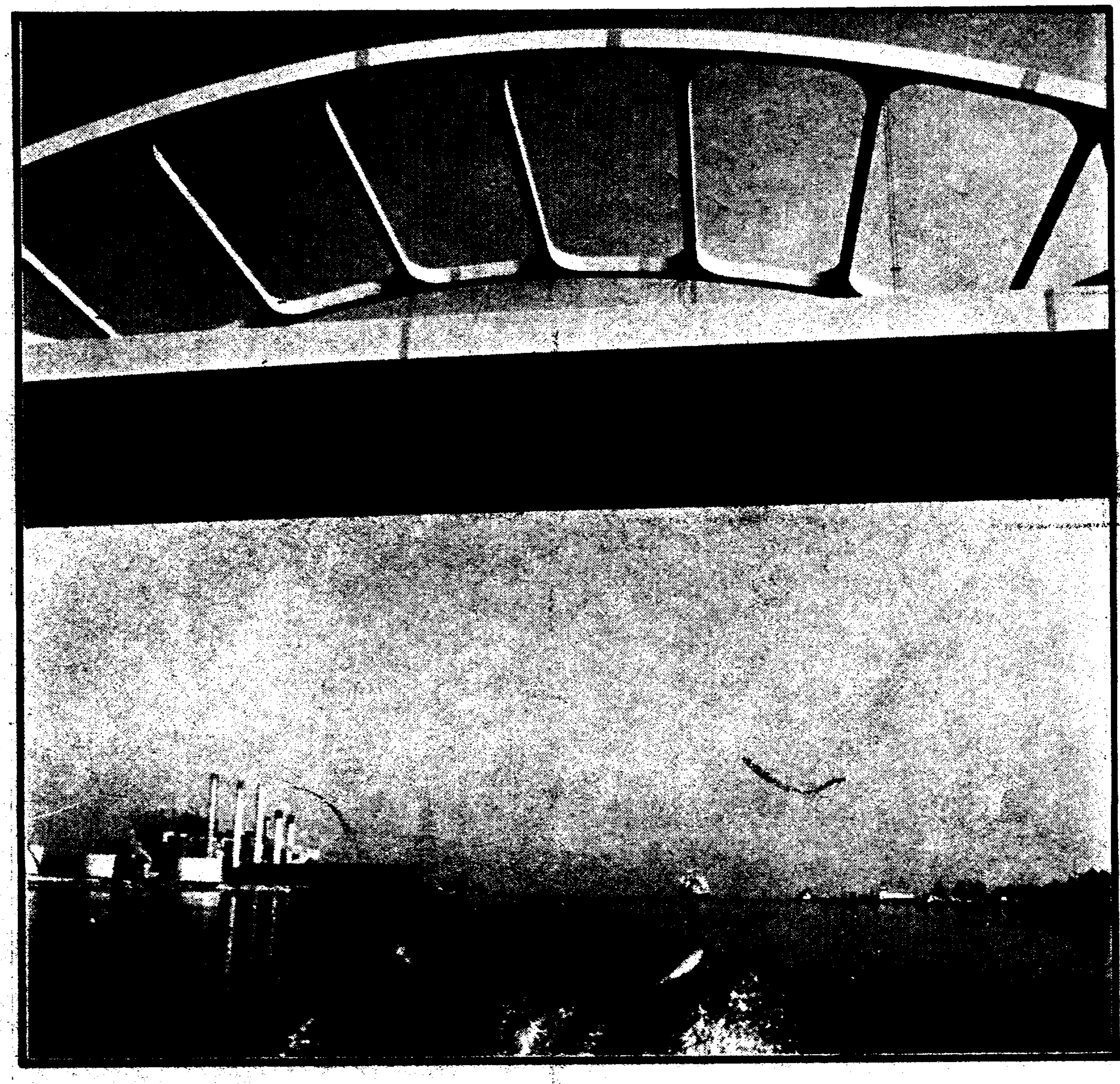
July 1987

Key Actions to Restore Beneficial Uses of the Lower Green Bay Area of Concern: A Summary Report



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Key Actions to Restore Beneficial Uses of the Lower Green Bay Area of Concern: A Summary Report

Consolidation of Objectives and Recommendations
of the
Eutrophication and Nutrient Management
Biota and Habitat Management
and Toxic Substances Management
Technical Advisory Committee Reports

Report of the Ad Hoc Task Group
to Review Recommendations for Ecosystem Management
January 4-6, 1987
to the Steering Committee of the Citizens Advisory Committee
Lower Green Bay and Fox River Remedial Action Plan

July 1987

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PREFACE

The International Joint Commission has identified Lower Green Bay and the adjacent Fox River as one of 42 aquatic ecosystems in the Great Lakes that suffer severe water quality problems. As part of the international commitment to clean water, the Great Lakes states, the U.S. Environmental Protection Agency, the Canadian provinces and Environment Canada have agreed to prepare remedial action plans to rehabilitate these degraded ecosystems, which have been officially designated Areas of Concern. The Wisconsin Department of Natural Resources (WDNR) has agreed to prepare a remedial action plan for Lower Green Bay and the Fox River with the goal of restoring beneficial uses to this estuary of Lake Michigan.

A Citizens Advisory Committee and four Technical Advisory Committees (TACs) have advised WDNR during preparation of the Lower Green Bay Remedial Action Plan. At the request of the Citizens Advisory Committee, an Ad Hoc Task Group of scientists wrote this summary after consolidating the objectives and recommendations from three of the TAC reports. This summary attempts to focus attention on primary objectives and management recommendations that were identified by the technical committees; it is not meant as a substitute or replacement for the TAC reports or for the Remedial Action Plan. Readers may refer to the appropriate section of the TAC reports for details associated with any given action. This summary and the TAC reports themselves are included as appendices to the Remedial Action Plan.

Members of the Task Group who worked on this report were selected because of their special knowledge and familiarity with the Green Bay ecosystem and/or their familiarity with the TAC reports. They are:

Dr. H. J. Harris	University of Wisconsin-Green Bay Speciality: Wetland and Wildlife Ecology
Ms. Victoria Harris	WDNR-Lake Michigan District Chair: Eutrophication and Nutrient Management TAC Specialty: Water Quality Planner (Benthos)
Dr. Val Klump	UW-Milwaukee, Center for Great Lakes Studies Specialty: Sediment and Sediment Processes
Mr. Cliff Kraft	UW Sea Grant Institute Specialty: Fishery Science
Dr. John Magnuson	UW-Madison, Center for Limnology Specialty: Limnology and Fishery Science
Mr. Lee Meyers	WDNR-Lake Michigan District Chair: Biota and Habitat Management TAC Specialty: Fish Management
Ms. Lynn Persson	WDNR-Madison, Remedial Action Plan Coordinator Specialty: Planning, Aquatic Biology, Soil Science
Dr. Sumner Richman	Lawrence University Specialty: Limnology and Trophic Dynamics

Dr. Paul Sager	UW-Green Bay Specialty: Limnology, Eutrophication, Trophic Dynamics
Mr. Jack Sullivan	WDNR-Madison Chair: Toxic Substances Management TAC Specialty: Chemistry, Toxics
Ms. Paula Allen	(Recorder) WDNR

The Task Group that produced this report was charged with consolidating the objectives and recommendations of the TAC reports into a coherent and cohesive summary (see Appendix). Consolidating these objectives and recommendations carried a risk that important elements might be left out inadvertently or that biases of Task Group participants might skew the final summary. The Task Group made a conscious effort to include all vital elements of the TAC reports in the summary and to check biases, where they may have occurred, with diverse professional judgments.

This report contains a brief description of the procedures used by the Task Group; a table of Key Actions identified by the Task Group, their expected ecosystem effects and anticipated restored uses; a narrative description of each Key Action; and a discussion of monitoring that will be required to follow trends in the Lower Green Bay-Fox River ecosystem as it responds to these actions.

I thank Task Group members for their willingness to contribute their time and knowledge to this report and for their hard work on a very difficult task.

H. J. "Bud" Harris
Convenor

PROCEDURES

During a workshop in January 1987, the Task Group reviewed and summarized the objectives and management recommendations that were identified in reports of the Eutrophication and Nutrient Management, Biota and Habitat Management, and Toxic Substances Management Technical Advisory Committees. (The report of the Institutional Technical Advisory Committee was not complete at that time.)

Participants began by consolidating the 40 objectives for the Lower Green Bay Remedial Action Plan that were identified in the reports of the three committees. Participants noted that some objectives may be subsidiary, if not subordinate, to others and could be subsumed under the broader categories. For example, the objectives Reduce Algae, Increase Water Clarity, and Support More Diving Ducks all can be linked to the objective Decrease Phosphorus Concentrations, given conventional knowledge of aquatic ecosystems and specific knowledge of the Lower Green Bay ecosystem.

The Task Group consolidated the 40 objectives for the remedial action plan into 12 action items that were designated Key Actions. (The objective Decrease Phosphorous Concentrations was translated into the action item Reduce Phosphorous Inputs to focus attention on efforts to reduce phosphorous levels in Green Bay and the Fox River.) The action items are:

* Reduce phosphorous inputs.
* Reduce sediment and suspended solids inputs.
* Eliminate toxicity of industrial and municipal discharges.
* Reduce availability of toxic chemicals from contaminated sediments.
* Continue control of oxygen-demanding waste from industrial and municipal discharges.
* Protect wetlands and manage wildlife habitat.
* Manage endangered species and other wildlife.
* Reduce/control populations of problem fish.
* Increase populations of predator fish.
* Reduce sediment resuspension.
* Reduce bacteria inputs from point and nonpoint sources.
* Virtually eliminate toxicity caused by nonpoint and atmospheric sources.

The Institutional TAC report, which was completed after the workshop was held, identifies four additional action items related to the "people portion" of the Lower Green Bay-Fox River ecosystem. These action items are:

* Increase public awareness, participation, and support of river and bay restorative efforts.
* Create a coordinating council and institutional structure for plan implementation.
* Develop, through joint efforts, innovative solutions that will benefit both the environment and the economy.
* Enhance public and private shoreline uses.

After establishing the original list of 12 action items, the Task Group attempted to consolidate about 160 management recommendations that were identified in the TAC reports. Participants agreed that most of these recommendations were options for achieving desired changes in the Lower Green Bay and Fox River area of concern. Particular recommendations or sets of recommendations could be associated with the action items to achieve desired changes (effects) in the ecosystem. These desired changes were clearly associated with restored or improved uses in the area of concern. Consequently, the Task Group focused its attention on the action items and how they might achieve desired changes and bring about restored or improved uses.

The Task Group then addressed actions, effects, and resulting use improvements in the Green Bay area of concern, especially the level of certainty that could be given to any particular action item with regard to achieving a desired effect. (These discussions were recorded as brief caveats and serve only to signal the need for additional consideration.)

The outcome of these deliberations is summarized in a table and a brief narrative for each action item in the following section. Following the completion of the tables, the Task Group ranked action items in one of three categories -- high, medium, low -- with regard to perceived priority. Each member ranked action items by the following criteria: extent of remedial effects on the ecosystem; importance with regard to timing; goodness of fit with the Citizens Advisory Committee's Desired Future State; and technical probability of implementing.

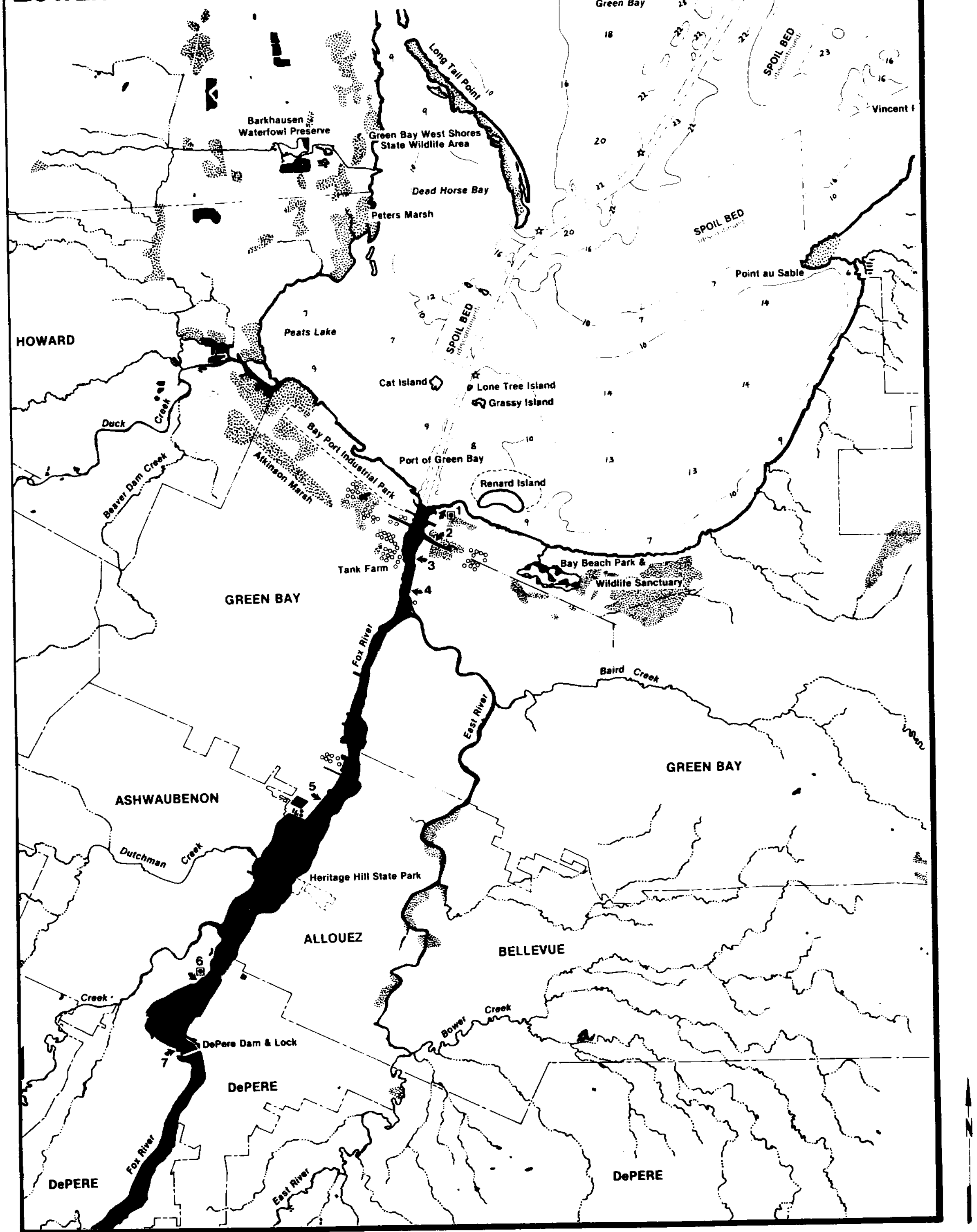
Agreement on priorities was more common than disagreement, and differences of opinion were resolved by discussion and consensus. During these discussions, participants concluded that the action item Manage Endangered Species and Other Wildlife was redundant and could be subsumed under other action items, particularly Protect Wetlands and Manage Wildlife Habitat. Consequently, the item was dropped from the list. Priorities for the remaining 11 action items are given in the following tables.

The Task Group concluded the workshop by developing an outline of monitoring activities that will be required to track the response of the Lower Green Bay-Fox River ecosystem after remedial action items are implemented. This outline is included as a separate section of this report.

KEY ACTIONS
FOR THE LOWER GREEN BAY-FOX RIVER
REMEDIAL ACTION PLAN

The following tables summarize priorities for the 11 Key Actions, effects they are expected to have on the Lower Green Bay-Fox River ecosystem, and uses of the ecosystem they are expected to restore or improve. A brief narrative for each Key Action follows.

LOWER GREEN BAY AREA



LEGEND:

Effluent Outfalls

1 Green Bay Metropolitan Sewage District
2 James River
3 Green Bay Packaging
4 Proctor and Gamble
5 Fort Howard Paper
6 DePere Sewage Treatment Plant
7 Nicolet Paper

Corporate Boundary
Oil Storage Tanks
Wetland
Municipal Sewage Treatment Plant
Spoil Bed (discontinued)
Intermittent Streams
Ponds or Lakes
Light
Depth Contour in Feet (1986 data)
Scale (Approximate)
1 mile

The area of concern extends from the DePere dam north to an imaginary line across the bay from Long Tail Point to Point Au Sable.

KEY ACTION 1: Reduce Phosphorous Inputs

PRIORITY	High
EFFECTS	Reduce algae. Improve water clarity. Increase growth of submerged vegetation. Increase numbers of diving and dabbling ducks. Reduce dissolved oxygen fluctuations. Alter existing food web. Improve fish spawning and nursery habitat. Improve benthos habitat. Improve feeding efficiency of sight-feeding fishes and fish-eating birds.
USE IMPROVEMENTS	Meet legal water visibility requirements for swimming at public beaches. Increase recreational opportunities. Improve waterfowl hunting. Improve sport and commercial fishing. Improve aesthetics. Increase diversity of fishes. Reduce fouling of ships and recreational vessels.
CAVEATS	The level of phosphorous reduction will determine extent of effects. Improvements will not occur without phosphorous reduction. Moderate uncertainty exists as to required level of reduction. Potential exists for conflict if submerged vegetation affects recreational boating and swimming.

KEY ACTION 2: Reduce Sediment and Suspended Solids Inputs

PRIORITY	High
EFFECTS	Improve water clarity. Reduce bacteria inputs. Increase growth of submerged vegetation. Reduce toxic inputs from point and nonpoint sources. Improve stream and lake spawning habitat. Improve fish egg survival. Improve benthos habitat. Increase numbers of diving and dabbling ducks. Improve feeding efficiency of sight-feeding fishes and fish-eating birds. Reduce sedimentation in depositional areas such as channels and harbors.
USE IMPROVEMENTS	Meet legal water visibility requirements for swimming at public beaches. Increase recreational opportunities. Improve waterfowl hunting. Improve sport and commercial fishing. Improve aesthetics. Increase diversity of fishes. Decrease maintenance dredging. Decrease cost of water treatment.
CAVEATS	The precise amount of turbidity due to sediment particles is undetermined. However, recent modeling efforts suggest that reductions of sediment particles and algae particles will act synergistically to increase light penetration of the water.

KEY ACTION 3: <u>Eliminate Toxicity Of Industrial and Municipal Discharges</u>

PRIORITY	High
EFFECTS	Reduce toxic loadings. Protect fish and aquatic life from acute and chronic toxicity. Promote long-term reduction of toxics in the environment, especially in sediments. Decrease bioaccumulation of toxics in organisms.
USE IMPROVEMENTS	Decrease potential human health risks from eating Green Bay fish and waterfowl. Protect furbearers, wildlife and endangered species from toxic effects. Protect aquatic life, particularly zooplankton, from conventional pollutants such as ammonia, which may improve the zooplankton community in portions of the area of concern.
CAVEATS	Overall effect of ammonia on zooplankton communities in the area of concern is not well documented. Available information indicates the potential effects of ammonia will be deleterious.

KEY ACTION 4: Reduce Availability of Toxic Chemicals From Contaminated Sediments

PRIORITY High

EFFECTS

Reduce PCB concentrations in fish, plankton, benthos and fish-eating wildlife and humans.

Increase reproductive success of Forster's tern, walleye and other biota.

USE IMPROVEMENTS

Decrease potential human health risks from eating Green Bay fish and waterfowl.

Protect furbearers, wildlife and endangered species from toxic effects.

CAVEATS

The action may have short-term adverse effects on turbidity and PCB concentrations in fish.

KEY ACTION 5: Continue Control of Oxygen-Demanding Waste From Industrial and Municipal Discharges

PRIORITY	High
EFFECTS	Decrease suspended solids and sediments. Decrease sediment oxygen demand. Reduce variation in dissolved oxygen. Improve benthos habitat. Improve fish habitat. Alter foodweb structure. Reduce discharge of toxic substances.
USE IMPROVEMENTS	Improve commercial and recreational fishing. Improve aesthetics. Increase nonconsumptive recreational uses.
CAVEATS	Many changes and improved uses in the ecosystem have already occurred. This action must be continued.

KEY ACTION 6: Protect Wetlands and Manage Wildlife Habitat

PRIORITY	Medium
EFFECTS	Increase pike spawning habitat. Increase habitat for marsh-nesting birds, including Forster's tern. Increase certain benthos. Increase numbers of dabbling ducks. Increase migrant duck use (the number of migrant ducks is declining). Improve water clarity. Improve particulate food quality. Reduce sediment resuspension. Improve nursery ground for fish. Increase endangered species production. Increase or maintain other wildlife populations.
USE IMPROVEMENTS	Improve duck hunting. Improve bird watching. Increase opportunities for commercial/sport northern pike fishing. Increase furbearer production for trapping. Improve aesthetics. Improve educational values.
CAVEATS	Marsh diking has both benefits and disadvantages. Some wildlife benefits may preclude some fishery benefits.

KEY ACTION 7: Reduce/Control Populations of Problem Fish

PRIORITY	Medium
EFFECTS	Reduce sediment resuspension and water turbidity. Increase growth of submerged vegetation. Increase utilization of wetlands by ducks. Improve production of some benthos. Extract small amounts of toxic contaminants from benthic environment and ecosystem. Decrease nutrient release from sediment. Improve nursery area for some fish species. Increase number of marsh-nesting birds.
USE IMPROVEMENTS	Improve waterfowl hunting. Improve nearshore fishing. Improve aesthetics. Increase opportunities for nonconsumptive recreation.
CAVEATS	The degree of reduction of problem fishes needed to achieved desired effects is not clear. A control program may be impractical, considering the size of the system.

KEY ACTION 8: Increase Populations of Predator Fish

PRIORITY	Medium
EFFECTS	Increase populations of northern pike. Decrease populations of all forage fish, including young carp, alewife, shad and perch. Increase large cladocerans and copepods (zooplankton). Reduce blue-green and green algae.
USE IMPROVEMENTS	Increase sport fishery for predator fish. Potentially improve swimming, water sports and aesthetics. Potentially improve waterfowl hunting.
CAVEATS	The effectiveness of "top down" ecosystem management is uncertain in a large, highly eutrophic system. This management strategy might have uncertain impacts on perch populations.

KEY ACTION 9: Reduce Sediment Resuspension

PRIORITY	Low
EFFECTS	Improve water clarity. Reduce bacteria in water column. Increase growth of submerged vegetation. Reduce algae. Improve feeding efficiency of sight-feeding fishes and fish-eating birds. Improve fish spawning and nursery habitat. Reduce toxics availability.
USE IMPROVEMENTS	Meet legal water visibility requirements for swimming at public beaches. Improve waterfowl hunting. Improve sport and commercial fishing. Improve aesthetics. Increase diversity of fishes.
CAVEATS	Reduced sediment resuspension may have broad beneficial effects on the ecosystem, but the strategies to accomplish this are largely impractical.

KEY ACTION 10: Reduce Bacteria Inputs from Point and Nonpoint Sources

PRIORITY	Low
EFFECTS	Reduce infectious bacteria and viruses in water column and sediments. Reduce potential for human and animal diseases.
USE IMPROVEMENTS	Improve conditions for swimming, water contact sports and other recreation. Improve safety of upstream livestock.
CAVEATS	Heavy use of chlorine may prompt formulation of unwanted toxic compounds.

KEY ACTION 11: Virtually Eliminate Toxicity Caused By Nonpoint and Atmospheric Sources

PRIORITY	Low
EFFECTS	Similar to effects of reducing point and in-place toxics depending on proportion of nonpoint source load in total load.
USE IMPROVEMENTS	Unknown at this time.
CAVEATS	At present there is little reason to believe that this is a significant problem, but some action is needed to further define the nature and magnitude of the situation.

KEY ACTION 1: Reduce Phosphorous Inputs

Phosphorous loading stimulates excessive algae production and contributes significantly to problems of water turbidity in Lower Green Bay and the Fox River. (Turbid water has a high proportion of suspended particles, including algae, in the water column, and highly turbid water impairs many uses of the Lower Green Bay-Fox River area of concern.) Phosphorous inputs to the ecosystem from point and nonpoint sources must be cut to reduce algae production, lessen water turbidity, and restore and enhance beneficial uses. However, the extent of algae reduction that would yield desired water clarity (0.7 meter-1.3 meter secchi disk depth) and the load estimates for reducing phosphorous are moderately uncertain.

Combining reductions in phosphorous inputs with other remedial actions may work synergistically to achieve desired changes, especially the reduction of average summer total phosphorous concentrations into the range of 100-125 mg/L and chlorophyll a concentrations into the range of 35-45 mg/L. Therefore, the strategy for implementing this action should be flexible in order to respond to changes that may occur as other actions are implemented during the next 10 years. The strategy should contain a combination of point and nonpoint source controls that will allow future adjustment, benefits outside the area of concern, and a reasonable certainty of reductions in phosphorous inputs.

Phosphorous load reductions can be achieved by effluent limits (compatible with plant management improvements) and watershed management projects such as erosion control and stormwater runoff, riparian buffer strips, animal management, urban nonpoint source controls and correction of failing septic systems. Phosphorous reductions in the area of concern may have wide ranging effects and will be necessary if the desired future state identified by the Citizen's Advisory Committee is to be realized.

EFFECTS
Limiting the availability of phosphorous should reduce algae densities which, in turn, should abate dissolved oxygen fluctuations in the lower bay due to localized algae blooms and internally-produced biological oxygen demand (BOD). Lower algae densities also will contribute to improved water clarity and increased growth of submerged vegetation. Improved water clarity will improve the feeding efficiency of sight-feeding fishes and fish-eating birds and could increase ultraviolet light penetration, an improvement which would reduce numbers of bacteria and viruses in the water column. Increased growth of submerged vegetation will increase duck populations because diving and dabbling ducks depend on submerged vegetation for food, both for the plant material itself and for the animals associated with the plants. Submerged vegetation also will improve fish spawning and nursery habitat and habitat for some forms of benthos. These developments may alter the existing food web and shift energy into the grazing food chain rather than the detrital food chain.

USE IMPROVEMENTS
This action will prompt the effects described above to some degree. These effects will be determined more strongly by the synergistic interactions of various actions, including not only phosphorous reductions but other actions such as reduced sediment and suspended solids inputs, carp control and increased populations of predator fishes. Improvements in waterfowl hunting

and sport and commercial fishing should be apparent when average summer secchi disk depth approximates 1 meter. Swimming at public beaches could be restored when secchi disk depth reaches 1.3 meters. Other use improvements would include an enhanced aesthetic environment and reduced recreational and industrial fouling.

KEY ACTION 2: Reduce Sediment and Suspended Solids Inputs

The Lower Green Bay-Fox River area of concern receives considerable particulate matter from point and nonpoint sources. Soil particles, particularly clays and silts, enter the ecosystem from agricultural and urban runoff. Organic and inorganic suspended solids enter the ecosystem from municipal and industrial waste discharges. The annual load of suspended solids in the Fox River has been estimated at 220,000 to 240,000 tons, and tributaries to the river contribute significantly to this load. For example, the U.S. Geological Survey estimates that 21 percent of the sediment yields at the mouth of the Fox River between April and November 1985 came from the East River.

Sediments and suspended solids, along with algae, contribute to the highly turbid water in Lower Green Bay and the Fox River. (The contribution of sediments and suspended solids, relative to algae, to this water quality problem is not known.) Efforts to reduce phosphorous inputs from point source effluents will reduce some inputs of suspended solids. Therefore, other efforts to reduce inputs of sediment and suspended solids need to be directed toward nonpoint sources in agricultural and urban areas. These efforts should include programs and regulations to control soil erosion and stormwater runoff, to rehabilitate and protect streambanks, to adopt animal waste management ordinances, and to implement urban nonpoint source programs. Watershed management of nonpoint source pollution deserves special emphasis. This effort should involve the federal Clean Water Act nonpoint source program, the state Priority Watershed Program, and local soil and water conservation programs. Efforts to reduce sediment and suspended solid inputs, along with efforts to reduce phosphorous inputs, will have multiple effects in the Green Bay-Fox River ecosystem and adjacent watersheds.

EFFECTS

Reducing inputs of sediment and suspended solids will contribute to increased water clarity and many of the effects associated with decreasing phosphorous inputs. This action also will reduce sedimentation in depositional areas, such as channels and harbors, and in tributary streams. Sediment reductions in river and streams in the area of concern will improve spawning habitat and the survival of fish eggs. Improvements in animal waste management should reduce bacteria inputs to the ecosystem's tributaries, especially the East River. Soil management, erosion control, and urban nonpoint source control may reduce inputs of toxic compounds since many of these chemicals adhere to particles. Additional reduction of suspended solids from municipal and industrial sources also would reduce the discharge of toxic substances since toxic compounds are frequently associated with suspended solids.

USE IMPROVEMENTS
This action will improve fishing and waterfowl hunting opportunities and other recreational activities, particularly swimming. It also should decrease maintenance dredging and possibly reduce costs of water treatment for industrial uses.

KEY ACTION 3: Eliminate Toxicity of Industrial and Municipal Discharges

Toxic contaminants enter the aquatic ecosystem through both water and air. During the past decade, levels of some toxic compounds, notably PCBs, in industrial and municipal effluents have been markedly reduced. However, recent bioassays still show some effluents to be acutely toxic to fish (fathead minnow) and other aquatic life (daphnia).

Effluents from industrial and municipal point sources can be monitored relatively easily for toxicity to aquatic life, and problems with toxic effluents can be addressed relatively directly. Monitoring and remedying air emissions of toxic contaminants is more difficult because the concentration of a potentially toxic substance in one medium (air) must be translated into a concentration known to be toxic in another medium (water). Direct measures of toxicity are not possible. Cross-medium transfer complicates the problem of setting air emission limits but it does not negate the need for these limits. The most immediate actions in regard to airborne emissions of toxic contaminants should include efforts to: compile and evaluate existing information in order to identify potential sources of toxic air emissions; compile and evaluate existing stack test data to estimate loads; and monitor coal-fired combustion sources for dioxins, furans, PCBs and heavy metals.

The Citizens Advisory Committee's Desired Future State document calls for "...water quality that protects human health and wildlife from effects of contaminants." Eliminating toxicity of point source discharges will not assure water quality that offers this protection. However, this action is a necessary and integral part of any plan that intends to provide such protection and consequently deserves high priority.

EFFECTS
Eliminating toxicity of point source discharges will reduce the overall loading of toxic substances to the ecosystem and will protect fish and other aquatic life. This action also will lead to a long-term reduction of contaminants in the environment, particularly in sediments, and will help reduce bioaccumulation of contaminants in organisms.

USE IMPROVEMENTS
This action alone may reduce the risk of health effects from eating Green Bay fish to an undetermined degree. However, it probably will not reduce PCB levels in all fish to standards set by the U.S. Food and Drug Administration.

KEY ACTION 4: Reduce Availability of Toxic Chemicals From Contaminated Sediments

Of the many toxic substances known to be present in sediments of the Fox River and Lower Green Bay, PCBs comprise the group of chemicals that are of overriding concern. PCBs are known to exist at high concentrations in sediments of the Fox River. Their presence contributes to: PCB levels above FDA standards in some fish in the area of concern; a potential human health hazard from eating these fish; impaired reproduction of some fish and wildlife species; and complications in navigational dredging.

Compliance with the international Great Lakes Water Quality Agreement, the federal Clean Water Act, and the identified desired future state for Green Bay and the Fox River demands action to deal with in-place pollutants. However, the best remedial strategies to deal with these pollutants are not readily apparent. In some areas, dredging appears inevitable; other approaches may be more appropriate in other locales. The problem of in-place pollutants is of such magnitude that establishment of a multiagency federal and state task force -- one that would include the U.S. Army Corps of Engineers and U.S. Geological Survey -- should be considered. This task force should initiate a remedial investigation/feasibility study along the lines suggested by the In-place Pollutant Subcommittee and described in the Toxic Substances Management TAC Report.

EFFECTS
Reducing the availability of in-place toxic substances, particularly by removing contaminated sediments, will cause a decline of PCB concentrations in fish, plankton, benthos and fish-eating wildlife. It also should improve the reproductive potential or success of populations of the Forster's tern, walleye and other biota.

USE IMPROVEMENTS
This action will reduce human cancer risks from eating fish from Lower Green Bay and the Fox River. It also will lessen the problems associated with toxic contaminants for furbearers, wildlife and endangered species, and will improve opportunities for existing and future uses of the ecosystem such as fishing and hunting. However, this action probably will have adverse short-term effects on water turbidity and probably will produce a transitory increase in PCB concentrations in fish.

KEY ACTION 5: Continue Control of Oxygen-Demanding Waste From Industrial and Municipal Discharges

Before 1970, heavy loading of organic materials from point sources created intolerable conditions for some fish and many forms of aquatic life in the Lower Green Bay-Fox River area of concern. Improved effluent treatment processes have significantly reduced discharges of oxygen-demanding waste from municipal and industrial sources during the past decade, and these reductions have changed the ecosystem favorably. Control of oxygen-demanding waste should continue as an integrated part of other proposed actions rather than as an isolated action.

EFFECTS
Control of point source discharges of organic waste has, most importantly, reduced variations in dissolved oxygen. It also has decreased suspended solids and sediments, decreased sediment oxygen demand, improved habitat conditions for benthos, improved habitat conditions for fish, altered food web structure, and reduced discharge of toxic substances.

USE IMPROVEMENTS
This action has and will continue to improve recreational and commercial fishing, expand nonconsumptive recreational uses and improve aesthetics.

KEY ACTION 6: Protect Wetlands and Manage Wildlife Habitat

Animal populations need high quality habitat to thrive. The degradation or loss of habitat in the Lower Green Bay-Fox River area of concern has adversely affected fish and wildlife populations. Poor water quality has degraded habitat for some fish and wildlife species, and habitat improvements require changes associated with water clarity improvements (see Key Actions 1 and 2). Wetland habitats are important to many desirable species. However, about 90 percent of the original marshes in the Lower Green Bay-Fox River ecosystem were lost between 1834 and 1975, and, to a large extent, these losses are irreversible.

Protection and improvement of remaining wetlands and development of aggressive management programs for other habitats are essential. Emphasis should be placed on "community management" rather than species management, although endangered or threatened species may require special consideration. Wetlands in the area of concern and associated tributaries can be protected through land acquisition, zoning, incentive programs for private landowners and changes in bulkhead lines. Diking of marshes may or may not provide the desired mix of long-term benefits. Many programs or ordinances are already in place and may only need to be strengthened. Other habitat management opportunities include improving wetland mitigation areas near Interstate Highway 43; creating or improving fish spawning or rearing areas in or on rocks, gravel and marshes; building experimental reefs and promoting tern colonization of suitable areas. Habitat management for both fish and wildlife should be an integral part of priority watershed projects. Wetland protection and habitat management are needed to rehabilitate the Lower Green Bay-Fox River area of concern. However, this action has been assigned a medium priority because Key Actions 1 and 2 are considered prerequisites to long-term habitat improvement and may have more extensive ecological effects.

EFFECTS
Wetland protection and habitat management should increase northern pike spawning habitat and improve nursery grounds for several other fish species. Improvements of emergent marshes will increase littoral zone benthos production and increase habitat for marsh-nesting birds, including the Forster's tern. These developments also may increase dabbling duck production and migrant duck use. Protecting or increasing wetland or riparian habitats also will maintain or increase other wildlife populations. Protection and management strategies could be used to increase numbers of targeted species such as the common tern.

USE IMPROVEMENTS
This action -- coupled with Key Actions 1, 2, 4, 7 and 8 -- should support increased opportunities for commercial and sport northern pike fishing and improve waterfowl hunting. Enhancement of wetland and riparian habitats also could increase furbearer production for trapping and could increase the aesthetic and educational values of the ecosystem.

KEY ACTION 7: Reduce/Control Populations of Problem Fish

Some fishes in Green Bay, especially carp and sea lamprey, have been singled out for reduction and/or control. Sea lamprey are well known for their devastating impact on large predatory fish populations. The potential for a lamprey invasion of the Fox-Wolf river system increases as water quality and habitat improve at the downstream end of this river system. Lamprey control methods are established and a contingency plan exists to deter or control an invasion of the Green Bay-Fox River area of concern. Monitoring at the De Pere Dam in the lower Fox River during the past several years has not revealed any lamprey, but advance planning for lamprey control would be prudent.

The detrimental effect of carp on littoral zone vegetation has been extensively documented, and there is good reason to believe carp are degrading littoral areas and marshes in the Lower Green Bay-Fox River ecosystem. However, the reduction and control of existing carp populations is problematic, particularly in a large system such as Green Bay. The carp population in the ecosystem has not been reliably estimated and the reduction that would be needed to achieve desired affects is uncertain. Present conditions in the ecosystem favor carp propagation. The existing benthic community and abundant organic material provide ample food for these bottom feeders. In addition, carp populations face little pressure from natural predation or commercial harvesting. Low numbers of predators are present to feed on young carp and highly turbid water does not favor these sight-feeding fishes. High concentrations of PCBs in carp preclude harvesting them for commercial marketing. Carp could be reduced by intensive harvesting, particularly during periods when carp mass in certain locations in spawning and winter schools. However, the benefits of intensive harvesting would be short-lived unless it was accompanied by changes in water clarity, habitat conditions and numbers of predators. Consequently, this action would be most effective in combination with Key Actions 1, 2, 4 and 8. Reduction and control of carp populations could provide substantial beneficial effects but only if combined with these other actions and initiated when reductions in ambient phosphorous concentrations are apparent. In essence, strategies to reduce and control carp populations should combine actions in such a manner as to "tip the scales" in favor of self-correcting processes in the ecosystem, thereby reestablishing a more desirable level of ecosystem performance.

EFFECTS
Reducing and controlling problem fishes such as carp would help reestablish submerged aquatic vegetation in the littoral zone, which would stabilize the substrate and reduce resuspension of particulates. Reducing numbers of carp also would cut the release of nutrients from sediment. Harvesting carp also would remove some PCBs from the ecosystem. These effects will improve habitat for fish and waterfowl.

USE IMPROVEMENTS
This action would improve waterfowl hunting and nearshore fishing.

KEY ACTION 8: Increase Populations of Predator Fish.

The existing fish community in the Lower Green Bay-Fox River area of concern is unbalanced and characterized by low abundance and low diversity of both top predators and native forage species. A desirable fish community would be a coolwater fishery containing percid and pike species such as walleye, perch, northern pike, and muskellunge. This fish community also would include forage species such as spottail, emerald shiners, trout-perch and darter species. This action is aimed at establishing a predator-to-prey ratio ranging from 1:10 to 1:20 and altering the food web so large zooplankton (cladocerans and copepods) become more prevalent. Stocked walleye have survived and are growing well in the area of concern, although successful reproduction appears to be minimal. Stocking other predators, principally northern pike and muskellunge, should be preceded by efforts to assess and enhance available spawning habitat.

EFFECTS
Stocking top predators would have several advantages. It would enlarge the sport fishery, reduce forage fish populations, increase the abundance of zooplankton that feed on algae, improve the efficiency of the food chain and increase water clarity. Stocking northern pike and muskellunge also could increase predator pressure on carp populations. However, these predators also could feed on perch, which are desirable for both sport and commercial fishing.

USE IMPROVEMENTS
This action would increase fishing opportunities and could potentially improve aesthetics and opportunities for swimming and water sports.

KEY ACTION 9: Reduce Sediment Resuspension

The extreme southern portion of Green Bay is periodically subject to considerable wind stress and wave action. This portion of the bay is very shallow and, as a result, large quantities of sediment are resuspended in the water column. (Islands that once acted as wind breaks in the inner bay have eroded, partly as a result of high water.) Resuspension of solids can aggravate water clarity problems. Resuspension also can release materials, such as phosphorous and PCBs, that are attached to the sediments, thereby reintroducing them into the ecosystem and promoting algae production and bioaccumulation of toxic contaminants. The wind and wave actions that contribute to resuspension also deter establishment of submerged vegetation. Reduced sediment resuspension would have many beneficial effects and technology is available for pursuing this action. However, strategies to accomplish this action are largely impractical, so it is given low priority.

EFFECTS
Reducing sediment resuspension would improve water clarity, fish spawning and nursery habitats, and the efficiency of sight-feeding fishes and fish-eating birds. It also would increase the growth of submerged vegetation.

USE IMPROVEMENTS
The action would bring water closer to the legal water visibility requirements for swimming at public beaches. It also would increase fish diversity and improve waterfowl hunting, sport and commercial fishing, and aesthetics.

KEY ACTION 10: Reduce Bacteria Inputs from Point and Nonpoint Sources

The Green Bay Health Department routinely takes bacteria counts in the Lower Green Bay-Fox River area of concern. The bacteria that are monitored are not themselves pathogenic, but they are indicators of the possible presence of infectious bacteria and viruses. At times, bacteria counts are within acceptable limits for swimming, but bacteria counts are periodically higher than limits set for "full body contact." Municipal waste and nonpoint animal waste are sometimes identified as the causes for these excessive levels.

Chlorination of effluents from sewage treatment plants and industries that process animal wastes is a standard practice for killing bacteria. However, routine chlorination is not without problems because the free chlorine radical can combine with organic compounds to form chlororganics that may have toxic properties. Other means of sanitizing waste effluent should be explored. Animal waste management programs, as well as programs to reduce urban and rural runoff, will help reduce bacterial numbers in the area of concern. This action was given low priority because it has relatively less effect on the ecosystem, the problem with high numbers of bacteria is not always apparent, and other actions will help correct or prevent this problem.

EFFECTS
Reducing bacteria from point and nonpoint sources will lower the incidence of infections and levels of bacteria, viruses and sediments in the water, which will in turn reduce the potential for human and animal diseases.

IMPROVED USES
The action would improve recreational opportunities, especially for swimming and other water-contact sports, and it would improve the safety of livestock watering upstream.

KEY ACTION 11: Virtually Eliminate Toxicity Caused By Nonpoint and Atmospheric Sources

The extent of toxic contamination in the Lower Green Bay-Fox River area of concern from nonpoint and atmospheric sources is unknown. At present, toxic contamination from these sources does not appear to be significant, but some action is needed to further define the nature and extent of this potential problem.

MONITORING NEEDS

ECOSYTEM TREND MONITORING

1. A monitoring program should be implemented to track total phosphorous concentrations; the size of particles, including plankton particles; chlorophyll; and zooplankton and phytoplankton species. The monitoring program should include:

   * Two or more stations in Lower Green Bay. (Consult Paul Sager at UW-Green Bay.)

   * Collection of two-meter integrated vertical samples from the bay using a vertical tow and 35-micron mesh. Each sample should contain 100 liters of water to provide statistically significant numbers of organisms.

   * Sampling twice monthly during summer months. When possible, this should be coordinated with satellite overflights to cooperate with remote sensing investigations of Green Bay by UW Sea Grant researchers.

2. Programs should be implemented to monitor the net flow of the Fox River and to estimate phosphorous and total suspended solid loads in the Green Bay and Fox River. The monitoring program should include:

   * Two continuous integrated monitoring stations, one of them at the De Pere Dam. (Consult Paul Sager.)

   * Automatic samplers to collect 24 discrete samples per day (one sample per hour).

   * Samples collected weekly for at least one year, preferably one to three years.

3. Analysis of phytoplankton and zooplankton biomass should be conducted using both high-precision liquid chromatography (HPLC), a state-of-the-art method for estimating algae biomass, and historical methods for estimating species and size. Using both HPLC and historical methods will allow correlations of historical biomass data and comparisons of data obtained by both historical and state-of-the-art techniques. Using both methods also will ensure more accurate estimates of biomass in the future.

4. * A benthic sampling program should be initiated. The program should include:

   * Sampling six times a year -- twice in summer, twice in spring, and twice in fall -- at two stations in the area of concern.

   * Benthic grab samples collected using the Smith/Mack sampler, which collects a larger volume of sediment than traditional methods such as Ponar samples and the Ekman dredge. For the first two years of monitoring, a Ponar sample also should be collected for comparison with Smith/Mack and historical records. (Howmiller and Beeton used Ponar samples.) This sampling will require a boat with a winch.

* Epibenthic samples obtained from artificial substrates at two stations in the area of concern. This sampling should use the same methods as studies by the Institute of Paper Chemistry in order to compare results with IPC studies of the Fox River.

FISH MONITORING -- The following monitoring programs have been proposed, are underway, or will be initiated:

1. Carp -- The U.S. EPA and WDNR will study carp biomass if funding is available. The Task Group recommends either Mark/Recapture or DeLury methods.

2. Alewives -- John Magnuson of UW-Madison will begin a three-year study using acoustics and vertical gill netting of pelagial fish (alewives, perch, walleye) to estimate biomass, size and species composition.

3. Perch and walleye -- WDNR routinely conducts virtual population analysis (VPA) and sport fish creel census for size.

4. Forage Fish Index -- WDNR conducts routine fishing trawl and shoreline seining. (Consult Brian Belonger, WDNR-Marinette).

5. Sea Lamprey -- The U.S. Fish and Wildlife Service routinely conducts wire mesh trapping and monitoring of incidental catches below the De Pere Dam.

The Task Group recommends:

* Continuation of routine DNR activities regarding perch, walleye and forage fish populations listed above in items 3 and 4.

* Continuation of permanent lamprey monitoring below the De Pere Dam listed above in item 5.

* That additional monitoring be postponed until evaluation of results from the carp and alewife studies listed above in items 1 and 2.

SEDIMENT SAMPLING -- Sediment deposition monitoring would not yield consistent or reliable results because deposition fluctuates in the Lower Green Bay-Fox River area of concern, and no permanent depositional areas in Green Bay are located south of Long Tail Point. Sediment deposition should be studied further, but no permanent monitoring is recommended. Descriptive analysis of sediments should continue in conjunction with benthic monitoring (six times a year at two sites) as outlined above in the section on Ecosystem Monitoring.

TOXICS TREND MONITORING

1. Fish should be monitored for PCBs and any compound with a log P 3.5. Log P relates to the solubility of compounds. Highly soluble compounds have the greatest potential for bioaccumulation.

   Carp and walleye within three size ranges should be tested for total PCBs and for specific congeners. Carp will provide examples of contamination of a benthic species; walleye will provide examples of contamination of a pelagic species. Sampling should occur twice each fall.

2. The Fox River should be monitored for ambient toxicity at five stations along the entire length of the river.

   Previous river sampling has found high levels of PCBs during both high and low flows. Future water sampling should be taken twice a year and be related to flow conditions.

   The U.S. Geological Survey, with the support of the Green Bay Metropolitan Sewage District, is installing an acoustical velocity meter (AVM) at the mouth of the Fox River to assess the net flow of both the Fox and East rivers. (The assessment will account for seiche and reverse flow.) This effort relates to Key Action 9.

3. Point source bioassays should continue (see Toxic Substances Management TAC Report for details).

4. A tissue bank should be established to store samples for future research on trends regarding bioaccumulation of toxic contaminants.

APPENDIX

Charge to the Ad Hoc Task Group to Review Recommendations for Ecosystem Management

REMEDIAL ACTION PLAN: A PEER REVIEW OF THE RECOMMENDATIONS FOR ECOSYSTEM MANAGEMENT

The meeting will bring together a small group, not to exceed 12, of professionals, including a majority of University faculty who have direct experience with research on Green Bay. This group will review drafts of reports by the three technical advisory committees on Toxics, Nutrients and Eutrophication, and Biota and Habitat. The objective of the meeting will be consolidation of the large number of existing objectives and recommendations in the three reports into a coherent and cohesive summary. In this consolidation, the group will assess the consistency of any given objective or recommended action with:

* Restoring impaired uses of the ecosystem.
* Meeting EPA Clean Water Act criteria.
* Meeting the intent and guidelines of the International Water Quality Agreement.
* Maintaining scientific credibility.

After listing integrated recommendations for management, the meeting will examine their priority; that is, which options for managing the Green Bay ecosystem should be implemented first and the way the effectiveness of these activities can be monitored. This effort should yield:

1. A list of impaired uses.
2. An edited list of integrated objectives.
3. A priority list of recommended actions.
4. Identified monitoring and research needs.
5. Explanation of the choices of objectives and actions and, where necessary, caveats regarding the degree of confidence associated with a particular recommended action.

It is expected that this effort will require two days and that it would be counter-productive to include broader goals, such as the institutional and socioeconomic features related to the remedial action plan. It is also suggested that a significant attempt be made to encourage objectivity and to limit the number of people participating to assure a healthy exchange and full participation. It is possible that a facilitator for the conduct of this workshop could be provided by the James River Corporation. It is also understood that a grant from a local foundation has been provided to pay expenses. A report summarizing the meeting results will be written. It should serve as a keystone of the RAP report.