogen, total Kjeldahl nitrogen, chloride, cadmium, chromium, and other metals. Combined sewer overflows account for approximately 20-40% of pollutant loadings to the Inner Harbor.

Tables VI. 4., 5., 6.

Table VI.4.

SUMMARY OF ANNUAL LOADINGS AND SOURCES OF POLLUTANTS TO THE TRIBUTARY RIVERS UPSTREAM OF THE ESTUARY: 1981-1983

Pollutants	Combined Sewer Overflows		Other Point Sources		Nonpoint Sources		Total	
	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total
Total Suspended Solids.	6,132,000	13.4	907,500	2.0	38,820,500	84.6	45,860,000	100.0
Volatile Suspended Solids . . .	3,280,000	26.2	- -	0.0	9,244,000	73.8	12,524,000	100.0
Biochemical Oxygen Demand .	2,044,000	32.6	683,500	10.9	3,539,500	56.5	6,267,000	100.0
Total Phosphorus	48,000	21.1	17,100	7.5	162,600	71.4	227,700	100.0
Ammonia Nitrogen	41,000	13.7	8,100	2.7	250,900	83.6	300,000	100.0
Lead	25,500	30.1	60	0.1	59,240	69.8	84,800	100.0

Source: SEWRPC.

Table VI.5.

SUMMARY OF ANNUAL LOADINGS AND SOURCES OF POLLUTANTS TO THE INNER HARBOR: 1981-1983

Pollutants	Combined Sewer Overflows						Other Point Sources: Upstream and Directly Tributary To Inner Harbor		Upstream Nonpoint Sources		Direct Draining Nonpoint Sources		Total	
	Upstream		Direct Inner Harbor		Total									
	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent	Loading (pounds)	Percent	Loading (pounds)	Percent	Loading (pounds)	Percent of Total
Total Suspended Solids.	6,132,000	10.6	11,336,000	19.6	17,468,000	30.2	907,500	1.6	38,820,500	67.0	722,000	1.2	57,918,000	100.0
Volatile Suspended Solids . . .	3,280,000	17.5	6,064,000	32.3	9,344,000	49.8	- -	0.0	9,244,000	49.2	187,400	1.0	18,775,400	100.0
Biochemical Oxygen Demand .	2,044,000	20.2	3,778,000	37.4	5,822,000	57.6	683,500	6.8	3,539,500	35.0	58,600	0.6	10,103,600	100.0
Total Phosphorus	48,000	15.2	88,000	27.8	136,000	43.0	17,100	5.4	162,600	51.3	1,000	0.3	316,700	100.0
Ammonia Nitrogen	41,000	10.9	76,000	20.2	117,000	31.1	8,100	2.1	250,900	66.7	300	0.1	376,300	100.0
Lead	25,500	19.0	47,000	35.1	72,500	54.1	60	0.1	59,240	44.2	2,200	1.6	134,000	100.0

Source: SEWRPC.

Table VI.6.

SUMMARY OF ANNUAL LOADINGS AND SOURCES OF POLLUTANTS TO THE OUTER HARBOR[a]: 1981-1983

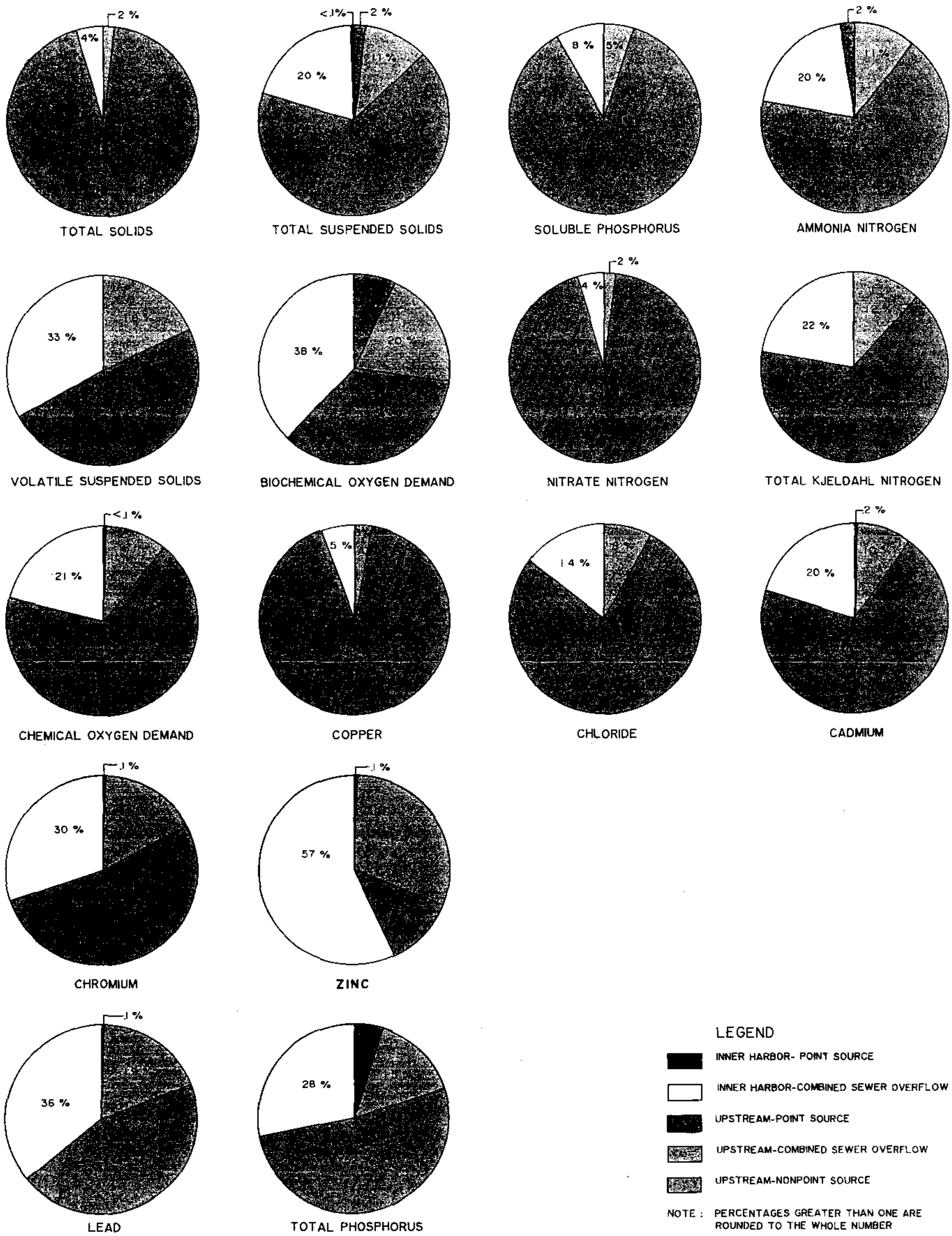
Pollutants	Inner Harbor		Jones Island Wastewater Treatment Plant		Combined Sewer Overflows Discharged Directly to Outer Harbor		Total	
	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total	Loading (pounds)	Percent of Total
Total Suspended Solids.	22,593,500	73.4	7,060,100	22.9	1,115,000	3.7	30,768,600	100.0
Biochemical Oxygen Demand . .	6,018,900	54.9	4,569,000	41.7	372,000	3.4	10,959,900	100.0
Total Phosphorus	220,400	55.2	169,500	42.5	9,000	2.3	398,900	100.0
Ammonia Nitrogen	121,800	4.5	2,561,000	95.2	8,000	0.3	2,690,800	100.0
Lead	68,800	67.5	28,600	28.0	4,600	4.5	102,000	100.0

[a]*Does not include pollutant loadings to the outer harbor from Lake Michigan.*

Source: SEWRPC.

Figure VI.1

EXISTING SOURCES OF POLLUTION TO THE INNER HARBOR



Source: SEWRPC.

Urban runoff samples from commercial, high density residential, medium density residential, and parking lot areas, were collected and analyzed under the Nationwide Urban Runoff Program study in Milwaukee County (Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Bannerman et. al, WDNR, USGS, SEWRPC, 1983). The lead, copper and zinc acute toxicity standard for warm water fish communities was frequently exceeded in the storm sewers monitored during the NURP study. Based upon NR 105 and NR 106, Wis. Adm. Codes, for toxic water quality criteria, lead, copper, and zinc acute toxicity standards at a hardness of 100 mg/l $CaCO_3$, are 169 ug/l, 17 ug/l and 103 ug/l, respectively. Hardness of 100 mg/l $CaCO_3$ is considered typical for stormwater in the Milwaukee area. Table VI.7. listed the percent of the monitored events that exceeded the acute toxicity standard. The standard was compared to probability plots of the event mean concentrations for each metal. The event mean concentration is a flow weighted measure used by the U.S.EPA to determine if a water quality standard has been exceeded.

Table VI. 7. Probability of Storm Water Runoff Exceeding Acute Toxicity Criteria for Warm Water Fish Communities[1]

	Percent Probability of Exceeding Acute Toxicity Criteria[2]			
Tributary Area Land Use	Lead	Zinc	Copper	Cadmium
Commercial	90%	90%	>50%	0%
Parking Lots	45%	55%	>10%	0%
High Density Resid.	70%	75%	>10%	0%
Med. Density Resid.	20%	30%	>10%	0%

1 Based on measured data obtained from storm sewer outfalls.

2 As determined by stormwater runoff event mean pollutant concentrations.

Source: Wisconsin Department of Natural Resources, A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, 1990.

The Nationwide Urban Runoff Program studies also found that, in general, toxic organic pollutants were present in the runoff at problem levels much less frequently than metals. The most commonly detected organic substances include the plasticizer bis(2 ethyl hexyl)phthalate and the pesticide alpha-hexachlorocyclohexane (alpha BHC), which were detected in 22 and 20 percent of the urban runoff samples, respectively.

Runoff from Adjacent Industrial Areas

During the SEWRPC Milwaukee Harbor Estuary Study, two stormwater runoff quality surveys were conducted to determine the type, concentration, and loadings of pollutants being discharged from industrial areas immediately adjacent and directly tributary to the Inner Harbor. Stormwater runoff samples were collected on August 30, 1984, and on September 24 and 25, 1984. The sampling was conducted at eight stations, as described in Table VI. 8. Of the eight stations, five are located on the Menomonee River portion of the estuary and three along the Kinnickinnic River portion of the estuary. Stormwater runoff from coal, salt, and scrap iron storage areas, as well as from general industrial use areas, was sampled.

Table VI.8.

DESCRIPTION OF INDUSTRIAL SITE SAMPLING STATIONS

Station Number	Description
1	Menomonee River salt pile—Station is located adjacent to the Menomonee River on the north side between 16th and 25th Streets, east of the Schwerman Trucking Company lot. Samples were collected from overland flow.
2	Wisconsin Electric Power Company coal pile—Station is located adjacent to the South Menomonee Canal on the north side, to the east of S. 11th Street. Samples were collected from a storm drain leading to the canal.
3	Morton Salt Company storage pile—Station is located at east end of Canal Street adjacent to the Burnham Canal. Samples were collected from overland flow.
4	Cargill railroad yard—Station is located adjacent to South Menomonee Canal, on the south side. Samples were collected from buried container in overland flow path to canal.
5	Miller Compressing Company scrap iron yard—Station is located adjacent to the Burnham Canal on the north side. Sample collected from storm drain.
6	Kinnickinnic River turning basin scrap iron yard—Station is located at the south end of the basin on the west side. Samples were collected from ponded areas adjacent to scrap iron piles.
7	Kinnickinnic River turning basin salt pile—Station is located on east side of basin near U. S. Steel Corporation warehouse. Samples were collected from overland flow.
8	Milwaukee heavy lift dock—Station is located adjacent to Kinnickinnic turning basin on east side at north end. Samples were collected from storm drain.

Source: U. S. Geological Survey.

A summary of the water quality data collected during the two runoff events is set forth in Table VI. 9. The samples were analyzed for a total of 32 water quality indicators. Concentrations of several toxic metal and organic substances were detected in the surface runoff, although, with the exception of phenols, the concentration of organic substances were very low.

Table VI.9.

WATER QUALITY DATA COLLECTED AT DIRECTLY TRIBUTARY INDUSTRIAL STATIONS: AUGUST 30 AND SEPTEMBER 25, 1984

Indicator	Sample Stations and Date																
	1		2		3		4		5		6		7		8		
	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Aug. 30	Sept. 25	Mean
Aldrin (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic (μg/l)	--	3	--	7	--	3	--	3	--[a]	4	--	2	--	4	--	1	3
Barium (μg/l)	<100	400	100	200	100	200	300	400	--[a]	400	<100	200	200	400	<100	200	200
Beryllium (μg/l)	<10	10	<10	<10	90	<10	<10	<10	--[a]	<10	<10	<10	10	<10	<10	<10	10
Calcium (mg/l)	83	130	41	85	1,100	720	1	380	--[a]	81	17	17	110	420	18	38	218
Chlordane (μg/l)	<0.10	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	--[a]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium (μg/l)	40	40	10	20	170	180	100	60	--[a]	70	20	50	60	210	20	20	70
Cobalt (μg/l)	210	110	< 50	480	4,500	1,800	270	140	--[a]	500	<50	390	1,400	2,000	<50	260	800
Copper (μg/l)	50	40	420	90	470	330	510	290	--[a]	600	40	120	120	220	30	60	230
DDD (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
DDE (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	0.0160	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.011
DDT (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	0.020	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Dieldrin (μg/l)	<0.010	--	<0.010	<0.010	<0.010	0.020	<0.010	0.020	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Endosulfan (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Endrin (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Heptachlor (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Heptachlor Epoxide (μg/l)	<0.010	--	<0.010	<0.010	<0.010	0.020	<0.010	<0.010	--[a]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (μg/l)	6,700	11,000	23,000	9,300	7,900	4,900	54,000	26,000	--[a]	24,000	6,300	53,000	3,900	14,000	3,300	2,700	16,700
Lead (μg/l)	200	400	300	85	2,200	1,500	1,200	700	--[a]	1,700	<80	300	700	1,400	85	49	721
Lindane (μg/l)	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	--[a]	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.010	<0.010
Lithium (μg/l)	10	20	60	30	90	40	40	10	--[a]	50	10	10	10	10	<10	10	30
Magnesium (mg/l)	19	38	13	28	140	75	360	150	--[a]	16	6	6	19	110	6	13	67
Manganese (μg/l)	260	490	360	180	280	260	1,400	770	--[a]	480	210	580	240	470	190	280	430
Mercury (μg/l)	0.7	0.2	0.6	0.3	0.9	1.0	0.3	0.2	--[a]	7	0.10	0.50	0.60	1.6	0.10	0.30	1.0
Methoxychlor (μg/l)	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--[a]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mirex (μg/l)	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--[a]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum (μg/l)	1	--	31	--	29	--	29	--	--[a]	--	330	--	31	--	3	--	65
Napthalenes, Polychlor (μg/l)	<0.10	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	--[a]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PCB's (μg/l)	<0.10	--	<0.10	<0.10	<0.10	<0.10	0.30	<0.10	--[a]	<0.10	<0.10	<0.10	0.60	<0.10	<0.10	<0.10	0.06
Perthane (μg/l)	<0.10	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	--[a]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenols (μg/l)	<1	4	<1	2	<1	3	<1	2	--[a]	39	19	9	160	1	8	24	18
Toxaphene (μg/l)	<1	--	7	<1	<1	<1	<1	<1	--[a]	<1	4	<1	<1	<1	<1	<1	1

[a] *No data, insufficient runoff.*

Source: U. S. Geological Survey.

A pollutant loading analysis was conducted for arsenic, chromium, lead, mercury, and phenols because relatively high levels of the substances were measured, and because theses substances are representative of the types of pollutants found in the runoff. Annual pollutant loadings to the Inner Harbor were estimated using the Hydrological Simulation Program-Fortran (HSPF) model. The model was used to simulate runoff from salt, coal, and scrap iron storage areas and from general industrial areas.

An average contaminant concentration was determined for each type of storage station using the data from the runoff sample analysis. Annual pollutant loadings to the estuary were estimated using the annual runoff volume from each type of storage area and the average concentration for each pollutant. In estimating the loadings from each type of facility, the area adjacent to each storage pile which appeared to be saturated with material as well as the storage pile itself was considered. Loads from each type of storage area were then summed for each pollutant to determine the total load to the Inner Harbor from the industrial areas directly tributary to the Menomonee and Kinnickinnic River portions of the estuary.

A summary of the annual loading estimates to the Inner Harbor from directly tributary industrial areas is set forth in Table VI. 10.

Table VI.10.

ESTIMATED ANNUAL POLLUTANT LOADINGS OF LEAD, PHENOLS, CHROMIUM, MERCURY, AND ARSENIC TO THE INNER HARBOR FROM DIRECTLY TRIBUTARY INDUSTRIAL AREAS: 1981-1983

	Estimated Loading (pounds)		
Pollutant	1981	1982	1983[a]
Lead	856	1,205	817
Phenols	17.5	22.0	16.3
Chromium	50.8	65.8	49.1
Mercury.	1.6	1.9	1.4
Arsenic	2.7	3.4	2.6

[a]From January 1 through September 30, 1983. About 82 percent of annual loading typically occurs from January through September.

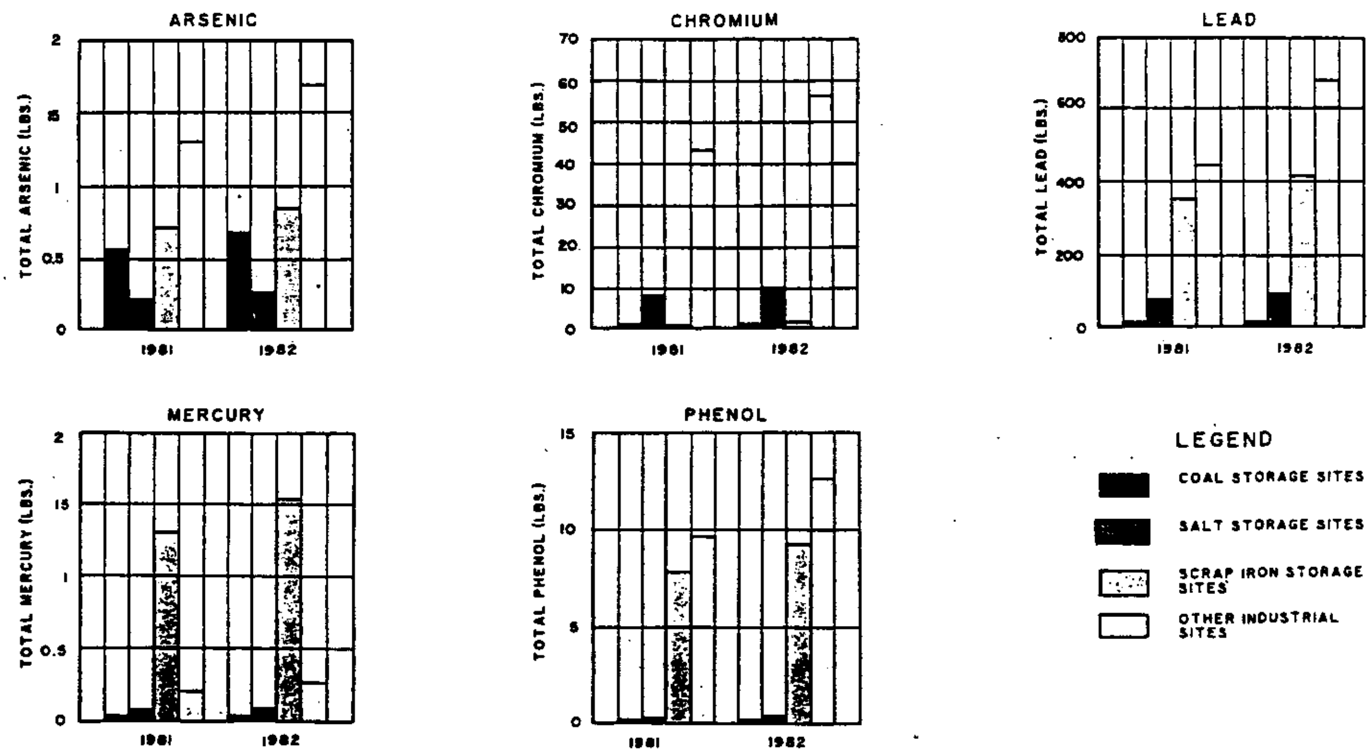
Source: U. S. Geological Survey.

Mean annual lead loadings to the Inner Harbor from the Menomonee and Kinnickinnic Rivers were estimated to total 14,200 pounds. The annual lead loadings from directly tributary industrial areas of 900 to 1200 pounds represents 6 to 8 percent of the total river loading of lead to the Menomonee and Kinnickinnic River portions of the estuary.

The sources of the loadings of arsenic, chromium, lead, mercury, and phenols from directly tributary industrial areas are illustrated in Figure VI. 2. The "other industrial sites" category accounts for the majority of the loadings of all pollutants analyzed, except mercury. Scrap iron storage stations contribute about 80 percent of the mercury loadings. For arsenic, lead, and phenols, the scrap iron storage stations constitute the second largest source. Salt storage areas constitute the second largest source of chromium loadings, and other industrial areas constitute the second largest source of mercury loadings.

Figure VI.2.

SOURCES OF POLLUTANTS FROM DIRECTLY TRIBUTARY INDUSTRIAL AREAS TO THE MENOMONEE AND KINNICKINNIC PORTIONS OF THE ESTUARY: 1981-1982



Source: U. S. Geological Survey.

In-place Pollutants/Contaminated Sediment as a Source

The heavily contaminated sediments in the Milwaukee area of concern serve as a source as well as a sink for a variety of pollutants. Sediment oxygen demand is the primary cause of dissolved oxygen depletion in the Inner Harbor under low-flow conditions. Sediment oxygen demand is the oxygen consumed by bacteria that decompose sediment organic matter.

Toxic substances pose the greatest threat to aquatic life when they are released from the sediment to the interstitial water, where biological uptake can occur.

A preliminary analysis of the release of toxic organic substances to the interstitial water under worst case conditions was conducted during the SEWRPC Milwaukee Harbor Estuary Study to determine whether concentrations of toxic substances in the interstitial water of the Inner and Outer Harbors exceed the acute or chronic criteria protecting warmwater fish and aquatic life. Likewise a preliminary analysis was developed for Chapter V, Problem Identification, to evaluate sediment analyses conducted since the SEWRPC Milwaukee Harbor Estuary Study.

Table VI.11. lists the 62 organic substances evaluated in the preliminary analysis of interstitial water concentrations conducted by SEWRPC in the Estuary Study. Sediment concentrations for 23 of the 62 substances analyzed in the SEWRPC study were found to be always below the minimum laboratory detection levels, and theses substances were therefore not evaluated further. The preliminary analysis of worst case conditions indicated that the calculated interstitial water concentrations of 18 of the remaining 39 substances may violate acute and chronic criteria for warmwater fish and aquatic life. These 18 substances were further evaluated.

For the final analysis, the interstitial water concentration of the 18 toxic organic substances were recalculated using the average concentration of organic carbon measured in the bottom sediments of each water body over the period 1982 through 1983. In comparison to the worst case conditions evaluated in the preliminary analysis, the final analysis presents a more realistic estimate of those substances which actually violate the criteria within the interstitial water.

The organic substances evaluated in the final analysis are listed in Table VI.12. While the preliminary analysis indicated that 18 organic substances may violate the criteria assuming the minimum organic carbon content, the final analysis indicated that only 11 of the substances would violate the criteria assuming the mean organic carbon content. The organic substances that were estimated to violate the acute or chronic criteria in the final analysis are listed in Table VI. 13. The criteria were estimated to be violated within the interstitial water for six organic substances within the Milwaukee River estuary, six organic substances within the Kinnickinnic River estuary, and eight organic substances within the Outer Harbor.

Sediment in the Milwaukee area of concern will continue to serve as a major source of pollutants until dredged or covered over by clean sediment.

Atmospheric Deposition

Atmospheric long-range transport and deposition of heavy metals and organic compounds such as PCBs is of concern in the Great Lakes, primarily because of the tremendous surface area involved. The "wet" portion of the Milwaukee area of concern is only 1600 acres in surface area. Using a PCB deposition rate of 10 ug/m^2 (Armstrong, 1990), this amounts to only about

60 grams of input annually from the atmosphere. It is unlikely that long-range transport and deposition is a major source of pollutants to the Milwaukee area of concern. No information is available on the importance of local emission and local deposition. Further study is needed to examine the impact of atmospheric deposition on the entire tributary river system and the Milwaukee River Basin.

Table VI.11.

ORGANIC SUBSTANCES EVALUATED IN THE PRELIMINARY ANALYSIS OF INTERSTITIAL WATER CONCENTRATIONS

Alpha-BHC	Endosulfan Sulfate
Acenapthene	Endrin
Beta-BHC	Fluoroanthene
Bis (2-chloroethyl) Ether[a]	Gamma-BHC
Bis (2-chloroethoxyl) Methane	Heptachlor
Bis (2-chloroisopropyl) Ether	Hexachlorobenzene[a]
Bis (2-ethylhexyl) Phthalate[a]	Hexachlorobutadiene
4-Bromophenol Phenyl Ether[a]	Hexachloroethane[a]
Butyl Benzyl Phthalate[a]	Hexachlorocyclopentadiene
Chlordane	Isophorone[a]
2-Chloronaphthalene[a]	Naphthalene
2-Chlorophenol	Nitrobenzene[a]
4-Chlorophenyl Phenyl Ether[a]	2-Nitrophenol
Delta-BHC[a]	4-Nitrophenol[a]
1,3-Dichlorobenzene[a]	n-Nitrosodimethylamine
1,4-Dichlorobenzene[a]	n-Nitrosodi-n-propylamine
1,2-Dichlorobenzene	N-nitrosodiphenylamine[a]
Dichloro diphenyl dichloro ethane	Pentachlorophenol[a]
Dichloro diphenyl dichloro ethylene	Phenols
Dichloro diphenyl trichloro ethane	Polychlorinated Biphenyls (PCB's)
Dichloromethane	Aroclor 1016[a]
2,4-Dichlorophenol	Aroclor 1221
Dieldrin	Aroclor 1242
Diethyl Phthalate[a]	Aroclor 1248
4,6-Dinitro-o-cresol	Aroclor 1254
2,4-Dimethylphenol	Aroclor 1260
2,4 Dinitrotoluene	Toluene
Di-n-butyl Phthalate[a]	Toxaphene
Di-n-octyl Phthalate[a]	1,2,3-Trichlorobenzene[a]
1,2-Diphenylhydrazine	2,4,6-Trichlorophenol[a]
Endosulfan I	Trichloroethene[a]
Endosulfan II	

[a]*Organic substances that were always below detection level.*

Source: SEWRPC.

Table VI.12.

ORGANIC SUBSTANCES EVALUATED IN THE FINAL ANALYSIS OF INTERSTITIAL WATER CONCENTRATIONS

Inner Harbor			
Milwaukee River	Menomonee River	Kinnickinnic River	Outer Harbor
Acenapthene[b]	Acenapthene[a]	Dichloro diphenyl dichloro ethane[b]	Chlordane[b]
Dichloro diphenyl dichloro ethane[b]	Dichloro diphenyl dichloro ethane[b]	Heptachlor[b]	Dieldrin[a]
Dichloro diphenyl trichloro ethane[b]	Dichloro diphenyl trichloro ethane[b]	Naphthalene[a]	Endrin[b]
Dichloromethane[b]	Endrin[b]	Polychlorinated Biphenyls Aroclor 1221[b] Aroclor 1242[b] Aroclor 1248[a] Aroclor 1254[b]	Gamma-BHC[b]
Endrin[b]	Naphthalene[a]		Heptachlor[b]
Fluoroanthene[b]	Phenols[b]		Phenols[a]
Gamma-BHC[b]	Polychlorinated Biphenyls Aroclor 1242[b] Aroclor 1254[b]		Polychlorinate Biphenyls Aroclor 1242[b] Aroclor 1248[a] Aroclor 1254[b]
Heptachlor[b]			
Phenols[b]			
Polychlorinated Biphenyls Aroclor 1242[b] Aroclor 1248[b] Aroclor 1254[b] Aroclor 1260[b]			
Toluene[b]			

NOTE: Those substances that were below the detection level were not evaluated in the final analysis.

[a]*Based on the preliminary analysis, the concentration of these substances in the interstitial water may violate the chronic criteri*

[b]*Based on the preliminary analysis, the concentration of these substances in the interstitial water may violate both the chron. and acute criteria.*

Source: SEWRPC.

Table VI.13.

ORGANIC SUBSTANCES WHICH MAY VIOLATE THE ACUTE OR CHRONIC CRITERIA IN THE INTERSTITIAL WATER OF THE BOTTOM SEDIMENTS: FINAL ANALYSIS

Organic Substance	Octanol Water Partition Coefficient (Kow, in l/Kg)	Warmwater Fish and Aquatic Life Criteria (µg/l)		Inner Harbor						Outer Harbor	
				Milwaukee River		Menomonee River		Kinnickinnic River			
		Acute	Chronic	Maximum Substance Concentration in Sediment (mg/kg dry weight)	Calculated Substance Concentration in the Interstitial Water (µg/l)	Maximum Substance Concentration in Sediment (mg/kg dry weight)	Calculated Substance Concentration in the Interstitial Water (µg/l)	Maximum Substance Concentration in Sediment (mg/kg dry weight)	Calculated Substance Concentration in the Interstitial Water (µg/l)	Maximum Substance Concentration in Sediment (mg/kg dry weight)	Calculated Substance Concentration in the Interstitial Water (µg/l)
Chlordane	2,108	6.9	0.2	--	--	--	--	--	--	0.44	8.70[b]
Dichloromethane	17.8	118,000	20,000	30.0	63,500[a]	--	--	--	--	--	--
Endrin	1,619-4,050	0.33	0.15	0.02	0.47[b]	--	--	--	--	0.03	0.77[a]
Gamma-BHC	643	10.5	3.3	--	--	--	--	--	--	0.06	3.89[a]
Heptachlor	7,366	1.8	1.26	0.25	1,28[b]	--	--	0.25	1.57[a]	1.10	6.22[b]
Naphthalene	1,300-2,239	6,600	620	--	--	--	--	24.30	865[a]	--	--
Polychlorinated Biphenyls (PCB's)											
Aroclor 1221	630-12,300	2.02	2.02	--	--	--	--	1.00	73.50[b]	--	--
Aroclor 1242	380,200	2.64	0.35	31.7	3.14[b]	17.0	1.79[a]	40.60	4.94[b]	68.20	7.47[b]
Aroclor 1248	1,288,000	29	0.2	32.0	0.94[a]	--	--	11.09	0.39[a]	33.00	1.07[a]
Aroclor 1254	1,071,500-2,017,000	1.18	0.27	--	--	--	--	11.03	0.48[a]	15.30	0.59[a]
Phenols	28.8	17,500	1,370	1.56	2,044[a]	3.51	4,793[a]	--	--	2.83	3,805[a]

NOTE: Those substances that were below the detection level were not evaluated in the final analysis. The mean organic carbon contents measured in each water body were used to calculate the substance concentrations within the interstitial water.

[a] *Violates chronic criterion only.*

[b] *Violates acute and chronic criteria.*

Source: SEWRPC.

Spills, Illegal Dumping, and the Improper Disposal of Household Hazardous Waste

Industrial spills, illegal dumping, and the improper disposal of household hazardous waste in total may contribute a potentially significant amount of oil, gasoline and other pollutants to the AOC.

For years there has been substantial spilling of oil into Lincoln Creek from storm sewers and other sources (see map in Appendix VI.E). In 1988, the WDNR spent over $25,000 for repeated clean-ups of Lincoln Creek because of chronic pollution due to illegal storm sewer hook-ups. Similarly, from March, 1990 until February, 1991, more than $33,000 has been spend in the recovery or containment of spills on Lincoln Creek and the Kinnickinnic and Milwaukee Rivers.

Leaking underground gasoline storage tanks are also a serious potential source of pollution. In Milwaukee County, there are currently more than 500 cases of leaking underground tanks under investigation for corrective action by the WDNR.

The improper disposal of household hazardous waste may also be an additional source of pollutants to the AOC as used motor oil, paints, and other household hazardous wastes are dumped in alleys or down storm sewers. In Wisconsin each year, "do-it-yourself" mechanics dump approximately 90,000 gallons of used oil down storm sewers and another 2.6 million gallons on the ground. In an effort to address this problem, the City of Milwaukee has sponsored a "Clean Sweep" program which, in 1990, collected more than 2,000 gallons of used motor oil and nearly 8,000 gallons of other household hazardous wastes.

Although not quantified, this source category needs additional study as a potentially significant source of pollution to the AOC. The problem of spills and illegal dumping must be addressed.

SOURCES UPSTREAM OF THE AOC

Point Source Discharges

As of 1990, Wisconsin Pollutant Discharge Elimination System (WPDES) specific permits were issued to 11 municipal wastewater treatment facilities and 63 industrial wastewater dischargers which discharge to surface waters upstream of the inner harbor. Table VI. 14. summarizes the 1984 estimated pollutant loadings to surface waters from municipal and industrial wastewater discharges based upon flow and pollutant concentrations measurements contained within the DNR discharge monitoring reports. Table VI. 15. indicates that the point sources generally make up less than 10 percent of the total river pollutant loadings to the Inner Harbor. Other than combined sewers, pollutant loadings being discharged from point sources directly into the Inner Harbor are very low.

Table VI.14.

SUMMARY OF ESTIMATED DISCHARGE AND POLLUTANT LOADINGS FROM MUNICIPAL AND INDUSTRIAL WASTEWATER DISCHARGES: 1984[a]

Watershed and Type of Facility	Name of Facility	Mean Reported Discharge (mgd)	Suspended Solids	Fecal Coliform (No. x 10^7 per year)	Total Phosphorus	Ammonia Nitrogen	Biochemical Oxygen Demand	Chemical Oxygen Demand	Dissolved Solids	Chlorine	Cadmium	Chromium	Cobalt	Lead	Zinc	Oil/Grease	Dichloroethylene	Methylene Chloride	Phenols	Tetrachloroethane	Toulene	Trichloroethane
Kinnickinnic Industrial	Caterpillar Tractor Company	0.003	180	..	..	..	..	..	..	..	..	..	..	..	..	10	..	..				..
	Kurth Malting Corporation	0.430	..	..	..	..	..	..	..	700	..	..	..	..	..	..	..	..				..
	Rexworks, Inc.	0.020	180	..	..	..	..	..	..	..	..	..	..	..	..	180	..	..				..
	Union Oil Company of California	0.004	..	..	..	..	..	..	..	..	..	..	..	..	..	25	..	..				..
	Unit Drop Forge	0.094	2,380	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..				..
	Subtotal	0.511	2,700	..	..	..	..	..	..	700	..	..	..	..	..	215	..	..				..
Menomonee Industrial	Amoco Oil Company	0.007	..	..	..	..	..	..	..	..	..	..	..	..	..	40	..	..	..	..	..	..
	Briggs & Stratton[b]	0.193	..	..	..	..	..	..	..	..	..	..	..	..	..	2,110	..	..	..	..	..	..
	Chicago, Milwaukee, St. Paul & Pacific Railroad	0.301	5,800	..	..	..	..	..	..	..	..	..	..	..	..	4,175	..	..	..	..	..	..
	Chicago & North Western Transportation Company	0.020	480	..	..	..	..	..	..	..	..	..	..	..	..	530	..	..	..	..	..	..
	Falk Corporation	0.981	71,300	..	..	..	..	..	..	..	..	..	..	..	..	6,775	..	..	..	..	..	..
	Harnischfeger Corporation	0.282	2,700	..	..	..	..	..	..	..	..	..	..	..	..	2,520	..	..	..	..	..	..
	Koppers Company/Thiem Corporation	0.091	1,880	..	..	..	760	..	..	..	..	..	..	..	..	860	..	..	..	..	..	..
	Miller Brewing Company	1.519	..	..	..	..	15,490	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Milwaukee Marble Company[b]	0.001	20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Rexnord, Inc.-West Milwaukee Facility	0.132	1,100	..	..	..	..	..	..	..	..	..	9	..	..	1,160	..	..	..	..	..	..
	Stroh Die Casting Company, Inc.	0.008	120	..	..	..	5,000	..	..	..	..	..	..	..	..	825	..	..	..	..	..	..
	Union Oil Company of California	0.003	..	..	..	..	..	..	..	..	..	..	..	..	..	80	..	..	..	..	..	..
	United Parcel Service	0.11	1,720	..	40	..	1,620	..	..	..	..	..	..	..	..	2,300	..	..	..	..	..	..
	Veteran Administration Medical Center	0.004	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Waste Management of Wisconsin-Menomonee Falls	0.081	2,180	..	..	80	380	..	..	..	..	..	..	..	..	..	..	..	56	..	..	..
	Waste Management of Wisconsin-Omega Hills	0.103	5,880	..	..	..	1,590	8,810	..	..	..	..	..	..	..	..	0.76	0.37	381	0.38	0.38	0.38
	West Shore Pipeline Company-Granville Station	0.001	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..
	Western Metal Specialty Division	0.017	..	..	..	..	..	..	..	..	..	..	..	4	18	670	..	..	..	..	..	..
	Wisconsin Electric Power Company (Valley)[b]	73.50	..	..	..	..	..	..	..	875	..	..	..	..	..	..	..	..	..	..	..	..
	Subtotal	77.344	92,830	..	40	80	25,810	8,810	..	875	..	..	9	4	18	22,030	0.76	0.37	437	0.38	0.38	0.38
Menomonee Municipal	Germantown Sewage Treatment Plant	1.277	47,770	383,300	1,880	..	43,880	..	..	2,471	..	..	..	..	..	..	..	..	..	..	..	..
	Subtotal	1.277	47,770	383,300	1,880	..	43,880	..	..	2,471	..	..	..	..	..	..	..	..	..	..	..	..
Milwaukee Industrial	A. O. Smith Corporation	2.633	30,840	..	200	..	..	..	..	..	..	3	..	..	45	10,320	..	..	..	..	..	..
	Advance Die Casting	0.011	..	..	..	..	..	..	..	..	..	..	..	..	9	..	..	..	..	..	..	..
	American Motors Corporation-Milwaukee Manufacturing Plant	0.100	1,040	..	..	..	..	..	..	..	..	..	..	..	..	440	..	..	..	..	..	..
	Aqua-Chem, Inc.	0.028	30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Badger Meter, Inc.	0.125	..	..	..	..	..	..	..	..	..	..	..	..	..	410	..	..	..	..	..	..
	Culligan Water Conditioning of Milwaukee	0.032	1,000	..	..	..	..	..	26,350	..	..	..	..	..	..	..	..	..	..	..	..	..
	James B. Downing Company	0.329	21,000	..	..	2,210	..	..	80	..	..	..	..	..	..	..	..	..	..	..	..	..
	Johnson Brass & Machine Foundry	0.016	280	..	..	..	..	..	..	..	..	..	..	..	..	210	..	..	..	..	..	..
	Level Valley Dairy Company	0.272	358,130	..	..	..	324,900	..	..	140	..	..	..	..	..	..	..	..	..	..	..	..
	Evinrude Motors-Division of Outboard Marine Corporation	0.042	..	..	..	..	..	..	..	..	..	..	..	..	..	900	..	..	..	..	..	..
	Regal Ware, Inc.	0.332	1,410	..	..	..	..	..	..	..	3	..	..	57	..	..	..	..	..	..	..	..
	Subtotal	4.707	413,730	..	200	2,210	324,900	..	26,430	140	3	3	..	57	63	12,280	..	..	..	..	..	..
Milwaukee Municipal	Random Lake Sewage Treatment Plant	0.304	2,880	2,400	450	..	3,310	..	..	66	..	..	..	..	..	..	..	..	..	..	..	..
	Kewaskum Sewage Treatment Plant	0.441	11,180	5,840,000	900	1,300	56,712	..	..	1,316	..	..	..	..	..	..	..	..	..	..	..	..
	Campbellsport Sewage Treatment Plant	2.121	83,110	2,008,700	..	..	89,503	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Cascade Sewage Treatment Plant	0.052	3,060	137,000	..	..	2,950	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Cedarburg Sewage Treatment Plant	2.022	126,930	31,718,100	4,080	1,680	45,160	..	..	190	..	..	..	..	..	..	..	..	..	..	..	..
	Fredonia Sewage Treatment Plant	0.187	2,350	38,600	..	..	8,080	..	..	120	..	..	..	..	..	..	..	..	..	..	..	..
	Grafton Sewage Treatment Plant	1.187	27,980	1,426,100	2,580	1,980	15,510	..	..	2,130	..	..	..	..	..	..	..	..	..	..	..	..
	Jackson Sewage Treatment Plant	0.348	5,718	38,500	580	880	4,470	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Newburg Sewage Treatment Plant	0.061	4,490	3,428,700	..	..	4,840	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Saukville Sewage Treatment Plant	0.518	12,220	100,500	800	..	17,730	..	..	266	..	..	..	..	..	..	..	..	..	..	..	..
	Thiensville Sewage Treatment Plant	0.983	34,020	2,521,300	..	..	21,320	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	West Bend Sewage Treatment Plant	3.760	4,810	3,370,800	5,390	310	7,000	..	..	85	..	..	..	..	..	..	..	..	..	..	..	..
	Subtotal	11.881	318,118	50,333,200	14,770	5,850	276,580	..	..	4,190	..	..	..	..	..	..	..	..	..	..	..	..
Upstream Industrial		9.081	509,040	..	240	2,270	350,710	8,810	26,430	840	3	3	9	61	69	37,415	0.76	0.37	437	0.38	0.38	0.38
Upstream Municipal		13.158	365,880	50,718,500	18,330	5,850	320,240	..	..	4,190	..	..	..	..	..	..	..	..	..	..	..	..
Upstream Total		22.219	874,920	50,718,500	18,570	8,120	670,950	8,810	26,430	5,030	3	3	9	61	69	37,415	0.76	0.37	437	0.38	0.38	0.38
Inner Harbor[b] Industrial		73.501	70	..	..	..	..	..	..	875	..	..	..	..	..	2,110	..	..	..	..	..	
Inner Harbor[b] Municipal		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Inner Harbor[b] Total		73.501	70	..	..	..	..	..	..	875	..	..	..	..	..	2,110	..	..	..	..	..	
Total Industrial		82.582	509,080	..	240	2,270	350,710	8,810	26,430	1,415	3	3	9	61	69	34,525	0.76	0.37	437	0.38	0.38	0.38
Total Municipal		13.158	365,880	50,718,500	18,330	5,850	320,240	..	..	4,190	..	..	..	..	..	..	..	..	..	..	..	..
Total		95.770	874,940	50,718,500	18,570	8,120	670,950	8,810	26,430	5,606	3	3	9	61	69	34,525	0.76	0.37	437	0.38	0.38	0.38

[a] Unless otherwise noted, all figures indicate pounds per year.

[b] Facilities which discharge directly to the Inner Harbor.

Source: Wisconsin Department of Natural Resources, Wisconsin Pollutant Discharge Elimination System Permits and Discharge Monitoring Reports.

Table VI.15.

COMPARISON OF THE EXISTING UPSTREAM POINT SOURCE LOADINGS TO THE TOTAL RIVER LOADINGS OF POLLUTANTS

Pollutant	Known Point Source Loadings Upstream of Inner Harbor (pounds unless noted)	Total River Loadings to Inner Harbor (pounds unless noted)	Point Source Percent of Total River Loading
Suspended Solids	907,500	45,860,000	1.98
Fecal Coliform	5.0×10^{14} counts	537.1×10^{14} counts	0.93
Phosphorus	17,100	227,700	7.51
Ammonia Nitrogen	8,100	300,000	2.70
Biochemical Oxygen Demand	683,500	6,267,000	10.91
Chemical Oxygen Demand	6,800	43,800,000	0.02
Cadmium	3	1,800	0.17
Chromium	3	8,000	0.04
Lead	61	84,800	0.07
Zinc	69	22,200	0.31

Source: SEWRPC.

Nonpoint Sources

Annual loadings of pollutants transported into the Inner Harbor via the Milwaukee, Menomonee, and Kinnickinnic Rivers were estimated using the 1981 through 1983 baseline water quality data collected during the SEWRPC Milwaukee Harbor Estuary Study. The loadings were estimated for the Milwaukee River at the North Avenue dam, for the Menomonee River at S. 37th Street, and for the Kinnickinnic River at S. 9th Place, which were the first sampling stations located on each river upstream of the Inner Harbor.

A summary of the estimated annual pollutant loadings to the Inner Harbor from the tributary rivers over the period 1981 through 1983 is set forth in Table VI. 16. For the various water quality indicators shown in the table, the Milwaukee River contributes from 57 to 97 percent of the total river loadings; the Menomonee River contributes 3 to 33 percent; and the Kinnickinnic River contributes less than 1 and up to 19 percent.

Nonpoint source pollution to tributary streams greatly outweighs point source discharge, and is a serious problem upstream of and within the area of concern.

Table VI.16.

SUMMARY OF THE ESTIMATED ANNUAL POLLUTANT LOADINGS TO THE INNER HARBOR FROM THE MILWAUKEE, MENOMONEE, AND KINNICKINNIC RIVERS: 1981-1983[a]

Year	Station	Total Solids	Total Suspended Solids	Volatile Suspended Solids	Fecal Coliform	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Inorganic Carbon	Total Phosphorus	Soluble Phosphorus
1981	Milwaukee River at North Avenue Dam (RIV-5)	823,000	33,500	9,790	289.0	4,430	--	--	--	191	88
	Menomonee River at S. 37th Street (RIV-10)	89,300	6,230	1,070	229.0	--	--	--	--	31	13
	Kinnickinnic River at S. 9th Place (RIV-13)	17,700	709	220	29.6	--	--	--	--	2	2
	Total	730,000	40,439	11,080	547.6	4,430	--	--	--	224	103
1982	Milwaukee River at North Avenue Dam (RIV-5)	810,000	34,100	9,820	544.0	3,810	40,100	9,320	45,500	207	102
	Menomonee River at S. 37th Street (RIV-10)	147,000	11,300	4,820	203.0	2,940	5,960	126	729	64	28
	Kinnickinnic River at S. 9th Place (RIV-13)	27,100	2,640	864	6.39	889	3,370	446	1,300	7	3
	Total	984,100	48,040	15,004	753.4	7,619	49,430	11,026	54,090	268	133
1983	Milwaukee River at North Avenue Dam (RIV-5)	518,000	31,800	10,300	222.0	3,260	31,000	11,000	62,600	156	86
	Menomonee River at S. 37th Street (RIV-10)	177,000	11,100	1,980	78.7	935	6,580	2,330	12,700	33	17
	Kinnickinnic River at S. 9th Place (RIV-13)	20,800	309	87	9.31	125	687	181	1,160	2	1
	Total	716,800	43,209	12,377	308.1	4,310	38,267	13,511	76,460	191	104
Mean	Milwaukee River at North Avenue Dam (RIV-5)	650,000	33,100	9,870	352.0	3,830	35,500	10,160	54,000	185	92
	Menomonee River at S. 37th Street (RIV-10)	137,000	9,540	2,580	170.0	1,940	6,270	1,800	10,000	39	19
	Kinnickinnic River at S. 9th Place (RIV-13)	21,900	1,220	294	15.1	497	2,030	314	1,230	4	2
	Total	708,900	45,860	12,524	537.1	6,267	43,800	12,274	65,230	228	113

Year	Station	Ammonia Nitrogen	Un-ionized Ammonia Nitrogen	Nitrate Nitrogen	Nitrite Nitrogen	Total Kjeldahl Nitrogen	Chlorophyll-a	Chlorides	Cadmium	Chromium	Copper	Iron	Lead	Zinc
1981	Milwaukee River at North Avenue Dam (RIV-5)	189.0	6.8	990.0	25.0	1,590.0	82.6	47,800	--	--	--	--	--	--
	Menomonee River at S. 37th Street (RIV-10)	32.8	0.7	212.0	5.7	143.0	15.0	9,280	--	--	--	--	--	--
	Kinnickinnic River at S. 9th Place (RIV-13)	5.4	0.3	17.8	1.1	22.3	0.2	1,720	--	--	--	--	--	--
	Total	207.2	7.8	1,219.8	31.8	1,755.3	84.3	58,580	--	--	--	--	--	--
1982	Milwaukee River at North Avenue Dam (RIV-5)	319.0	6.7	1,290.0	29.2	1,420.0	24.3	84,000	1.20	5.5	127.0	141	67.7	15.7
	Menomonee River at S. 37th Street (RIV-10)	58.1	0.9	315.0	7.6	230.0	1.8	30,800	0.10	0.9	0.6	33	5.8	1.5
	Kinnickinnic River at S. 9th Place (RIV-13)	9.0	0.3	26.7	1.2	40.9	0.3	5,700	0.03	1.4	0.1	7	0.8	0.4
	Total	386.1	7.9	1,631.7	38.0	1,690.9	26.4	90,500	1.33	7.8	127.7	180	74.3	17.6
1983	Milwaukee River at North Avenue Dam (RIV-5)	253.0	6.2	1,150.0	28.7	1,307.0	23.1	59,500	1.80	5.7	5.2	713	73.5	21.6
	Menomonee River at S. 37th Street (RIV-10)	51.1	1.9	224.0	7.7	263.0	3.3	32,900	0.50	2.2	1.8	136	20.1	4.3
	Kinnickinnic River at S. 9th Place (RIV-13)	2.8	0.2	14.7	0.8	21.5	0.2	5,040	0.05	0.2	0.2	13	1.8	1.0
	Total	306.9	8.3	1,388.7	37.2	1,591.5	26.6	97,440	2.35	8.1	7.3	862	95.2	26.9
Mean	Milwaukee River at North Avenue Dam (RIV-5)	247.0	6.6	1,140.0	27.6	1,440.0	36.7	63,700	1.50	5.6	66.1	427	70.6	18.6
	Menomonee River at S. 37th Street (RIV-10)	47.3	1.2	250.0	7.0	212.0	2.2	24,300	0.30	1.6	1.2	84	13.0	2.9
	Kinnickinnic River at S. 9th Place (RIV-13)	5.7	0.3	19.7	1.0	28.2	0.2	4,150	0.04	0.8	0.2	10	1.2	0.7
	Total	300.0	8.1	1,410.0	35.8	1,680.0	39.1	92,150	1.80	8.0	67.5	521	84.8	22.2

[a] All loadings in 1,000 pounds except fecal coliform, in No. x 10^{14}.

Source: SEWRPC.

Landfills

In that portion of the Milwaukee River Basin comprised of Milwaukee County, there are 90 known active or abandoned landfills, and most are located within one mile of the three tributary rivers of their adjoining streams (Appendix IV.G.). The extent to which these sites contribute to pollution in the Milwaukee estuary is largely unknown and needs further evaluation.

Upstream Sites of Major Contamination

Cedar Creek

The 126-square-mile Cedar Creek watershed (Appendix VI.E.), which lies north of the AOC, is the smallest of the five major drainage areas comprising the Milwaukee River basin. A 5.7 mile section of Cedar Creek flows through Cedarburg and joins the Milwaukee River approximately 24 miles upstream from the AOC. This stream section includes five dams and impoundments. Four of the impoundments contain sediments heavily contaminated with PCBs. In 1986, the WDNR (Warzyn and Wakeman, 1986) studied the distribution of PCB-contaminated sediments in these four impoundments and concluded:

1. PCB-contaminated fish populations exist in the lower stream miles of Cedar Creek, extending to the lower stream miles of the Milwaukee River and into Milwaukee Harbor.

2. Large volumes of PCB-contaminated sediments exist throughout the four-pond study area (approximately 165,267 cubic yards, with a length weighted mean PCB concentration of 54.1 ppm).

3. The PCB isomer Aroclor 1260 was by far the predominant isomer present in the sediments, and the only isomer detected in fish tissue.

4. The most PCB-contaminated "hot spots" were immediately downstream of the wastewater discharge points form four historic point sources.

5. Mixing in the upper sediments and an influx of cleaner sediments occurs slowly.

6. The PCB-laden in situ sediments are a threat to the biota.

The predominance of Aroclor 1260 suggests significant source(s) exist or existed in the drainage of Ruck Pond, the northernmost contaminated impoundment. The downstream distribution of Aroclor 1260 suggests contaminated sediment in Ruck Pond may be the major source of Aroclor 1260 downstream. Recent analysis of sediment cores from Ruck Pond found concentrations of Aroclor 1260 as high as 41,000 ppm. (4.1 percent) (Wisconsin State Laboratory of Hygiene, October, 1990).

The WDNR is accessing possible state and federal remediation programs and initiated an investigation to be completed in 1991 of Potentially Responsible Parties (PRPs) for PCB contamination in Cedar Creek. Also expected in 1991 are preliminary results of a study begun by WDNR in 1990 determining the amount of PCB-contaminated sediment carried from Cedar Creek downstream. The contaminated sediments in Cedar Creek are potentially a significant source to the Milwaukee River and the AOC.

Lincoln Creek

Lincoln Creek is also a potential, significant source of contamination to the AOC. The 9-mile long creek is a continuous tributary to the Milwaukee River draining 19.3 square miles of the communities of Milwaukee, Glendale, and Brown Deer. Lincoln Creek joins the Milwaukee River approximately 4 miles north of the AOC (See Appendix VI.E).

The most recent chemical and physical water quality information for Lincoln Creek was collected from 1975-1977. Samples indicated nutrient, heavy metal, BOD^5 and chloride concentrations increased downstream as a result of urban runoff and municipal and industrial point source contributions. One water sample contained 3.2 ug/l of PCB as Aroclor 1248 and 0.1 ug/l as the pesticide Lindane. DDT and its isomers DDD and DDE were also detected. Lead and zinc concentrations exceeded or approximated the recommended instream chronic toxicity water quality standard in NR 105. Elevated heavy metal concentrations occur during rainstorms and snowmelts.

In developing "A Nonpoint Source Control Plan for the Milwaukee River South Priority Watershed Project", information about existing and planned urban development was used by the WDNR in its Source Loading and Management Model (Pitt and Voorhees, 1989) to estimate urban nonpoint source loads for three pollutants, sediment, phosphorus, and lead.

In the plan lead was presumed to indicate the likely presence of other toxic pollutants. Identification of the magnitude and distribution of urban nonpoint source loadings and land use contributing to the loads was derived from existing data. Using urban development plans, WDNR estimated future pollution potential associated with uncontrolled development. In addition, an assessment was made of the urban management levels necessary to reduce urban pollutant loads to acceptable levels by the year 2000.

Using this modeling method, the WDNR concludes the Lincoln Creek subwatershed contributes 40 percent of the urban pollutant load generated in the entire Milwaukee River South Watershed, including 42 percent of total lead (approximately 8,000 pounds), 43 percent of total phosphorus (approximately 8,000 pounds), and 43 percent of suspended solids (approximately 1,900 tons). (A Nonpoint Source Control Plan for the Milwaukee River South Priority Watershed Project", 1990). The WDNR calculates Lincoln Creek has a flow weighted annual concentration of lead of 270-290 ug/l. Based on this calculation, a 35 to 40 percent reduction in lead loading is required to reduce the average concentrations below the acute toxicity standard in NR 105 (170 ug/l, hardness of 100 mg/l $CaCO_3$).

In addition, the sediment load of Lincoln Creek is 6,505 tons per year, or 56 percent of the suspended sediment load of the major tributary subwatersheds in the Milwaukee River South Watershed (WDNR, 1990). Of this load, 65 percent is from construction site erosion, while an additional 29 percent comes from the three urban areas of the subwatershed and 7 percent is the result of streambank erosion (WDNR, 1990). Based on EPA Region V Sediment Classification of Great Lakes Harbor Sediments, sediment samples from Lincoln Creek indicates sediments are "moderately" to "heavily polluted" by zinc, oil and grease, chromium and copper. (Triad Engineering/MMSD, 1987).

In addition to nonpoint sources, municipal and industrial point sources contribute to Lincoln Creek's degraded water quality. As of 1984, approximately 18 known industrial dischargers and 55 municipal sanitary sewer relief devices or combined sewers discharged to Lincoln Creek. Of the 18 industrial dischargers, 15 are non-contact cooling water dischargers-two of which include water treatment or biocide additives.

Since prior to 1983 one or more known sources of iron sulfate and other heavy metals randomly discharge into Lincoln Creek via a major storm sewer. Similarly, industrial spills (intentional or accidental) are a chronic problem in Lincoln Creek and include solvents, paint, cutting and lubricating oils, fuel oils and "pickling" liquor (Fe_2SO_4). In addition, leachate seepage from an abandoned municipal and U.S. Army Reserve landfill was identified as a source of ammonia-nitrogen and iron to Lincoln Creek, with leachate concentrations of ammonia-nitrogen reported at 7.2 mg/L and 9.3 mg/L and iron at 2.3 mg/L. Other landfills may also be discharging polluted groundwater to the creek.

MMSD is leading a restoration project for Lincoln Creek. The project will address flood control and channelization issues as well as water quality problems and fish and wildlife habitat impairments. Recommendations from this project will be incorporated into Stage II of the RAP.

Lincoln Creek is a potential, significant source of sediment, heavy metals, nutrients, oil and grease, and other toxic pollutants to the AOC. Lincoln Creek's water quality problems and their potential impact on the AOC, indicate the need to develop pollution abatement recommendations for areas outside of the AOC as part of Stage II of the RAP.

Moss-American Superfund Site

The Moss-American Superfund Site is the location of a former wood preserving facility that treated railroad ties with a creosote and fuel oil mixture. The 88-acre site is located in the northwest corner of the city of Milwaukee at the intersection of Brown Deer Road and Granville Road (Appendix VI.E). The site includes a 5-mile downstream reach of the Little Menomonee River which extends from the northernmost edge of the site to the river's confluence with the Menomonee River, approximately 8 miles upstream from the AOC. During its operation from 1921 until 1976 when closed by former owner Kerr-McGee Chemical Corporation, liquid waste were discharged to settling ponds which drained into the Little Menomonee River. Environmental problems observed at the site are related to the use and disposal of creosote.

PAH and creosote contamination at the site was first reported during the late 1960s. In 1973, the EPA financed the dredging of approximately 5,000 feet of the river from the site south to Bradley Road. The plant facilities were demolished in 1978, and some oil-saturated soil was excavated and shipped to the Nuclear Engineering Landfill in Sheffield, Illinois.

EPA initiated Superfund activities in 1983. The Superfund Remedial Investigation was completed in January, 1980, and the Feasibility Study of remediation alternatives was finished in May, 1990. In addition to Kerr-McGee, "Potential Responsible Parties" include Milwaukee County, which owns 65 acres of the site, and Chicago and Northwestern Railroad, which owns and uses 23 acres of the site as an automobile loading and storage area.

In the Remedial Investigation (RI), numerous organic contaminants were detected in the onsite soil. The most prevalent contaminants are PAHs, common constituents of creosote. Total PAH concentrations detected were as high as 32,000 ppm (3.2 percent of the sample).

A highly contaminated groundwater plume, which may be up to 400 feet wide extends from the former processing area on the site east to the river. Total PAHs measured as high as 11,000 ug/l in monitoring wells near the settling ponds. PAHs and other contaminants were not detected in surface water samples.

Sediment contamination was found throughout the reach of the Little Menomonee River between the site and its confluence with the Menomonee River. Contaminants detected were similar to those in the soil with PAHs the primary contaminants of concern. Total PAH concentrations in sediments were as high as 5.9 ppm., and individual PAH concentrations were as high as 4,600 ppm. (for phenanthrene). Sediment sampling results indicate background levels for total PAHs lie between 6.9 ppm and 24 ppm. More than 70 percent of the sediment samples collected in the Little Menomonee River downstream from the original property during the RI exceeded this range of concentrations.

As part of the RI, EPA conducted a risk assessment that evaluated potential threats to public health and the environment from the Moss-American site in the absence of remedial action. Public health threats were estimated by making assumptions about the length and frequency of exposure. The EPA is generally concerned with carcinogenic risks that could exceed an excess lifetime cancer risk of 1×10^{-6} to 1×10^{-4}. A risk of 1×10^{-6} means exposure to site contaminants could cause one additional case of cancer per 1 million people; a risk of 1×10^{-4} means that site contaminants could cause an additional 100 incidence of cancer per 1 million people. The risk assessment determined the primary population at risk of exposure to site-related contaminants are neighboring children who may play at the site. The risk assessment also concluded that, while immediate risks are low, repeated exposure to the site's contaminated soil and river sediment could result in as many as three additional cancer cases per 100 people.

Also of concern are the effects of the acute dermal exposure to creosote. Skin irritations from contact with sediment from the Little Menomonee River have been documented. The potential for skin irritation is assumed to still exist, but the risk cannot be quantified.

Exposure of birds, terrestrial wildlife, and aquatic plants and animals can occur through direct contact, or ingestion of contaminated surface soils or contaminated sediments in the Little Menomonee River. Many types of wildlife use the river and the river corridor as a food and water source. Similarly, sediment PAH concentrations at the site are substantially higher then levels that have been found to induce tumors in fish (Baumann, 1990).

The recommended remedial proposal for the site includes rerouting the Little Menomonee River, removing and treating highly contaminated soil and sediment using an on-site slurry bioreactor, collecting and treating contaminated groundwater, and covering the remaining untreated soil and sediments. Costs for implementing this proposal are projected at $26 million. Clean-up will begin in 1992 and take 3 to 4 years for completion.

The remedial goals for addressing sediment contamination at the site are to minimize direct contact or ingestion of contaminants in sediment, minimize acute and chronic effects on aquatic life posed by contaminants, and to minimize downstream transport of sediments to the AOC.

PAH levels in three sediment samples collected in a one half mile reach of the Menomonee River downstream from the site do not indicate that the site has contributed to the contamination already present in the river (EPA, 1990). However, further evaluation is needed to assess the site's potential impact on the AOC.

Groundwater as a Source

Some nonpoint source pollutants may be transported to surface waters via the groundwater system. During the Milwaukee Harbor estuary study, groundwater flow and quality data were collected for 14 months from November 1982 through January 1984 at six observation wells installed in the Menomonee Valley in order to evaluate the potential impact of groundwater on surface water quality and on pollutant loadings to the estuary. The groundwater samples were analyzed for toxic organic substances, metals, phosphorus, and other dissolved inorganic contaminants.

The concentrations of toxic organic substances in the groundwater were found to be very low: a single sample of only two substances, dieldrin and phenol, were found to be above the minimum detection level. The well samples, however, did contain detectable levels of 31 metals and other inorganic substances. The transfer of groundwater to the estuary was also found to be very small at the test sites due to subsurface impermeability. Groundwater loadings were found to constitute less than 0.2 percent of the total pollutant loadings to the Menomonee River. It was concluded that groundwater is not a significant source of pollutants to the estuary.

SUMMARY OF MAJOR SOURCES AND LOADINGS TO THE AOC

1. Pollutants to the Milwaukee Harbor estuary are contributed by both point and nonpoint sources with about one-half of the pollutant loadings studied coming from nonpoint sources.

2. The largest and most important point source loadings are those discharged from combined sewers, both upstream of, and directly to the Inner and Outer Harbors. Most of the combined sewer overflow loadings are discharged directly to the Inner Harbor.

3. Pollutants contributed from nonpoint sources are primarily transported to the Inner Harbor via the three tributary rivers. Most nonpoint source pollutants are discharged to surface waters upstream of the Milwaukee Harbor estuary, rather than directly to the estuary.

4. The primary sources of pollutants to the three tributary rivers upstream of the estuary, nonpoint sources, combined sewer overflows, and point sources, are quantified in Table VI.4.

    a. Nonpoint sources account for most of the pollutant loadings (between 56 and 85%).

    b. The combined sewer overflows that discharge upstream of the estuary account for about 13-33% of pollutant loadings to the streams.

c. Other point sources of pollution to the tributary rivers are relatively insignificant (0.1 to 11%).

5. The three primary sources of pollutants to the Inner Harbor, combined sewer overflows, nonpoint sources, and other point sources, are quantified in Table VI.5.

   a. Combined sewer overflows, including those that discharge upstream and also directly to the Inner Harbor contribute about 30-60% of the pollutant loadings.

   b. Compared to nonpoint source contributions to the tributary rivers, nonpoint sources to the Inner Harbor account for a smaller, yet significant portion of loadings (36 to 68%).

   c. The Inner harbor loadings from point sources, other than combined sewer overflows, were the same as the tributary river point source loadings (0.1 to 7%).

6. Sources of pollutants to the Outer Harbor are quantified in Table VI.6.

   a. Input from the Inner Harbor contributes about 50 to 75% of the pollutant loads.

   b. The Jones Island wastewater treatment plant is a major point source of pollutants to the Outer Harbor, contributing 20 to 40% of the pollutant load.

   c. The two combined sewer overflows discharging directly to the Outer Harbor account for 2 to 5% of the pollutant loads to the Outer Harbor.

CHAPTER SEVEN GOALS AND OBJECTIVES

This chapter describes specific goals and objectives for resolving the Milwaukee AOC's water quality related environmental problems (discussed in Chapters Five and Six) and for restoring beneficial uses. The goals and objectives provide the standards for determining the short-and long-term pollution abatement and resource management decisions needed to clean up the estuary. The goals and objectives draw upon the legal mandates of the Clean Water Act, the Great Lakes Water Quality Agreement and the environmental protection and resource management authority established by state statutes, plus previous ongoing activities such as the nonpoint source pollution abatement and integrated resource management plans for the Milwaukee River South and Menomonee River watersheds. However, the RAP goals and objectives are not limited by existing regulations and actions. The goals and objectives identify a high quality estuary and river system with all resources free of toxic contamination as the endpoint to attain.

The goals and objectives have been derived from the CAC's "Desired Future State," which the CAC adopted on February 19, 1990. The "Desired Future State" is a statement of the vision the CAC holds for the future of the estuary that will result from the successful implementation of the RAP's recommendations.

"Desired Future State"

1. *Waterways which because of their purity, contribute greatly to the economic vitality and quality of life in Milwaukee.*

2. *Waters, sediments, and biota free of toxic, persistent, or harmful substances resulting from industrial or other human activities - past, present or future.*

3. *Maximum public access and recreational opportunities along the rivers and near shore areas of Lake Michigan for boating, swimming, fishing, hiking, bicycling, nature study, and other leisure activities.*

4. *An estuary whose cleanliness and continued multiple uses have broad community and governmental support and are a top priority for the local political agenda.*

The supporting documentation on how the desired future state was developed is in Appendix VII.A.

Goals and Objectives of the Milwaukee Estuary Remedial Action Plan

The CAC also developed goals with input from the Technical Advisory Committee (TAC). Goals express the ecosystem ideals and aspirations applied to the Milwaukee RAP. The CAC approved goals on May 21, 1990. They are:

1. Restore the estuary through a community partnership including business and industry which achieves a clean estuary and sustained economic growth.

2. Achieve and maintain water quality that protects the ecosystem, including human health.

3. Eliminate the contribution of contaminants from sediments to the ecosystem.

4. Establish high quality fisheries and urban wildlife populations that are free from toxic contamination and other human-made hazards.

5. Develop high quality aquatic and wildlife habitats.

6. Provide an aesthetically pleasing and accessible estuary.

7. Generate community wide appreciation for the characteristics, ecological health and importance of the estuary.

8. Generate community wide participation in restoration and responsibility for the vitality of the estuary.

Objectives

Objectives have been developed through the input of WDNR resource managers from different programs, the TAC and the CAC. The TAC worked carefully on the objectives, which were then reviewed by the CAC. The CAC reviewed, modified and approved objectives on June 18, 1990. The objectives provide specific guidance on the conditions that should be met if goals are to be achieved. Objectives are listed under the applicable goal. However, in many cases, objectives will apply to more than one goal.

Goal 1. Restore the estuary through a community partnership, including business and industry that achieves a clean estuary and sustained economic growth.

Objectives:

A. Maintain an economically healthy and environmentally responsible commercial port.

B. Encourage waste generators to implement waste minimization and source reduction technologies that help restore water quality.

C. Support growth in Milwaukee by promoting improved water quality and reduced water treatment costs.

D. Promote improved water quality - and an improved quality of life - that encourages business relocation to Milwaukee and ensures that new or expanding businesses and associated development do not degrade water quality.

E. Weigh both environmental and economic efficiencies and impacts of all alternatives prior to recommendation and implementation.

F. Where waterfront development is to occur, encourage development that is compatible with improving and protecting water quality.

G. Achieve a community stewardship ethic for a clean estuary by attaining the goals of the RAP.

Goal 2. Achieve and maintain water quality that protects the ecosystem, including human health.

Objectives:

A. Achieve adequate dissolved oxygen concentrations, pH levels, and temperature to support warm water and migratory cold water fish and aquatic life.

B. Reduce excessive nutrient loadings and manage other factors contributing to excessive algae growth.

C. Protect recreational uses from possible impacts of toxic substances and objectionable micro-organisms; eliminate beach closings resulting from high fecal coliform levels.

D. Eliminate acute and chronic toxicity to biota.

E. Eliminate or significantly reduce the discharge of toxic substances to the AOC via direct and indirect discharges, including runoff, and air emissions.

F. Once desired levels of water quality are achieved, maintain these through effective implementation and enforcement of a strong antipollution policy.

Goal 3. Eliminate the contribution of contaminants from sediments to the ecosystem.

Objectives:

A. Implement an effective, environmentally sound method for abating contaminated sediments.

B. Target significant sediment deposits of toxic pollutants for priority remedial efforts.

C. Improve sediment quality such that its disposal is not restricted because of contaminants.

Goal 4. Establish high quality fisheries and urban wildlife populations free from toxic contamination and other human-made hazards.

Objectives:

A. Eliminate the need for fish and wildlife consumption advisories and reduce toxic contamination to levels that do not adversely affect other biota.

B. Establish high quality fisheries by restoring both cold water and warm water species such as yellow perch, northern pike, smallmouth bass, walleye, trout and salmon, etc.

C. Protect against significant infestations of the sea lamprey, zebra mussel and other undesirable exotic species.

D. Establish a balanced predator/prey ratio in the resident fish community.

E. Restore and protect the quantity and quality of the benthic macroinvertebrate, aquatic macrophyte, phytoplankton, and zooplankton communities.

F. Establish high quality, desirable, native wildlife populations. Such wildlife populations would include song birds, peregrine falcons, perching birds (sparrows, cardinals, etc.), migratory birds of prey (short-eared owls, marsh hawks, etc.), native shore birds (herring gulls, ring-billed gulls, etc), waterfowl (Canada geese, ducks, etc.), wading birds (herons, bitterns, etc.), waterbirds (belted king fishers, purple martins, etc.), turtles, mink, muskrat, and resident and migratory butterflies.

Goal 5. Develop high quality aquatic and wildlife habitats.

Objectives:

A. Upgrade aquatic conditions and provide and protect streambank vegetation and in-stream habitat in the Menomonee, Kinnickinnic, and Milwaukee Rivers and their tributaries to restore, to the fullest extent possible, species historically present but currently lost or present only in small numbers.

B. Evaluate and implement recommendations regarding removal or modification of human-made obstructions along the rivers which restrict navigation and natural fish movement, spawning, feeding, protection, development or winter habitat.

C. Restore and/or enhance upstream fish and wildlife habitat.

D. Establish protective cover and food sources for native wildlife species.

E. Prevent contamination of local and migratory wildlife from confined disposal facilities.

F. Protect upstream wetlands from any further loss or degradation and increase wetlands by restoration wherever feasible.

G. No filling of near shore areas of Lake Michigan unless it also improves aquatic and wildlife habitat.

H. Where filling is to occur, assure that any filling does not negatively impact water quality and is designed to optimize fish and wildlife habitat.

Goal 6. Provide an aesthetically pleasing and accessible estuary.

Objectives:

A. Eliminate or significantly reduce grease, oil, scum, excessive algae, litter and debris from the estuary and minimize objectionable odors.

B. Provide optimal public access in all waterfront development.

C. Develop environmental and recreational corridors in the estuary.

D. Preserve and protect the existence of sheltered water.

Goal 7. Generate community-wide appreciation for the characteristics, ecological health and importance of the estuary.

- and -

Goal 8. Generate community-wide participation in restoration and responsibility for the vitality of the estuary.

Objectives:

A. Increase understanding of the sources of pollution and support for the implementation of pollution abatement and management efforts among the general public and the private sector.

B. Encourage understanding and active support of pollution abatement and management effort, as a high priority among public officials.

C. Coordinate with existing programs and promote new efforts to involve volunteers in the physical clean-up of the estuary and other aspects of water quality improvement projects.

D. Develop and implement teacher training and a kindergarten through 12th grade curriculum for our school systems highlighting the Milwaukee estuary, upstream tributaries, and Lake Michigan.

E. Include public participation as an integral ingredient in the development and implementation of management programs that affect the Milwaukee estuary.

F. Develop a sense of public stewardship for water quality, naturally sustainable fisheries and urban wildlife populations.

Rationale

The first goal and the corresponding objectives emphasize the need for a community partnership and communitywide stewardship ethic to achieve RAP implementation. This partnership recognizes our future local economic vitality goes hand-in-hand with restoring the estuary. Businesses must implement waste minimization and source reduction strategies. Waterfront development is to be compatible with improving and protecting water quality. A restored estuary, in turn, will facilitate business development and sustained economic growth.

Goals 2, 3, and 4 and the related objectives focus on protecting aquatic life, wildlife, and human health from the adverse effects of toxic substances. Moreover, they call for reduced exposure to toxic substances so no consumption advisories are needed. These goals and objectives are consistent with the Great Lakes Water Quality Agreement's objective, "The discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated. Objectives "2D" and "2E", in particular, support a policy of "zero discharge" of toxic substances.

Goal 4 and the corresponding objectives list some of the desired species of fish and urban wildlife populations for the AOC. Goal 5 describes aquatic and wildlife habitat restoration and protection necessary to achieve healthy population species. These two goals and objectives also reflect an awareness of the human impacts on habitat.

Goal 6 and the related objectives outline a vision of an aesthetically pleasing estuary that provides optimal opportunities for public enjoyment and use. Goals 7 and 8 and the corresponding objectives further address the need to develop a sense of public stewardship throughout the community. Goal 7 stresses the importance of citizen education, while Goal 8 focuses on citizen participation. The importance of both of these activities warrants separate goals. Implementing these goals includes achieving an understanding of the sources of pollution among the general public, emphasizing water quality education and ecosystem health in school curricula, encouraging citizen participation in RAP implementation activities, and convincing public officials that pollution abatement is a high priority.

GLOSSARY FOR TERMS, ABBREVIATIONS AND MEASUREMENT UNITS FOUND IN THIS PLAN

Abbreviations

208 PLANS: Areawide Water Quality Management Plans.

ACP: Agricultural Conservation Program.

AOC: Area of Concern.

ASCS: Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture.

BACT: Best Available Control Technology.

BCT: Best Conventional Technology.

BMP: Best Management Practice.

BOD: Biochemical Oxygen Demand.

BPT: Best Practicable Technology.

CDF: Confined Disposal Facility.

COD: Chemical Oxygen Demand.

COE: United States Army Corps of Engineers.

CFS: Cubic Feet Per Second, a measure of flow in streams.

CSO: Combined Sewer Overflow.

DO: Dissolved Oxygen.

EF: Enrichment Factors

EPA: U.S. Environmental Protection Agency.

FDA: Federal Drug Administration

GLFC: Great Lakes Fishery Commission.

IJC: International Joint Commission Study.

LD_{50}: The dose (amount actually ingested by an organism) of a toxic substance which is lethal to 50% of the test population.

LCC: Land Conservation Committee (of the county board).

LC_{50}: Concentration of a toxic substance in water which is lethal to 50% of the test population exposed to the toxic substance. *See Bioassay.*

LUST: Leaky Underground Storage Tanks.

MGD: Million of Gallons Per Day; a measurement of water flow from wastewater treatment plants. 1 MGD = 1.55 cfs.

mg/L: Milligrams Per Liter; a unit of measure of concentration generally equivalent to parts per million.

ng/L: Nanograms Per Liter; a unit of measure for concentration generally equivalent to parts per trillion (ppt).

NH_3: Unionized ammonia.

NH_3-N: Ammonia-Nitrogen

NH_4: Ammonium or ionized ammonia.

NOAA: National Oceanic and Atmospheric Administration.

NO_2: Nitrite.

NO_3: Nitrate.

NPDES: National Pollution Discharge Elimination System. Requires permits for wastewater discharges.

NPS: Nonpoint Source Pollution.

O&G: Oil and Grease

O & M: Operation and Maintenance.

PAHs: Polycyclic Aromatic Hydrocarbons.

PCBs: Polychlorinated Biphenyls.

POTW: Publicly owned treatment works.

PPM: Parts Per Million; a unit of measure for concentration.

RAP: Remedial Action Plan.

RI/FS: Remedial Investigation/Feasibility Study

RPC: Regional Planning Commission.

RCRA: Resource Conservation and Recovery Act of 1976.

SCS: Soil Conservation Service of the United States Department of Agriculture.

SOD: Sediment Oxygen Demand

SS: Suspended Solids.

SSO: Sanitary Sewer Overflow.

SO_2: Sulphur Dioxide

TKN: Total Kjeldahl Nitrogen

TMDL: Total Maximum Daily Load.

TOC: Total Organic Carbon

TSCA: Toxic Substances Control Act, a federal law.

TVS Total Volatile Solids

ug/L: Micrograms Per Liter; a unit of measure for concentration generally equivalent to parts per billion (ppb).

USDA: United States Department of Agriculture.

USEPA: United States Environmental Protection Agency.

USFWS: United States Fish and Wildlife Service, U.S. Department of Interior.

USGS: United States Geological Survey.

USLE: Universal Soil Loss Equation. Used to determine the amount of sediment carried in runoff.

UWEX: University of Wisconsin - Extension

VOC: Volatile Organic Compound.

WDATCP: Wisconsin Department of Agriculture, Trade and Consumer Protection.

WDHSS:	Wisconsin Department of Health and Social Services.
WDILHR:	Wisconsin Department of Industry, Labor and Human Relations.
WDNR:	Wisconsin Department of Natural Resources.
WDOA:	Wisconsin Department of Administration.
WDOD:	Wisconsin Department of Development.
WDOT:	Wisconsin Department of Transportation.
WGNHS:	Wisconsin Geologic and Natural History Survey.
WLA:	Wasteload Allocation.
WPDES:	Wisconsin Pollution Discharge Elimination System.
WSLH:	Wisconsin State Laboratory of Hygiene.
WWTP:	Wastewater Treatment Plant.

Measurement Units

mg/Kg	milligram per kilogram	part per million (ppm)
μg/Kg	microgram per kilogram	part per billion (ppb)
ng/Kg	nanogram per kilogram	part per trillion (ppt)
mg/L	milligram per litre	part per million (ppm)
μg/L	microgram per litre	part per billion (ppb)
ng/L	nanogram per litre	part per trillion (ppt)

Terms

ACTION LEVEL:

Concentration of a contaminant in fish or wildlife which would trigger issuance of a Fish or Wildlife Consumption Advisory.

ACUTE TOXICITY:

Any poisonous effect produced by a single, short-term exposure to a chemical that results in a rapid onset of severe symptoms.

ADDITIVITY:

The characteristic property of a mixture of toxicants that exhibit a cumulative toxic effect equal to the arithmetic sum of the individual toxicants.

ADVANCED WASTEWATER TREATMENT:

The highest level of wastewater treatment for municipal treatment systems. It requires removal of all but 10 parts per million of suspended solids and biological oxygen demand and/or 50% of the total nitrogen. Advanced wastewater treatment is also known as " tertiary treatment."

AGRICULTURAL CONSERVATION PROGRAM (ACP):

A federal cost-sharing program to help landowners install measures to conserve soil and water resources. ACP is administered by the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture through the Agricultural Conservation Program.

ALGAE (or PHYTOPLANKTON):

A group of microscopic, photosynthetic water plants. Algae give off oxygen during the day as a product of photosynthesis and consume oxygen during the night as a result of respiration. Nutrient-enriched water increases algae growth.

AMMONIA:

A form of nitrogen (NH_3) is unionized ammonia found in human and animal wastes. Ammonia is toxic to aquatic life depending upon pH, temperature and ionic strength of the water. Ammonium (NH_4) is ionized ammonia found in human and animal waste.

ANAEROBIC:

Without oxygen.

ANTIDEGRADATION:

A policy which states that water quality will not be lowered below background levels unless justified by economic and social development considerations.

AREA OF CONCERN:

Areas of the Great Lakes identified by the International Joint Commission (IJC) as having serious water pollution problems.

AREAWIDE WATER QUALITY MANAGEMENT PLANS (208 PLANS):

A plan to document water quality conditions in a drainage basin and make recommendations to protect and improve basin water quality. Each basin in Wisconsin must have a plan according to section 208 of the Clean Water Act.

AROCLOR:
A Monsanto Chemical Company trade name for various types of PCBs. Presented as a four digit number with the first two digits listing the number of carbons in the biphenyl molecule, while the last two digits represent the weight percentage of chlorine atoms.

ASSIMILATIVE CAPACITY:
The ability of a water body to purify itself of pollutants without detriment to fish and aquatic life or other beneficial uses of the water body.

ARSENIC:
A highly poisonous heavy metal having three allotropic forms. Use of arsenic and its compounds includes insecticides, weed killers and alloys.

BACTERIA:
Single-cell, microscopic organisms. Some can cause disease, and some are important in the stabilization of organic wastes.

BALANCED COMMUNITY:
A community that supports an abundant and usually diverse population of forage fish, game fish, and other aquatic biota (zooplankton, phytoplankton, macroinvertebrates).

BASIN PLAN:
See Areawide Water Quality Management Plan.

BENEFICIAL USES:
Uses that maintain the chemical, physical and biological integrity of an ecosystem.

BENTHIC ORGANISMS (BENTHOS):
The organisms living in or on the bottom of a lake or stream.

BEST MANAGEMENT PRACTICE (BMP):
The most effective, practical measures to control nonpoint sources of pollutants that run off from land surfaces.

BIOACCUMULATION:
The uptake and retention of substances by an organism from its surrounding medium and from its food. Chemicals move through the food chain and tend to end up at higher concentrations in organisms at the upper end of the food chain such as predator fish, or in people or birds that eat these fish.

BIOASSAY:

A test for pollutant toxicity. Tanks of fish or other organisms are exposed to varying doses of wastewater effluent; lethal doses of pollutants in the effluent are thus determined.

BIOAVAILABILITY:

The degree to which toxic substances or other pollutants that are present in sediments or elsewhere in the ecosystem are available to affect or be taken up by organisms. Some pollutants may be "bound up" or unavailable because they are attached to clay particles or are buried by sediment. The amount of oxygen, pH, temperature and other conditions in the water can affect availability.

BIOCHEMICAL OXYGEN DEMAND (BOD):

A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. BOD_5 is the biochemical oxygen demand measured in a five day test. Carbonaceous BOD is the result of the same test conducted in a shorter time period. The greater the degree of pollution by organic matter the higher the BOD.

BIODEGRADABLE:

Waste which can be broken down by bacteria into basic elements. Most organic wastes such as food remains and paper are biodegradable.

BIOTA:

All living organisms that exist in an area.

BUFFER STRIPS:

Strips of grass or other erosion-resisting vegetation between disturbed areas and a stream or lake.

BULKHEAD LINES:

Legally established lines which indicate how far into a stream or lake an adjacent property owner has the right to fill. Many of these lines were established many years ago and allow substantial filling of the bed of a river or bay. Other environmental laws may limit filling to some degree.

CARCINOGENIC:

The ability of a chemical to cause cancer.

CATEGORICAL LIMITS:

The basic level of treatment required for all point source discharges. For municipal wastewater treatment plants this is secondary treatment (30 mg/l effluent limits for SS and BOD). For industry the level is dependent on the type of industry and the level of production. Effluent limits more stringent than categorical may be required if necessary to meet water quality standards.

CHLORINATION:

The application of chlorine to wastewater to kill bacteria and other organisms.

CHLORORGANIC COMPOUNDS (CHLORORGANICS):
A class of chemicals which contain chlorine, carbon and hydrogen. Generally refers to pesticides and herbicides that can be toxic. Examples include PCB's and pesticides such as DDT and dieldrin.

CHLOROPHYLL-a:
A green pigment in plants used as an indicator of plant and algae productivity.

CHRONIC TOXICITY:
Injurious or debilitating effects of long-term exposure of nonlethal toxic chemicals to organisms. An example of the effect of chronic toxicity could be reduced reproductive success.

CLEAN WATER ACT:
See Public Law 92-500.

COMBINED SEWERS:
A wastewater collection system that carries both sanitary sewage and stormwater runoff. During dry weather, combined sewers carry only sanitary sewage to the treatment plant; during heavy rainfall, the sewer becomes swollen with stormwater and sewage. If the treatment plant cannot process the added flow, untreated sewage is discharged to surface waters via a treatment plant bypass or a combined sewer overflow.

COMPLIANCE MAINTENANCE:
A Wastewater Program that identifies actions municipal treatment facilities should take to ensure they continue to meet existing and future effluent limits.

CONFINED DISPOSAL FACILITY (CDF):
A structure built for the containment and disposal of contaminated dredged material.

CONGENERS:
Chemical compounds that have the same molecular composition, but have different molecular structures and formula. For example, the congeners of PCB have chlorine located at different spots on the molecule. These differences can cause differences in the properties and toxicity of the congeners.

CONSERVATION TILLAGE:
Planting row crops while disturbing the soil only slightly. Therefore, a protective layer of plant residue stays in the surface and erosion is decreased.

CONSUMPTION ADVISORY:
A health warning issued by a public agency that recommends people limit the fish they eat from some rivers and lakes based on levels of toxic substances found in the fish.

CONVENTIONAL POLLUTANT:
Refers to suspended solids, fecal coliforms, biochemical oxygen demand, and pH as opposed to toxic pollutants.

CRITERIA:
See Water Quality Criteria.

DDT:
A chlorinated hydrocarbon insecticide that has been banned because of its persistence in the environment.

DESIGNATED MANAGEMENT AGENCIES:
Any agency designated in an Areawide Water Quality Management Plan as having responsibility for implementing specific plan recommendations. This may be done through direct activities of the designated management agency or through delegation to other agencies or units of government.

DIOXIN (2,3,7,8-tetrachlorodibenso-p-dioxin):
A chlorinated organic chemical which is highly toxic.

DISINFECTION:
A chemical or physical process that kills organisms which cause disease. Chlorine is often used to disinfect wastewater.

DISSOLVED OXYGEN (DO):
Oxygen dissolved in water. Low levels of dissolved oxygen cause bad smelling water and threaten fish survival. Low levels of dissolved oxygen are often due to inadequate wastewater treatment. The Wisconsin Department of Natural Resources considers 5 ppm DO necessary to support a balanced community of fish and aquatic life.

DREDGING:
Removal of sediment from the bottom of water bodies.

ECOSYSTEM:
The interacting system of a biological community and its nonliving surroundings.

EFFLUENT:
Solid, liquid or gas wastes (byproducts) which are disposed on land, in water or in air. As used in the RAP generally means wastewater discharges.

EFFLUENT LIMITS:
These establish the maximum amount of a pollutant that can be discharged to a receiving stream. Limits depend on the pollutants involved, the water quality standards that apply for the receiving waters, and the characteristics of the receiving water.

EMISSION:
A direct (smokestack particles) or indirect (busy shipping center parking lot) release of any contaminant into the air.

ENVIRONMENTAL CORRIDOR:

Environmentally sensitive areas within sewer service areas which are not eligible for sewered development. Environmental corridors may include wetlands, shorelands, floodway and floodplains, groundwater recharge areas, and other sensitive areas.

ENVIRONMENTAL PROTECTION AGENCY (USEPA):

The federal agency responsible for enforcing federal environmental regulations. The Environmental Protection Agency delegates some of its responsibilities for water, air and solid waste pollution control to state agencies.

ENVIRONMENTAL FUND (EF):

A fund established by the Wisconsin Legislature to deal with abandoned landfills and other sites (e.g. drycleaning facilities, chrome-plating shops, etc.) that have caused soil and groundwater contamination. Funding is only used when there is not a cooperative party.

EUTROPHIC:

Refers to a nutrient-rich lake or stream. Large amounts of algae and aquatic plants characterize a eutrophic water body. *See also Oligotrophic and Mesotrophic.*

EUTROPHICATION:

The process of nutrient enrichment of a water body. Eutrophication can be accelerated by human activity such as agriculture and improper waste disposal.

FACILITY PLAN:

A preliminary planning and engineering document that identifies alternative solutions to a community's wastewater treatment problems.

FECAL COLIFORM:

A group of bacteria used to indicate the presence of other bacteria that cause disease. The number of coliforms is particularly important when water is used for drinking and swimming.

FLY ASH:

Particulates emitted from coal burning and other combustion, such as wood burning, and exited into the air from stacks, or more likely, collected by electrostatic precipitators.

FOOD CHAIN:

A sequence of organisms in which each uses the next as a food source.

FURAN (2,3,7,8-tetra-chloro-dibenzofuran):

A chlorinated organic compound which is highly toxic.

GROUNDWATER STANDARDS:

Numerical standards for substances of health or welfare concern which consist of an enforcement standard and a preventive action limit (PAL) - the PAL being a percentage of the enforcement standard which indicates a problem may be developing.

HABITAT:
The place or type of site where a plant or animal naturally lives and grows.

HEAVY METALS:
A group of metals which may be present in municipal and industrial wastes that pose long-term environmental hazards if not properly disposed. Heavy metals can contaminate ground and surface waters, fish and food. The metals of most concern are: arsenic, cadmium, chromium, copper, lead, mercury, selenium and zinc.

HERBICIDE:
A type of pesticide that is specifically designed to kill plants and can also be toxic to other organisms.

HYDROCARBONS:
Any of a large class of chemicals containing carbon and hydrogen in a virtually infinite number of combinations.

HYPEREUTROPHIC:
Refers to a lake with excessive fertility. Extreme algae blooms and low dissolved oxygen are characteristics.

IN-PLACE POLLUTION:
As used in the RAP refers to pollution from contaminated sediments. These sediments are polluted from past discharges from municipal and industrial sources.

INTERNATIONAL JOINT COMMISSION (IJC):
An agency formed by the United States and Canada to guide management of the Great Lakes and resolve border issues, particularly water quality issues.

LANDFILL:
A conventional sanitary landfill is "a land disposal site employing an engineered method of disposing of solid wastes on land in a manner that minimizes environmental hazards by spreading solid wastes in thin layers, compacting the wastes to the smallest practical volume, and applying cover materials at the end of each operating day."

LEACHATE:
The contaminated liquid which seeps through a landfill or other material and contains water, dissolved and decomposing solids. Leachate may enter the groundwater and contaminate drinking water supplies.

LITTORAL:
Zone of a lake between high and low water marks.

LOAD:
The total amount of materials or pollutants reaching a given water body.

MACROINVERTEBRATES:
Animals without a vertebral column and which are visible to the unaided eye.

MACROPHYTE:
A rooted aquatic plant.

MARGINAL USE:
A use that cannot support a fishery or a balanced community of aquatic organisms because of natural conditions (physical, chemical, biological or human activities).

MASS BALANCE:
A study that examines all parts of the ecosystem to determine the amount of toxic or other pollutants present, their sources, and the processes by which the pollutant moves through the ecosystem.

MESOTROPHIC:
Refers to a moderately fertile nutrient level of a lake between the oligotrophic and eutrophic levels. *See also Eutrophic and Oligotrophic.*

MITIGATION:
The effort to lessen the damages caused, by modifying a project, providing alternatives, compensating for losses, or replacing lost values.

MIXING ZONE:
The portion of a stream or lake in which effluent is allowed to mix with the receiving water. The size of the area depends on the volume and flow of the discharge and receiving water. For streams, the mixing zone is one-third of the lowest flow that occurs once every 10 years for a seven day period.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES):
A federal permit system to monitor and control the point source dischargers of wastewater. Dischargers are required to have a discharge permit and meet the conditions it specifies.

NITRATE:
NO_3, a form of nitrogen used by algae. Excessive concentrations result in eutrophication and algal blooms.

NITRITE:
NO_2, a form of nitrogen toxic to aquatic life which rapidly oxidizes to nitrates.

NONPOINT SOURCE POLLUTION (NPS):
Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources include eroding farmland and construction sites, urban streets, and barnyards. Pollutants from these sources reach water bodies in runoff, which can best be controlled by proper land management.

OLIGOTROPHIC:

Refers to an unproductive and nutrient-poor lake. Such lakes typically have very clear water. *See also Eutrophic and Mesotrophic.*

OUTFALL:

The mouth of a sewer, drain or pipe where wastewater effluent is discharged.

pH:

A measure of acidity or alkalinity, measured on a scale of 0 to 14 with 7 being neutral and 0 being most acid, and 14 being most alkaline (basic).

PATHOGEN:

A virus, bacteria or other infective agent capable of producing disease.

PELAGIC:

Refers to the open water portion of a lake.

PESTICIDE:

Any chemical agent used for control of specific organisms, such as insecticides, herbicides, fungicides, etc.

PHENOLS:

Organic compounds that are byproducts of petroleum refining, textile, dye, and resin manufacturing. High concentrations can cause taste and odor problems in fish. Higher concentrations can be toxic to fish and aquatic life.

PHOSPHORUS:

A nutrient that in excess amounts in lakes and streams can lead to overfertile (eutrophic) conditions and algae blooms.

PHYTOPLANKTON:

See Algae.

PLANKTON:

Tiny plants (phytoplankton or algae) and animals (Zooplankton) that live in water.

POINT SOURCES:

Sources of pollution that have discrete discharges, usually from a pipe or outfall.

POLYCHLORINATED BIPHENYLS (PCBs):

A group of 209 compounds, PCBs have been manufactured since 1929 for such common uses as electrical insulation and heating/cooling equipment, because they resist wear and chemical breakdown. Although banned in 1979 because of their persistence in the environment, they have been detected in air, soil and water, and recent surveys have found PCBs in every section of the country, even those remote from PCB manufacturers.

POLYCYCLIC AROMATIC HYDROCARBONS (PAH):

PAHs are the result of incomplete combustion or organic compounds due to insufficient oxygen and are associated with oils and greases and other components derived from petroleum products which may end up in sediments and be measured as a component of oil and grease. Examples of compounds in the PAH group include benzo(a) anthracene, benzo(b) fluoranthene, benzo(a) pyrene, chrysene, phenanthrene, and pyrene.

PRETREATMENT:

Partial wastewater treatment required from some industries. Pretreatment removes some types of industrial pollutants before the wastewater is discharged to a municipal wastewater treatment plant.

PRIORITY POLLUTANT:

Toxic chemicals identified by the federal government because of their potential impact on the environment and/or human health. Major discharges are required to monitor for all or some of these chemicals when their WPDES permits are reissued (referred to as a 2C screening).

PRIORITY WATERSHED:

A drainage area selected to receive Wisconsin fund money to help pay the cost of controlling nonpoint sources of pollution through implementation of Best Management Practices (BMPs). Because money is limited, the watersheds selected for funding are those where problems are critical, control is practical, and cooperation is likely.

PRODUCTIVITY:

A measure of the amount of living matter which is supported by an environment over a specific period of time. Often described in terms of algae production for a lake.

PUBLIC LAW 92-500 (CLEAN WATER ACT):

The federal law that set national policy for improving and protecting the quality of the nation's waters. The law set a timetable for the cleanup of the nation's waters and stated that they are to be fishable and swimmable. This also required all pollutant dischargers to obtain a permit and meet the conditions of the permit. To accomplish this pollution cleanup billions of dollars have been made available to help communities pay the cost of building sewage treatment facilities. Amendments to the Clean Water Act were made in 1977, 1981 and 1989.

PUBLICLY OWNED TREATMENT WORKS (POTW):

A wastewater treatment plan owned by a city, village or other unit of government.

REMEDIAL ACTION PLAN (RAP):

A plan designed to restore all beneficial uses to a Great Lakes Area of Concern.

REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS):

An investigation of problems and assessment of management options conducted as part of a superfund project.

RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 (RCRA):

This federal law amends the Solid Waste Disposal Act of 1965 and expands on the Resource Recovery Act of 1970 to provide a program which regulates hazardous wastes to eliminate open dumping and to promote solid waste management programs.

RUNOFF:

Water from rain, snow melt or irrigation that flows over the ground surface and returns to streams. Runoff can collect pollutants from air or land and carry them to receiving waters.

SANITARY DISTRICT:

A special-purpose unit of government providing sanitary service in its jurisdictional area. A town sanitary district is created by order of either the town board or the Dept. of Natural Resources. The sanitary district is a designated management agency for collection systems. Each district has three commissioners who plan, construct and maintain a system of water supply, solid waste collection, and disposal of sewage including drainage improvements, sanitary sewers, surface sewers or storm water sewers. The commissioner performs a special assessment which is funded by residents of the sanitary district.

SANITARY SEWER OVERFLOWS:

Overflows of sewer systems that carry sanitary sewage. Overflows occur when sewers cannot handle the flow and relief valves allow discharges to surface waters. Such overflows result from storm events.

SECONDARY TREATMENT:

Two-stage wastewater treatment that allows the coarse particles to settle out, as in primary treatment, followed by biological breakdowns of the remaining impurities. Secondary treatment commonly removes 90% of the impurities. Sometimes "secondary treatment" refers simply to the biological part of the treatment process.

SEDIMENT:

Soil particles suspended in and carried by water as a result of erosion. Particles are deposited in areas where the water flow is slowed (e.g. harbors, wetlands, lakes).

SEDIMENT OXYGEN DEMAND (SOD):

A measure of the amount of dissolved oxygen demand by sediment reactions. The SOD can have a significant influence on the amount of dissolved oxygen available in the water column.

SEWER SERVICE AREA:

An area presently served and anticipated to be served by a sewage collection system.

SLUDGE:

A byproduct of wastewater treatment; waste solids suspended in water.

SOLID WASTE:

Unwanted or discharged material with insufficient liquid to be free flowing.

STANDARD INDUSTRIAL CLASSIFICATIONS (SIC):

The United States SIC (Standard Industrial Classification) numbering system was developed to classify all firms by type of activity to facilitate compilation and presentation of data for uniformity and comparability.

The 4-digit number defines the specific Industry within a Sub-Group. The first three digits represent the Sub-Group within a Major Group. The first two digits indicate the Major Group.

Example: SIC-35 is the Major Group Number for Machinery Except Electrical.
353 is the Sub-Group Number for Construction, Mining and Materials Handling and Equipment.
3537 is the Industry Number for industrial trucks, tractors, trailers and stackers.

STANDARDS:

See Water Quality Standards.

STORM SEWERS:

A system of sewers that collect and transport rain and snow runoff. *See Combined Sewers.*

SUPERFUND:

A federal program administered by the EPA which provides for cleanup of major hazardous waste landfills and land disposal areas.

SUSPENDED SOLIDS (SS):

Small particles of solid matter suspended in water. Cloudy or turbid water is due to the presence of suspended solids in the form of silt or clay particles. These particles may carry pollutants adsorbed to the particle surfaces.

SYNERGISM:

The characteristic property of a mixture of toxic substances that exhibits a greater-that-additive cumulative toxic effect.

TAXA:

Groups of classified organisms.

TERTIARY TREATMENT:

See Advanced Wastewater Treatment.

TOTAL MAXIMUM DAILY LOADS (TMDLs):

The maximum amount of a pollutant that can be discharged into a stream without causing a violation of water quality standards.

TOTAL ORGANIC CARBON (TOC):

One of several chemical parameters used to measure the enrichment of sediment with organic materials. TOC levels can effect the bioavailability of organic contaminants.

TOXIC SCREENING:
The process used in the Areawide Water Quality Management Plans which may affect water quality or treatment plant performance and provide management recommendations for the control for these substances.

TOXIC SUBSTANCE:
A substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring or a substance which can become poisonous after concentration in the food chain or in combination with other substances.

TOXICITY:
The degree of danger posed by a toxic substance to animal or plant life. Also see acute toxicity, chronic toxicity and additivity.

TOXICITY REDUCTION EVALUATION:
For a discharger, it is required that causes of toxicity in an effluent be determined and that measures be taken to eliminate the toxicity. The measures may be treatment, product substitution, chemical use reduction or other actions achieving the desired result.

TREATMENT PLANT:
See wastewater treatment plant.

TROPHIC STATUS:
The level of growth or productivity of a lake as measured by phosphorus concentration, algal biomass and depth of light penetration. The major categories of trophic status are oligotrophic, mesotrophic, eutrophic, and hypereutrophic.

TURBIDITY:
Turbidity is the lack of water clarity usually closely related to the amount of suspended solids in water.

UTILITY DISTRICT:
Provide services such as highway, sewers, sidewalks, lighting and water for fire protection to towns, villages, and 3rd and 4th class cities who may establish a utility district. The funding is provided by district property taxes. The utility district could be a designated management agency for their collection systems.

VARIANCE:
Government permission for a delay or exception in the application of a given law, ordinance or regulation. Also, see water quality standard variance.

VOLATILE:
Any substance that evaporates at a low temperature.

WASTELOAD ALLOCATION:
Division of the amount of waste a stream can assimilate among the various dischargers to the stream. This results in a limit on the amount (in pounds) of a chemical or biological constituent discharged from a wastewater treatment plant to a water body. A water quality model may be used to calculate allowable loadings, which vary seasonally due to flow. *See Assimilative Capacity.*

WASTEWATER:
Water that has become contaminated as a byproduct of some human activity. Wastewater includes sewage, washwater and the waterborne wastes of industrial processes.

WASTEWATER TREATMENT PLANT:
A facility for purifying wastewater. Modern wastewater treatment plants may be capable of removing 95% of organic pollutants.

WATER QUALITY AGREEMENT:
The Great Lakes Water Quality agreement was initially signed by Canada and the United States in 1972 and was subsequently revised in 1978 and 1987. It proves guidance for the management of water quality, specifically phosphorus and toxics in the Great Lakes.

WATER QUALITY LIMITED SEGMENT:
A section of river where water quality standards will not be met if only categorical effluent limits are met.

WATER QUALITY CRITERIA:
Measures of the physical, chemical or biological characteristics of a water body necessary to protect and maintain different water uses (fish and aquatic life, swimming, etc.).

WATER QUALITY STANDARD VARIANCE:
When natural conditions of a water body preclude meeting all conditions necessary to maintain full fish and aquatic life and swimming a variance may be granted.

WATER QUALITY STANDARDS:
The legal basis and determination of the use or potential uses of a water body and the water quality criteria, physical, chemical, or biological characteristics of a water body, that must be maintained to keep it suitable for the specified use.

WATERSHED:
The land area that drains into a lake or river.

WETLANDS:

Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support specific types of vegetative or aquatic life. Wetland vegetation requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes and bogs.

WISCONSIN ADMINISTRATIVE CODE:

The set of rules written and used by state agencies to implement state statutes. Administrative codes are subject to public hearing and are enforceable.

WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM (WPDES):

A permit system to monitor and control the point source dischargers of wastewater in Wisconsin. Dischargers are required to have a discharge permit and meet the conditions it specifies. This program is delegated to the state from the federal NPDES program.

ZOOPLANKTON:

Minute, free-floating or weakly swimming aquatic animals. They form an important food supply for larger aquatic animals.

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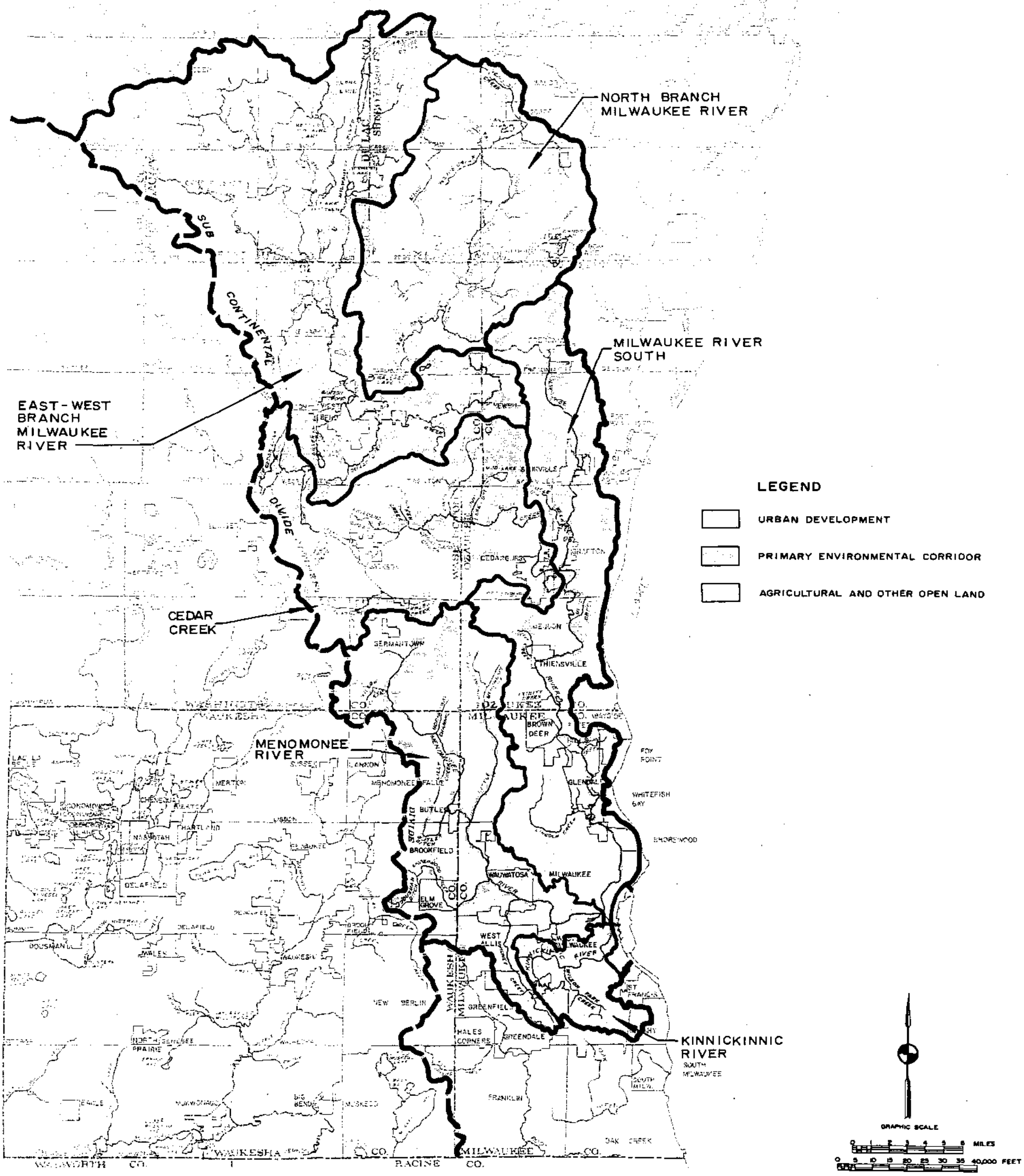
Note: Please see further references on pages 9 and 10 of Appendix V-G and at the end of Appendix V-G.

Figure IV.3

GENERALIZED LAND USE IN THE MILWAUKEE RIVER PRIORITY WATERSHEDS: 1985



Source: SEWRPC.