United States
Environmental Protection
Agency

Region 5
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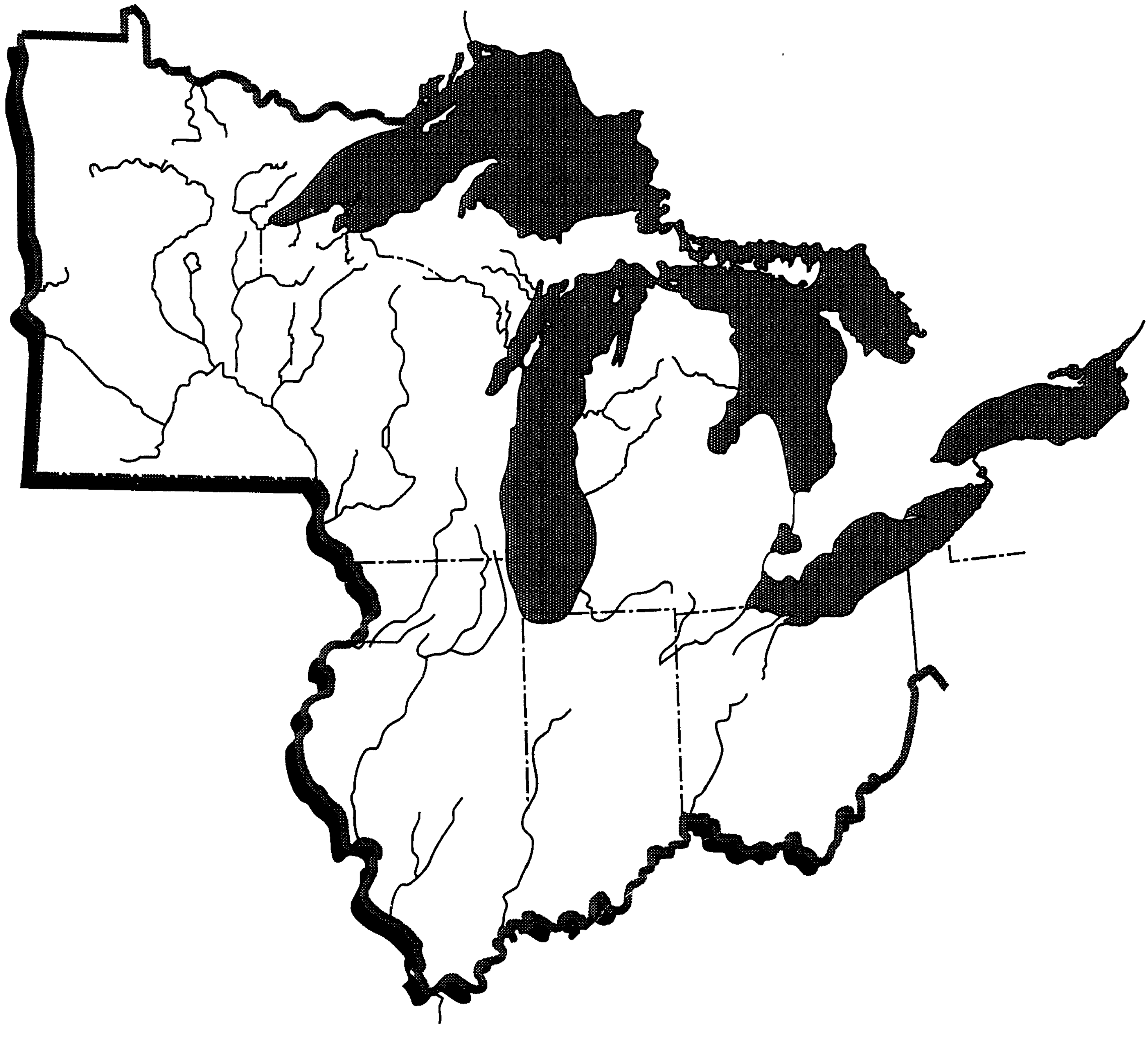
Environmental Sciences Division, Region 5 and Office of Policy, Planning and Evaluation

EPA

Environmental Indicators For Surface Water Quality Programs

Pilot Study



EXECUTIVE SUMMARY

CHAPTER 1. INTRODUCTION

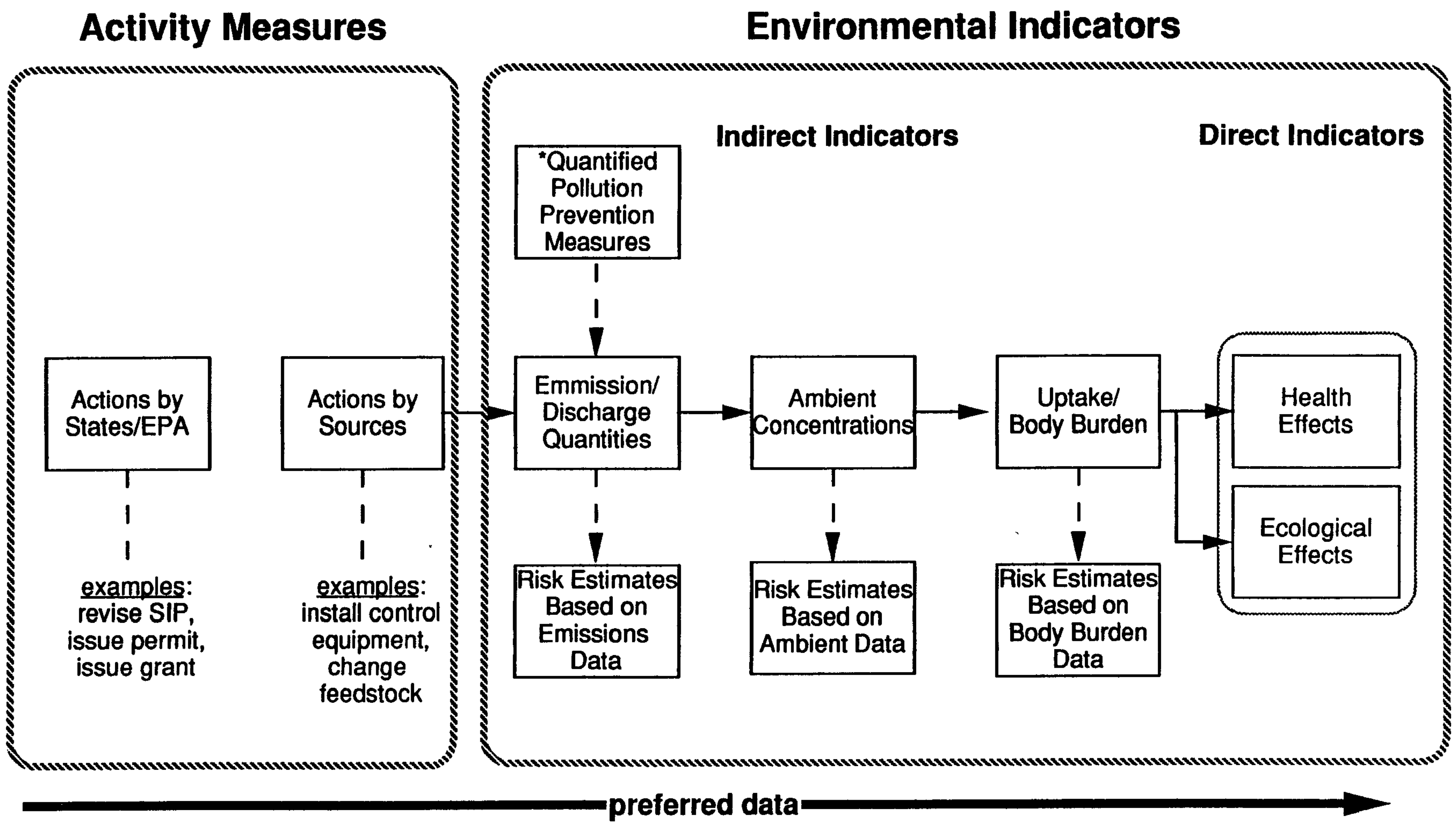
This report presents the results of a study on how water quality data currently being collected by the States in EPA's Region 5 (Minnesota, Wisconsin, Indiana, Illinois, Michigan, and Ohio) support water quality planning and management and the development of environmental indicators. Environmental indicators, in the context of this report, refer to a variety of measures of the quality of water resources (Table E-1). This study was undertaken as the beginning of the third phase of a project designed to develop a series of environmental indicators for the nation's surface waters.

In the first phase of this project, Environmental Protection Agency (EPA) staff developed a candidate list of environmental indicators that can be used to identify trends and emerging threats, evaluate programs, target resources, and communicate results to the public and legislators. Staff then conducted a workshop involving Federal and State water quality professionals to review, revise and narrow down the candidate indicator list. In the project's second phase, personnel from EPA and the National Oceanic and Atmospheric Administration (NOAA) evaluated the feasibility of collecting data and reporting on the six indicators identified as highest priority at the workshop -- designated use support, shellfish harvest area classifications, trophic status of lakes, toxicants in fish and shellfish, biological community measures, and pollutant loading from point sources. The results of this study are presented in *Feasibility Report on Environmental Indicators for Surface Water Programs* (U.S. EPA, 1990c).

EPA and State personnel are now working to develop specific recommendations to facilitate the development and reporting of environmental indicators, looking specifically at potential improvements for assessing designated use attainment. Information on the ability of various waterbodies to meet their designated uses is reported to EPA every two years in the State 305(b) reports.

The 305(b) reports include information on a variety of designated uses including the ability of specific waterbodies to support aquatic fish and wildlife populations and to support recreational, agricultural, industrial and navigational uses. Inconsistencies among States in how water quality information is collected, analyzed, and reported and inconsistencies in sampling activities within individual States limits the utility of designated use information to support national or regional environmental indicators or even to assess trends within individual States. These problems notwithstanding, one of the conclusions reached in the 1990 feasibility study and supported by the Office of Water (OW) was that the 305(b) reports are the best vehicle for reporting on existing and proposed environmental indicators.

Table E-1. Continuum of Environmental Measures



Theme 1: Managing Environmental Results. Data to the right are closer to the "adverse ultimate imacts of pollution" that the States and EPA are charged with preventing or mitigating. All else being equal, data further to the right are better indicators of environmental result than data further to the left.

Theme 2: Emphasizing Pollution Prevention. Pollution prevention should result in the same kinds of environmental improvements as all Agency programs, so all these indicator types may be used to reflect pollution prevention successes. However, to prove the results are due to pollution prevention, data would needed on the box marked with an asterisk.

To help ensure more accuracy and consistency in the reports, OW established a National 305(b) Consistency Workgroup to develop more specific guidance to the States in assembling their reports. The effort described in this report-- to assess the current status of water quality assessment programs in the Region 5 States and the ability of this data to support water quality planning and management objectives and the development of regional and national environmental indicators --complements the activities of the 305(b) Workgroup. In addition, the work of the project team supports a number of other ongoing efforts including EPA's Environmental Monitoring and Assessment Program (EMAP) and the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program by describing their relationship to State programs. The development of data needed for environmental indicators cannot proceed independently from identification of data requirements for effective water resource management. The two share several goals and objectives including water resource evaluation, problem identification and characterization, management strategy development, implementation and evaluation, and communication of results to the general public and legislators.

The Region 5 Project

The project team, consisting of EPA Headquarters, Region 5, and contractor personnel conducted interviews with State monitoring personnel (in-person and by telephone) and reviewed documents and data management systems from Federal, Regional, and State agencies to identify and describe, for each Region 5 State, the following:

Methods for estimating total waters (see Chapter 2)

Assessment of designated use support (see Chapter 3)

Surface water monitoring programs (see Chapter 4) and

Assessment-related data management systems (see Chapter 5).

Each chapter of this report, the major findings of which are summarized below, contains a general description of the issue, specific information from each of the Region 5 states, and recommendations for potential improvements to assist in water quality planning and management and in the development of environmental indicators. The final chapter (chapter 6) discusses the Region 5 study in the broader context of water resource policy.

CHAPTER 2. METHODS FOR ESTIMATING TOTAL WATERS

Accurate and consistent quantification of surface water resources is essential to improving designated use support as an environmental indicator. The total water estimate acts as the denominator for calculating the percentage of waters known to be supporting designated uses. Without this information the relative proportions of designated use support categories (i.e., "fully supporting", "fully supporting but threatened", "partially supporting", and "not supporting") cannot be consistently determined nor can meaningful comparisons be made spatially or temporally.

At the present time, estimates of total waters are not comparable among States because each State employs its own method of measurement. Lacking a national database of accurate hydrologic features, each State selects its own criteria for including waterbodies in these estimates. In addition, varying definitions of surface water resource categories (e.g., how are rivers and streams, lakes and wetlands identified and described?) among States are another source of inconsistent resource quantification.

As seen in Table E-2, there is a lot of variability among state total water estimates. Most Region 5 states use mechanical methods for estimating their waters, while Minnesota uses digitized data. In 1991, the 305(b) Consistency Workgroup recommended that the best estimates can be obtained using EPA's Reach File Version 3 (RF3), a computer system based on the USGS Digital Line Graph (DLG) database that provides the first national database with sufficient detail to calculate reliable total State water values.

Recommendations

- RF3 is the best available national database for calculating State total waters and is detailed enough for most State applications. However, States should be given the flexibility and tools to modify their RF3 databases to add further detail, and to allow States that have digitized their waters to a greater level of detail than RF3 to report their own total waters. Minnesota is an example of such a State.

- The 305(b) Consistency Workgroup should review the results of the effort by Region 5 States to summarize use support separately for perennial, intermittent and border streams and ditches/canals (including miles of waters being monitored and assessed in each category). The Workgroup should then consider options for improving national reporting on miles supporting aquatic life.

- EPA should resolve the issue of a lower size cutoff for lakes included in State total waters. Not all RF3 impoundments are waters of the State--e.g., wastewater lagoons or borrow pits have filled with water as a result of highway construction.

CHAPTER 3. ASSESSMENT OF DESIGNATED USE SUPPORT

As noted earlier, States set specific standards and designate uses for their own waterbodies. They also have the independence to decide which types of measures (e.g., chemical concentrations, toxicants in fish and shellfish or biocommunity data) will be used to

Table E-2. Estimates of Total Stream and River Mileages for Region 5 States

	State Estimates		DLG/RF3 Mileages[a]			
State	Method	Mileage Reported by the State	Perennial[b]	Intermittent	Ditches/ Canals	Total
Illinois	Mechanical	26,310 (mainly perennial streams)	33,009	44,462	2,341	79,812
Indiana	Unknown (probably mechanical with extrapolation)	90,000 (includes 70,000 mi of ditches)	21,095	8,409	6,169	35,673
Michigan	Unknown (probably mechanical; 1940 estimates)	36,350	30,221	22,793	3,080	56,094
Minnesota	Digitized from 1:24,000 and 1:62,500 maps	91,944 (includes ditches)	31,108	33,761	7,726	72,595
Ohio	Mechanical (1960 estimates)	25,165 (named or included in WQS)[c]	29,113	29,602	2,818	61,532
Wisconsin	Mechanical using 1:24,000 topo maps	43,600 (mainly perennial)	30,359	25,735	797	56,890

DLG=Digital Line Graph
RF3=Reach File Version 3
WQS=Water Quality Standards

[a] Source: U.S. EPA, 1991. (Total Waters Document)

[b] Includes the DLG categories "perennial streams" and "wide rivers"

[c] Ohio also reports a total of 43,917 miles of named or unnamed streams (including an estimate for ditches); however, 29,113 miles is used in the 305(b) for total waters.

support designated use assessments. States use a wide variety of approaches for assessing designated use support, ranging from integrated bio-survey based approaches to best professional judgement and citizen questionnaires. These inconsistencies in approaches among States make it difficult to accurately report indicator information at a regional or national level. Often in reviewing State 305(b) reports, the decision process used to make use support determinations is unclear. One of the objectives of this study was to clearly document the approaches used in the Region 5 States to promote more accurate, consistent and reproducible assessments.

This section describes the approaches of each Region 5 State in assessing designated use support, with a special focus on aquatic life support. Aquatic life support is a particularly useful environmental indicator because it measures the overall integrity of surface waters. Figures E-1 and E-2 show the specific measures used by each Region 5 State to assess aquatic life support for rivers and streams and lakes, respectively.

Recommendations

- Aquatic life support should be the direct environmental indicator for surface waters and be primarily based upon assessments of the fish, benthos, and habitat. This assessment should also include all other available information such as chemical concentrations in water and sediments, physical measurements, and toxicological endpoints. This recommendation is consistent with those recommendations and conclusions made at the July 1991 EPA conference in Baltimore, Maryland -- *Environmental Indicators: Policies, Programs and Success Stories.*

- EPA and the States should use the specific measures selected for aquatic life use attainment to meet EPA's requirements to develop biological criteria. Particular emphasis should be placed on wider use of fish and benthic macroinvertebrate communities and habitat for use attainment assessment.

- Greater consistency in the methods and approaches for determining use attainment is necessary to use environmental indicators in State, Regional and National 305(b) programs.

- EPA and the States should cooperatively develop the environmental indicators (measures) which will directly support the assessment of aquatic life support for both resource types (rivers/streams and lakes).

CHAPTER 4. SURFACE WATER MONITORING PROGRAMS

As noted earlier, States currently collect, assess, and report on a great deal of information relating to surface water quality. Historically, these data collection efforts have tended to

Figure E-1. Indicators Used in Assessing Aquatic Life Uses for Rivers and Streams by State

Indicators	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
Water chemistry	●	●	●	●	●	●
Sediment chemistry	○	○	○		○	○
Fish community	●	○	●	○	●	●
Macroinvertebrate Community	●	○	●	○	●	○
Fish tissue contamination	○	●	●	●	●	●
Habitat evaluations	●	○	●	○	●	●
Fish kills	○	○	○	○	○	○
Effluent chemistry & toxicity	○	○	○	○	○	○

● - Primary data type for assessments

○ - Secondary data type used to support assessments

Figure E-2. Indicators Used in Assessing Aquatic Life Uses for Lakes by State

Indicators	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
Trophic status	●	●	●		●	●
Water chemistry	○	○	○	○	○	○
Sediment chemistry	○					
Amount of aquatic macrophytes	●	○			○	○
Amount of sediments	●				○	
Fish kills		○				
Fish tissue contamination		○	○	●	○	○
Effluent chemistry & toxicity		○			○	

● - Primary data type for assessments

○ - Secondary data type used to support assessments

focus on individual sources of pollution, especially municipal sewage treatment plants and industrial facilities. This 'technology-based' approach emphasized the establishment of specific effluent limits for certain pollutants.

While this approach has been successful in addressing pollutants from specific sources, EPA and the States recognize the need to place more emphasis on nonpoint sources of pollution and to address watersheds with a more integrated, rather than a point source driven, perspective. Consistent with this more holistic view of water quality management is the need to use biological monitoring data to complement the chemical data collection that predominates in most State programs. One of the goals of this project was to evaluate the type (e.g., fixed station chemical, biological community) and extent (e.g., number of stations, number of intensive surveys) of water quality monitoring being done by Region 5 States.

Table E-3 summarizes State monitoring programs for rivers, streams, and lakes in Illinois. Chapter 4 contains similar tables for each of the Region 5 States.

Recommendations

- The States must receive adequate resources and training to support the collection and use of more direct, comprehensive measures for determining use support (e.g., fish, benthos and habitat assessments). These direct measures, along with indirect measures related to sources and causes of impairment, should become integrated into EPA's planning and management activities.

- Integrated monitoring of watersheds, that includes the collection of biological, chemical and physical data, should be fully coordinated with management activities (e.g., permitting, enforcement actions, and best management practices) to provide valuable feedback information on the results of management and protection programs

- States should clearly document assessment approaches for all designated uses, monitoring program structure, data uses, and database management methods in their biennial State 305(b) reports to minimize ambiguities in each State's decision process and monitoring program.

CHAPTER 5. ASSESSMENT-RELATED DATA MANAGEMENT

For a 305(b) assessment, each State compiles and analyzes data from diverse sources including national and State databases and data systems. Figure E-3 shows the State and national data systems/databases used by the various States for 305(b) assessments. Easy access to multiple data sources is essential for integrated (chemical/biological/habitat)

Table E-3. Illinois Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1. Ambient Water Quality Monitoring Network (AWQMN)	F; 6-week freq.	208 stations	• Chemical network -- parameters are pH, T, conductivity, flow, D.O., TSS, VSS, NH3-N, NO3+NO2-N, total P, diss. P, COD, fecal coliform, turbidity, and 21 metals • 7 parameters are used to calculate a WQ index for assessments	• Network was revised in 1977 to: establish baselines and trends in representative land use areas generally outside immediate impact zones of PSs (except in major population centers); identify problems; and trigger intensive surveys. • Although sampling frequency has declined and some stations have been dropped, many have been monitored for over 15 years.	2-1 1-1 1-2	A,B,F G,E A,B,F
2. CORE Subnetwork of AWQMN	F; see program description for frequency	38 stream stations from AWQMN plus 3 Lake Michigan stations	• Mainly chemical network • Includes 3 Lake Michigan Stations monitored by City of Chicago • Organochlorine pesticides and PCBs • Frequency: twice yearly for water column organics; biennially for fish contamin; triennially for sediment and macroinvertebrates	• Established as required by EPA under the National Water Quality Surveillance System; no longer required but IEPA still maintains. • Purpose was to measure baseline WQ trends nationwide	2-1 1-2	A,B,F A,B,F
3. Pesticide Subnetwork of AWQMN	F; 6-week freq. April-July; 12-week freq. August-March	30 stations from AWQMN	•Chemical network • Parameters are 15 herbicides and organophosphate insecticides, PCBs, and organochlorine pesticides	• 26 stations predominantly agricultural, 4 nonagricultural watersheds •Begun in 1985	2-1	A,B
4. Industrial Solvents Sub-network of AWQMN	F; 6-week frequency	31 stations from AWQMN	• Chemical network • 19 organic chemicals (e.g., chloroform, trichloroethylene, benzene)	• Begun in 1988 •Stations located in urban areas except for 1 control site.	2-1	A,B
5. Intensive River Basin Surveys	I; each basin studied every 10-15 years	No. of stations varies; 4 basins surveyed in FY'90	•Multimedia sampling -- water column chemistry, habitat, macroinvertebrate and fish populations, sediment and fish tissue contaminants, and sediment type. • Example: In the Kaskaskia Basin Survey (1981-82), over 140 sites were sampled	• Sites selected to characterize stream resources of the basin and to provide data for permit development	2-1 3-2 1-2 2-2	A,B B B B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table E-3. Illinois Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
6. Fish Contaminant Program	F stream stations annually; F lake stations biennially; I stations vary	73 stream stations (F); 20 lake stations (F); approx. 36 I stations	• Composited fish fillet samples at all stations; whole fish samples at 41 stations. • Pesticide/PCB analyses (20 parameters) on all samples • GC/MS wide scan on < 25 whole fish samples • Hg, dioxine as needed • Results compared to FDA Action Levels	• Fixed sites widely distributed throughout state on major streams (Mississippi, Wabash, Kankakee, Illinois, Fox rivers, e.g.) • Includes sites with past contamination problems • Both main streams and tributaries sampled during basin surveys	2-1 2-2 3-3	B B B
7. Facility-related Stream Survey Program	I	Approx. 94 stream stations in 88-89 in 12 basins	• Evaluates WQ impacts from point sources • Macroinvertebrates, chemistry, flow, habitat data collected upstream and downstream	•Sites selected based on location of discharges, closely linked to NPDES issuance and compliance	2-1 2-2 3-2 3-3	A,B
8. Special Surveys	I	Varies	• Includes enforcement cases, Pesticides Study, Livestock Waste Monitoring	•Varies according to type of survey	2-2 3-3	A,B,F,G
Lakes						
9. Ambient Lake Monitoring Program (ALMP) (includes Clean Lakes Program, Trend Lakes, and Diagnostic Evaluation Lakes)	I	20 -40 lakes per year; 1 to 3 sites per lake	• Three types of lakes monitored - Clean Lakes Program Phase I and II (2 times per month May-Sept.; monthly or bimonthly Oct.-Apr.) - Trend lakes (6 times Apr.-Oct.) - Diagnostic evaluation lakes (5 times spring through fall) • Parameters -- DO, T, TSS, nutrients, chlorophyll, other field tests (in addition, CLP lakes -- phytoplankton, benthos, fish, vegetation, sediment chemistry)	• CLP lakes selected by CLP process • Trend lakes are formed CLP lakes, lakes representative of various types of WQ; lakes where various pollution controls implemented • Diagnostic lakes selected from list of lakes needing controls or effectiveness monitoring	3-3 2-1 2-2 3-2	B B,F B B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table E-3. Illinois Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
10. Volunteer Lake Monitoring Program	F; twice per month May-Oct.	176 lakes in 1989; 3 or more sites per lake	• Citizen monitoring program involving 225 volunteers • Secchi disk and field observations at all lakes • Nutrients and TSS at 30-50 lakes •	• Lakes selected according to citizen interest, within areas served by three regional planning commissions	4-1 2-1 3-3	NA B,F B,F
11. Lake Michigan Network	F	85 stations	• Conducted by City of Chicago • Reported separately from 305(b)	Sites selected where public recreation occurs and in vicinity of Chicago water supply intakes	2	A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Figure E-3. State Use of 305(b)-related Data Systems

Data System	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
STORET	●	●	●	●	●	●
BIOS	●			○*		
State Biological Systems	●	●		●	●	●
RF3/WQAS	○	○*	○	○*	○*	
EPA WBS		○	○	○*	●	○
State 305(b) System	●		●	●		●

● - Current user

○ - Interested or beginning to use

* - Expressed concern or assistance needed

assessments. Data sources include computerized databases as well as paper files (e.g., fish kill records, intensive survey reports, drinking water files, compliance inspection reports). The advantages of using computerized data sources for 305(b) assessments include the following:

- Only a computerized database can be used to screen the thousands of water quality data points collected each year.

- Data systems make it easier to track assessment results from one 305(b) cycle to the next.

- Different types of information for the same waterbodies can be compared through the use of consistent geographic locators.

Recommendations

- Indiana and Michigan could benefit from using the EPA Waterbody System (WBS) and should proceed with its implementation. These States do not have comparable systems, and WBS should meet most or all of their assessment tracking requirements. Illinois and Minnesota already have fully implemented State systems with some capabilities not offered by WBS.

- Hardware should no longer limit access to the mapping and graphical capabilities of EPA's national water data systems. For only about $2000, a PC can be upgraded to simulate a graphics terminal on the EPA/NCC mainframe.

- States requested additional training, user-friendly documentation, and user support for their national water data systems. Onsite training or EPA-subsidized travel to training sites was suggested because of State travel restrictions. The Waterbody System's package of support--a Users Group that makes suggestions for system improvements, a newsletter, telephone user support, and the *User's Guide*--was cited as a good example.

- EPA should prepare a report or brochure, with examples, on the potential applications of the combined RF3/WBS/WQAS systems to State water quality planning and management. The report should also discuss State obligations for system implementation.

CHAPTER 6. OPPORTUNITIES FOR DEVELOPING AND USING ENVIRONMENTAL INDICATORS

Water resource policy is undergoing important changes at the Federal, State and local levels that reflect a fundamental shift in the approach to environmental protection and management. The conventional approach, characterized by fragmented, reactive policies derived from a myriad of statutes and regulations that respond to public perception of environmental risks, is gradually being replaced by an integrated, anticipatory risked-based approach that relies more heavily on scientific information and pollution prevention. While this new approach offers more effective environmental protection, it also poses new information needs for water resource planners and managers. The capacity of monitoring and assessment programs to support existing and new information needs will determine, to a large extent, how effectively water resource policies can be implemented at the Federal, State and local levels.

This chapter discusses the Region 5 study in the broader context of water resource policy by describing potential opportunities for developing and using environmental indicators for water resource evaluation, problem identification and characterization, management strategy development, implementation and evaluation, and communication of results to the public and legislators. Chapter 6 provides specific discussion and recommendations related to these four primary planning and management objectives.

Four overall recommendations from Chapter 6 are listed below:

1. EPA and States should develop a tiered classification scheme for environmental indicators that relates characteristics of indicators (e.g., spatial and temporal coverage, scientific defensibility, and relationships to environmental impact) with planning and management objectives. For example, some indicators, such as designated use support, are best suited for overall water resource evaluation. Others, such as water column chemistry, sediment chemistry, and tissue contamination provide more detailed information related to cause-effect mechanisms.

2. EPA and States should develop a long-term plan for integrating environmental indicators across water resources, including surface water, ground water and ecological resources. Once environmental indicators are developed for specific water resource categories (e.g., rivers and streams, wetlands), the plan should address how resource-specific and generic indicators can be developed and implemented, taking into account factors such as technical feasibility, costs and presentation value.

3. EPA, other Federal agencies, interstate organizations and States should take advantage of shared and complementary interests related to water resource planning and management. States, in particular, must have the basic capabilities for assessment activities such as site-specific studies (e.g., assimilative capacity/TMDL development), assessment of program success over wide geographic areas, and development of protective standards such as biocriteria and other geographically stratified criteria. These groups should continue and improve upon their working relationships to ensure that monitoring and assessment programs support planning and management objectives, both collectively and independently. Pilot projects could be excellent mechanisms for improving State capabilities and fostering the much needed coordination.

4. EPA should conduct studies in other EPA Regions that are similar or identical to the Region 5 project.

CONTENTS

FIGURES

FIGURES (continued)

TABLES

ACRONYMS

AWQMN	Ambient Water Quality Monitoring Network
BIOS	National biological information management system (subset of STORET)
BPJ	Best professional judgment
DLG	Digital line graph
DO	Dissolved oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ERFB	Environmental Results and Forecasting Branch, OPPE
FDA	Food and Drug Administration
FINS	Fish information system (Ohio)
FORTRAN	FORmula TRANslation, a computer programming language
FY	Fiscal year
GIS	Geographic information system
GLEAS	Great Lakes and Environmental Assessment Section, MDNR
IBI	Index of biotic integrity
ICI	Invertebrate community index
IDEM	Indiana Department of Environmental Management
IEPA	Illinois Environmental Protection Agency
Iwb	Index of well-being
LCI	Lake condition index (Ohio)
MBI	Macroinvertebrate biotic index
MDDM	Mapping and graphical display manager
MDNR	Michigan Department of Natural Resources
MIDGES	Microinvertebrate data generation and evaluation system (Ohio)
MIRIS	Michigan resource information system
MPCA	Minnesota Pollution Control Agency
NASQAN	National stream quality accounting network (USGS)
NAWQA	National water quality assessment program (USGS)
NCC	National computer center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National pollutant discharge elimination system
NWI	National wetlands inventory

OEPA	Ohio Environmental Protection Agency
OPPE	Office of Policy, Planning and Evaluation, EPA Headquarters
ORD	Office of Research and Development, EPA Headquarters
OW	Office of Water, EPA Headquarters
OWOW	Office of Wetlands, Oceans, and Watersheds, Office of Water
PIBI	Potential index of biotic integrity
RF3	Reach file version 3
SAB	Science Advisory Board
STORET	STORage and RETrieval System
TSI	Trophic status index
USGS	U.S. Geological Survey
UTM	Universal transverse mercator (coordinate system)
WBS	Waterbody system
WDNR	Wisconsin Department of Natural Resources
WQAS	Water quality analysis software
WQI	Water quality index
WQSS	Water Quality Surveillance and Standards Branch (Indiana DEM)

GLOSSARY

Ambient Monitoring: All forms of monitoring conducted beyond the immediate influence of a discharge pipe, including sampling of sediments and living resources.

Antidegradation Policies: Policies which are part of each State's water quality standards. These policies are designed to protect water quality and provide a method of assessing activities that may impact the integrity of the waterbody.

Aquatic Community: An association of interacting populations of aquatic organisms in a given waterbody or habitat.

Assessed Waters: Waterbodies for which the State is able to make use support decisions based on actual information. Such waters are not limited to waters that have been directly monitored -- it is appropriate in many cases to make judgments based on other information.

Benthic Fauna (or Benthos): Organisms attached to or resting on the bottom, or living in the bottom sediments of a waterbody.

Biological Assessment: An evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of resident biota in surface waters.

Biological Criteria (or Biocriteria): Numerical values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.

Biological Integrity: Functionally defined as the condition of the aquatic community inhabiting unimpaired waterbodies of a specified habitat as measured by community structure and function.

Biological Monitoring: The use of a biological entity as a detector and its response as a measure to determine environmental conditions. Toxicity tests and biological surveys are common biomonitoring methods.

Biological Survey (or Biosurvey): Consists of collecting, processing and analyzing representative portions of a resident aquatic community to determine the community structure and function.

BIOS: The component of EPA's STORET system (see STORET definition) which contains biological field survey data on aquatic communities.

Community Component: Any portion of a biological community. The community component may pertain to the taxomonic group (fish, invertebrates, algae), the taxonomic category (phylum, order, family, genus, species), the feeding strategy (herbivore, omnivore, carnivore) or organizational level (individual, population, community association) of a biological entity within the aquatic community.

Designated Uses: Uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Ecoregions or Regions of Ecological Similarity: A relatively homogeneous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variable. Regions of ecological similarity help define the potential for designated use classifications of specific waterbodies.

Environmental Indicators: Direct or indirect measures of environmental quality that can be used to assess status and trends in the environment's ability to support human and ecological health (for EPA's purposes).

Evaluated Waters: Waterbodies for which the use support decision is based on information other than current site-specific ambient data, such as data on land use, location of sources, predictive modeling using estimated input variables, and surveys of fish and game biologists.

Fixed Station Monitoring: The repeated long-term sampling or measurement of parameters at representative points for the purpose of determining environmental quality characteristics and trends.

Geographic Information System: A computerized system for combining, displaying, and analyzing geographic data. A GIS produces maps for environmental planning and management by integrating physical and biological information (soils, vegetation, hydrology, living resources, etc.) and cultural information (population, political boundaries, roads, bank and shoreline development, etc.).

Impact: A change in the chemical, physical or biological quality or condition of a waterbody caused by external sources.

Impairment: A detrimental effect on the biological integrity of a waterbody caused by an impact that prevents attainment of the designated use.

Intensive Survey: The sampling or measurement of parameters at representative points for a relatively short period of time within a limited geographic area to determine environmental quality conditions, causes, effects, or cause-and-effect relationships of such conditions.

Major Contribution to Impairment: A cause/source makes a major contribution to impairment if it is the only one responsible for less than full support, or if it predominates over others.

Minor Contribution to Impairment: A cause/source has minor contribution to impairment if it is one of multiple causes/sources responsible for less than full support and others predominate.

Moderate Contribution to Impairment: A cause/source makes a moderate contribution to impairment if it is one of multiple causes/sources responsible for less than full support and none predominate.

Monitored for Toxicants: If ambient monitoring information is collected that is capable of indicating the presence of toxic substances. This measure includes waters so monitored but for which no toxicants were found.

Monitored Waters: Waterbodies for which the use support decision is principally based on current site-specific ambient data believed to accurately portray water quality conditions.

NASQAN: The National Stream Quality Accounting Network, operated by the U.S. Geological Survey, encompassing more than 300 monitoring stations around the country at which many water-quality characteristics are measured at regular intervals.

Nonpoint Source Pollution: A contributory factor to water pollution that cannot be traced to a specific spot; e.g., pollution resulting from water runoff from urban areas, construction sites, agricultural and silvicultural operations.

NPDES: The National Pollutant Discharge Elimination System, a permit program under Section 402 of the Clean Water Act that imposes discharge limitations on point sources, basing them on a control technology's effluent limitation capabilities or on local water quality standards.

Point Source Pollution: Pollution discharged through a pipe or some other discrete source from municipal water treatment plants, factories, confined animal feedlots, or combined sewers.

Population: An aggregate of interbreeding individuals of a biological species within a specified location.

River Reach: A river or stream segment of a specific length. Most reaches extend between the points of confluence with other streams.

STORET: EPA's computerized water quality database that includes physical, chemical, and biological data measured in waterbodies throughout the United States. This system contains physical-chemical data on over 680,000 sampling sites with over 170 million observations, including groundwater, fish tissue, and sediment chemistry.

Threatened Waters: Waters that fully support their designated uses but that may not fully support uses in the future (unless pollution control action is taken) because of anticipated sources or adverse pollution trends.

Total Maximum Daily Load (TMDL): The total allowable pollutant load to a receiving water such that any additional loading will produce a violation of water quality standards.

Toxicity Test: A procedure to determine the toxicity of a chemical or an effluent using living organisms. A toxicity test measures the degree of effect on exposed test organisms of a specific chemical or effluent.

Water Quality Criteria: Criteria which are comprised of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

Water Quality-Limited Segment: A stretch or area of surface waters where technology-based controls are not sufficient to prevent violations of water quality standards. In such cases, new permit limitations are based on ambient water quality considerations.

Water Quality Standard: A law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

Water Resource Assessment: Determines the condition of a waterbody using biological surveys, chemical-specific analyses of pollutants in waterbodies, toxicity tests, and physical habitat assessment methods.

Watershed: The land area that drains into a stream, river, lake, estuary, or coastal zone.

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1. INTRODUCTION

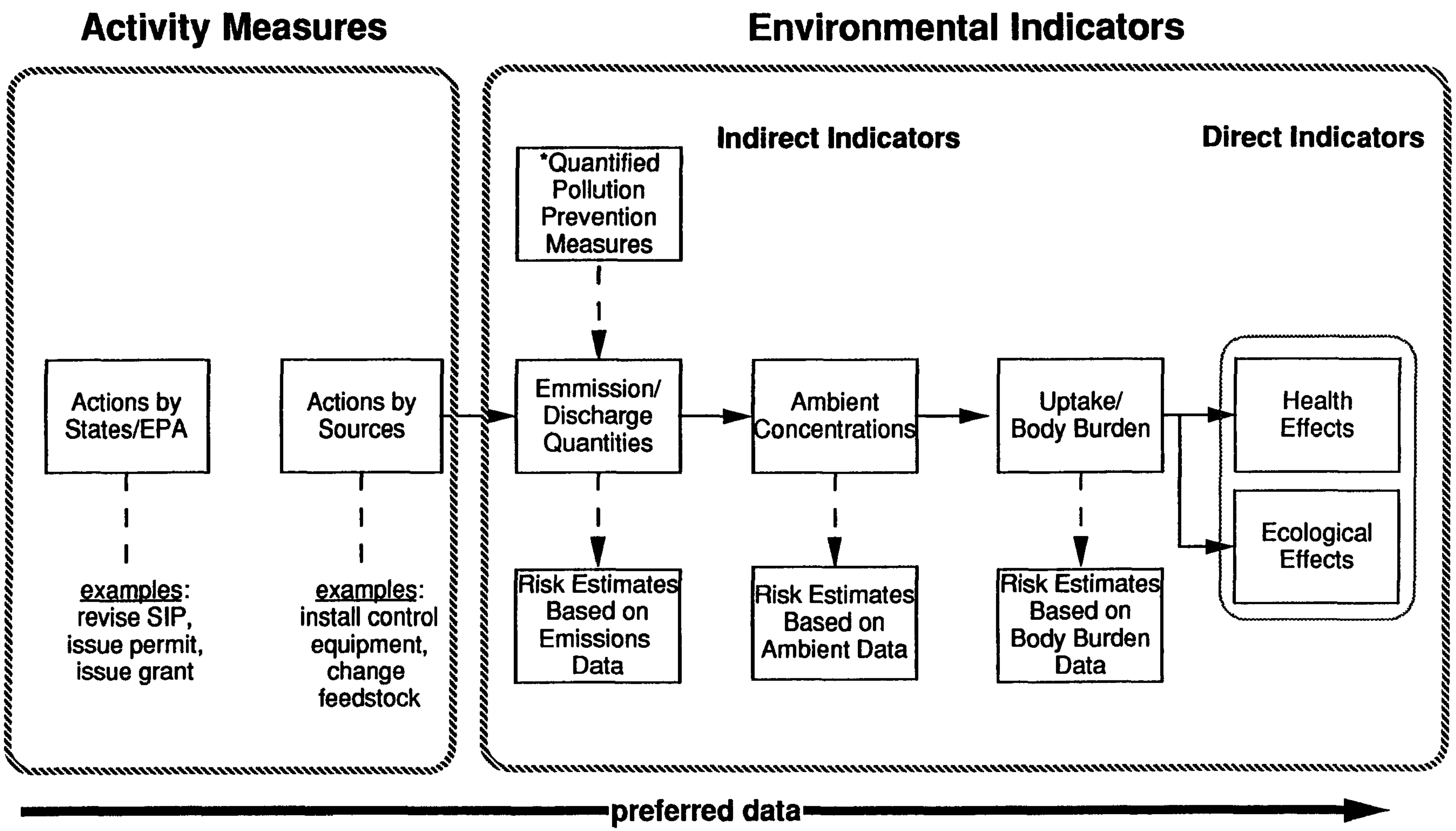
This report marks the beginning of the third phase of a three-phase Environmental Protection Agency (EPA) project to develop a series of environmental indicators for surface waters. Environmental indicators, in the context of this report, refer to a variety of measures of water resource quality for evaluating the environment's ability to support human and ecological health. These indicators can be used by EPA, State officials, and the public for a number of purposes including: identifying trends over time and space, evaluating program effectiveness, targeting resources to the greatest environmental risks, identifying emerging problems, achieving the greatest environmental improvements, and communicating results to the public and legislators (Figure 1-1).

In the first phase of this project, EPA staff developed a preliminary list of measures that could be used as indicators for freshwater, estuarine, and coastal environmental quality. The Agency then conducted a workshop of Federal and State personnel to review, the list and add or delete candidates as necessary. Workshop participants were asked to discuss suitable goals for the use of surface water indicators and appropriate criteria to help evaluate the indicators and to identify a set of measures for more detailed evaluation and review. Background material for the workshop and a summary of the workshop conclusions are provided in three documents: *Resource Document for the Workshop on Environmental Indicators for the Surface Water Program* (U.S. EPA, 1989a), *Workshop on Environmental Indicators for the Surface Water Program* (U.S. EPA, 1989c), and *Results: Workshop on Environmental Indicators for the Surface Water Program* (U.S. EPA, 1989b).

In the project's second phase, EPA, the National Oceanic and Atmospheric Administration (NOAA), and contractor personnel assessed the feasibility of reporting on the following indicators identified at the workshop: designated use support, attainment of Clean Water Act (CWA) goals, shellfish harvest area classifications, trophic status of lakes, toxic contamination in fish and shellfish, biological community measures, and pollutant loadings from point sources. These indicators were selected as most meaningful or practical for one or more of the following purposes: status and trend reporting, overall water program evaluation, and evaluation of the effectiveness of individual program components (e.g., point source regulation or toxic chemical controls). Evaluation criteria included: data availability, data consistency/comparability, spatial and temporal representativeness, relationship to ultimate impact, scientific defensibility, sensitivity to change, relationship to risk, data collection and analytical costs, relationship to existing programs, and presentation value. The results of that review are presented in *Feasibility Report on Environmental Indicators for Surface Water Programs* (U.S. EPA, 1990c).

Now in the third phase of the project, EPA and State personnel are developing options and recommendations for implementing a selected set of identified indicators at the national, regional, State, and watershed levels. These efforts are reflected by the Environmental

Figure 1-1. Continuum of Environmental Measures



Theme 1: Managing Environmental Results. Data to the right are closer to the "adverse ultimate imacts of pollution" that the States and EPA are charged with preventing or mitigating. All else being equal, data further to the right are better indicators of environmental result than data further to the left.

Theme 2: Emphasizing Pollution Prevention. Pollution prevention should result in the same kinds of environmental improvements as all Agency programs, so all these indicator types may be used to reflect pollution prevention successes. However, to prove the results are due to pollution prevention, data would needed on the box marked with an asterisk.

Indicators Workshop held in Baltimore during July 1991, the formation of an Environmental Indicators Committee sponsored by OW, and an Environmental Indicators Task Group formed under the Interagency Task Force for Monitoring Water Quality. At present, EPA assembles and reports on the quality of the Nation's water resources through the State and Tribal Section 305(b) reports, using as the primary indicator designated use attainment (see discussion in Section 1.2) for aquatic life and human health concerns in each major category of waters (rivers and streams, lakes, estuaries, and some coastal waters). One of the conclusions reached in the *Feasibility Report on Environmental Indicators for Surface Water Programs* (U.S. EPA, 1990c) and supported by the Office of Water (OW) is that the National Water Quality Inventory, and the State and Tribal Section 305(b) reports from which water information is extracted and summarized, are the best vehicles for reporting on existing and proposed environmental indicators. Unfortunately, detailed information on how 305(b) assessments are conducted is not generally available outside the States.

1.1 Project Overview

To mark the beginning of the third phase of the indicators project, Region 5 and the Office of Policy, Planning and Evaluation (OPPE) initiated a joint pilot study in November 1990 to document how individual States conduct their 305(b) assessments and use environmental indicators. The project team, consisting of EPA Headquarters, Regional, State and contractor personnel, identified and described for each Region 5 State: (1) methods for estimating total waters, (2) approaches for assessing designated use, (3) current surface water monitoring programs (especially those supporting status and trends), and (4) data management. These issues are addressed in Chapters 2 through 5 of the report. Each chapter consists of a general description of the issue and specific information from each of the six States. Chapter 6 discusses the Region 5 study in the broader context of water resource policy.

The first step in preparing this report was to develop assessment questionnaires and monitoring network profiles, and to fill out these forms to the extent possible using readily available information (e.g., State 305(b) reports, EPA reports, data system documentation). Then OPPE and Region 5 staff and contractor personnel met with officials in each State to complete the assessment questionnaires and monitoring profiles. Follow-up communication was conducted as needed to fill data and information gaps or clarify important issues.

Among the issues evaluated by the study were the following:

1. How do Region 5 States estimate the extent of surface water resources within or on their boundaries and how will this change in the future? (see Chapter 2)

2. What is each State's decision process for determining designated use support? (see Chapter 3)

3. What environmental indicators do States use to assess designated use support? (see Chapter 3)

4. What monitoring programs do or could support the 305(b) process and water quality planning and management? (see Chapters 4 and 6)

5. What State monitoring programs provide status and trends information and how were the programs designed? (see Chapter 4)

6. How does each State manage surface water monitoring data? (see Chapter 5)

7. To what extent does or could EPA's computerized Waterbody System (WBS), or State WBS-compatible systems, support water quality planning and management? (see Chapters 5 and 6)

1.2 The 305(b) Process and Environmental Indicators

States collect, assess, and report information on a variety of designated uses for their surface waters including the ability of the water resource to support aquatic fish and wildlife populations and communities (i.e., assemblages) and to support recreational, agricultural, industrial, and navigational uses. Each State designates beneficial uses for individual waterbodies and establishes numeric and/or narrative water quality criteria against which the ability of the waterbody to support their designated uses is evaluated. Section 305(b) of the CWA requires the States to report on the degree to which assessed waters are fully supporting, fully supporting but threatened, partially supporting, or not supporting their designated uses. The States are also required to use the information in their 305(b) reports for water quality planning and management. Specifically, the States must base their continuing planning process on water quality management plans and problems identified in the latest 305(b) report (40 CFR 130.6). Furthermore, many States use their 305(b) report to satisfy the Section 205(j) annual reporting requirement by certifying that the most recently submitted 305(b) report is current (40 CFR 130.8(d)). States use a variety of measures, including ambient chemical concentrations, estimates of pollutant loads from point and nonpoint sources, toxicants in fish and shellfish, biological community measures, trophic status of lakes, and habitat structure, in making their use support designations and evaluating causes of nonsupport. The 305(b) reports include information on the type of data used to make assessments (actual monitoring data or more subjective evaluations), the sources and/or causes of water quality impairment, and the percentage of total waters that are actually assessed. The 305(b) reports should be produced using an integrated set of reliable environmental indicators and a consistent monitoring effort. (Further discussion of 305(b) assessments is given in Section 3.1.)

One of the strengths of the use support framework is the independence it gives individual States to set specific standards and designate uses for their own waterbodies. This independence can cause difficulties, however, when the State-specific information is used to support development of regional or national environmental indicators. Inconsistencies in the decision-making framework used by each State to assess designated use attainment and major inconsistencies in the amounts of ambient waters monitored or evaluated, from State to State and in given States over time, produce information that can not be used to determine trends in National water quality or to compare water quality among individual States. Furthermore, there are considerable misunderstandings and disagreements about the objectives of the 305(b) process, for example:

1. Does the current 305(b) process provide information on the quality of the water resources, and progress to restore and protect those resources, that Congress intended? (The intent of Congress was made clear in the 1972 Clean Water Act.)

2. Is there general agreement on the definitions of the terms "status" and "trends"?

3. Is the 305(b) process meant to address State-specific issues in selected geographic areas only, or is it also meant to provide broad-based, statistically-representative information on the status and trends of the Nation's water resources?

4. Is 305(b) information intended for State and National assessment of ambient conditions, or is it intended simply to track progress of pollution control efforts in targeted areas?

The Office of Policy, Planning, and Evaluation (OPPE) and OW managers and staff have committed to identifying, clarifying, and resolving these issues of inconsistency and uncertainty through a variety of mechanisms. OW established a National 305(b) Consistency Workgroup to develop more specific and consistent national guidance for the States to use in developing their 1992 and subsequent 305(b) reports. Project staff from OPPE and Region 5 have participated directly in the revision of the 1992 305(b) Guidelines. In addition, OW and OPPE have and will continue to sponsor meetings and workshops with Regional and State personnel to help clarify monitoring objectives and develop strategies for using information gathered through the 305(b) process as environmental indicators.

1.3 Water Quality Planning and Management

This section discusses the Region 5 pilot study in the broader context of water quality planning and management.

The four primary objectives of water quality planning and management are

1. Water Resource Evaluation;
2. Problem Identification and Characterization;
3. Management Strategy Development, Implementation, and Evaluation; and
4. Communication of Results to the Public and Legislators.

These four goals, which are described in more detail in Table 1-1, parallel the goals/objectives for environmental indicators noted earlier.

This pilot study focused on how water-related environmental data collected by Region 5 States, especially data supporting the 305(b) reporting requirements, currently support Water Resource Evaluations and Problem Identification and Characterization. In addition, the results of this study provide some information on use of the information to support management objectives 3 and 4.

Comprehensive water resource planning and management depends on the spatial and temporal analysis of a number of key variables including: the physical dimensions of the resource (e.g., river and stream miles, lake acres, wetland acres, and shore miles); quantitative hydrologic parameters; the biological, chemical and physical integrity of the resource; stressors affecting resource integrity (e.g., agricultural and urban runoff); and the uses and functions provided by the resource to humans and natural systems. Designated use support, with some significant improvements, could become the principal conveyer of this information to water resource managers, legislators and the general public (Figure 1-2). This study, to a large extent, identifies what general changes are necessary to make designated use support a more useful, over-arching indicator to support water quality planning and management (see Chapter 6). In particular, this study describes how aquatic life use support, and a suite of related environmental indicators (e.g., biological community measures, ambient chemical concentrations, toxicants in fish) do or could support the management objectives shown in Table 1-1.

1.4 Related Studies and Initiatives

The findings and recommendations in this report are intended to be useful to OW and the States in planning the development and use of water-related environmental indicators. To the extent possible, this report identifies and describes activities within and outside EPA that may affect the 305(b) process and implementation of water-related environmental indicators. Understanding the relationship between this study and related activities may help ensure better use of available data, highlight important opportunities for improved coordination, and enhance the usefulness of future data collection and analysis efforts. A few important studies and programs especially relevant to this study are discussed below.

Table 1-1. Water Quality Planning and Management Objectives: Examples of Program Activities and Supporting Data

1. Water Resource Evaluation

Status: Physical, Chemical and Biological Characteristics of Resource
- Hydrologic data and chemical data for water, sediment, and biota
- Characterizing the physical extent of water resources
- Biological community measures and habitat assessment
- Development of reference site values

Trends: Spatial and Temporal Changes in Status
- Site or waterbody-specific temporal changes in water chemistry (State followup monitoring)
- Basin-wide intensive surveys
- EPA's Environmental Monitoring and Assessment Program
- USGS's National Stream Quality Monitoring Network

2. Problem Identification and Characterization

Problem Identification
- Impairment of biological assemblages (community)
- Exceedance of water quality standards
- Citizen complaints/ Discovery of fish kills
- Source monitoring
- Land-use surveys/ Habitat alteration

Cause-Effect Characterization
- Wasteload allocation/ Integrated total maximum daily load development
- Intensive survey
- Facility inspections and toxicity testing

3. Management Strategy Development, Implementation, and Evaluation

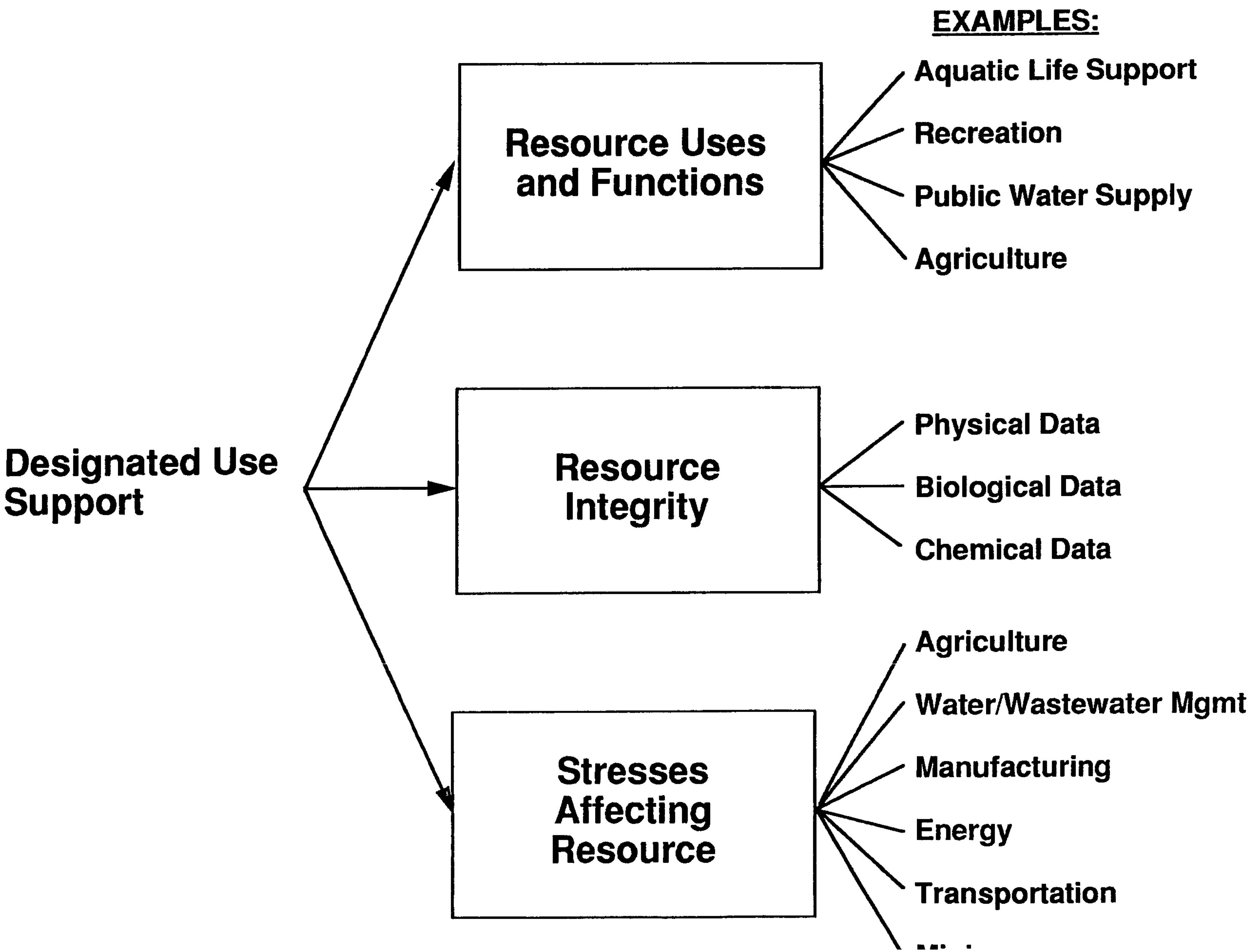
Management Strategy Development
- Developing water-quality-based controls
- Setting priorities and targeting resources
- Tactical and strategic planning
- Watershed-specific water quality management plans

Management Strategy Implementation/Evaluation
- Setting water quality standards
- Permitting and enforcement actions
- Installing best management practices for nonpoint source pollution
- State monitoring to evaluate effectiveness of point and nonpoint controls

4. Communication of Results to Public and Legislators
- EPA's National Water Quality Inventory and Summary Report (biennial)
- USGS's National Water Summary (annual)
- NOAA's Shellfish Register (5-year)
- State 305(b) reports to Congress (biennial) and other public information reports
- Public involvement through volunteer/citizen monitoring

Sources: *(1)* *Surface Water Monitoring: A Framework for Change (U.S. EPA, 1987)*; (2) pre-1991 versions of the National 305(b) Guidelines; *(3)* *Feasibility Report on Environmental Indicators for Surface Water Programs (U.S. EPA, 1990c)* and (4) knowledge and experience of individuals involved with the Region 5 study.

Figure 1-2. Information Provided By an "Ideal" Indicator for Water Resource Planning and Management



Surface Water Monitoring: A Framework for Change (U.S. EPA, 1987), prepared jointly by OW and OPPE, identified major changes to EPA's surface water monitoring program that would be required to support current and future information needs of water quality managers and planners. As suggested by Figure 1-3, information needs will increase significantly as EPA and the States move toward integrated environmental management strategies. In many ways, the Region 5 pilot study is a followup of this study, building on many of its findings and recommendations. Table 1-2 presents the major challenges, obstacles, and recommendations presented in the 1987 report.

Several products or results from *Surface Water Monitoring: A Framework for Change* (U.S. EPA, 1987) are directly or indirectly evaluated in the Region 5 pilot study. A fundamental finding of the 1987 study was that the OW lacked a clear strategy for ensuring that State surface water monitoring fulfilled basic information needs -- both at the time of the study and for the future. The lack of clearly defined management objectives and State inconsistencies identified by the 1987 report prompted OW to initiate several actions, including the preparation of profiles of State monitoring and assessment activities, to get a sense of what data States collected and for what purposes. Unfortunately, OW was unable to complete the work on the State monitoring profiles, in part because there was concern over the data collection burden placed on States. It is anticipated that the information collected in the Region 5 study may help, to a limited extent, in continuing this effort by documenting what data States collect and how the data are used to support planning and management.

Surface Water Monitoring: A Framework for Change (U.S. EPA, 1987) is one of several documents that have encouraged the use of biological assessments of surface water resources at the State level. This Region 5 pilot study examines the extent to which biological indicators, along with physical and chemical indicators, are used to assess aquatic life support, generally considered the most useful measure of the overall integrity of surface water resources (see Chapter 3 for State assessment approaches for aquatic life support and Chapter 4 for summary information on monitoring programs).

The Framework for Change report also highlighted the importance of sound data management to support better water quality planning and management. Several EPA systems, including the WBS, Reach File 3, and STORET were influenced by the 1987 report. Chapter 5 of this Region 5 pilot study examines the extent to which these systems are used and how they might be improved to enhance decision-making and planning at the State, Regional, and National levels.

In September 1990, the EPA's Science Advisory Board (SAB) issued a report entitled *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (U.S. EPA, 1990d) that recommended fundamental changes to the Agency's approach to environmental planning and management (Table 1-3).

Figure 1-3. Surface Water Quality Management Is an Increasingly Complex and Information-Intensive Task Modified from *Surface Water Monitoring: A Framework for Change* (U.S EPA, 1987)

	Early 1970s		1976-84		1985-90		Beyond 1990
What	Chemical Data Indicative of Water Quality: • BOD and DO • Suspended and Disolved solids • Bacteria • Nutrients • Temperature • pH	+	Priority Pollutants ——— Effluent Guideline Chemicals ——— Pretreatment Chemicals	+	Toxics Control Strategy: • Water Quality-Based Permits • Non-point Source Assessments ——— Additional Pretreatment Chemicals: • Domestic Sewage • RCRA/TSCA/ FIFRA	+	Multimedia Risk Management: • Air • Groundwater • Drinking water • Soil
Where	Surface, Marine, and Estuarine Water Columns ——— Municipal and Industrial Sources	+	Sediments ——— Benthic Organisms ——— Fish Tissue	+	Sampling Matrices Remain the Same ——— Ecoystem Analysis Begins	+	Ecosystem Analysis Matures
How	Chemical Analysis: • Ambient Fixed Stations • Effluents	+	Improved Chemical Analysis ——— Biological Monitoring ——— Intensive Surveys ——— Special Studies: • Toxicology • Bioaccumulation • Acid Deposition • Fisheries Survey	+	Further Improvements in Chemical Analysis: • New Analytical Tests • Lower Detection Levels • Ecosystem Surveys ——— Rapid Assessment Methods: • Toxicity Testing	+	Integration of Environmental Data from Multiple Sources ——— Use of Existing Monitoring Data in Program Planning and Priority Setting

Table 1-2. Challenges, Obstacles and Recommendations Presented in *Surface Water Monitoring: A Framework for Change (U.S. EPA, 1987)*

Challenges

1. Develop and Use Biological Testing Methods to Control Toxic Water Pollutants

2. Increase Use of Biological Monitoring to Characterize Aquatic Systems and Identify Problems and Trends

3. Demonstrate That Pollutant Control Investments are Achieving Desired Results

4. Identify and Characterize Toxic, Conventional, and Anthropogenic Pollutants from Nonpoint Sources

5. Expand Efforts to Identify and Control Pollution Problems in Near-Coastal and Ocean Waters

Obstacles

1. Inadequate Methods and Resources for Characterization, Problem Identification, and Trend Assessment in Inland, Near-Coastal, and Marine Waters

2. Inability to Assess the Effectiveness of Point Source Control and Nonpoint Source Management Actions in Terms of Environmental Results

3. Insufficient Use of Existing Water-Related Data to Guide, Complement, or Avoid New Monitoring

Recommendations

1. Issue Guidance on Efficacious Approaches to Characterization, Problem Identification, and Trend Assessment

2. Accelerate the Development and Application of Promising Biological Monitoring Techniques

3. Analyze the Feasibility of Requiring NPDES Permittees to Conduct Ambient Follow-up Monitoring Studies

4. Continue and Expand Efforts to Improve Information on National Progress in Water Pollution Control

5. Improve EPA andState Knowledge About Sources and Uses of Existing Water-Related Data

6. Establish Central Coordination of EPA Activities to Integrate Water-Related Data

Since its beginning, EPA has operated in a reactive mode, driven by a myriad of statutes and regulations reflecting public perception of environmental risks. The SAB report, recommends an integrated, anticipatory, risked-based approach that may allow EPA to deal more effectively with existing and emerging environmental problems. Although this new approach offers more effective environmental protection, it also poses new information needs for water resource planners and managers. Some important opportunities, challenges, and obstacles related to these new information needs are discussed in Chapter 6 of this Region 5 pilot study.

In response to the need for better status and trends information on the Nation's ecological resources, the EPA's Office of Research and Development (ORD) initiated the Environmental Monitoring and Assessment Program (EMAP) (U.S. EPA, 1991). EMAP is designed to address the following objectives at a national or regional scale:

- Estimate current status, extent, changes, and trends in indicators of the condition of the Nation's ecological resources;

- Monitor indicators of pollutant exposure and habitat condition, and seek associations between human-induced stresses and ecological conditions that identify possible causes of adverse effects; and

- Publish annual statistical summaries and periodic interpretive reports on status and trends to the EPA Administrator and the public.

Seven ecological resource groups makeup EMAP: agroecosystems, arid lands, forests, Great Lakes, near coastal systems, inland surface waters, and wetlands. Figure 1-4 presents the proposed spatial resolution of EMAP's inland surface water program, based on aggregated Omernik ecoregions. Greater spatial resolution may be provided through cooperative efforts with States and other federal agencies. EMAP networks are being designed statistically to allow extrapolation from individual stations to entire ecosystems. EMAP encompasses six primary activities:

1. Strategic evaluation, testing, and development of indicators of ecological condition, pollutant exposure and habitat condition, and protocols for collecting data on these indicators (see Figures 1-5 and 1-6);

2. Design and evaluation of a comprehensive and versatile integrated monitoring framework;

3. Nationwide characterization of the extent and location of ecological resources;

4. Demonstration studies and implementation of integrated sampling designs;

Table 1-3. **The Ten Recommendations (From *Reducing Risk: Setting Priorities and Strategies for Environmental Protection (U.S. EPA, 1990d).***

1. **EPA should target its environmental protection efforts on the basis of opportunities for the greatest risk reduction.**

2. **EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk.**

3. **EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks.**

4. **EPA should reflect risk-based priorities in this strategic planning processes.**

5. **EPA should reflect risk-based priorities in its budget process.**

6. **EPA - and the Nation as a whole - should make greater use of all the tools available to reduce risk.**

7. **EPA should emphasize pollution prevention as the preferred option for reducing risk.**

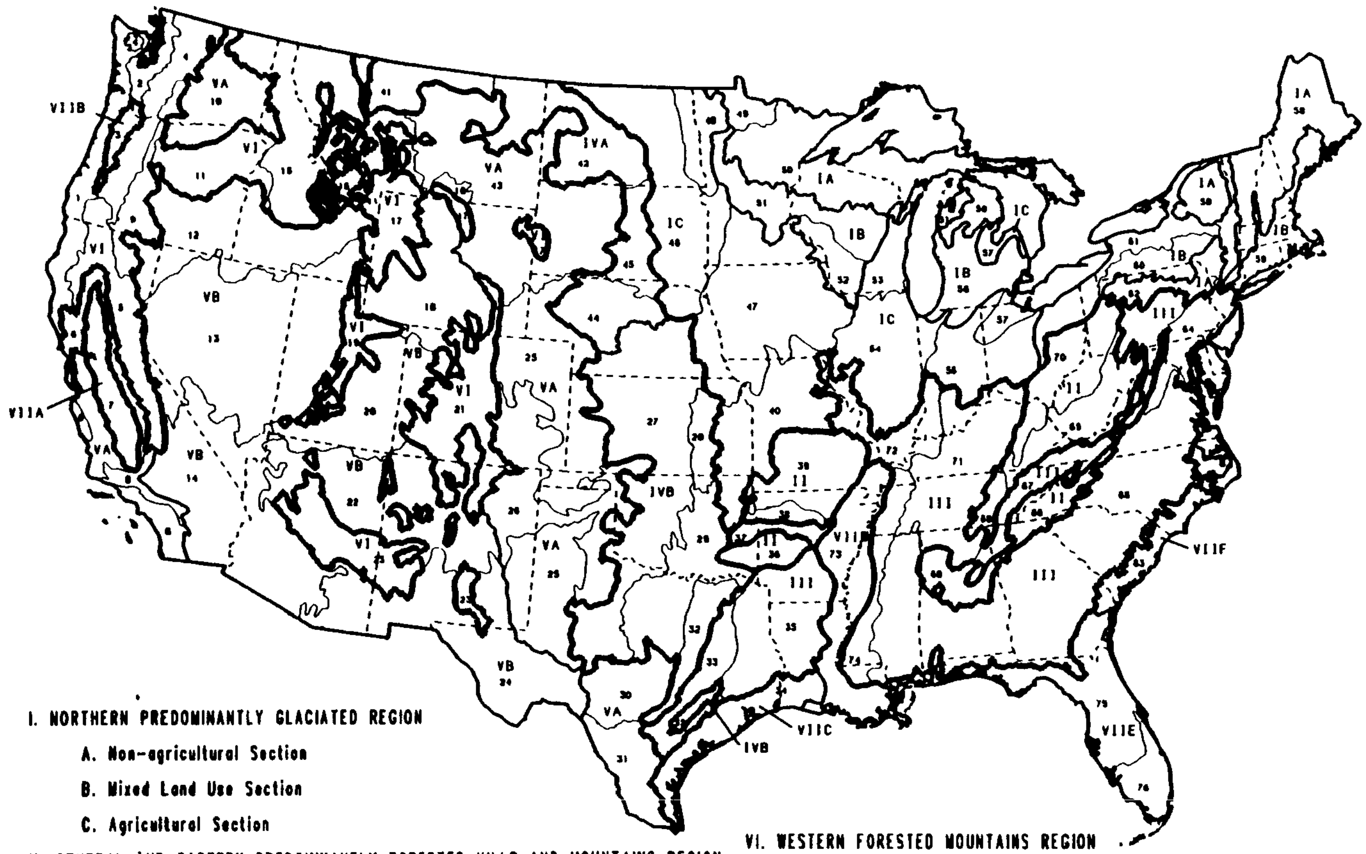
8. **EPA should increase its efforts to integrate environmental considerations into broader aspects of public policy in as fundamental a manner as are economic concerns.**

9. **EPA should work to improve public understanding of environmental risks and train a professional workforce to help reduce them.**

10. **EPA should develop improved analytical methods to value natural resources and to account for long-term environmental effects in it economic analyses.**

Figure 1-4. Proposed Spatial Resolution of EMAP's Inland Surface Water Program, Based on Aggregated Omernik Ecoregions

From *Surface Waters Monitoring and Research Strategy - Fiscal Year 1991* (U.S. EPA, 1991)



I. NORTHERN PREDOMINANTLY GLACIATED REGION
- A. Non-agricultural Section
- B. Mixed Land Use Section
- C. Agricultural Section

II. CENTRAL AND EASTERN PREDOMINANTLY FORESTED HILLS AND MOUNTAINS REGION

III. SOUTH CENTRAL AND SOUTHERN HUMID, MIXED LAND USE REGION

IV. SUBHUMID AGRICULTURAL PLAINS REGION
- A. Northern Section
- B. Southern Section

V. WESTERN XERIC REGION
- A. Semi-arid Section
- B. Arid Section

VI. WESTERN FORESTED MOUNTAINS REGION

VII. UNIQUE ALLUVIAL AND COASTAL PLAINS REGIONS
- A. Central California Valley
- B. Willamette Valley
- C. Western Gulf Coast
- D. Mississippi Alluvial Plain
- E. Florida Coastal Plain
- F. Middle Atlantic Coastal Plain

The Arabic numerical ecoregion designations on the map are the same as on the published national map (19).

Figure 1-5. General Approach for Identifying Indicators

From *Surface Water Monitoring and Research Strategy-Fiscal Year 1991* (U.S. EPA, 1991)

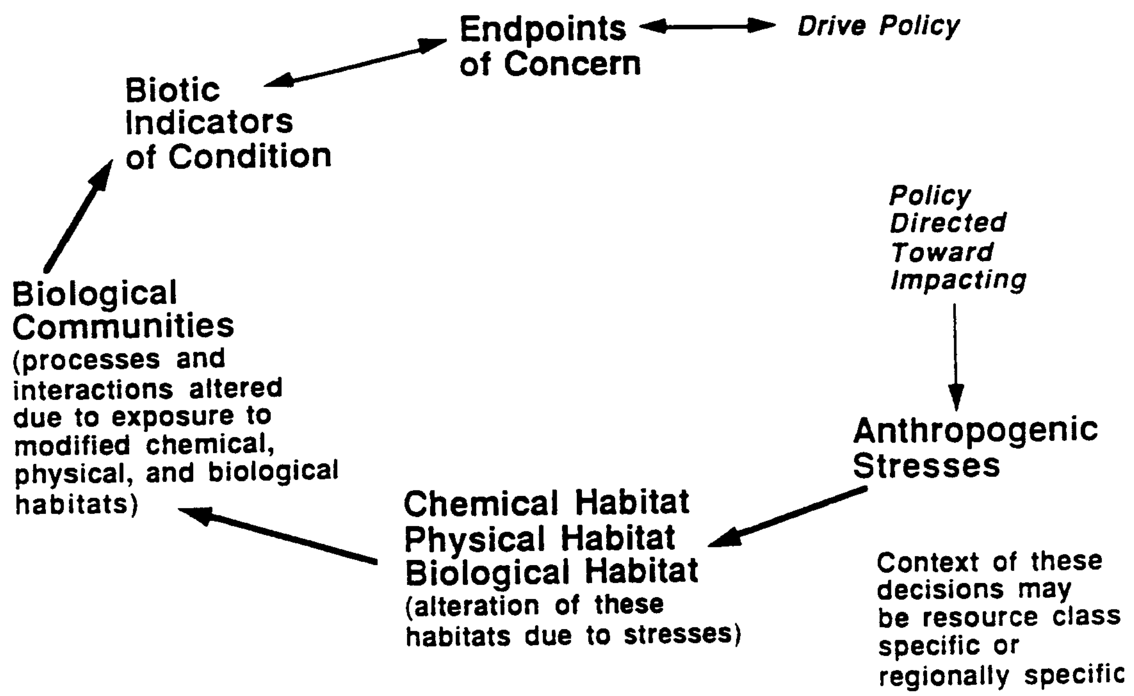


Figure 1-6. Indicator Approach for EMAP-Surface Waters Showing Candidate Indicators and the Top-Down Approach to Problem Identification and Diagnosis of Probable Cause

From *Surface Water Monitoring and Research Strategy-Fiscal Year 1991* (U.S. EPA, 1991)

ENDPOINTS	RESPONSE INDICATORS	IMPACTS	EXPOSURE INDICATORS	RESULTS	STRESSOR INDICATORS
	ORGANISMS				
Trophic State	Fish	Eutrophication	Physical Habitat Index	Nutrient Loadings	Landuse/Landcover
Fishability	Macro-invertebrates	Acidification	Water Quality	Contaminant Loadings	Atmospheric deposition/emissions
Biotic Integrity	Phytoplankton/Periphyton	Contamination	Toxicity Bioassays	Water quality degradation	Chemical application estimates
	Sedimentary Diatoms	Habitat alteration		Physical habitat deterioration	Flow/stage records
	Semiaquatic Vertebrates			Decrease or extirpation of native species	Stocking and harvesting records

← Direction of impact

→ Direction of diagnosis

2. METHODS FOR ESTIMATING TOTAL WATERS

2.1 Overview

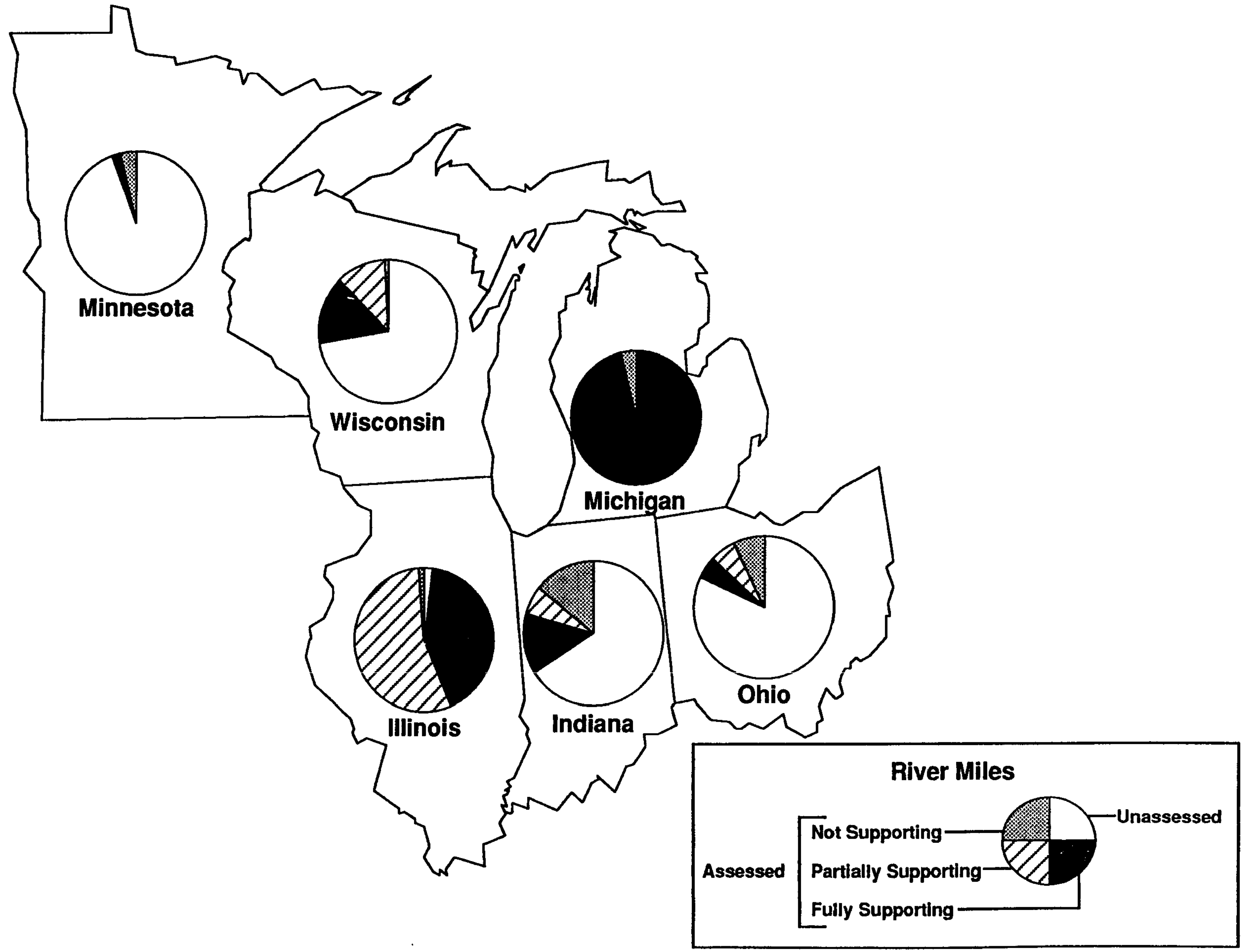
The historical and institutional separation of water quantity and water quality, which contradicts our understanding of how water resources exist and are used, has hampered the Nation's ability to manage and protect its water resources. While quantitative data (e.g., stream length and flow, lake area, depth and volume, and wetland acreage) are important individually for planning and management purposes, these data are inextricably linked to water quality assessments in that they help convey the extent or magnitude of water quality problems (see Section 6.3.2 - Problem Characterization). This study examined how Region 5 States estimate river and stream miles, lake acreage and wetland acreage in the context of designated use support assessments reported in State 305(b) reports.

Accurate and consistent quantification of surface water resources is essential to improving designated use support as an environmental indicator. A total water estimate is the denominator for calculating the percentage of waters known to be supporting designated uses. Without and accurate and consistent estimate of total waters, the relative proportions of designated use support categories (i.e., fully supporting, partially supporting, and not supporting) cannot be consistently determined nor can meaningful comparisons be made spatially (among States or nationally) and temporally (from one reporting cycle to another). Figure 2-1 illustrates how misleading these statistics can be if States do not have accurate and consistent total waters estimates. Such statistics are questionable and can not be used to compare State efforts, or even to evaluate progress within a State. It is also important to note that comparing waterbodies by overall designated use is misleading because different waterbodies are designated for different uses (e.g., aquatic life support vs. industrial use). Because different criteria are often established for different uses, it is more meaningful to compare waterbodies by the same designated use (see Chapters 3 and 4).

Total water estimates also reveal the percentage of a State's waters being assessed and the extent of the use of monitoring data versus evaluative information. Reliable estimates of total waters give legislators, water quality planners, and the public a basis for evaluating the success of pollution control efforts and the need for additional controls (see Table 1-1, Objective 3). For example, to take action on a finding that 60 percent of the waters of a State are impaired by agricultural sources, policymakers need to know that the basis for the percentage is sound and defensible.

Estimates of total waters currently are not comparable among States because each State employs its own methods of measurement. Lacking a national database of accurate hydrologic features, each State selects its own criteria for including waterbodies in these estimates.

Figure 2-1. Percentage of River Miles Supporting Designated Uses in 1990 - Region 5 States



Source: 1990 305(b) reports

Varying definitions of surface water resource categories (e.g., rivers and streams, lakes and wetlands) among States are another source of inconsistent resource quantification. Even if accurate and consistent quantification methods are employed, designated use support categories will not be comparable if inconsistent definitions of resources categories are used. For example, if one State includes intermittent streams with their inventory of total rivers and streams and another State with similar hydrologic conditions does not, comparisons between the two States would be misleading.

In FY91, a workgroup of representatives from several States, EPA Regions, and EPA Headquarters recommended priority for developing of a consistent methodology for estimating total State waters. This 305(b) Consistency Workgroup determined that the best currently available estimates can be obtained using EPA Reach File Version 3. RF3 is a computer data system based on the USGS 1:100,000 scale Digital Line Graph (DLG) database, and provides the first national database of hydrologic traces with the detail needed to calculate reliable total State water values. This use of RF3 data is described in Section 2.2. Section 5.2.1 provides a more general description of RF3.

2.2 Methods for Quantifying Surface Water Resources

2.2.1 Mechanical Methods

States historically have relied on mechanical methods for estimating total waters. For rivers and streams, these methods involve physical measurement of map traces using map wheels, dividers, or rulers. A map wheel is a simple, hand-held device with a wheel at the bottom and a meter that displays cumulative distance. The operator rolls the wheel along the stream trace, and the resulting distance is converted to stream length according to the scale of the map. Dividers are instruments with two sharp points that are set apart at a specified chord length. The operator then "walks" the dividers along the stream trace and counts the number of chords. The chord length is typically set using the map's scale, e.g., to 0.1 mile; the shorter the chord length, the more precise the measurement.

Mechanical measurements can be quite accurate when performed on 1:24,000 scale USGS topographic maps and subjected to good quality control. The State of North Carolina, for example, measured all classified streams using triplicate map wheel readings; readings were repeated until satisfactory agreement was achieved. The process was extremely time consuming but results have been well accepted.

For lakes and wetlands, a planimeter is often used to measure size. A planimeter is a hand-held, mechanical or electronic device with two arms. To measure the area of a lake, the end of one arm is fixed on a point while the operator traces the shoreline with the other arm. As the moving arm closes the shoreline trace, the planimeter displays a measurement of the area enclosed by the trace. This area is then converted to the surface area of the lake. Another approach is to overlay a map with a scaled, transparent grid; the number of grid units (dots or boxes) covering the waterbody of interest is then used to calculate size.

Mechanical methods for measuring Great Lakes shoreline mileage, wetlands and lake acreage are straightforward. However, the possibility of overlapping acreage may warrant further study.

2.2.2 Digital Methods

For over a decade it has been possible to convert stream traces into computerized data files. Using an electronic pen or mouse, an operator typically follows the streams on a hydrologic or topographic map; a program converts map coordinates at regular time or distance intervals along the trace to digital location data. A computer program sums the distances between each point to obtain stream length. This approach has been used with geographic information systems (GISs).

Automated optical scanning methods are also available. A scanner may pass over an entire map's surface, interpreting it as a matrix of grid cells or pixels. Appropriate grid cells are interpreted as stream traces.

Digital methods can also be used to calculate wetland size. The most detailed data are being made available through the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI). NWI maps show wetland boundaries at uniform scale under the Service's wetland classification scheme. The maps can be digitized and wetland areas calculated using a GIS or other platform.

2.2.3 USGS Digital Line Graph Database

In a major national effort, USGS created the DLG database of all hydrologic features found on its 1:100,000 scale map series. This is the most detailed scale available nationally in digital form and includes an estimated 75 to 90 percent of the hydrologic features on the 1:24,000 scale topographic map series. Most of the traces were actually digitized off the 1:24,000 scale maps, so the accuracy of locational data is extremely high. The DLG database distinguishes intermittent streams and ditches from perennial streams and rivers according to their visual appearance on the USGS maps rather than any strict hydrologic criteria.

The DLG database was designed to draw detailed maps rather than to integrate information or perform calculations (i.e., the traces are not networked). It has not been widely used by States for estimating total waters. DLG data are not suitable for estimating lake, wetland, and pond sizes without considerable processing.

2.2.4 EPA Reach File

EPA Reach File Version 3 (RF3) is based on the DLG database and is housed on the EPA National Computing Center (NCC) mainframe computer. RF3 contains additional connectivity data linking DLG hydrologic traces into a true waterbody network. RF3 contains over 3 million reaches or stream segments. The system is designed for routing and modeling applications and serves as the primary integrator among the EPA national water databases. Other systems such as STORET, the Waterbody System, and the Permit Compliance System can be linked with each other by a common geographic locator, the Reach Number.

State-by-State estimates of total river and stream mileages using DLG have recently been completed by Research Triangle Institute (RTI) for the EPA Assessment and Watershed Protection Division (U.S. EPA, 1991). RF3 also makes it possible to calculate lake and pond acreage from the DLG database; this work is underway. RF3 is expected to provide resolution to a minimum lake size of approximately 1 acre. RF3 estimates for total lake acreage by State are to be completed in the first quarter of FY92. Either the raw DLG traces or networked RF3 data files can be readily imported into GIS systems and used in the GIS environment.

2.3 State Methods, Estimates, and Future Plans

Tables 2-1, 2-2, and 2-3 summarize the methods used, data sources, and the results of State total waters estimates for rivers and streams, lakes, and wetlands in Region 5. For rivers and streams, Table 2-1 provides DLG/RF3 estimates and values reported in the 1990 305(b) report to allow comparison. These results are explained in the following sections, along with the State-specific implications of using the RF3 estimates for total waters.

2.3.1 Illinois

In the 1990 305(b) report, Illinois used a value of 14,080 miles for total river and stream size. Since then, the 1989 Inventory of Illinois Surface Water Resources has been completed by the Department of Conservation. The Illinois EPA plans to use the new estimate, 26,310 miles, in the next 305(b) report unless it is superseded by RF3 estimates. The State estimate is based on mechanical measurements using 1:24,000 scale topographic maps and input from local resource managers. Total lake acreage of 305,847 includes over 85,000 ponds or small lakes under 6 acres in size and 2,940 lakes greater than 6 acres in size.

The DLG/RF3 estimate of 33,009 miles for perennial streams and rivers is in reasonable agreement with the new Illinois State estimate of 26,310. However, the DLG/RF3 estimate of 44,462 miles for intermittent streams and 2,341 for ditches/canals result in a

Table 2-1. Estimates of Total Stream and River Mileages for Region 5 States

	State Estimates		DLG/RF3 Mileages[a]			
State	Method	Mileage Reported by the State	Perennial[b]	Intermittent	Ditches/ Canals	Total
Illinois	Mechanical	26,310 (mainly perennial streams)	33,009	44,462	2,341	79,812
Indiana	Unknown (probably mechanical with extrapolation)	90,000 (includes 70,000 mi of ditches)	21,095	8,409	6,169	35,673
Michigan	Unknown (probably mechanical; 1940 estimates)	36,350	30,221	22,793	3,080	56,094
Minnesota	Digitized from 1:24,000 and 1:62,500 maps	91,944 (includes ditches)	31,108	33,761	7,726	72,595
Ohio	Mechanical (1960 estimates)	25,165 (named or included in WQS)[c]	29,113	29,602	2,818	61,532
Wisconsin	Mechanical using 1:24,000 topo maps	43,600 (mainly perennial)	30,359	25,735	797	56,890

DLG=Digital Line Graph
RF3=Reach File Version 3
WQS=Water Quality Standards

[a] Source: U.S. EPA, 1991. (Total Waters Document)

[b] Includes the DLG categories "perennial streams" and "wide rivers"

[c] Ohio also reports a total of 43,917 miles of named or unnamed streams (including an estimate for ditches); however, 29,113 miles is used in the 305(b) for total waters.

Table 2-2. Methods Used by Region 5 States to Determine Total Lake Acreage and Reported Values

State	Method and Size of Lakes Included	Acreage Reported by State	Acreage Reported by RF3[a]
Illinois	Mechanical; includes over 80,000 lakes <6 acres in size	305,847	283,967
Indiana	Mechanical	105,540	142,871
Michigan	Mechanical: Michigan State University report circa late 1960s; includes all lakes/ponds >0.1 acres in size	840,960	963,194
Minnesota	Mechanical: MN Department of Natural Resources Inventory of Minnesota Lakes; from planimetered aerial photos; includes all lakes >10 acres	3,411,200	3,208,326
Ohio	Mechanical; includes all 50,000 lakes in Ohio; includes 66,000 acres of lakes <5 acres in size	200,000	188,461
Wisconsin	Mechanical; planimeter	957,288	951,105

Table 2-3. Wetland Totals for Region 5 States

State	1990 Fish and Wildlife Service Estimates[b]	Source
Illinois	1,254,000	IL Dept. of Conservation
Indiana	750,633	NWI
Michigan	5,583,400	NWI
Minnesota	8,700,000	University of Minnesota, 1981
Ohio	482,800	NWI and OH Dept. of Natural Resources
Wisconsin	5,331,392	WI Dept. of Natural Resources

[a] EPA, 1991
[b] Dahl, 1990

grand total three times the State estimate. If the same number of stream miles were assessed in 1992 as in the 1990 305(b) assessment, the percent of total stream miles assessed would be only about 16 percent using the DLG/RF3 estimate versus about 50 percent using the 26,310 figure. However, Illinois staff recognize the higher level of accuracy of the DLG/RF3 mileages and will probably have no problem in using them for 305(b) purposes. In fact, the DLG/RF3 estimates may be seen as more desirable because all Illinois waterways are classified in the State water quality standards, not just perennial streams.

The use of DLG/RF3 for total lake acreage may not cause significant problems for Illinois because State estimates already include many small lakes. However, the State does not intend to assess the thousands of ponds, borrow pits, and small lakes under 6 acres in size. State staff raised the issue of whether a lower size cutoff would be appropriate for computing total waters. Illinois, for example, has thousands of borrow pits left over from interstate highway construction that have filled with water.

Two estimates of total wetlands were obtained. The 1990 305(b) report states that less than 1,750,000 acres remain, and Dahl (1990) reports 1,254,000 acres (Table 2-3).

2.3.2 Indiana

Indiana estimates its total perennial streams and rivers at 10,000 miles and its total waterways (including intermittent streams and ditches) at 90,000 miles. The State estimates were generated some years ago and no references or detailed methods were provided for this project. Presumably the estimates are based on mechanical measurements with some extrapolation from part of the State to the entire State. The DLG/RF3 estimate of 21,095 miles for perennial streams and rivers is more than twice the State estimate. In contrast, the DLG/RF3 estimate for intermittent streams is about the same as the State estimate of 10,000 miles.

The greatest difference between State and DLG/RF3 estimates is in miles of ditches and canals. This is significant because Indiana's water quality standards protect many drainageways as small as roadside ditches. Most of the State's estimated 70,000 miles of ditches are too small to be found on 1:24,000 scale topographic maps and hence are not included in DLG/RF3 estimates. DLG/RF3 estimates almost certainly represent more accurate totals for perennial and intermittent streams. Despite the differences in mileage estimates, Indiana staff have indicated that the use of DLG/RF3 mileages for 305(b) reporting will probably be acceptable to them. They recognize that the 90,000-mile figure may not be suitable for use support purposes, because (by their estimates) only about 10,000 miles of perennial streams and 10,000 miles of intermittent streams are capable of supporting designated uses. The 90,000 mile figure is important in other ways, because it enables the State to issue permits protective of very small waterways.

Indiana reports publicly owned inland lakes totalling 105,540 acres. The basis for this acreage was not provided for the study. Wetlands are estimated at 100,000 acres in the 1990 305(b) report. This is a crude estimate and not based on detailed mapping. The current NWI estimate is 750,633 acres.

2.3.3 Michigan

Michigan's estimate of 36,350 miles of total streams and rivers is believed to date back to the 1940s (Brown 1944, Sommers 1977). It does not appear that this number accurately represents all classified waters of the State. DLG/RF3 estimates were 30,221 miles of perennial streams, 22,793 miles of intermittent streams, and 3,080 miles of ditches/canals.

Michigan will probably find RF3 estimates acceptable in principle. A potential problem for them is that RF3 totals for ditches might include some channelized streams that are protected by water quality standards, whereas most ditches are not protected. Another State-specific issue is that Michigan distinguishes between "intermittent" and "ephemeral" streams; ephemeral streams contain water only during runoff events, and intermittent streams contain water at other times as well. Intermittent streams are protected by standards; ephemeral streams are not. DLG/RF3 estimates are based on cartographic traces and cannot distinguish between the two types of streams.

Michigan's estimate of 840,960 acres of lakes includes ponds as small as 0.1 acre. Staff are concerned over the selection criteria for the lower cutoff in lake size to be used in RF3 estimates of total waters. The State has not determined if an RF3 lower cutoff value of 1 acre would be acceptable to Michigan; such a lower limit would capture all but the smallest ponds.

Michigan is completing a wetland inventory, which resides on the Michigan Resource Information System (MIRIS), a GIS. Total size is estimated at 3,200,000 acres but may change as MIRIS results come in. NWI estimates Michigan's wetlands at 5,583,400 acres.

2.3.4 Minnesota

Minnesota's total stream miles estimate of 91,944 comes from the digitized center traces of most streams, rivers, and ditches shown on 1:24,000 and 1:62,500 scale topographic maps. All data are referenced to the universal transverse mercator (UTM) zone 15-coordinate system. Separate estimates for perennial and intermittent streams are not available. The 91,944 miles includes an estimated 20,022 miles of ditches and canals.

Minnesota's total stream mile estimate serves as a good test of the DLG/RF3 estimates because both were derived by digitizing stream traces from topographic maps. Minnesota's estimate would be expected to be higher because of the map scales used; DLG/RF3 relied on 1:100,000 scale maps, which are believed to contain 75-90 percent of the hydrologic features on the 1:24,000 scale maps. Indeed, the DLG/RF3 estimate of 72,595 miles represents 79 percent of Minnesota's estimate.

Minnesota will make a case for using its own total streams and rivers estimate since it contains more detail than the DLG/RF3 estimate. DLG/RF3 has the advantage of distinguishing among the different waterbody types (perennial stream, intermittent stream, wide river, ditch/canal), but this is not significant to Minnesota because the State wants all potential receiving waters included in total waters estimates.

Minnesota reports 3,411,200 acres of lakes greater than 10 acres in size. Lake estimates were obtained using planimeters on aerial photographs and were checked against USGS topographic maps. The State's reaction to RF3 total lake acreage will likely depend on the RF3 selection criteria and results.

Minnesota's wetlands were estimated by Department of Natural Resources staff at roughly 5,000,000 acres. A 1981 University of Minnesota study reported a total of 8,700,000 acres (Dahl, 1990).

2.3.5 Ohio

For total streams and rivers, the Ohio EPA uses an estimate of 25,165 miles. This was obtained by measuring waterbodies large enough to be named on USGS 1:24,000 scale topographic maps and/or designated in State water quality standards. These waters have been assigned aquatic life use designations. This measurement agrees well with the DLG/RF3 value of 29,113 miles for perennial streams and rivers.

Although not used for 305(b) purposes, there is also a 1960 State estimate of 43,917 miles, based on measurements of all named streams and estimates for unnamed streams and ditches. Many of these waters are not capable of supporting permanent aquatic communities. This estimate can be compared with the DLG/RF3 total of 61,532 miles for all categories of streams, rivers, and ditches/canals.

Ohio EPA plans to update their list of waters by adding any missing perennial stream segments from RF3. Although they believe they have covered the universe of streams and rivers in their total waters estimates, they are willing to use DLG/RF3 values for the sake of national consistency, especially considering that these estimates agree reasonably well with their current universe of waters.

The total wetland acreage of Ohio is being quantified by the Remote Sensing Program of the Department of Natural Resources and the U.S. Soil Conservation Service using LANDSAT data. The inventory is scheduled for completion in 1991. Unpublished NWI data suggest a total acreage of 5,583,400 (Table 2-3).

2.3.6 Wisconsin

Wisconsin determined total stream and river miles mechanically using 1:24,000 topographic maps. Only perennial streams were measured, in an attempt to capture all streams with aquatic populations. The State's estimate is 43,600 miles, compared with the DLG/RF3 perennial streams total of 30,359 miles (70 percent of the State estimate). DLG/RF3 also calculates 25,735 miles of intermittent streams and 797 miles of ditches/canals for a total of 56,890 miles.

The State estimate may be more detailed for perennial streams. If EPA selects perennial waters as the basis for 305(b) total waters, Wisconsin may seek to use its own estimate for total waters. Wisconsin measured 957,288 acres of lakes using planimeters. Wisconsin's wetlands are estimated at 5,331,392 acres from a 1985 Department of Natural Resources inventory using aerial photographs.

2.4 Findings and Recommendations

2.4.1 Rivers and Streams

A wide range of approaches and sources were used by the Region 5 States to estimate total waters. In the case of rivers and streams, approaches range from digitization of stream traces from detailed topographic maps (Minnesota) to limited mechanical measurements with extrapolation (Indiana). Illinois and Wisconsin restrict their measurements largely to perennial streams, while Indiana and Minnesota include intermittent streams and ditches in their estimates. Ohio includes only streams that are named or included in State water quality standards.

Two categories of inconsistency in total waters estimates have been identified among the Region 5 States--inconsistency due to differences in measurement technique or level of detail and inconsistency due to State policy or regulation. The first category of inconsistency is remedied by using the best available national database of stream and lake sizes, RF3. An example of the second type of inconsistency is discrepancy in the inclusion of intermittent streams and ditches in State water quality standards and total waters.

An issues for States is that the use of RF3 total waters will significantly reduce the percentage of total waters assessed. That is, the "unassessed" portions in Figure 2-1 will typically become larger. This may give a negative impression about a State's monitoring program, even though the State may be assessing a relatively high percentage of waters that are capable of supporting aquatic life.

To help resolve this issue, the Region 5 States have set a goal of reporting use support separately for each of the following categories: perennial streams, intermittent streams, canals/ditches, and border streams. For each category, total assessed mileage will be reported, as well as mileage supporting each designated use. This expanded level of reporting in the 1992 305(b) reports will provide information at the Regional level on what types of waters are monitored and assessed. A knowledge of what types of waters are being monitored, coupled with studies showing aquatic life values for intermittent streams, may help guide the interpretation of "percent of waters assessed" in the future 305(b) reports.

A recommendation is made in Section 2.4.4 that the 305(b) Consistency Workgroup look into this issue based on the results of the analysis by Region 5 States. This review may find, for example, that aquatic life support could be more viable as an indicator if States would give two separate totals: waters with potential to support aquatic life, and total waters. In such a case, the aquatic life waters might consist of perennial streams and selected intermittent streams, ditches and canals.

2.4.2 Lakes

The issues associated with lakes are less clear-cut because the RF3 estimates by State are not yet available. RF3 is expected to include more lake acreage than most States have had the resources to measure by hand. As such, RF3 totals will be an improvement for Region 5 States other than Michigan and Minnesota, where highly detailed measurements have been made. The primary question seems to be how to set the minimum lake or pond size to be included in the RF3 total waters estimates. State-specific concerns remain to be defined. Illinois staff expressed concern over including thousands of small borrow pits from highway construction that have filled up with water. However, Illinois does include some ponds under 6 acres in its total lake acreage. Ohio includes lakes/ponds under 5 acres in its estimate, while Michigan includes ponds under 0.1 acre, and Minnesota drew the line at 10 acres. RF3 includes ponds down to the 1-acre size range. No matter which lower size cutoff is selected for RF3, it will probably not suit all States. RF3 estimates for total lake acreage by State are to be completed in the first quarter of FY92.

2.4.3 Wetlands

Accurate and consistent totals for wetlands are probably years away for many States. Wetland boundaries are subject to considerable interpretation. Ultimately, the most consistent and complete source of wetland totals will be the NWI. However, States should be allowed to adjust the NWI totals based on detailed ground truthing or other defensible considerations.

Prior to completion of the NWI, the current best estimates are probably found in a recent Report to Congress entitled *Wetland Issues in the United States, 1780's to 1980's* (Dahl, 1990). The State-by-State totals in this report represent the Service's best efforts to reconcile conflicting datasets, and include NWI estimates and States estimates where appropriate. These wetland totals are recommended for national use until better estimates are available (see Table 2-3).

2.4.4 Recommendations

- RF3 is the best available national database for calculating State total waters and is detailed enough for most State applications. However, States should be given the flexibility and tools to modify their RF3 databases to add further detail, and to allow States that have digitized their waters to a greater level of detail than RF3 to report their own total waters. Minnesota is an example of such a State.

- The 305(b) Consistency Workgroup should review the results of the effort by Region 5 States to summarize use support separately for perennial, intermittent and border streams and ditches/canals (including miles of waters being monitored and assessed in each category). The Workgroup should then consider options for improving national reporting on miles supporting aquatic life.

- EPA should resolve the issue of a lower size cutoff for lakes included in State total waters. Not all RF3 impoundments are waters of the State--e.g., wastewater lagoons or borrow pits have filled with water as a result of highway construction.

3. ASSESSMENT OF DESIGNATED USE SUPPORT

3.1 Overview

At present, EPA reports on the Nation's surface water quality by compiling and summarizing the biennial State reports called for under Section 305(b) of the CWA (U.S. EPA 1991). As part of these reports, States assess and report on a variety of designated beneficial uses for the waterbodies. Under each State's water quality standards program, the State designates beneficial uses for waterbodies (e.g., recreation, aquatic life protection) and establishes numeric and narrative water quality criteria standards the State determines are needed to protect each use (U.S. EPA, 1983). The extent to which the assessed waters meet or fail the established criteria determines whether or not, and to what degree, the designated use is considered to be met. States also report on whether the use support decision is based on actual monitoring data or more subjective evaluations.

Surface waters may be designated for one or more uses including, but not limited to: domestic water supply, aquatic fish and wildlife support, recreation, agriculture, industrial use, navigation, and nondegradation waters. However, the most consistent designated use which is reported by the States is the "aquatic life" use. Some States have tiered aquatic life uses based upon habitat quality to more accurately determine their expectations for community-based measures and numeric water quality standards (Figure 3-1).

States determine whether the designated uses are supported by compiling and interpreting data on a variety of physical, chemical, and biological measures. Chemical and physical measures, corresponding to properties for which water quality criteria have been adopted in State standards, are the most common measures used to evaluate use support; however, biological measures are becoming more common and necessary.

In reporting on designated use support, States set water quality goals and measure progress in meeting them. States report on the degree to which assessed waters are: fully supporting, fully supporting but threatened, partially supporting, or not supporting their designated uses. In addition, information provided on the causes and sources of pollution allows managers to identify emerging and existing problems so that they can target their resources more effectively. Information reported is used by the States in identifying problems, monitoring compliance actions, setting control priorities, and educating the public.

The 305(b) reporting mechanism provides OW with a State-driven information system that already serves as a source of indicator data and can be improved upon for future use. If desired by OW, and agreed upon by the States, changes in the reporting system could allow for more uniform collection of information needed to develop selected environmental indicators. One of the major problems facing various Offices at EPA in developing

Figure 3-1. Aquatic Life Use Designations by State

Aquatic Uses	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
General	●	●		●		●
Exceptional Warmwater					●	
Warmwater			●		●	●
Coldwater			●	●	●	●
Modified Warmwater					●	
Limited Resource Water					●	●
Indigenous	●					

indicator programs is finding ways to compile and analyze the information available from various sources. OW, through the biennial 305(b) reports and the computerized WBS, already has such a system in place (Chapter 5 for discussion of WBS).

The current value of the 305(b) reports as a source of environmental indicator data is severely limited, due to the large inconsistencies among States in how water quality data are generated, analyzed, and reported. States assess different subsets of their waters annually through site-specific and intensive surveys while the Fixed Station Networks provide the only link from one year to the next. In some instances, States even change their accounting of total waters from one cycle to the next (see Chapter 2). One problem in using this information for national reporting purposes stems from the considerable discretion that States have under the law in developing their own water quality standards. State water quality standards are comprised of a designated beneficial use of the waterbody, narrative or numeric criteria established to ensure protection of that use, and an anti-degradation statement. As a result of these differences among States and in the type of information they provide to EPA in their 305(b) reports, making comparisons between States or trying to assess national status and trends is essentially impossible and useless. The inconsistencies in sampling design and decision-making from year to year make it difficult to assess trends even within individual States. However, with the additional attention that EPA and the States are placing on the 305(b) process (e.g., the National 305(b) Consistency Workgroup) these issues should be minimized in the future.

This chapter describes the approaches of each Region 5 State in assessing aquatic life support, an important subset of the aggregate indicator for surface waters - designated use support (see Figure 1-2). Aquatic life support is a particularly useful environmental indicator because it is the most direct measure of the overall integrity of surface waters. The types of biological, chemical, and physical indicators used in State assessments of rivers, streams, and lakes and the manner in which they are used are discussed in this chapter, and issues of spatial sampling design are discussed in Chapter 4.

3.2 State Assessment Approaches for Aquatic Life Use Support

Figures 3-2 and 3-3 show the environmental indicators used by each Region 5 State to assess aquatic life support for rivers and streams, and for lakes, respectively. These tables also convey whether each indicator has a primary, secondary or supporting role in the assessments. In general, best professional judgment (BPJ) is widely used in the assessment process, highlighting the importance of documenting each State's decision process to help promote more accurate, consistent, and reproducible assessments. Brief descriptions of the approaches used by Region 5 States for assessing designated use secondary support for rivers and streams, and lakes are provided in the following sections.

Figure 3-2. Indicators Used in Assessing Aquatic Life Uses for Rivers and Streams by State

Indicators	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
Water chemistry	●	●	●	●	●	●
Sediment chemistry	○	○	○		○	○
Fish community	●	○	●	○	●	●
Macroinvertebrate Community	●	○	●	○	●	○
Fish tissue contamination	○	●	●	●	●	●
Habitat evaluations	●	○	●	○	●	●
Fish kills	○	○	○	○	○	○
Effluent chemistry & toxicity	○	○	○	○	○	○

● - Primary data type for assessments

○ - Secondary data type used to support assessments

Figure 3-3. Indicators Used in Assessing Aquatic Life Uses for Lakes by State

Indicators	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
Trophic status	●	●	●		●	●
Water chemistry	○	○	○	○	○	○
Sediment chemistry	○					
Amount of aquatic macrophytes	●	○			○	○
Amount of sediments	●				○	
Fish kills		○				
Fish tissue contamination		○	○	●	○	○
Effluent chemistry & toxicity		○			○	

● - Primary data type for assessments

○ - Secondary data type used to support assessments

3.2.1 Illinois

Approach for Rivers and Streams

Assessments are performed by Illinois Environmental Protection Agency (IEPA) staff in the Planning Section of the Division of Water Pollution Control. Indicators used in assessments include fish community data, habitat evaluation data, macroinvertebrate data, water chemistry, sediment chemistry, and fish tissue contamination (Illinois EPA 1985, 1987, 1989). Data sources include STORET (See Appendices), State biological data files, and Intensive Basin Survey Reports. Most of the work is done by Regional Office Staff, including analysis of biological data. Headquarters staff of the Section provide instruction and guidance and interpret physical/chemical water quality data. Headquarters staff also combine Regional input to the State Waterbody System.

The use support decision algorithm is complex but well documented in the State's 305(b) report. Predominant data types used are:

- Fish community measures--through use of an Index of Biotic Integrity (IBI);
- Habitat observations and measurements--through a Potential Index of Biotic Integrity (PIBI); and
- Physical/chemical water chemistry--through use of the Region 10 Water Quality Index, or WQI.

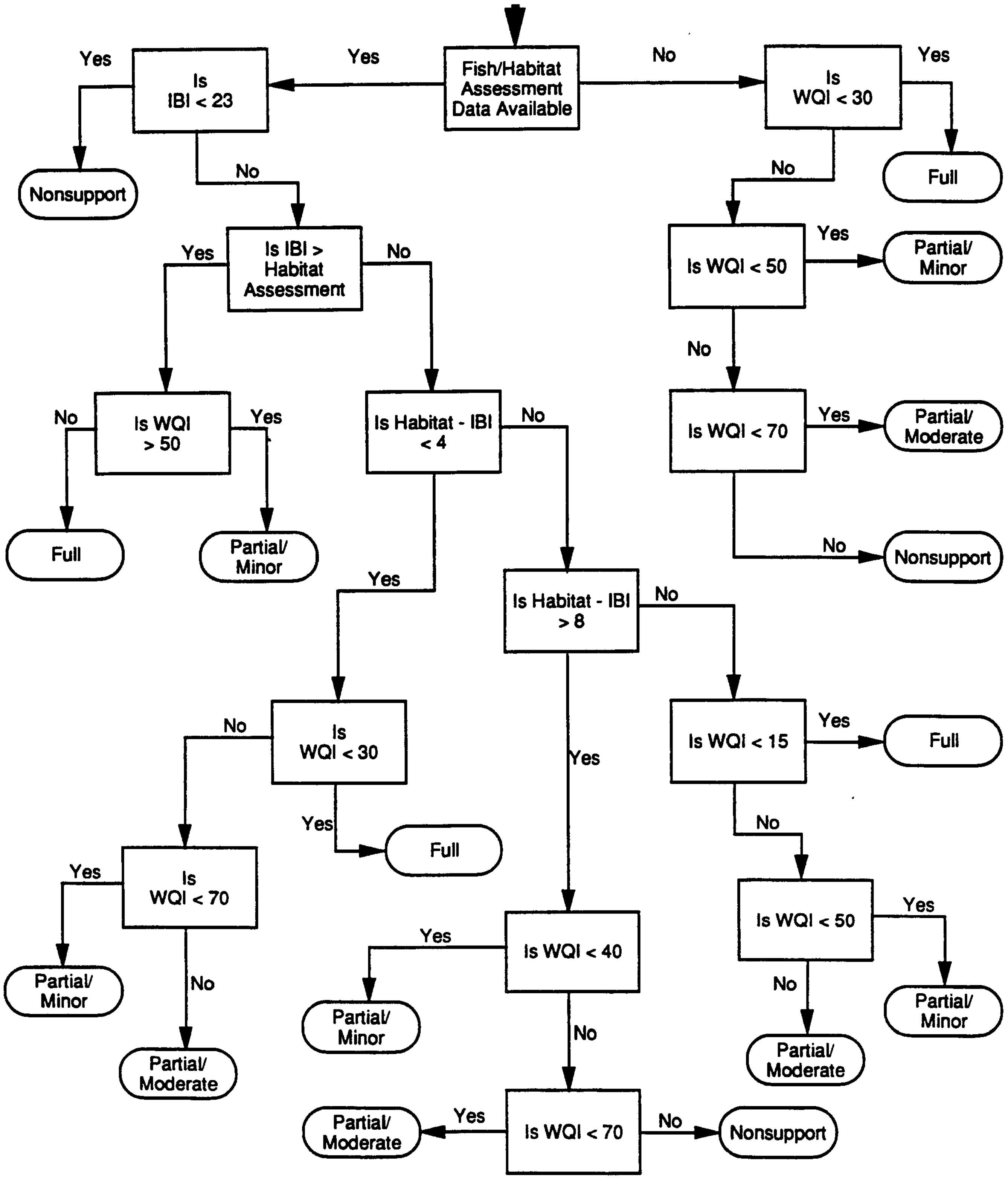
As shown in Figure 3-4, the Illinois approach gives greater weight to the measured IBI and habitat (PIBI) than to water chemistry (WQI). However, water chemistry data are always used where available, even though they can be overridden by fish community data. The following text explains Figure 3-4. If fish or habitat data are not available, the WQI is relied upon heavily. If all three types of data are available, the following approach is applied:

Step 1 Determine if IBI alone indicates nonsupport (IBI very low). If YES, waterbody is not supporting uses.

Step 2 If IBI alone does not indicate nonsupport, determine if measured fish community integrity exceeds that predicted by habitat only (i.e., if IBI exceeds PIBI). If yes, then look at chemistry; if WQI is greater than 50 then stream is achieving partial/minor support; if WQI is less than 50, stream fully supports uses.

Step 3 If fishery potential based on habitat alone moderately exceeds actual IBI, perform another WQI test to determine partial/minor, partial/moderate, or full support. If potential fish community integrity (based on PIBI) greatly exceeds measured fish

Figure 3-4. Aquatic Life Use Support Assessment Flow Chart for Fish, Habitat, and Water Quality Data - Illinois



community integrity (IBI), this is taken as evidence that water quality could be better, and increasingly higher WQIs are required for each level of support.

If IBI indicates a level of support of partial or full, then the WQI generally is used to distinguish between full or partial support. Only in extreme cases where habitat potential (PIBI) greatly exceeds measured fish community integrity (IBI) can water chemistry signal nonsupport.

Step 4 If macroinvertebrate data are available, determine if they are sufficient to override any of the above approaches. A rating system relates Macroinvertebrate Biotic Index (MBI) to level of use support.

Step 5 Determine if sediment data indicate elevated levels; if so, adjust use support appropriately. Likewise determine if fish tissue shows elevated levels of organochlorine compounds. If such compounds are routinely detected below levels of concern, the stream is partially supporting uses; if consistently exceeding Food and Drug Administration Action Levels, the stream is not supporting uses.

Step 6 Determine if water column chemistry shows elevated levels of pesticides and priority pollutants and adjust use support according to best professional judgment. Note: The IEPA approach does not employ toxicity testing results and effluent chemistry.

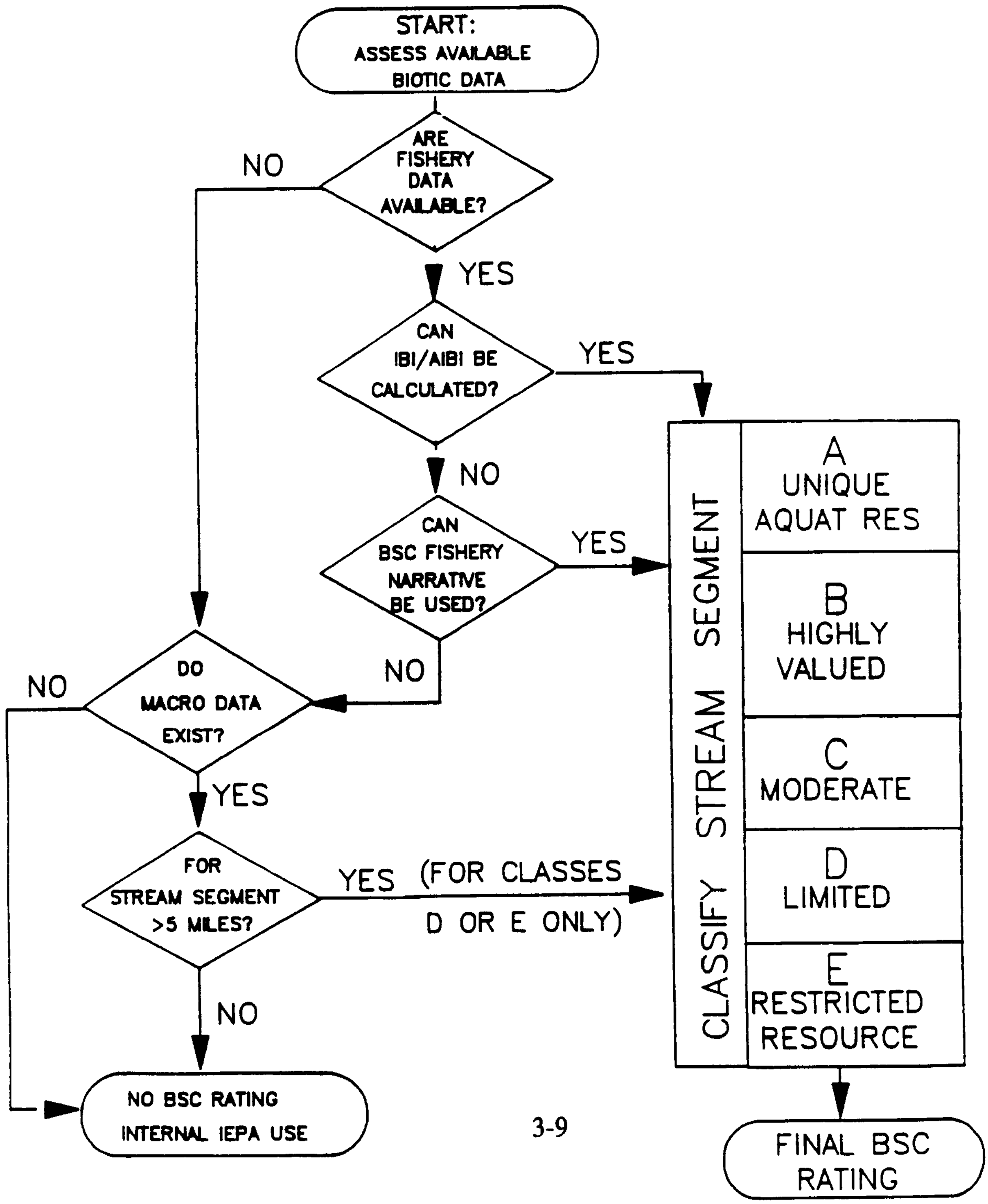
Illinois EPA developed a Biological Stream Characterization (BSC) program to assist in the management and protection of their natural resources by adapting the multi-metric Index of Biotic Integrity for use in Illinois and developing a stream habitat assessment procedure for predicting biotic potential (IEPA, 1989). Figure 3-5 illustrates how streams are classified within Illinois for aquatic life protection; however, it is not clear how these classifications are used in water quality standards programs or how biological criteria would be implemented. These classifications have yet to be linked directly with the State's designated uses.

Although Illinois EPA attempts to integrate benthic macroinvertebrate community measures into their assessments, this effort is hampered by the reliance of a single metric - the macroinvertebrate Biotic Index (MBI). The BSC manual states that the MBI, or macroinvertebrate narrative criteria are used only:

- When fisheries information is unavailable;
- On stream segments five miles in length, or longer; and,
- Only in the application of Class D or E Ratings.

Figure 3-5. Prioritization of Data Use in the Biological Stream Characterization Process - Illinois

From *Biological Stream Characterization (BSC)*, 1989



In these cases, only the MBI itself is generally used to make decisions on use attainment, but the State has acknowledged the need to expand the use of other benthic metrics such as those used in EPA's Rapid Bioassessment Protocols (EPA 1989) and/or other State programs.

Approach for Lakes

Assessments of lakes are performed by IEPA staff in the Planning Section of the Division of Water Pollution Control. Assistance in data collection and identification of causes and sources is provided by Areawide Planning Commissions (especially for Volunteer Lake Monitoring Program lakes), the Illinois Department of Conservation District Fishery Managers and Regional Administrators (based on 1977 fisheries questionnaires and updates), and the Illinois State Water Survey (lakes monitored under the Lake WQ Assessment grant). Data used in lake assessments include: measurements of Secchi transparency, total P, and chlorophyll *a*; other water column measurements with State standards; field observations of impairment of aquatic life and other uses; observations about potential for impairment due to urban or agricultural runoff; and other professional judgment. Data sources include: the 1984 Section 314 Lake Classifications report, data from IEPA's Ambient Lake Monitoring Program, data from Illinois' Volunteer Lake Monitoring Program, and data collected under Lake Water Quality Assessment grants.

For Illinois, a "fully supporting" lake fully supports all designated uses; a "partially supporting" lake has at least one use slightly to moderately impaired in a substantial portion of the lake (e.g., fishing impaired by excessive weeds); and a "not supporting" lake has at least one severely impaired use (e.g., widespread sedimentation blocks boating access).

Each lake is rated for severity of impairment according to statewide criteria. Illinois' Lake Use Impairment Index combines ratings for (1) the Carlson Trophic State Index (Carlson 1977), used by many States; (2) semi-quantitative ratings of the amount of sediment; and (3) semi-quantitative ratings of the amount of aquatic macrophytes. In addition, water column and sediment chemistry, biological data, field observations, and professional judgment are factored into the use support determination according to a relatively complex, but well-documented assessment algorithm. See Table 77 and Appendix J-4 of the 305(b) for details.

3.2.2 Indiana

Approach for Rivers and Streams

Assessments are performed by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Water Quality Surveillance and Standards Branch (WQSS). Indiana's 305(b) assessment process is in a state of flux as a result of two developments: the expansion of the biological monitoring program to include basin surveys and the implementation of the EPA WBS for tracking assessment results. In the past, the WQSS has requested input from Biological Monitoring and Survey and Inspection staff by providing STORET retrievals and the assessment pages from the last 305(b) report for their review. Presumably, a similar procedure will be followed for the 1992 report, except that assessment results will be entered into the WBS instead of typed onto the assessment tables.

Decision algorithms are documented in less detail in the Indiana 305(b) reports than in those of most other Region 5 States. Indicators used in assessments include water column and sediment chemistry, fish tissue contaminant data, discharge monitoring reports, fish kill reports, fish community data, and macroinvertebrate data. Data sources include STORET, Compliance Sampling Inspection, Department of Health fish consumption advisories, and State biological data files. Indiana relies heavily on the approach for analyzing water chemistry data described in the 1990 305(b) guidance (U.S. EPA, 1990). The STORET retrievals generated for this purpose are the basis for most assessment determinations. In addition to the above data types, fish kill information is provided by the Emergency Response Section of the Office of Water Management.

The next most widely used data type is fish tissue contamination data (Indiana's monitoring program emphasizes tissue monitoring to a large extent compared with other Region 5 programs). If the Indiana Department of Health has issued a fish consumption advisory, a waterbody is considered partially supporting; if a fish consumption ban has been issued, a waterbody is considered not supporting.

In the past, biomonitoring has, for the most part, been limited to the CORE fixed-station network, using in place samplers for macroinvertebrates and doing fish taxonomic work in conjunction with tissue contaminant sampling. IDEM is now broadening its biomonitoring to include the use of rapid bioassessment protocols for fish, macroinvertebrates, and habitat. In 1990, Indiana sampled the Central Corn Belt Plains Ecoregion in a cooperative project with Region 5, and in the summer of 1991, the project continued with sampling the Huron Erie Lake Plain and the Northern Indiana-Southern Michigan Tills Plain Ecoregions for biocriteria.

After the above data are accumulated and draft assessment tables completed by Biological Monitoring and Survey and Inspection staff, several WQSS managers meet to review the assessment results for each waterbody. At this time, results of the STORET analysis and recommendations of other staff may be overruled by supplemental information or BPJ.

Approach for Lakes

Use support determinations are made by WQSS staff. Only six lakes are specifically mentioned as not supporting or partially supporting designated uses. These determinations are BPJ calls based on a review of available information (IDEM Lake Eutrophication Index values, fish consumption advisories, fish kills, effluent data, and field observations of nuisance algae or lack of aquatic life). All remaining lakes in Indiana are considered threatened because of potential human impacts. Data used in assessments include: measurements of Secchi transparency, total P, soluble P, organic N, nitrate, ammonia, DO, percent light transmission at 3 feet, chlorophyll *a*, total plankton per liter, observations about potential for impairment due to urban or agricultural runoff, and other professional judgment.

Trophic status assessments are also performed by WQSS staff. Data sources include: 1988-89 Section 314 Clean Lakes monitoring (110 lakes) and the Indiana Department of Natural Resources Lake Enhancement Program. Indiana has established four trophic classes based on the IDEM Lake Eutrophication Index. This index is the sum of "eutrophy points" assigned for various measurements of the following parameters: Secchi transparency, total phosphorus, soluble phosphorus, organic nitrogen, nitrate, ammonia, dissolved oxygen, percent light transmission at 3 feet, chlorophyll *a*, total plankton per liter, and plankton counts from a 5-foot depth including the beginning of the thermocline. The four trophic classes are

1. Highest quality lakes, uses not impaired by eutrophication;
2. Moderately productive lakes; uses seldom impaired;
3. Most productive, eutrophic, or hypereutrophic, swimming, boating, and fishing uses sometimes impaired;
4. Remnant and oxbow lakes in an advanced state of senescence; some uses impaired by size, depth, or accessibility.

According to the above descriptions, there should be a correlation between trophic class and designated use support. Therefore, the 11 lakes falling within the trophic classes III and IV presumably are not fully supporting designated uses, even though the 305(b) does not explicitly state this.

3.2.3. Michigan

<u>Approach for Rivers and Streams</u>

Michigan's 305(b) reports require input and coordination from many State agencies. Indicators used in assessments include: fish community, habitat evaluation data, macroinvertebrate community data, water chemistry, fish tissue contamination, and effluent chemistry and toxicity. Data sources include: STORET, Department of Public Health Fish Consumption Advisory, List Michigan Department of Natural Resources (MDNR) biological surveys reports, effluent toxicity test reports, discharge monitoring reports and compliance survey reports, Great Lakes Area of Concern Remedial Action Plans, Michigan Waterbody System, and International Joint Commission reports.

The reports themselves are prepared by staff of the Great Lakes and Environmental Assessment Section (GLEAS) in the Surface Water Quality Division, Michigan Department of Natural Resources. Stream assessments are done within GLEAS with input from the Fisheries Division; lake assessments involve the Land and Water Management Division. The Department of Health also provides information on fish consumption advisories and other public health problems.

The procedure for stream assessments has evolved from the approach used to construct 304(l) lists in 1988. This procedure is not documented and is based largely on the BPJ of field staff and GLEAS managers. There is no clear prioritizing of data types, although recent biological data are considered the best data for aquatic life use assessments. A printout of the Michigan Waterbody System for each waterbody is sent to the appropriate district biologist within GLEAS (biologists are assigned to specific districts, although all biological staff work based in Lansing). These printouts are grouped into three categories--waterbodies with past WQS violations, waterbodies without a history of violations, and questionable waterbodies.

District biologists then update the WBS printouts based on new information, including ambient chemical and biosurvey data, effluent data, and other types of information listed above. In updating the printouts, biologists meet with the water quality staff (engineers, environmental scientists, and fisheries biologists) in each district for input and review. Regarding STORET data, Michigan does not have a standardized method for analyzing water chemistry data such as the approach recommended in the prior 305(b) guidelines. Likewise, Michigan's quantitative fish, macroinvertebrate, and habitat measures are not directly related to designated use support.

Michigan reports streams as either fully supporting or not supporting designated uses. Michigan WBS contains almost entirely impaired waters (mainly 304(l) long-list waters). There is no data system for information on streams that fully support uses. District biologists and other staff start with organized information only for known impaired waters and add waterbodies to the WBS as impaired waters are identified.

In 1990, Michigan DNR adopted GLEAS Procedure No. 15 entitled "Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers" using fish, benthos, and habitat multi-metric assessments. This procedure will greatly facilitate implementation of a biological criteria program and assist with the determination of designated use attainment for individual waterbodies. However, it is not yet clear how the State will precisely use the information generated in this new program.

Approach for Lakes

Lake assessments are done by GLEAS and Land and Water Management Division who do most of the Clean Lakes monitoring in the State. Lakes are either fully supporting, threatened, or not supporting. Data used in assessments include measurements of Secchi transparency, total P, and chlorophyll *a*, other water column measurements with State standards; field observations of impairment of recreation, aquatic life and other uses; observations about potential for impairment due to urban or agricultural runoff, and other professional judgment. Data sources include Michigan nonpoint source assessment reports and ambient data from the Clean Lakes program.

Fully supporting lakes meet all designated uses and generally one of the following conditions:

- Located in an isolated area or on public land, without influence by nonpoint sources;

- Located in a developed area, but relatively insensitive to pollutant load due to hydrologic or physical/chemical characteristics; and

- Naturally eutrophic system.

Threatened lakes meet one or more of the following conditions:

- Designated uses met, but minor water quality impacts noted;

- Watershed has high levels of agricultural or urban development;

- Lake is sensitive to development impacts; and

- Lake is oligotrophic or mesotrophic, hence "protected" under Michigan Rule 98 (antidegradation).

Other than the above general descriptions, no other documentation is available on assessment methods for inland lakes. Common reasons for nonsupport are fish consumption advisories resulting from metals contamination and failure of coldwater-designated lakes to meet the dissolved oxygen standard. Lake assessments are made by the district biologists in GLEAS and lake specialists in the Land and Water Management Division based on a BPJ evaluation of the above data types. In contrast to stream assessments, inland lakes assessments are stored and managed using the EPA WBS rather than their own State system. Trophic status is determined based on the Carlson Indexes for chlorophyll *a*, total phosphorus, and Secchi depth.

3.2.4 Minnesota

Approach for Rivers and Streams

Minnesota, the "Land of 10,000 Lakes," actually contains 12,034 lakes covering 3,411,200 acres. It is not surprising, therefore, to find that much of the Minnesota Pollution Control Agency's (MPCA) surface water monitoring efforts are directed toward lake resources. For the 1990 305(b) reporting cycle, MPCA monitored 2,234,800 (65.6%) of their lake acres and monitored only 4,684 (5.1%) of their 91,944 total stream miles. Part of this discrepancy is explained by the fact that one or two stations are used to assess an entire lake while one stream station covers only a single reach. As shown in Figures 3-2 and 3-3, Minnesota relies heavily on monitored rather than evaluated data in making designated use assessments. For future reports, however, MPCA would like to expand their use of evaluated data to provide a more comprehensive assessment of the State's water resources.

Of Minnesota's 91,944 stream miles, almost all (91,144 miles) are classified for fish and wildlife support and recreational uses. These uses are analogous to "Fishable Use" and "Swimmable Use." As detailed on p. 7 of the 1990 report, fishable use determinations are based on "ambient standards for dissolved oxygen, pH (low and high), un-ionized ammonia, total chromium and total copper, or on a fish consumption advisory." Fish consumption advisories are based on fish tissue contamination data. MPCA considers water chemistry data less than 10 years old and fish tissue data less than 5 years old to be monitored. Older data are considered to be evaluated. The majority of fishable use determinations are based on ambient chemical measures; about 10% are based on fish tissue data. Principal indicators in assessments are water chemistry and fish tissue contamination. Data sources include Minnesota's Fixed Station Ambient Network and Minnesota's Fish Tissue Analysis Program.

Aquatic life use determinations are made as follows:

Step 1 If >25 percent of values violate water quality standards or if there is a fish consumption advisory in place then the waterbody is <u>not supporting</u>.

Step 2 If >10 percent but <25 percent of values violate water quality standards then the waterbody is <u>partially supporting</u>.

Step 3 If <10 percent of values violate water quality standards then the waterbody is <u>fully supporting</u>.

In the future, MPCA plans to use biological community data in their use assessment decision process. They are currently developing an Index of Biotic Integrity for the Minnesota River watershed using fish community and habitat data. They plan to compare site-specific biological data with reference site data to determine use support.

Approach for Lakes

The "fishable" status of lakes is determined by fish tissue contamination data, and the "swimmable" use status is determined by aesthetics and Carlson's Trophic State Index (TSI) derived by the work of Heiskary and Wilson (1988). For aquatic life use support, assessments for lakes are based almost entirely on fish tissue contamination data (see Table 3-1). Data sources for decisionmaking include the Citizen's Lake Monitoring Program, the Lake Assessment Program, the Fish Tissue Analysis Program, and the Ecoregion Reference Lake Program. The relationships among TSI, use support status and trophic status are:

TSI	Use Support Status	Trophic Status	Impaired/Threatened
<40	Fully supporting	Oligotrophic	No
40-50	Fully supporting	Mesotrophic	No
51-59	Fully supporting, but threatened	Eutrophic	Threatened
60-65	Partially supporting	Eutrophic	Impaired
>65	Not supporting	Hypereutrophic	Impaired

Further discussion of Minnesota's use support assessments are documented on pages 17-29 of the State's 1990 305(b) report, and in Heiskary and Wilson (1988).

Table 3-1. Fish Contaminant Concentration for Each Use Category (from State 1990 305(b) Report) - Minnesota.

	Contaminant		
	TCDD (ng/kg)	PCB (ug/g)	Hg (ug/g)
Fully supporting (unrestricted consumption)	not detectable (<0.60)	not detectable (<0.05)	0.0-0.15
Partially supporting (moderate consumption)	detectable (>0.6)	detectable (>0.05)	0.16-2.80
Not supporting (no consumption advised)			>2.81

3.2.5. Ohio

Approach for Rivers and Streams

From 1974 to the present, Ohio EPA (OEPA) surface water assessments and standards have evolved from a singular focus on water quality to a broader focus on the water resource as a whole. To achieve this goal, OEPA moved from assessments based solely on water chemistry data to integrated evaluations consisting of chemical, physical, and biological assessments (Ohio EPA 1989a, 1989b, 1990b). OEPA believes this integrated approach is essential to accurate water quality management. OEPA has found that "simple ambient water chemistry monitoring missed nearly 50% of the waterbodies that were identified as impaired using a biosurvey-based integrated approach (Rankin and Yoder, 1990)." Chemical data are limited in assessing nonchemical and non-toxic impacts to waterbodies. Indicators used in assessments include fish community data, macroinvertebrate community data, habitat evaluation data, water chemistry, sediment chemistry, effluent chemistry and toxicity, and fish tissue contamination (Rankin 1989). Data sources include: integrated biosurvey-based assessments and fixed-station monitoring.

OEPA personnel believe that by lumping together diverse impacts into one measure, the 305(b) process places too much emphasis on "overall" use support. "Calculation of overall use support tends to muddle efforts to estimate very different problems in waterbodies. There should be a delineation between human health risks and aquatic life impacts. This would bring use support assessment up to the same relative level at which EPA is regulating (Yoder, 1991)." Ohio's 1990 305(b) report focuses primarily on attainment of aquatic life uses.

In assessing aquatic life uses, OEPA relies primarily on three biological indices (IBI, Invertebrate Community Index [ICI], and index of well being [Iwb]) that are calibrated to regional reference sites (Ohio EPA 1990). For the 1990 report, OEPA monitored 4,169 (16.6 percent) of their 25,165 total stream miles. Because of the limitations of chemical data in assessing nonchemical impacts, OEPA considers assessments based solely on fixed-station chemical data alone to be evaluated. For the 1990 report, OEPA evaluated 3,273 (13.0 percent) of their total stream miles. If biological data were available, the following approach was used for making aquatic life use support decisions (see Figure 3-6):

Step 1 ICI (macroinvertebrates), IBI (fish), and Iwb (fish) are calculated. If all three indices meet ecoregion criteria then the waterbody is in full attainment of its aquatic life use.

Step 2 If at least one of the indices does not meet ecoregion criteria and none of the indices suggest severe toxic impact then the waterbody is in partial attainment of its aquatic life use.

Step 3 If none of the indices meet ecoregion criteria or one of the indices suggests severe toxic impact then the waterbody is in nonattainment of its aquatic life use.

If biological data were not available, the following approach was used for making aquatic life use support decisions based on chemical data:

Step 1 If chronic (average) chemical criteria are not exceeded by the 10th percentile of instream values *and* the mean is less then the criteria then the waterbody is in full attainment of its aquatic life uses.

Step 2 If the chronic chemical criteria are exceeded by the 10th percentile of instream values *and* the mean is less than the criteria *or* chronic chemical criteria are not exceeded by the 10th percentile of instream values *and* the mean is greater than the criteria then the waterbody is in partial attainment of its aquatic life use.

Step 3 If the chronic chemical criteria are exceeded by the 25th percentile of instream values *and* the mean is less than the criteria *or* chronic chemical criteria are exceeded by the 10th percentile of instream values *and* the mean is greater than the criteria then the waterbody is in nonattainment of its aquatic life use.

Approach for Lakes

In sharp contrast to their stream monitoring program, Ohio's lake programs suffer from a lack of comprehensive monitored data. OEPA recognizes the need for a long-term integrated monitoring program for lakes similar to their stream program. For the 1990 report, OEPA assessed 91,607 (78.1 percent) of their 117,361 total lake acres (i.e., publicly owned lakes greater than 5 acres in size). The majority of these assessments, however, are based on evaluated data (i.e., BPJ or monitored data greater than 10 years old).

Ohio lakes were assessed using the Ohio Lake Condition Index (LCI), a multimetric index consisting of the 13 parameters listed under the following categories of lake condition:

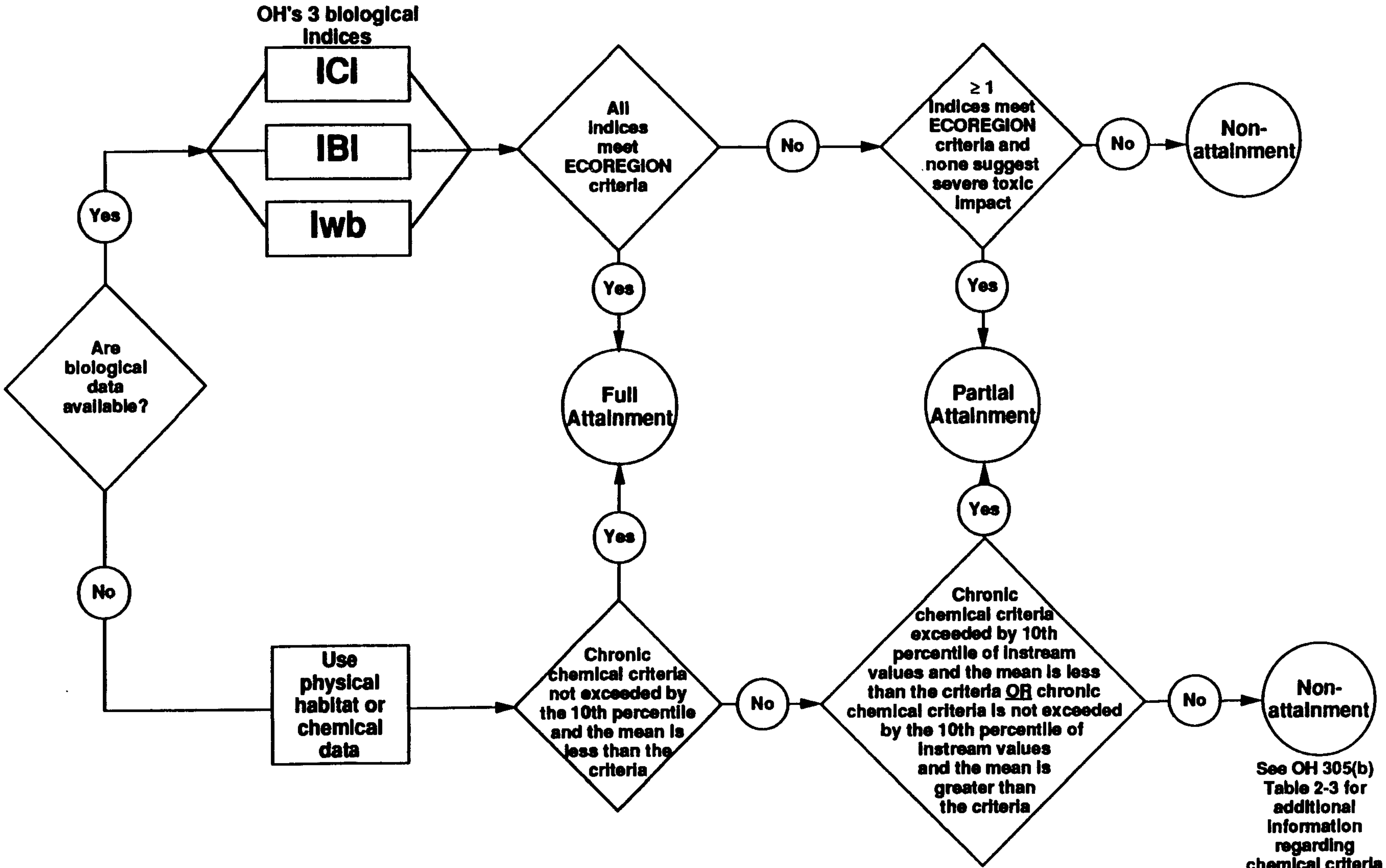
- Biological conditions: IBI (not yet developed), nuisance growth of macrophytes, fecal coliform bacteria, chlorophyll *a*, fish tissue contamination;

- Chemical conditions: nonpriority pollutants, priority organics (toxics), priority metals (toxics), total phosphorus, acid mine drainage;

- Physical conditions: volume loss due to sedimentation, Secchi depth; and

- Public perception of lake condition: aesthetics.

Figure 3-6. Criteria for Determining Use Attainment for Ohio's Rivers/Streams



Source: 1990 Ohio Water Resource Inventory

All Ohio publicly owned lake acres are designated for public water supply use and the aquatic life use--exceptional warmwater habitat. For each designated use, a subset of the LCI parameters is considered. To assess aquatic life use support, nonpriority pollutants, priority organics, priority metals, total phosphorus, IBI, and acid mine drainage are considered. To make an assessment based on LCI, more than 50 percent of the appropriate LCI parameters must have been assessed using monitored and/or evaluated data.

If sufficient data are available to make an assessment using the LCI, the following approach is used (Figure 3-7):

Step 1 If one or more LCI parameters indicate impaired status *or* more than 50 percent of the parameters indicate threatened status then the lake is in nonattainment of its aquatic life use.

Step 2 If one or more LCI parameters indicate threatened status *or* the lake is hypereutrophic (TSI >66) then the lake is in partial attainment of its aquatic life use.

Step 3 If all LCI parameters indicate full use support *and* one or more parameters indicate threatened status based on evaluated data *or* if the lake is eutrophic (TSI=48-66) then it is fully supporting, but threatened.

Step 4 If all LCI parameters indicate full use support then the lake is fully supporting its aquatic life use.

3.2.6 Wisconsin

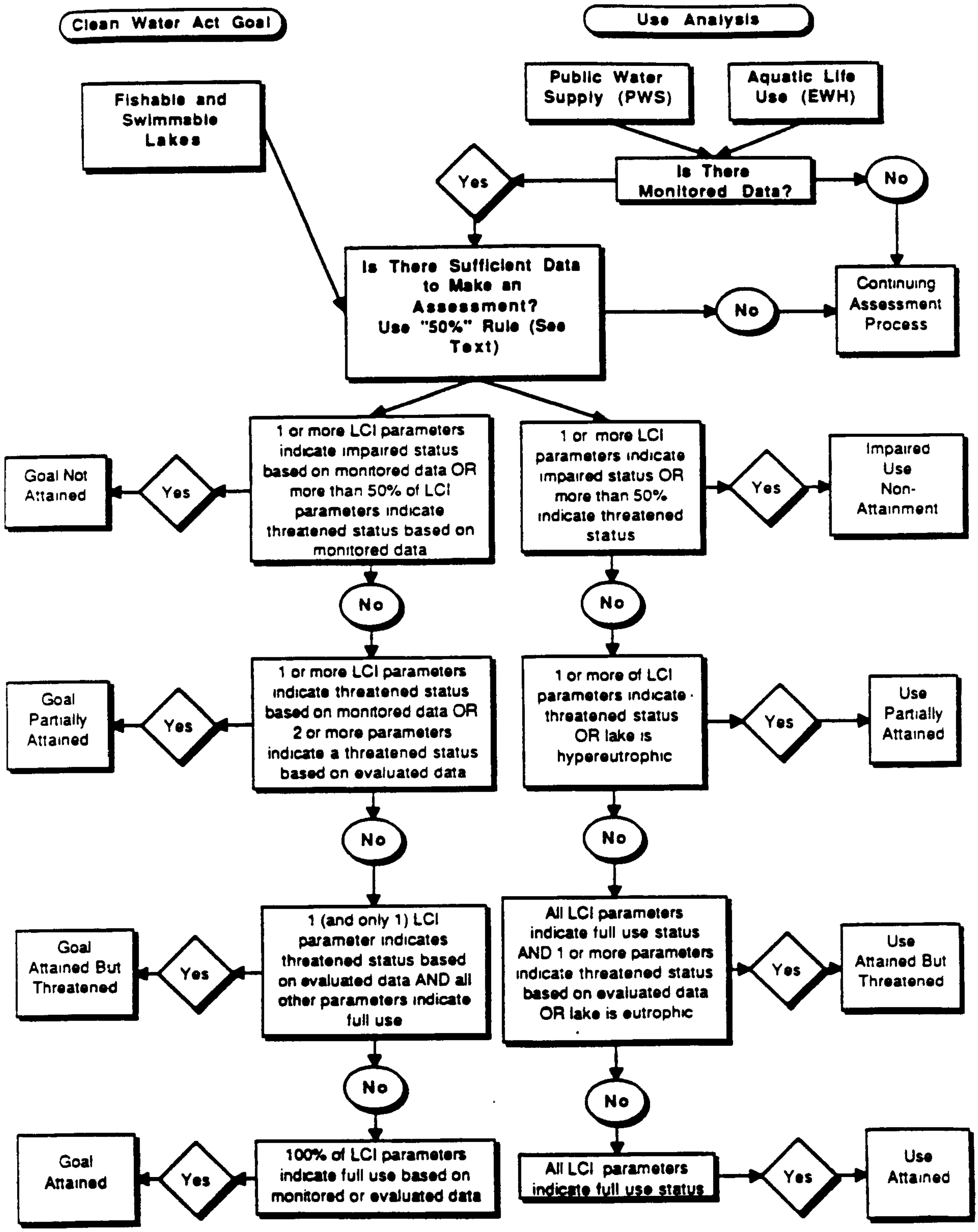
Approach for Rivers and Streams

The Wisconsin Department of Natural Resources (WDNR) is the agency responsible for performing use support assessments. Indicators used in assessments include water chemistry, fish tissue contamination, macroinvertebrate community, fish community data, and sediment chemistry. Data sources include the Fixed Station Monitoring Network, the Biological Sampling Program, the Sediment Sampling Program, and the Fish Tissue Monitoring Program. In the 1990 report WDNR personnel monitored 2,771 (6.4 percent) of their 43,600 total stream miles. In addition, they evaluated 10,824 (24.8 percent) of their total stream miles. Monitored data greater than 5 years old were considered to be evaluated unless best professional judgment strongly indicated that no change had taken place.

WDNR personnel collect a variety of water quality data but have no formal decision pattern for making use support assessments. Best professional judgment plays a major role

Figure 3-7. Use Attainment/Clean Water Act Goal Assessment Process for Ohio Lakes

From *Ohio Water Resource Inventory, Volume III*, 1990



in making use support decisions, because WDNR is confident that their field personnel are experts on the condition of their waterbodies. Listed below are the types of available data and how they are used for 305(b) assessments. No data priority type is implied.

- Water chemistry: Ambient data are compared to State water quality standards. Use attainment might be restricted when standards are exceeded, however, attainment is not restricted based solely on chemical data.

- Fish tissue contamination: WDNR, in cooperation with the State Division of Health, compares the edible portion of the fish to FDA Action Levels to issue fish consumption advisories. If a fish consumption advisory is in place for one species *or* specific size ranges among more than one species then the waterbody is partially supporting. If consumption advisories are in place for most game species *and* size ranges then the waterbody is not supporting.

- Macroinvertebrate: WDNR personnel use a modified version of Hilsenhoff's biotic Index for assessing water quality (Hilsenhoff 1977, 1982). If the community is impacted, then data are factored into the use assessment. Macroinvertebrate data alone would not change a use assessment.

- Fish community: Collection procedures for fish communities are standardized statewide, but assessment methodologies vary among districts. Some districts use quantitative methods (e.g., IBI) while others rely on qualitative assessments (e.g., BPJ) for making use support decisions.

- Sediment contamination: Assessments based on sediment contamination are subjective. There are no formal standards for sediments, but uses can be restricted as a result of high levels of sediment contamination if BPJ recommends such a restriction.

Approach for Lakes

According to the 1990 305(b) report (p. 87), "in terms of providing recreational opportunities for its citizens, Wisconsin's lakes are the State's most vital water resource component. The historic focus, however, of federal and state clean water programs...has been the control of pollutants to rivers and streams. As a result, lake protection and rehabilitation has been a low priority." To remedy this situation, Wisconsin DNR personnel have encouraged public involvement through the Self-Help Volunteer Monitoring program and initiated an EPA-funded Lake Water Quality Assessment project in 1989.

All of Wisconsin's 957,288 lake acres are designated for fishing, swimming, and recreation uses. For the 1990 report, DNR monitored 62,870 (6.6 percent) and evaluated 76,460 (8.0 percent) of their total lake acres. Data sources included the long-term Trend

Monitoring Program, the Self-help Volunteer Lake Monitoring Program, the Fish Tissue Monitoring Program, and the 1983 Landsat Trophic Status Survey. Types of data used in lake assessments include measurements of trophic status (Secchi depth, chlorophyll *a*, phosphorus), fish tissue contamination data, aquatic macrophytes, algal biomass, and dissolved oxygen (DO). Landsat trophic information (water clarity and chlorophyll *a*) is available for all Wisconsin lakes and reservoirs greater than 20 acres with a maximum depth of at least 8 feet Lakes with only Landsat data available were considered to be evaluated. If actual lake sampling data were available than the lake was considered to be monitored. For the 1990 assessments, lakes fully supporting their uses but sensitive to acidification, phosphorus input, or mercury contamination of sport fish were considered to be threatened.

The following approach is used for making use support decisions (see Figure 3-8):

Step 1 Use available trophic data to calculate Carlson's Trophic Status Index (TSI). If TSI indicates the lake is hypereutrophic (TSI=71-100) then the lake is <u>not supporting</u>.

Step 2 If DO is not sufficient to support fish *or* if there is a *severe* fish consumption advisory in place then the lake is <u>not supporting</u>.

Step 3 If TSI indicates that the lake is eutrophic (TSI=51-70) then it is <u>partially supporting</u>.

Step 4 If DO *somewhat* supports fish, if there is a *limited* fish advisory in place, *or* if there is a *severe* algal or plant problem then the lake is <u>partially supporting</u>.

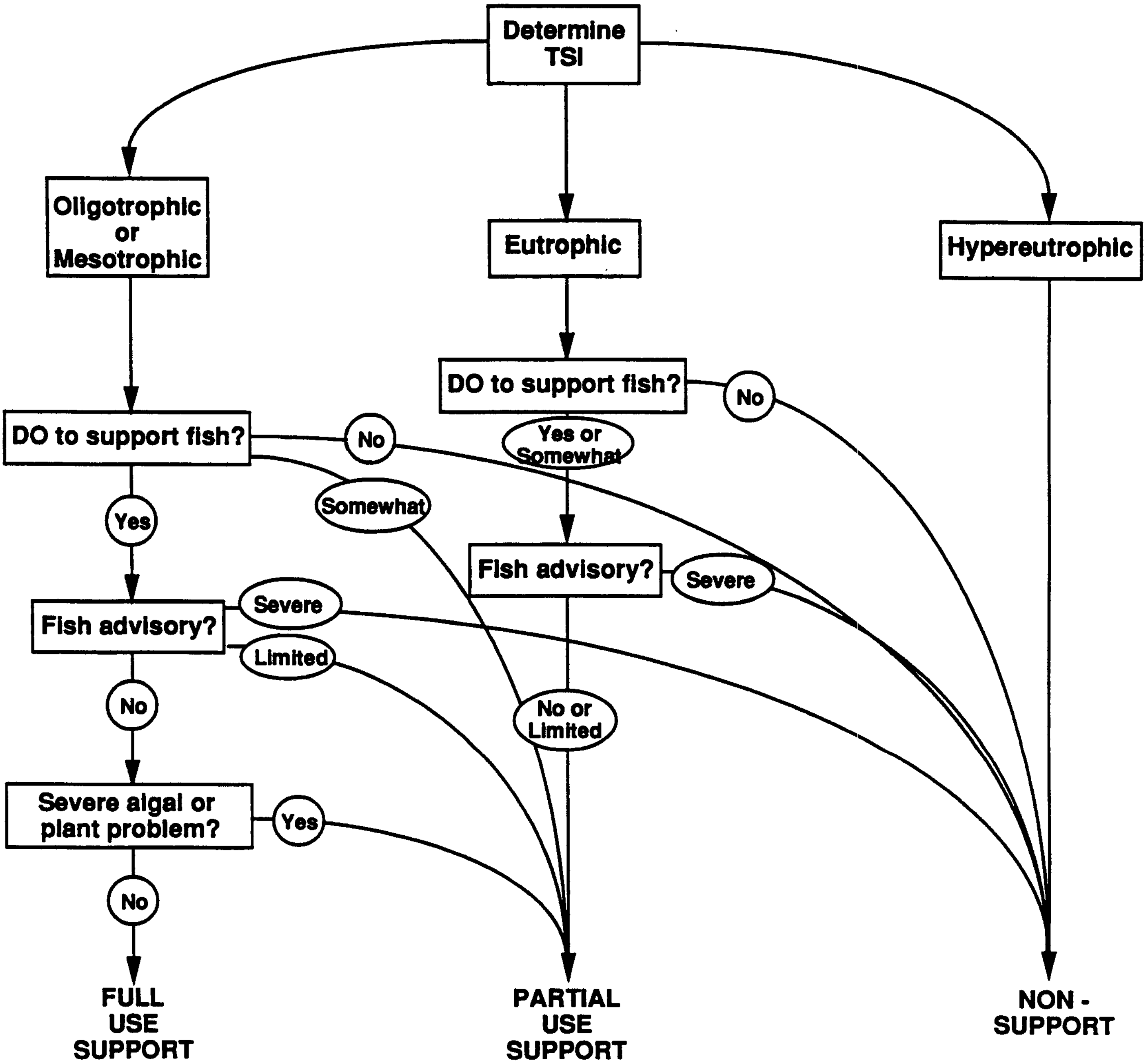
Step 5 If the lake is oligotrophic (TSI=0-40) or mesotrophic (TSI=41-50) *and* the conditions stated in the previous steps do not exist, then the lake is <u>fully supporting</u>.

3.3 Findings and Recommendations

The Region 5 States support the use of direct environmental indicators for surface water programs and specifically aquatic life use attainment as a direct indicator. The States all utilize a suite of direct environmental indicators to measure aquatic life use attainment to allow the best determinations regarding the status of a waterbody. The preference is to utilize the use attainment status as the overall direct indicator because it integrates the available data and allows for natural (or extreme man-made) differences in the expectations of water resource quality for a given area or region.

The States rely predominantly upon biological community and habitat assessments and water chemistry for aquatic life use attainment decisions in rivers and streams and focus on Carlson's Trophic State Index (TSI) for inland lakes supported by water chemistry and fish

Figure 3-8. Designated Use Support Assessment for Wisconsin Lakes



See page 41 of 1990 305(b) for details
No data type priority is implied

tissue data. However, the varied level of complexity and heavy reliance upon specific data types (e.g. water chemistry) for decision-making prevent the needed consistency and accuracy to portray Regional conditions, or even conditions within a given State from year to year.

Biological assessment programs within the States are rapidly evolving from simple single index approaches into multi-metric indices and multi-assemblage approaches including numerical habitat assessments. However, some States are having difficulty implementing some of these changes and therefore do not use their biological data consistently to make aquatic life use support decisions. Some of the barriers to full implementation include technical and resource limitations such as:

- The perceived lack of commitment by EPA Headquarter's Office of Water to support and promote the implementation of biological criteria in State and Regional programs, and

- The uncertainty within the States regarding their overall support of EPA's three basic biological criteria policy decisions: (1) the requirement to focus on adoption of narrative biological criteria in FY93 and numerical biological criteria in FY96, and (2) the policy of strict independent application which the States feel is contradictory to an integrated assessment program, and (3) the disallowance of instream biological community assessments as one method for site-specific criteria development.

- Reliance upon a single biotic index to represent the macroinvertebrate community,

- Shortage of staff in the field and laboratory to collect, identify, and interpret the data,

- Lack of enough qualified staff to make taxonomic identifications resulting in heavy reliance upon contractors and extended time-frames for report completion,

The States need an incentive to make the investment, and continue implementation, in more rigorous bioassessment approaches as part of the integrated assessment framework. Otherwise, States may choose the simplest and cheapest methods for biological assessment (even citizen monitoring) with less regard for accuracy and discriminatory power. Being able to discriminate among the confidence levels in assessment data is directly in support of EPA's policy on "risk-based" assessment approaches. Ohio EPA developed Figure 3-9 to illustrate this concept, as well as how it relates to EPA's desire for ensuring that quality bioassessments and utilized to develop biological criteria.

To further the use of biological assessments and criteria for aquatic life use support decisions and the wider use of environmental indicators in the water programs, the project team developed the following list of generic and specific recommendations shown below.

<u>Recommendations</u>

These recommendations should be implemented by working directly with the States and Regions to issue guidance which directly meets State and EPA needs. Guidance should be in the form of State-EPA technical training and workshops (e.g. Rapid Bioassessment Protocols, 305(b) workshops, etc.), improved annual State guidance under Section 106, greater Regional involvement in State Water Quality Management Plan development, and continued improvement towards consistent and accurate national guidelines on Section 305(b) reporting, biological assessment and criteria, and the myriad of other guidelines to support the nonpoint source and clean lakes programs.

- Aquatic life use support should be the direct environmental indicator for surface waters and be primarily based upon assessments of the fish, benthos, and habitat. This assessment should also include all other available information such as chemical concentrations in water and sediments, physical measurements, and toxicological endpoints. This recommendation supports those recommendations and conclusions made at the July 1991 conference in Baltimore, Maryland -- *Environmental Indicators: Policies, Programs and Success Stories.*

- Greater consistency in the methods and approaches for determining use attainment is necessary to use environmental indicators in State and Regional 305(b) programs.

- EPA and the States should cooperatively develop the environmental indicators (measures) which will directly support the assessment of designated use attainment for aquatic life for both resource types (rivers/streams and lakes).

- EPA and the States should use the environmental indicators and measures selected for aquatic life use attainment to meet EPA's requirements to adopt biological criteria. Particular emphasis should be placed on wider use of fish and benthic macroinvertebrate communities and habitat for use attainment assessment.

- Biological criteria development for rivers and streams should utilize the following multiple assemblage and multiple metric approach, at a minimum:

    1. Fish community (assemblage) assessments using the Index of Biotic Integrity (IBI) modified for that State or region, and any other tools demonstrated to be successful such as the modified or original Index of Well-Being. Each Region 5 State uses the IBI, although the extent of development and consistency varies widely among States.

Figure 3-9. Hierarchy of Ambient Biological Assessment Types Using Indigenous Communities - Ohio[1]

BIOASSESSMENT TYPE	SKILL REQUIRED[2]	ORGANISM GROUPS[3]	TECHNICAL COMPONENTS[4]	ECOLOGICAL COMPLEXITY[5]	ENVIRONMENTAL ACCURACY[6]	DISCRIMINATORY "POWER"[7]	POLICY RESTRICTIONS[8]
1. Stream Walk (Visual observations)	Non-biologist	None	Handbook	Simple	Low	Low	Many
2. Volunteer Monitoring	Non-biologist, Technician	Invertebrates	Handbook, Simple equip.	Low	Low to Moderate	Low	↓
3. Professional Opinion (EPA RBP Protocol IV)	Biologist w/ experience	None	Historical records	Low	?	Low	↓
4. EPA RBP Protocols I & II	Biologist w/ training	Invertebrates	Tech. Manual, Simple equip.	Low	Low to Moderate	Low	↓
5. Narrative Evalu- of Biosurvey Results	Aquatic Biolo- Biologist w/ training & experience	Fish &/or Invertebrates	Std. Methods, Detailed taxonomy, Specialized equipment	Moderate	Moderate	Moderate	↓
6. Single Dimension Indices - Biosurvey Results	(same)	(same)	(same)	Moderate	Moderate	Moderate	↓
7. EPA RBP Protocols III & V (Multimetric Indices, Local Reference Site)	(same)	(same)	Tech. Manual, Detailed taxonomy, Specialized equipment	High	Moderate to High	Moderate to High	↓
8. Multi-metric Indices, Regional Reference Sites	(same)	(same)	Same plus Baseline calibration of Multimetric Indices	High	High	High	Few

1 Applies to evaluation of aquatic life use attainment only - does not apply to bioaccumulation concerns, wildlife uses, human health, or recreation uses.
2 Level of training and experience needed toaccurately implement and use bioassessment type.
3 Organism groups that are directly used and/or sampled as part of the bioassessment type.
4 Handbooks, technical manuals, and data requirements for each bioassessment type.
5 Refers to ecological dimensions inherent in the basic dataroutinely generated by and used with each bioassessment type.
6 Refers to the ability of the ecological end-points or indicators to differentiatealong a scale of environmental conditions.
7 The relative power of the data derived from each assessment type to discriminate between different and increasingly subtle impacts.
8 Refers to the relationship of bioassessments to chemical-specifi, toxicological, physical, and other assessments and criteria that are intended to assessaquatic life use attainment/non-attainment.

Source: Ohio EPA

2. Benthic macroinvertebrate community (assemblage) assessments should be based upon a multi-metric approach similar to that of EPA's Rapid Bioassessment Protocols. Ohio and other States have already developed State-specific multiple metric indices.

3. Habitat assessments must be made based upon a numerical ranking which each Region 5 State already uses. Habitat assessments must be used not only to assess reasonable expectations for community (assemblage) performance, but also to monitor habitat quality to prevent, recover, and mitigate habitat degradation.

- Designated use attainment methods for lakes should be evaluated for the States to determine whether trophic status is the most significant indicator to track for aquatic life support or whether additional lake indicators could be used. This issue should be addressed through interstate meetings within Region 5 and by the National 305(b) Consistency Workgroup.

- Interstate (and interregional) selection of references sites where major faunal regions and ecoregions are in common should be initiated to encourage greater consistency and cooperation among EPA and the States in the development of numeric biocriteria. A prime example would be the northern Ohio River Basin covering Illinois, Indiana, Ohio, and part of Pennsylvania. EPA and States should ensure adequate resources are available to support this kind of activity. EMAP, in particular, should have a key role in this area.

- Database management and specific information should be maintained on all waterbodies assessed, not just those that are in non-attainment status.

- Re-evaluate EPA's decisions to mandate adoption of narrative biological criteria and focus efforts on increasing State's capabilities to develop numeric biocriteria.

- Re-evaluate EPA's policy of independent application of effluent toxicity, water chemistry, biological community, and habitat assessments in making designated use support decisions. This policy does not allow consideration of site-specific evaluations of the technical rigor of sample collection methods, quality assurance, reliability in the data, interpretation tools, and overall level of confidence in the data.

- The policy restrictions required by EPA should be inversely related to the "strength" of a State's bioassessment approach.

4. SURFACE WATER MONITORING PROGRAMS

4.1 Overview

Since the early 1970s, much of the State and EPA surface water monitoring and related assessment activities (e.g., effluent chemical and toxicity testing) have supported a technology-based regulatory system designed to control releases from large, obvious point sources (especially municipal sewage treatment plants and industrial facilities). Unfortunately, the ability of State and EPA monitoring and assessment programs to support the primary water quality planning and management objectives shown in Table 1-1 has been limited because of this historical focus on point source monitoring. For example, water resources impaired by nonpoint sources or habitat alteration may not be identified and characterized adequately with a point-source-dominated monitoring and assessment program. Furthermore, Federal and State efforts to collect data more supportive of management objectives (e.g., broad-based status and trends) have often been stymied due to resource constraints, inadequate coordination, or the low priority given to monitoring in support of permitting, enforcement, and other administrative activities.

Environmental indicators, as shown in Figure 1-1, are intended to complement administrative measures by conveying direct or indirect information on environmental conditions resulting from, or independent of, management and protection actions. Comprehensive, properly designed monitoring and assessment programs should convey administrative measures, environmental indicators, and other data (e.g., population and land use trends) necessary to support water resource evaluation; problem identification and characterization; management strategy development, implementation, and evaluation; and communication of results to the public and legislators.

4.2 State Surface Water Monitoring Programs

EPA has produced a number of guidance documents to direct State program implementation of the Clean Water Act. As national program emphasis changes, however, previous guidance documents have either become obsolete or have been ignored. In 1974, EPA produced a guidance entitled "Model State Water Monitoring Program" (U.S. EPA, 1974). This guidance was prepared by a National Water Monitoring Panel and covered the following elements: Planning and Management; Ambient Water Quality Monitoring (e.g., fixed station networks, intensive surveys, and groundwater monitoring); Biological Monitoring (i.e., biological surveys and tissue analysis); Compliance Monitoring; and Quality Assurance. The 1974 guidance advocated an integrated assessment program and even defined fixed station monitoring as using chemical, physical and biological measures. Shortly after the 1974 guidance, EPA established a Standing Workgroup on Water Monitoring which issued guidance for a "Basic Water Monitoring Program" in 1977 and was updated in 1978 (U.S. EPA, 1977, 1978). This guidance emphasized the utility of intensive surveys as the "primary vehicle in determining whether water quality conditions are improving or getting worse" and "interpretation of intensive survey data should be the basis for the Section 305(b) Report." The guidance also stated that the ambient fixed stations "will be operated by the State with the data to be aggregated nationally and will be used primarily to determine national trends in water use areas ... problem areas ... [etc.]." In fact, the basic (or core) program was designed to "redirect ambient and effluent monitoring at the State level from a fixed-station, single discharge approach to an intensive survey approach."

The next group of guidance documents appeared in 1984 and 1985 lead by the "Monitoring Strategy - Office of Water" (U.S. EPA, 1984a), "Planning and Managing Cooperative Monitoring Projects" (U.S. EPA, 1984b), and finally the "Guidance for State Water Monitoring and Wasteload Allocation Programs" (U.S. EPA, 1985). The 1985 guidance decidedly lead the States down the path to a predominant point source orientation with specific guidance on monitoring for compliance and enforcement and development of TMDLs and WLAs. This guidance divorced biological surveys from fixed station monitoring and encouraged the use of fixed station networks to increase the amount of assessed water for 305(b) reporting.

In 1990, EPA issued draft monitoring program guidance (U.S. EPA, 1990b) that emphasized intensive surveys, biological community assessments, and integrated assessment approaches in general (with no detected mention of fixed station monitoring). It is clear that as national emphasis and priorities change (with each revision of the Clean Water Act), EPA anticipates that States should change their fundamental programs. This section illustrates how the monitoring efforts of State programs have become diversified and how difficult it is to assess the collected data. It is important to note that the most successful monitoring approaches (integrated assessments, biocriteria development, and habitat assessments) were initiated in the States. Not surprisingly, Region 5 States interviewed in the course of this study highly recommend that EPA focus future monitoring program guidance to complement and support existing programs, rather than to change them.

Tables 4-2 through 4-7 summarize Region 5 State monitoring programs for rivers, streams, and lakes. Each table entry provides a general program description, comments on network design, type and frequency of sampling, number of stations or samples, types of environmental indicators collected, uses of data, and data analysis methods. Table 4-1 lists the data uses and data analysis methods used in the various State programs. In addition, Table 4-1 shows the relationship between the State's data uses and the four water quality planning and managing objectives listed in Table 1-1.

Table 4-1. Data Uses and Data Analysis Methods Shown in Tables 4-2 - 4-7

<u>Data Uses</u>	
1. Water Resource Evaluation	
Identifying temporal or spatial trends	1-1
Developing water quality baseline or reference levels	1-2
2. Problem Identification and Characterization	
Assessing use support and screening for existing/emerging problems	2-1
Investigating suspected water resource problems	2-2
3. Management Strategy Development, Implementation, and Evaluation	
Improving water quality goals and standards	3-1
Developing water-quality-based controls	3-2
Monitoring the effectiveness of point or nonpoint source controls	3-3
Setting priorities	3-4
4. Communication of Results to Public and Legislators	
Developing public support through information transferal	4-1
<u>Data Analysis Methods</u>	
Comparison of ambient data to State water quality standards	A
Comparison of ambient data to "decision criteria" not incorporated into State standards (e.g., lake trophic status, IBI)	B
Comparison of ambient data to ecoregional or site-specific criteria	C
Use of parametric statistical tests (e.g., regression, Student's t-test)	D
Use of nonparametric tests (e.g., Kendall's tau)	E
Use of water quality indices	F
Plots or tables of concentrations, loadings, or indices vs. time	G
Other (State-specific data analysis method)	H

Table 4-2. Illinois Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1. Ambient Water Quality Monitoring Network (AWQMN)	F; 6-week freq.	208 stations	• Chemical network -- parameters are pH, T, conductivity, flow, D.O., TSS, VSS, NH3-N, NO3+NO2-N, total P, diss. P, COD, fecal coliform, turbidity, and 21 metals • 7 parameters are used to calculate a WQ index for assessments	• Network was revised in 1977 to: establish baselines and trends in representative land use areas generally outside immediate impact zones of PSs (except in major population centers); identify problems; and trigger intensive surveys. • Although sampling frequency has declined and some stations have been dropped, many have been monitored for over 15 years.	2-1 1-1 1-2	A,B,F G,E A,B,F
2. CORE Subnetwork of AWQMN	F; see program description for frequency	38 stream stations from AWQMN plus 3 Lake Michigan stations	• Mainly chemical network • Includes 3 Lake Michigan Stations monitored by City of Chicago • Organochlorine pesticides and PCBs • Frequency: twice yearly for water column organics; biennially for fish contamin; triennially for sediment and macroinvertebrates	• Established as required by EPA under the National Water Quality Surveillance System; no longer required but IEPA still maintains. • Purpose was to measure baseline WQ trends nationwide	2-1 1-2	A,B,F A,B,F
3. Pesticide Subnetwork of AWQMN	F; 6-week freq. April-July; 12-week freq. August-March	30 stations from AWQMN	•Chemical network • Parameters are 15 herbicides and organophosphate insecticides, PCBs, and organochlorine pesticides	• 26 stations predominantly agricultural, 4 nonagricultural watersheds •Begun in 1985	2-1	A,B
4. Industrial Solvents Sub-network of AWQMN	F; 6-week frequency	31 stations from AWQMN	• Chemical network • 19 organic chemicals (e.g., chloroform, trichloroethylene, benzene)	• Begun in 1988 •Stations located in urban areas except for 1 control site.	2-1	A,B
5. Intensive River Basin Surveys	I; each basin studied every 10-15 years	No. of stations varies; 4 basins surveyed in FY'90	•Multimedia sampling -- water column chemistry, habitat, macroinvertebrate and fish populations, sediment and fish tissue contaminants, and sediment type. • Example: In the Kaskaskia Basin Survey (1981-82), over 140 sites were sampled	• Sites selected to characterize stream resources of the basin and to provide data for permit development	2-1 3-2 1-2 2-2	A,B B B B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-2. Illinois Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
6. Fish Contaminant Program	F stream stations annually; F lake stations biennially; I stations vary	73 stream stations (F); 20 lake stations (F); approx. 36 I stations	• Composited fish fillet samples at all stations; whole fish samples at 41 stations. • Pesticide/PCB analyses (20 parameters) on all samples • GC/MS wide scan on < 25 whole fish samples • Hg, dioxine as needed • Results compared to FDA Action Levels	• Fixed sites widely distributed throughout state on major streams (Mississippi, Wabash, Kankakee, Illinois, Fox rivers, e.g.) • Includes sites with past contamination problems • Both main streams and tributaries sampled during basin surveys	2-1 2-2 3-3	B B B
7. Facility-related Stream Survey Program	I	Approx. 94 stream stations in 88-89 in 12 basins	• Evaluates WQ impacts from point sources • Macroinvertebrates, chemistry, flow, habitat data collected upstream and downstream	•Sites selected based on location of discharges, closely linked to NPDES issuance and compliance	2-1 2-2 3-2 3-3	A,B
8. Special Surveys	I	Varies	• Includes enforcement cases, Pesticides Study, Livestock Waste Monitoring	•Varies according to type of survey	2-2 3-3	A,B,F,G
Lakes						
9. Ambient Lake Monitoring Program (ALMP) (includes Clean Lakes Program, Trend Lakes, and Diagnostic Evaluation Lakes)	I	20 -40 lakes per year; 1 to 3 sites per lake	• Three types of lakes monitored - Clean Lakes Program Phase I and II (2 times per month May-Sept.; monthly or bimonthly Oct.-Apr.) - Trend lakes (6 times Apr.-Oct.) - Diagnostic evaluation lakes (5 times spring through fall) • Parameters -- DO, T, TSS, nutrients, chlorophyll, other field tests (in addition, CLP lakes -- phytoplankton, benthos, fish, vegetation, sediment chemistry)	• CLP lakes selected by CLP process • Trend lakes are formed CLP lakes, lakes representative of various types of WQ; lakes where various pollution controls implemented • Diagnostic lakes selected from list of lakes needing controls or effectiveness monitoring	3-3 2-1 2-2 3-2	B B,F B B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-2. Illinois Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
10. Volunteer Lake Monitoring Program	F; twice per month May-Oct.	176 lakes in 1989; 3 or more sites per lake	• Citizen monitoring program involving 225 volunteers • Secchi disk and field observations at all lakes • Nutrients and TSS at 30-50 lakes •	• Lakes selected according to citizen interest, within areas served by three regional planning commissions	4-1 2-1 3-3	NA B,F B,F
11. Lake Michigan Network	F	85 stations	• Conducted by City of Chicago • Reported separately from 305(b)	Sites selected where public recreation occurs and in vicinity of Chicago water supply intakes	2	A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-3. Indiana Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1. Fixed Station WQ Monitoring Network	F; monthly or quarterly	106 stations	• Monthly sampling at 91 sites • Quarterly at 15 sites • 37 sites sampled quarterly for toxics • 41 sites sampled for phytoplankton • Parameters are adjusted for individual sites frequently based on BPJ	• Network redesigned based on BPJ in 1986; in part site selection based on review of WQ trends and exceedances in 1979-1985	2-1 2-2 3-2	A A H
2. Fish and Sediment Toxics Monitoring Program	F (biennially) and I	23 CORE (F)	• CORE is a subset of Fixed Station Network • 32 streams, 28 inland lakes, and Lake Michigan sampled in 1988-89 • Fish, macroinvertebrates, other aquatic biota, sediment PCBs; chlorinated pest., metals, organics	• Stream sites generally selected in known areas of contamination (e.g., having advisories) • Lake sites selected to screen for problem areas or to fulfill EPA CLP requirements	2 3	B B,G
3. Biological Monitoring Program	F and I	22 F sites biennially; no. of I sites not yet decided	• Small, but developing program • IDEM samples macroinvertebrates; EPA Region 5 assisting with fish • EPA Rapid Bioassessment Protocols used • Rotating basin surveys begun in 1991	• Fixed sites will be analyzed for trends • Sites selected to validate toxicity test and effluent chemistry data, or to evaluate hazardous waste sites, or to fulfill CLP	2-1 1-2 3-2	B,F B,F B,F
Lakes						
4. Clean Lakes Programs	I	~100 lakes in last 2-3 years. by IDEM; more by IDNR	• IDEM coordinates the EPA CLP monitoring (contracted to Indiana Univ.) •IDEM plans 7 year sampling cycle • IDNR operates state-funded Lake Enhancement Program	• IDEM program based largely on CLP priorities •IDNR selects lakes independent of CLP based on known or suspected problems	2-1 3-4	A,B A,B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-4. Michigan Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1. Fixed Station Monitoring Program	F and I; monthly	53 stations sampled every year; ≥ 50 stations rotated	• 8 CORE subnetwork has 20 permanent sites, 17 on Great Lakes tributaries and 3 on inland rivers • Urban subnetwork has 10 stations upstream and 10 downstream of major urban areas • Detroit River subnetwork has 13 stations • Fixed subnetworks (above) generally sampled monthly for 24-35 conventional pollutants and inorganic chemicals, annually for 15 more inorganics • Basin-Year Monitoring subnetwork -- approx. 75 rivers/streams per year on 5-year rotating cycle. Major Great Lakes tributaries, major inland streams; minor G.L. tributaries, minor inland streams. First 2 categories sampled monthly during the year.	• Most fixed stations date back to the 1970s; network was much larger • Current network selected to monitor loads of most major tributaries to Great Lakes. • Stations at mouths of major tributaries are presumed to reflect WQ of their basins.	3-3 2-1 3-4	A,B A A,B
2. Fish Contaminant Program	F and I	56 stations in 1988; 990 fish collected	• Fish tissue analyzed for organochlorine pesticides, heavy metals, and industrial chemicals • Majority of sites on inland lakes • 3-5 rivers per year tested for biological uptake by caged channel catfish (28-day test) at mouths of Great Lakes tributaries.	• Comprehensive program begun in 1986 to determine status of fish in Great Lakes, their major tributaries, inland lakes and streams • Sites having consumption advisories are included among fixed stations • Some sites selected for general problem ID.	2-1 3-3 2-2 1-1	B B B B,G
3.Biosurveys	I	79 sites in 1989	• Fish and macroinvertebrates communities; aquatic plant distribution and abundance. Quantitative or qualitative. Michigan rapid bioassessment protocols used. • Two types: problem evaluation surveys and basin surveys	• Basin survey sites are selected to support permit issuance and document basin WQ • Problem evaluation survey sites selected in response to known/suspected problems outside the rotating basin cycle	3-2 2-1 2-1 3-1	B,F B,F B,F B,F

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-4. Michigan Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Lakes						
4. Ambient Lake Program	F	50-60 lakes per year	• Sampled during spring overturn and summer stratification • Secchi depth, phosphorus, chlorophyll a, field parameters	• 8 Lakes selected to update previous classification efforts • Viewed as a limited program •MDNR proposing to monitor each publically owned lake every 15-20 years	2-1 3-4	B B
5. Volunteer Lake (Self-help) Program	F	160-175 lakes	• Secchi depth only • Mainly conducted by lake property owners	• Designed to monitor long-term changes in WQ	2-1	A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-5. Minnesota Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1.Routine Water Quality Monitoring Program	F Monthly; 9 months/ year	70-75 stations including 19 CORE stations	•Parameters include nutrients, bacteria, BOD, and general chemistry components. •Intensive surveys are also conducted at 3 new sites last year only	•Geographic representation •3-year rotation -- to focus on a particular area of the state (3 areas: South, Northwest, Northeast)	2-1	A C
2.Fish Tissue Analysis	I		•Between 1970 and 1989, fish from 80 river locations and over 200 lakes were sampled •Fish fillets are analyzed for PCBs, TCDD, and mercury contamination	•Designed for several purposes: trend, analysis, source id, and to id waterbodies where fish consumption could pose a human health, wildlife, or aquatic life risk.	2-1 3-2 2-2	B B B
3.Biological Community Monitoring (under development)	I	45 sites in 1990 10 sites in 1991	•Fish community and habitat characteristics are assessed for IBI	•MPCA is developing IBI for Minnesota River •First a reference site is selected,. then other sites within watershed are surveyed	3-1 2-1 3-3	B B B
4.Use Attainability/ Wasteload Allocation Studies	I		•Surveys conducted for 3 days two times in the same season •Water chemistry and flow measurements taken •At some sites, fish surveys are conducted	•Assess impacts of a discharger on a receiving stream	2-1 2-2 3-2	A A
5.Clean Water Partnership Program	I		•Projects are of 2-5 year duration and typically include a diagnostic study and an implementation plan	•Proposals by units of government and citizens groups are ranked and selected according to program criteria	3-3 2-2	H H
6.Residual Chlorine Detection Surveys (under development)	I	10 sites/ season	•4 visits/site (series of sampling stations at a discharge facility) •Parameters: flow, temperature, residual chlorine, turbidity, and color	•Based on permit expiration date or for facility planning where chlorine information is useful	3-2	A
Lakes						
7.Lake Assessment Program	I	8-10 lakes 2 sites/ lake	•Studies are conducted for 1 summer, but Secchi disk component continues as part of CLMP •Information collected includes: physical/chemical data, lake morphometric data, trophic status data, summary of land use	•Lakes where there is a strong local interest in managing/characterizing the lake	2-1 4-1	C NA

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-5. Minnesota Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
8.Citizen Lake Monitoring Program (CLMP)	F Weekly	over 500 lakes 1 site/ lake	•Secchi depth is monitored weekly from June through September •Participants also make ratings of recreational suitability and physical condition	•Lakes are selected by citizens who express interest in the program	1-1 2-1 4-1	E B NA
9.Fish Tissue Analysis	I		•Between 1970 and 1989, 267 lakes representing 1,689,090 acres were sampled •Fish fillets are analyzed for PCBs, TCDD, and mercury	•Heavily fished lakes where fish consumption could pose a health risk	3-2 2-1 2-2	A B B
10.Ecoregion Reference Lakes Program	F for 2-3 years		•Minimally impacted lakes are sampled for 2 or 3 summers to develop comprehensive baseline data of phosphorus concentrations by ecoregion	•Minimally impacted lakes from each ecoregion in the State	1-2 3-1	C A
11.Acid Rain Monitoring	F 2-3 times/ year	12 lakes	•Several hundred lakes were assessed at the initiation of program and currently about a dozen are assessed annually •Sampled for pH and more constituents commonly assessed	•Acid-sensitive lakes or lakes already exhibiting acid problems (i.e., lakes with low alkalinity and/or low color)	1-1 2-1	G C

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-6. Ohio Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1.Integrated Biosurvey-Based Assessments	I	150-250 sites annually	•Integrated assessments consist of combinations of fish community, macroinvertebrate community, physical habitat, ambient water chemistry, sediment chemistry, bioassay testing, and fish tissue samplings •For segments with biosurvey, physical habitat, and chemical data the biota is the principal arbiter of aquatic life use •3 biologic indices (IBI, ICI, Iwb) are compared to regional reference site criteria for use attainment decisions •Assessments cover 600-1000 stream miles per year •OH EPA feels integrated assessments are necessary for accurate water resource management	•Sampling coverage concentrates on: 1) streams and rivers with major permits due for reissuance, 2) streams with documented or suspected problems •OH EPA uses 5-year basin approach to coordinate data collection activities and permit reissuance	2-1 1-1 2-2,3-2, 3-3 3-4,1-2	C A B E,G
2.Fixed Station Monitoring	F	50-55 monthly	•Chemical data are collected at NAWQMN stations and State stations on 11 major rivers as well as on 12 large tributaries of Lake Erie •Data are combined with biological survey results to assess use attainment. In the absence of bio-data, aquatic life assessments based only on fixed station chemical data are considered as evaluated level data.	•Sites are located on major rivers, Lake Erie tributaries and at NAWQMN stations	1-1 2-1	G A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-6. Ohio Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
3.Regional Reference Sites	I & F	360 sites/ sampled at rate of 10% per year	•Regional reference sites reflect "least impacted" background conditions within an ecoregion. •Biological data collected from these sites over a 7 year period (1982-1989) are used to calibrate the multi-metric indices (IBI, ICI), set biological criteria, and determine signature species/taxa for each ecoregion and site type. •Approximately 10% of these sites are sampled annually in conjunction with monitoring performed for the 5-year basin approach.	•Non-random selection based on narrative criteria and the cultural characteristics of the watershed. •Stream and river size variability are accounted for. •Sampling is accomplished for fish, macroinvertebrates, and water column chemistry at all sites •Sediment samples are collected from approximately 100 reference sites	3-1, 1-1, 1-2	A,C
4.Fish Tissue Monitoring	I	25-50 sites/yr (50-100 samples)	•Annually 50-100 samples are analyzed for PCB/pesticides, BNAs, other organic compounds, and occasionally mercury. •Generally, there is a mix between fillets and whole-body composites	•Most samples are collected from waters being surveyed via the 5 yr basin approach. •Some additional samples may be sampled as part of the Inter-agency Task Force on Fish Contaminants	3-1,2-1, 1-1,2-2, 3-2, 3-3, 3-4, 4-1	A,B
5.Sediment Sampling	I	>100 sites/year	•Bottom sediments are usually collected in surveys via the 5yr Basin Approach •Analysis for heavy metals in all samples •Organic scans for 50% of samples.	•Most samples are collected from waters being surveyed via the 5 yr basin approach. •Some additional samples are collected in response to complaints and CERCLA site investigations.	3-1, 2-1, 2-2, 3-3	B,C
6.General Technical Assistance	I	~20-40 sites/year	•Biological, chemical, and/or physical monitoring performed in response to requests for assistance with specific programs including: 404/401 dredge and fill, State Revolving Loan Program, complaints, spills, anti-degradation issues, petitioned ditch projects, etc.	•Similar to design of subbasin surveys except at a smaller scale in most instances.	2-1, 2-2, 3-4	A,B,C
7.Cooperative Monitoring Network	F	15 sites/year	•Sites sampled by cooperating entities on the Scioto River. •Chemical/physical data are collected weekly	•Longitudinal design ("upstream/ downstream").	1-1, 3-3	A,C

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-6. Ohio Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Lakes						
8.Lake Water Quality Assessments		25 lakes between 1988 and 1990 reports	•OH EPA has developed a Lake Condition Index (LCI) for assessing lakes • LCI consists of 14 parameters: Biological Conditions: IBI, nuisance growth of macrophytes, fecal coliform bacteria, Chlorophyll *a*, fish tissue contamination Chemical Conditions: Nonpriority pollutants, priority organics, priority metals, sediment contamination, total phosphorus, acid mine drainage Physical Conditions: Volume loss due to sedimentation, Secchi depth Public Perception: Aesthetics •For 1990 report, all assessments were based on evaluated data due to a lack of monitored level data	•All significant public lakes (i.e., 417 lakes >5 acres and freely open to the public for recreation) •Recently has included citizen monitoring efforts (e.g., secchi dept, etc.)	2-1 1-1 2-1	B 10 B

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-7. Wisconsin Surface Water Monitoring Programs

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
Rivers/Streams						
1. Fixed Station Network	F Monthy; some quarterly	62 stations	•Parameters include: pH, temperature, conductivity, residue, total phosphorus, dissolved phosphorus, ammonia, Kjeldahl nitrogen, chloride, chlorophyll *a* and fecal coliform. Great lakes tributaries also analyzed for calcium, sodium, sulfate, and dissolved silica.	•Historically, most stations were located to assess point sources. •At present, they have no ambient reference stations.	2-1 1-1 4-1	A D NA
2. Fish Tissue Monitoring (toxics)	I-80% F-20%	1,500 samples	•An average of 1,500 samples (streams and lakes) are analyzed annually from streams, lakes and Great Lakes for PCBs, mercury, chlorinated pesticides, other metals and priority pollutants.	•Intensive surveys are designed to survey sites where fish may accumulate contaminants at levels posing a human health risk. •Fixed stations will be monitored on a rotating basis according to the "basin planning" schedule.	2-1 3-3	A A
3. Basin Assessment/ Nonpoint Source Program	I	6 basins (of 26)	•About 500-600 macroinvertebrate samples are analyzed annually using a modified Hilsenhoff's Biotic Index. •Fish communities are collected at selected sites and analyzed using a variety of techniques. •Habitat data are collected at fish sites, NPS sites, and for all use classifications •Water chemistry data are collected along with biology and habitat.	•Targeting NPS problems •Reference sites •Assessing existing conditions •Evaluating Pt/NPS management •Ambient lake monitoring •Use classifications	2-1 2-2 3-3	F F F
4.Sediment Sampling (toxics)	I	220 samples	•About 220 samples scheduled to be analyzed for metals, pesticides, PCBs, priority pollutants, and dioxin/furans.	•In past, sites chosen in conjunction with dredging activities • In future, driven by basin planning strategies	3-1,2-1, 1-1,2-2, 3-2,3-4, 4-1,1-2	B,C,G
Lakes						
5.Long-term Trend Monitoring Program	F 5 times annually	50 lakes	•This program is the backbone of WI's lake program •1 chemical site per lake; several biological sites per lake •Parameters: nutrients, Secchi depth, chlorophyll *a*, bacteria, macroinvertebrates, macrophyte, plankton, fish surveys	•Public access • >25 acres • Sufficient depth to stratify during summer • Availability of survey map	2-1, 1-1, 3-2	A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

Table 4-7. Wisconsin Surface Water Monitoring Programs (continued)

Program	Type/ Frequency	# of Stations/ # of Samples	Program Description	Network Design	Data Uses	Data Analysis
6.Self-Help Volunteer Lake Monitoring Program	F Bimonthly between May and September	310 lakes	•Secchi depth is monitored by volunteers at one site per lake •Program was expanded in 1990 to include measurements of phosphorus, chlorophyll, DO, temp., pH, lake level and precipitation on 34 lakes	•Lakes are selected by citizens who express interest in the program. There is no design to the network, the lakes are scattered throughout the State.	2-1 1-1 4-1	B NA
7.Fish Tissue Monitoring	I	1,500 samples	•See Stream program #2	•In past lakes were chosen based on low levels of alkalinity and a sustainable walleye population •In the future, lakes will be chosen based on the basin planning schedule	2-1 3-3	A

See Table 4-1 for Data uses and Data analysis methods
F - Fixed Station
I - Intensive Survey
NA - not applicable

4.3 Capacity of Surface Water Monitoring Programs to Support Planning and Management

The "effectiveness" of monitoring and assessment programs should largely be measured by the degree to which scientifically defensible data support the basic information needs of water resource planners and managers. In describing the capacity of Region 5 surface water monitoring programs to support planning and management objectives, it is useful to define relevant topics and describe supporting data and relationships that affect the overall effectiveness of monitoring programs.

Monitoring surface water resources to assess status and trends provides baseline information to support other planning and management objectives: problem identification and characterization; management strategy development, implementation, and evaluation; and communication of results to the public and legislators. The term "status" encompasses many water resource characteristics including biological community health, physical habitat, toxicologic measures, and water and sediment chemistry. Historically, the States and EPA have reported the status of surface water resources by describing the attainment or nonattainment of designated uses for waterbodies (see Chapters 1 and 3 for more detailed descriptions).

The principal method used by most States to determine use attainment or nonattainment has been to compare ambient chemical concentrations from water column samples with chemical criteria. Because the criteria for individual chemical parameters are derived from toxicologic responses of fish and macroinvertebrates in laboratory studies, it is assumed that the ambient chemical criteria, when properly applied, accurately reflect healthy aquatic conditions in a waterbody. Although water column chemistry provides information on the causes or sources of problems and the effectiveness of point source controls, it does not convey direct, comprehensive information on the overall status or integrity of a water resource. Recent studies suggest that integrated assessments, including biological, chemical and physical data, convey a much more accurate and complete picture of water resource status than an approach based solely on chemical criteria (Karr et al., 1986; Ohio EPA, 1990; Rankin, and Yoder 1990).

Acknowledging the limitations of approaches based solely on chemical criteria, EPA and the States are rigorously pursuing the development and implementation of biological criteria (or biocriteria) to provide effective tools for more accurately assessing the status or integrity of surface waters. *Biological Criteria: National Program Guidance for Surface Waters* (U.S. EPA, 1990a) defines biological criteria as:

> ' numerical values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.'

The national biocriteria guidance also highlights the important role biocriteria could have in supporting water quality planning and management objectives:

> ' When implemented, biological criteria will expand and improve water quality standards programs, help identify impairment of beneficial uses, and help set priorities. Biological criteria are valuable because they directly measure the condition of the resource at risk, detect problems that other methods may miss or underestimate, and provide a systematic process for measuring progress resulting from the implementation of water quality programs'.

The national policy on the Use of Biological Assessment and Criteria in the Water Quality programs issued in June of 1991 reiterates many of the uses of biological criteria in protecting and managing our water resources described in the national biocriteria program guidance. The policy states that "To help restore and maintain the biological integrity of the nation's waters, it is the policy of the Environmental Protection Agency (EPA) that biological surveys shall be fully integrated with toxicity and chemical-specific assessment methods in State Water Quality programs...." The policy further addresses State programs as follows: "It is also EPA's policy that States should designate aquatic life uses that appropriately address biological integrity and adopt biological criteria necessary to protect those uses." The policy discusses the important distinctions among the terms biological surveys, assessments, and criteria. Although all six Region 5 States conduct biological surveys, only a portion of the States fully utilize the biological survey data in their assessments of aquatic life use attainment (see Figures 3-1 and 3-2).

The biological criteria, which the program guidance and policy previously defined, should "consider various components (e.g., algae, invertebrates, fish)... of the larger aquatic community." All of the Region 5 States use at least fish and benthic macroinvertebrates in their biological survey programs to satisfy this policy recommendation, but the actual development of the biological criteria is not as complete. Only Ohio has developed and implemented numerical biological criteria in their water quality standards, although Indiana and Michigan are in the process of developing numerical biological criteria and will begin to incorporate the biological assessment data in their 1992 305(b) reports. The extent to which all of the Region 5 States adopt numerical biocriteria in their standards depends upon strong support and guidance at the national level. At this time, a national policy on numerical biological criteria is under development. However, all of the Region 5 States have recognized the importance of developing the capabilities for performing biological surveys and assessments consistent with the national policy and program guidance. Region 5 States will continue to actively expand the use of biological surveys for better assessment and the eventual use of numerical biocriteria.

Problems with a surface water resource are often identified when observed or measured "status" indicators have values significantly different from reference values for those indicators. As described in the national biocriteria guidance, biological assessments and criteria have some distinct advantages over chemical assessments/criteria in assessing status and identifying problems. Biological assessments and criteria allow direct comparison of aquatic community measures with reference conditions within a watershed, ecoregion or flow regime. Chemical assessments and criteria, on the other hand, provide indirect data, that are more susceptible to temporal and spatial variability in the field (e.g., concentrations are dependent on flow conditions) and problems with extrapolating data from controlled laboratory toxicological studies to field conditions. Rankin and Yoder (1990) provide convincing evidence that integrated, biosurvey-based assessments using biological, chemical, and physical data often identify problems that are either missed or underestimated using only ambient chemical assessments.

Once a surface water problem is discovered, chemical, physical data and whole effluent toxicity complement biological data by helping to define and/or characterize the causes or sources of impairment and measure the effectiveness of point and nonpoint control activities. Tissue contamination data from fish and macroinvertebrates, for example, provide important information for assessing human health and ecological risks from impaired waters. Measurement of water column chemistry helps, in protecting waterbodies for drinking water and swimming/recreational use. Water column chemistry can also provide information on threats to aquatic as well as threats to human uses. In summary, when biological, chemical, and physical data are collected and interpreted collectively, a more accurate, comprehensive picture of water resource status is conveyed.

4.4 Trend Assessment

Trends, as defined in this report, are the temporal and spatial changes in status or the measures used to estimate status (e.g., biological community health, physical habitat, toxicologic measures, water and sediment chemistry, and tissue contamination data). In many cases, changes in measures or indicators of status are often compared to reference levels such as biological and chemical criteria to identify potential human health and ecological effects. Trends are assessed to evaluate the effectiveness of management actions over specific time periods or geographic areas. Trends are often interpreted as statistically detectable changes over time of a series of measurements based upon parametric statistical techniques. This perception that all trend analysis must be statistically based has resulted in limited trend assessments of data within Region 5.

Although the concept of determining the status of a water resource, or the components of that resource, is the foundation of EPA and State monitoring programs, the issues of scale and representativeness of the monitoring location have been raised. State programs have been addressing water resource status on a very local scale--i.e., waterbody segments--and sometimes extrapolating that information to an entire waterbody or even watershed. This smaller scale meets the local/State's needs to respond to known water resource problems and issues. However, recent questions on the national scale such as "Have the quality of our water resources improved since the establishment of the Clean Water Act? " have highlighted the difficulties in aggregating these segment-scale assessments, to provide a larger-scale (e.g., national) perspective. These issues have been critically discussed by GAO (1981, 1986).

The problem with not being able to assemble a set of reliable national statistics is not because of the site-specific scale of State monitoring efforts. Rather, the problem can also be attributed to the wide variation in the depth, strengths, and weaknesses of the specific assessment tools and initial monitoring design of each State program. If each State had comparable methods and strength of their overall approaches, than computing national statistics would take care of itself. Thus what is needed is for EPA to assure the development of these assessments approaches by assuring that the monitoring "infrastructure" is adequate to do the job.

In 1988, the Science Advisory Board of EPA recommended implementing a program to monitor the status and trends not only of water resources but of the ecosystem. This recommendation initiated the Environmental Monitoring and Assessment Program (EMAP) which will provide "statistically unbiased estimates of status, trends, and associations with quantifiable confidence limits over regional and national scales for periods of years to decades." However, "Regional or national trends are expected to be discernible within 10-15 years. EMAP will provide little information about the conditions at any particular site for a period of 40-60 years" (U.S. EPA, 1990).

Contrasted with the scale of monitoring programs at the State level and the national level through EMAP are the watershed assessments at the Regional and national scales for the U.S. Geological Survey's NAWQA Program. The NAWQA Program, is designed to provide a nationally consistent description of current water quality conditions including statistical descriptions of water quality conditions and their changes with time, for a large part of the Nation's water resources (Hirsh et al., 1988). Although a significant portion of NAWQA data should be directly usable for State needs, neither EMAP nor NAWQA provides the consistent problem identification or specific pollution control monitoring efforts that the State programs require. It is very clear that EMAP, NAWQA, and State monitoring efforts have different objectives that are based largely on spatial and temporal scales. Besides the fact that States sample many more sites than EMAP or NAWQA, there are other differences. While EMAP and NAWQA have temporal integrity, they currently lack the spatial detail to discern environmental problems at the scale necessary to operate an effective water resource management program. Environmental problems and natural resources are not randomly distributed. Furthermore, EMAP selects all sites probabilistically for the assessment of national and regional trends--both spatial and temporal. State networks, on the other hand, are generally designed with multiple goals in mind: assessing designated use support of problem waters, setting priorities for cleanup, supporting standards development, and developing reference sites, to name a few.

We found that the States were taking vastly different approaches to evaluating the effectiveness of their management programs over time. While Illinois and Wisconsin have conducted a limited number of statistically based trend assessments using consistently collected chemical water quality data from their fixed-station networks, Ohio has begun to focus on assessing the water resource status at distinct intervals of several years. Although Ohio's approach is not considered to be a statistically based trend analysis, it provides the information needed to meet the State's objective of determining the effectiveness of their environmental management programs. Because the bulk of historical trend data in Region 5 States is predominate chemically based, the descriptions in the following sections highlight the use of their fixed-station chemical monitoring networks (Table 4-8).

4.4.1 Illinois

One of the primary objectives of IEPA's Ambient Water Quality Monitoring Network (AWQMN) is to characterize trends in the water quality of rivers and streams. Trend analyses are conducted for the 208 AWQMN stations using a Water Quality Index developed by U.S. EPA Region 10 and analyzing trends in specific parameters using Seasonal-Kendall tests, which include flow adjustments. Figure 4-1 shows the spatial distribution of AWQMN stations.

The WQI consists of the following parameters: water temperature, DO, pH, total phosphorus, turbidity, specific conductance and unionized ammonia. Trends were assessed in the 1990 Illinois Water Quality Report (305(b) report) by comparing WQI averages compiled for the periods 1979-1984 and 1985-1989 at each AWQMN station. Based on these comparisons, the State classified 124 stations (60.2 percent) improving, 81 stations (39.3 percent) declining in conditions, and 0.5 percent (1) station with no change in the WQI.

IEPA selected the Illinois River Basin to conduct Seasonal-Kendall trend tests on flow-adjusted and nonadjusted concentrations of more than 13 parameters. This study was conducted in cooperation with the U.S. Geological Survey. Water quality for a period of 12 years was assessed and showed consistent improvements in total ammonia throughout the basin and a consistent decline or no change in total sodium. Total suspended solids and ammonia-nitrogen showed improvements but the majority of the results showed no change. IEPA also identified and developed a Pesticide Subnetwork of the AWQMN consisting of 30 stations. A comparison of data collected from October 1985 to October 1988 showed no discernible trend in annual herbicide concentrations, but, as expected, seasonal relationships were pronounced.

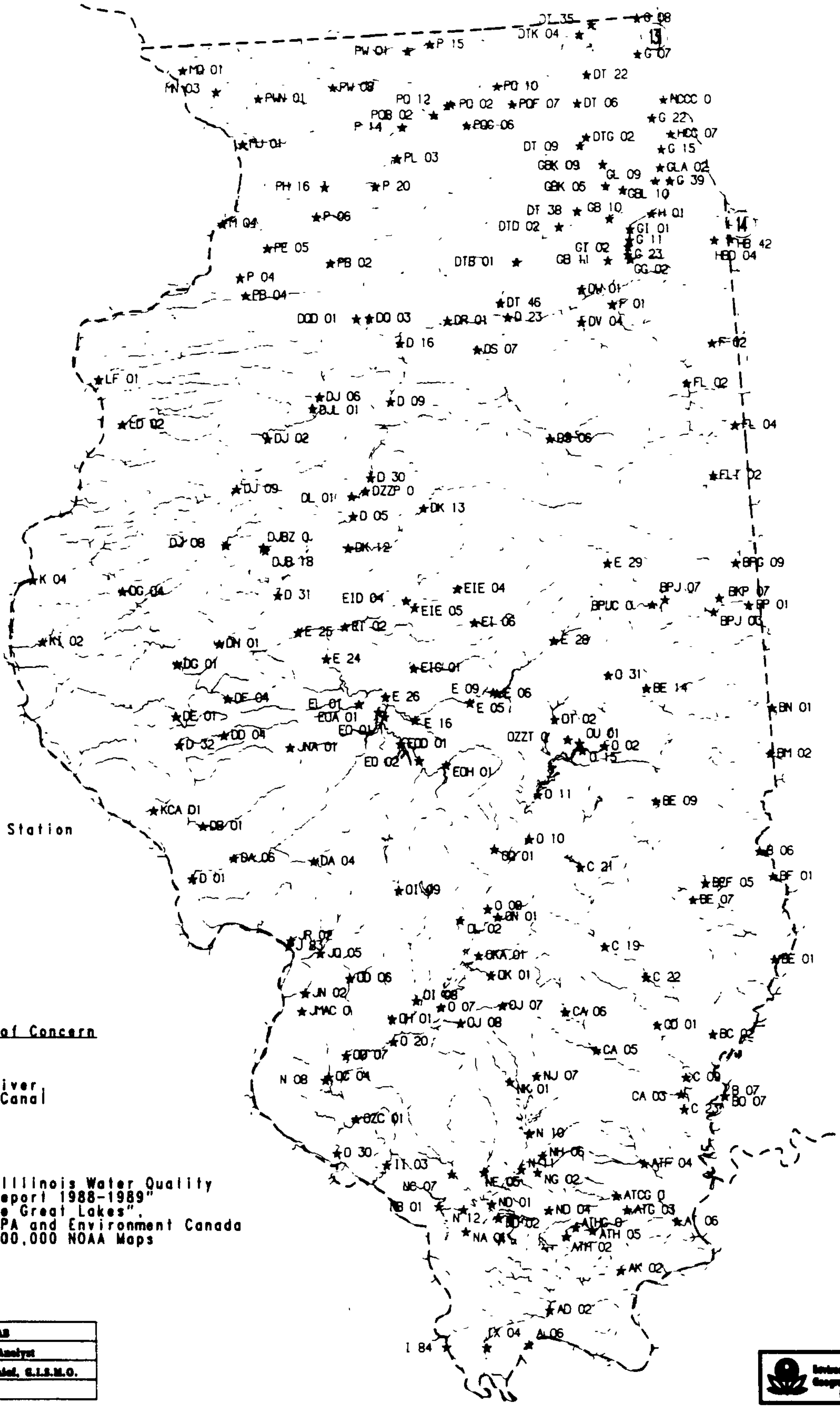
IEPA has expressed a strong interest in conducting flow-adjusted Seasonal-Kendall trend testing for all 208 AWQMN stations for the majority of parameters. Resource constraints prevent the IEPA from analyzing more than one or two basins for each 305(b) cycle.
In the 1990 305(b) report, lakes with three or more years of calculated trophic status index

Table 4-8. Fixed-Station Chemical Monitoring Programs by State

State	Number of Fixed Stations	Frequency	Period of Record (years)
Illinois	208	Every 6 weeks	~15
Indiana	106	Monthly or quarterly	~5
Michigan	60	Monthly	~10
Minnesota	70-75	Monthly	~15
Ohio	50-55*	Monthly	~15
Wisconsin	62	Some monthly; quarterly	~15

* Ohio has a network of 360 reference sites which are sampled at a rate of 10% per year. There are also 20-30 additional fixed station sites operated by cooperating entities and other agencies.

Figure 4-1. Illinois Fixed Station Network and Great Lakes Areas of Concern



★	STORET Fixed Station
◯	AOC Location
⋯	Major Rivers

Great Lakes Areas of Concern

Lake Michigan
13 Waukegan Harbor
14 Grand Calumet River, Indiana Harbor Canal

Data Sources

STORET Stations: "Illinois Water Quality Report 1988-1989"
AOC Locations: "The Great Lakes", USEPA and Environment Canada
Major Rivers: 1:500,000 NOAA Maps

Requested by: John Miller, MQAB
Prepared by: Barry Bolka, GIS Analyst
Approved by: Noel W. Kohl, Chief, G.I.S.M.O.
Date: February 1, 1991

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(TSI) were analyzed for trends using a linear regression, nonstatistical approach. Two hundred waterbodies were evaluated, with 41 percent showing fluctuating conditions and 34.5 percent showing declining conditions. The 18.5 percent of lakes showing improvements in water quality was attributed to in-lake restoration techniques or intensive watershed management projects. The remaining 6 percent of lakes indicated stable water quality conditions.

4.4.2 Indiana

The Indiana Department of Environmental Management operates a fixed-station chemical monitoring network at 106 sites along rivers and streams throughout the State. In 1985, the State conducted a review of this network, which included examining water quality trends between 1979 and 1985. Although this approach was described in their 1990 305(b) report, we have no documentation of any trend analysis, results, or assessment of those results.

The State compared the trophic status of 101 lakes between the mid-1970s and 1988-89. The changes reported in trophic condition included 21 lakes improving enough to upgrade their classification, 24 lakes declining to a lower classification, and 56 lakes remaining in their existing classification.

4.4.3 Michigan

MDNR has operated a somewhat inconsistent fixed-station network ranging from almost 600 stations in 1973 to only 58 in 1989. In 1989, MDNR operated stations for three programs: Great Lakes Tributary Monitoring (16 stations), Urban Area Monitoring (22 stations), and Detroit Rivers Monitoring (about 20 stations). The State refocused their program in 1990 to the following programs:

- Core River Monitoring,
- Urban Area Monitoring,
- Detroit River Monitoring,
- Basin-Year Monitoring, and
- Special Monitoring.

These five monitoring programs implemented in 1990 comprise almost 100 stations. Twenty core stations will be monitored monthly with the remaining stations rotated by basin to meet permit reissuance needs. The MDNR is currently preparing a 15-year trend report on the Detroit River data. However, there are no significant plans to conduct comprehensive trend analysis on all sample sites due to resource constraints.

4.4.4 Minnesota

The Minnesota Pollution Control Agency recently assessed the effectiveness of their fixed-station monitoring network for chemical trend analysis of rivers and streams. Their 1991 review established criteria for station selection, which resulted in 90 of their 269 stations being selected for trend analysis. The State used 21 years of data (1970-1990) to examine their water chemistry trends in each of their seven ecoregions. The parameters examined were: DO, un-ionized ammonia, nitrate-nitrite, and total suspended solids. The measure used for trend significance was the nonparametric correlation coefficient--Kendall's tau-b.

The most significant changes within their seven ecoregions that occurred during the 21-year period were decreases in total suspended solids (Northern Lakes and Forests ecoregion) and un-ionized ammonia (Northern Wetland and Northern Lakes and Forests ecoregions) and increases in nitrate-nitrite (Driftless Area ecoregion) and total suspended solids (Red River Valley ecoregion).

MPCA conducts lake trend assessments based on Secchi disk transparency data collected from their Citizen Lake Monitoring Program. In their 1990 305(b) report, the State calculated Kendall tau correlation coefficients for 101 lakes with close to an average of 10 years of data. Six lakes showed a significant decrease in transparency, all from the North Central Hardwood Forest ecoregion. Fourteen lakes showed significant increases in transparency in three ecoregions (mostly Central Hardwood Forests and Northern Lakes and Forests). The remaining lakes exhibited no significant trend in transparency. The State plans to conduct more rigorous trend analyses with other water quality indicators and to determine if land use changes have taken place to influence these results or further actions are warranted.

4.4.5 Ohio

Ohio initiated a trend assessment program 13 years ago to assess changes in the water resource quality over specified periods of time. For example, Ohio EPA submitted to the Regional Clearinghouse their first trend assessment report, which compared their biological and water quality study results for 1982 and 1990 in the Stillwater River Basin. This report identified trends in chemical water quality, pollutant loadings, biological community assessments, and use attainment status in the basin. To a large degree, Ohio's integrated assessment approach demonstrates State implementation of EPA's recent biocriteria policy and guidance. The improvement in water quality due to specific pollution control measures was documented, and remaining problems in the basin were identified. Recommendations in that report included changing some use classifications because of channelization and habitat modifications that occurred, per State law. Seven areas for additional monitoring and follow-up were also included. This report is the first of several the State is producing on trend assessments for each river basin they monitor. Ohio's trend assessment program is unique because they do not rely solely upon their fixed-station chemical monitoring network for their trends. They utilize the bulk of the water resource information collected to actually compare the status of a resource at different time intervals, which achieves a similar management objective as statistical time-series trend analysis. It is important to note that annual sampling is not necessary when using biological data because of its ability to integrate influences over a long-term period.

The State also has a subset of 50 fixed stations where macroinvertebrate community assessments are conducted. Some of this information was compiled in the 1988 305(b) report. At this time, the State has not conducted trend analyses on their lake quality data. Ohio EPA is currently inventorying all water quality sampling locations across the State sampled by government and private entities. This will likely yield greater than 100 sites with a long-term data base. Also, Ohio EPA considers the network of 305 plus reference sites as part of the fixed-station network.

4.4.6 Wisconsin

Wisconsin operates a fixed-station monitoring network of about 62 stations. The only known trend analysis was conducted in 1990 on nine stations on the Upper Wisconsin River. Monthly and quarterly data for 1984 through 1989 at each station were analyzed for trend direction, magnitude, and statistical significance using the Seasonal-Kendall Test. The strength of the trend significance was substantially weakened for some parameters going from monthly to quarterly data. The State is evaluating their fixed-station network and will conduct trend analyses on all of their sites for their evaluation.

For lakes, Wisconsin's Long Term Trend Lake Monitoring Program is designed to assess gradual changes in lake water quality. DNR staff have collected physical, chemical, and biological data on 50 lakes and their watersheds since 1986. With 4 years of data, DNR is beginning to analyze preliminary trends in lake water quality. Six years of data will be analyzed and included in the 1992 report. The State also sees great potential in using remote sensing to follow water quality trends in lakes associated with changes in land use/land cover in watersheds.

4.5 Findings and Recommendations

Region 5 States use a variety of tools to assess the status of their surface water resources. All six of the Region 5 States use integrated assessments (i.e., ambient chemical monitoring, biological surveys, toxicity testing, habitat assessments, and tissue contamination surveys) to some degree, but the frequency, spatial coverage, and the types of surface water resources assessed using this approach vary significantly. Furthermore, even when information from integrated assessments is available, the States may not be able to fully use it to support planning and management. For example, integrated assessments and permitting activities are sometimes not fully coordinated to provide useful information on program effectiveness. In other cases, States have insufficient resources to collect and interpret the wide array of data associated with integrated assessments.

Only Illinois has documented efforts to select broadly representative monitoring sites (in their Ambient Water Quality Monitoring Network), although the design process was not strictly probabilistic. Classical statisticians would argue that only probabilistic network design can select sites that are spatially representative of the State's waters. OPPE is sponsoring a separate project to explore issues of representativeness in State monitoring programs, including at least one Region 5 State as a case study.

Generally, across Region 5, integrated assessments are performed on individual watersheds, with most of the data collection targeted for rivers and streams. The frequency of integrated watershed surveys is variable (e.g., Ohio: 5-year interval, Illinois: 10-15 year intervals). The watersheds assessed are generally selected because there have been known or suspected problems or the resources are particularly highly valued (e.g., scenic rivers).

In some instances (e.g., Ohio's and Michigan's 5-year basin surveys), the assessments <u>are</u> clearly coordinated with management actions (e.g., permit reissuance) to provide valuable feedback to planners and managers. It should also be noted that Illinois' Facility Related Stream Survey Program uses biosurveys conducted at least one year in advance of permit renewal to support planning and management activities.

Interest in adopting or expanding integrated assessment programs is high among Region 5 States. However, the lack of sufficient human and financial resources and tools for assessing, analyzing, and managing data are often cited as the principal barriers to implementing or expanding programs. At least two States, Ohio and Illinois, have or are developing integrated approaches for lakes. None of the Region 5 States have sufficient capabilities to perform integrated, or even limited, assessments of wetlands.

In summary, the capacity of Region 5 surface water monitoring programs to provide comprehensive and accurate status information could be improved significantly by

- Increasing the frequency and spatial coverage of integrated assessments;

- Developing and implementing integrated approaches for lakes and wetlands (an important component is information and technology transfer among Region 5 States); and

- Encouraging greater consistency among Region 5 States concerning the collection, analysis, and management of data associated with integrated assessments.

Recommendations

- The States must receive adequate resources and training dedicated for water monitoring and assessment programs to support the collection and use of more direct, comprehensive measures for determining use support (e.g., fish, benthos and habitat assessments). These direct measures, along with indirect measures related to sources and causes of impairment, should become integrated into EPA's planning and management activities.

- Integrated monitoring of watersheds, that includes the collection of biological, chemical and physical data, should be fully coordinated with management activities (e.g., permitting, enforcement actions, and best management practices) to provide valuable feedback information on the results of management and protection programs

- States should clearly document assessment approaches for all designated uses, monitoring program structure, data uses, and database management methods in their biennial State 305(b) reports to minimize ambiguities in each State's decision process and monitoring program.

- States should maintain an inventory all existing monitoring networks and utilize other agency and private organization monitoring provided it meets quality assurance and control standards.

- EPA should more fully utilize and integrate the information in State documentation produced at EPA's request (examples include monitoring strategies, annual program plans, 305(b) reports, and water quality management plans).

- EPA should solicit State recommendations on improving the Grant Guidance for State monitoring and assessment programs which are sent annually to assist the States in preparing their program plans. This issue should also be addressed on a national scale by the Regional Water Monitoring Coordinators Workgroup.

- EPA and States should conduct integrated, rotational monitoring of watersheds (preferably, at 5-year intervals or less) to provide more accurate, comprehensive status information and better spatial and temporal coverage. EPA should support the States in conducting trend assessments of their historical monitoring networks; 10 to 15 years of data are often available .

- Results of trend analysis should be evaluated to determine causes and sources of trends (improvement or decline) and compare those trends with the expectations for resource quality.

- States may not need to use a statistically based time-series trend analysis to evaluate environmental results over a period of time. Depending on the data, status assessments at specific time intervals may provide substantial information on tracking environmental progress.

5. ASSESSMENT-RELATED DATA MANAGEMENT

5.1 Overview

For a 305(b) assessment, it is required that each State compile and analyze data from diverse sources in several government agencies. Easy access to multiple data sources is essential for integrated (chemical/biological/habitat) assessments, as well as the ability to manipulate and integrate those data sources (U.S. EPA, 1991).

Data sources include computerized databases (see Section 5.2) as well as paper files (e.g., fish kill records, intensive survey reports, drinking water files, and compliance inspection reports). The advantages of using computerized data sources for 305(b) assessments include the following:

- Computerized sources are more likely to be used--State 305(b) writers do not have the time to go through paper files;

- Only a computerized database can be used to screen the thousands of water quality data points collected each year;

- Data systems make it easier to track assessment results from one 305(b) cycle to the next;

- Turnover in State 305(b) staff necessitates having standardized procedures and user-friendly data access; and

- Different types of information for the same waterbodies can be compared through the use of consistent geographic locators.

5.2 Findings--Assessment-Related Data Systems in Region 5

The Region 5 States use several national and State databases/data systems for 305(b) assessments, as shown in Figure 5-1. These are discussed in the following subsections by type of data.

Ambient Physical/Chemical Data
The Region 5 States use STORET extensively for storing and analyzing water column data, and is also used by some States for managing data on toxics in fish tissue and sediments. STORET has been available to the States since the 1970s, and allows users to access over 150 million water samples from 800,000 sites nationwide. The system provides data analysis capabilities including canned statistical summaries as well as maps and plots of data.

Figure 5-1. State Use of 305(b)-related Data Systems

Data System	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
STORET	●	●	●	●	●	●
BIOS	●			○✱		
State Biological Systems	●	●		●	●	●
RF3/WQAS	○	○✱	○	○✱	○✱	
EPA WBS		○	○	○✱	●	○
State 305(b) System	●		●	●		●

● - Current user

○ - Interested or beginning to use

✱ - Expressed concern or assistance needed

Ambient Biological and Habitat Data

As noted in Chapter 4, several Region 5 States have prominent monitoring programs for fish and macroinvertebrate communities and habitat. Other biological data (e.g., macrophytes, phytoplankton) are also collected.

Illinois and Minnesota are using BIOS to manage their biological data, and Wisconsin has expressed some interest in the system. BIOS is a subset of the STORET system and is EPA's national biological information management system. BIOS manages data on the distribution, abundance, and physical condition of aquatic organisms, as well as descriptions of their habitats. For example, Illinois has included current data and historical data back to 1982 for both biological and habitat data. Users can relate BIOS data with STORET water chemistry data. BIOS also contains a taxonomic database and can be used to store data on tissue contamination.

The States using BIOS reported some concerns with the system, including lack of a clear message from EPA supporting their use of the system and difficulty in using BIOS for tissue concentration data. Five States use in-house programs to manage their ambient biological data:

- Illinois uses a dBASE program to manipulate data prior to upload to BIOS.

- Michigan does have a computerized data management system for the biosurvey data. Results are published in hard-copy reports.

- Minnesota does not have all of their ambient biological data on one integrated computerized system. Minnesota stores some biological data in BIOS, some in STORET, some in SAS files on the NCC mainframe and some in PC files.

- Ohio has developed the Fish Information System (FINS) (over 3600 sites) for fish and the Macroinvertebrate Data Generation and Evaluation System (MIDGES) (over 1400 sites) for macroinvertebrates. Recently, these have been merged into a new system called Ohio ECO that also handles habitat data, chemical data, and the WBS files.

- Wisconsin maintains a dBASE macroinvertebrate data management containing over 3000 samples.

5.2.1 Hydrographic Data

The EPA Reach File is the only hydrographic database identified as having the potential for widespread use in Region 5. The Reach File is a national system containing geographic information on streams, lakes, and estuaries. It provides standardized geographic locators that can be used throughout a State's databases. Thus it serves as the integrator of information on monitoring sites, point and nonpoint source discharges, water intakes, and political and waterbody boundaries. Because all streams and lakes in the system are networked hydrologically, the Reach File can be used for routing and modeling. As discussed in Chapter 2, the system can also provide estimates of total State waters for streams and lakes.

The smallest unit of record in the system is the reach, which is typically a short stretch of stream or shoreline. Reach File Version 3 improves upon earlier versions by including all hydrologic features on the USGS 1:100,000 scale map series. Most traces were actually digitized from the 1:24,000 scale maps, so the resolution is extremely high. Figure 5-2 shows the hydrologic traces in RF3 for one USGS 1:24,000 scale topographic map near Raleigh, North Carolina.

RF3 contains over 3 million reaches nationwide, including reach names and geographic locators. Any point on a stream or shoreline can be defined using a reach number. RF3 production work has recently been completed for Region 5, and Michigan has begun to access and use RF3 data. As shown in Figure 5-1, four States expressed interest in the capabilities of RF3 and companion software such as the Water Quality Analysis Software (WQAS) and the Mapping and Graphical Display Manager, (MDDM).

Very few of the senior State staff interviewed for this project had basic knowledge of the applicability of RF3 to State programs and the systems's resource requirements.States expressed the need for written information on the following aspects of RF3:

- Capabilities of RF3, alone and in concert with other Office of Water software and data systems;
- State resources required to fully use the system;
- Additional user documentation; and
- Availability of EPA technical assistance for incorporating the RF3 system.
- Hands-on training on RF3 and other Office of Water systems was requested.

The above listed information needs to be provided before some States can make a decision to incorporate RF3 coordinates into their other databases. This "indexing" of other databases to RF3 is a key to EPA's plans for national level mapping of data from the WBS. At present, Illinois, Ohio, and Wisconsin have clear plans to reach-index their waterbodies to RF3. In the case of Illinois, it plans a long-term update of State WBS with RF3 detail. In addition to 305(b) assessment tracking, the State will then utilize its system to track stream classifications given detail provided by RF3.

5.2.2 Assessment Results

The States have designated thousands of waterbodies for 305(b) reporting and makes use support determinations for each waterbody. Various computer systems have been developed for tracking the results of these biennial assessments. To foster consistency in reporting and to aid States without such systems, EPA developed the WBS in the late 1980s. WBS provides a geographical framework for entering, tracking, and reporting information on the quality of individual waterbodies. Each State delineates waterbodies as it chooses. The system stores water quality assessment results, not the raw data that support the assessment. All information is organized by waterbody and assessment date. WBS contains the following main types of data elements:

- Identifiers--e.g., waterbody name, identification number, type of waterbody (stream, lake, estuary, etc.), geographic locators (counties, Reach File indexing expressions, latitude/longitude);

- Assessment types--e.g., based on monitored vs. evaluated data, type of monitoring, media/pollutants assessed;

- Assessment results dealing with status--use support, trophic status, water quality-limited status; and,

- Assessment results dealing with causes and sources--pollutants causing impairment, point and nonpoint sources contributing to impairment.

WBS was used by many States for their 1990 305(b) assessments. The system is currently being upgraded at the users' request to increase speed and user-friendliness and to incorporate Windows software.

States' use of WBS and/or interest in the system is shown in Figure 5-1 and described in more detail in Table 5-1. Ohio is currently the major WBS user in Region 5. Ohio has used WBS for one 305(b) cycle and is satisfied with its usefulness, especially for organizing data with a geographic perspective. In its 1990 305(b) report, Ohio describes its use of WBS:

> ' The 1990 cycle marked Ohio's first full use of the WBS software. Ohio uses the PC version of the WBS for entering and updating the assessment information of waterbodies. Data entered into this system is [SIC] also uploaded to the mainframe version of the WBS. In addition to the variables tracked by the U.S. EPA WBS, Ohio EPA maintains numerous data files containing biological, physical and chemical data that are geo-referenced to the files in the WBS'.

Figure 5-2. Example of Hydrologic Traces in EPA Reach File 3 (RF3) Map of USGS Topographic Quadrangle near Raleigh, North Carolina

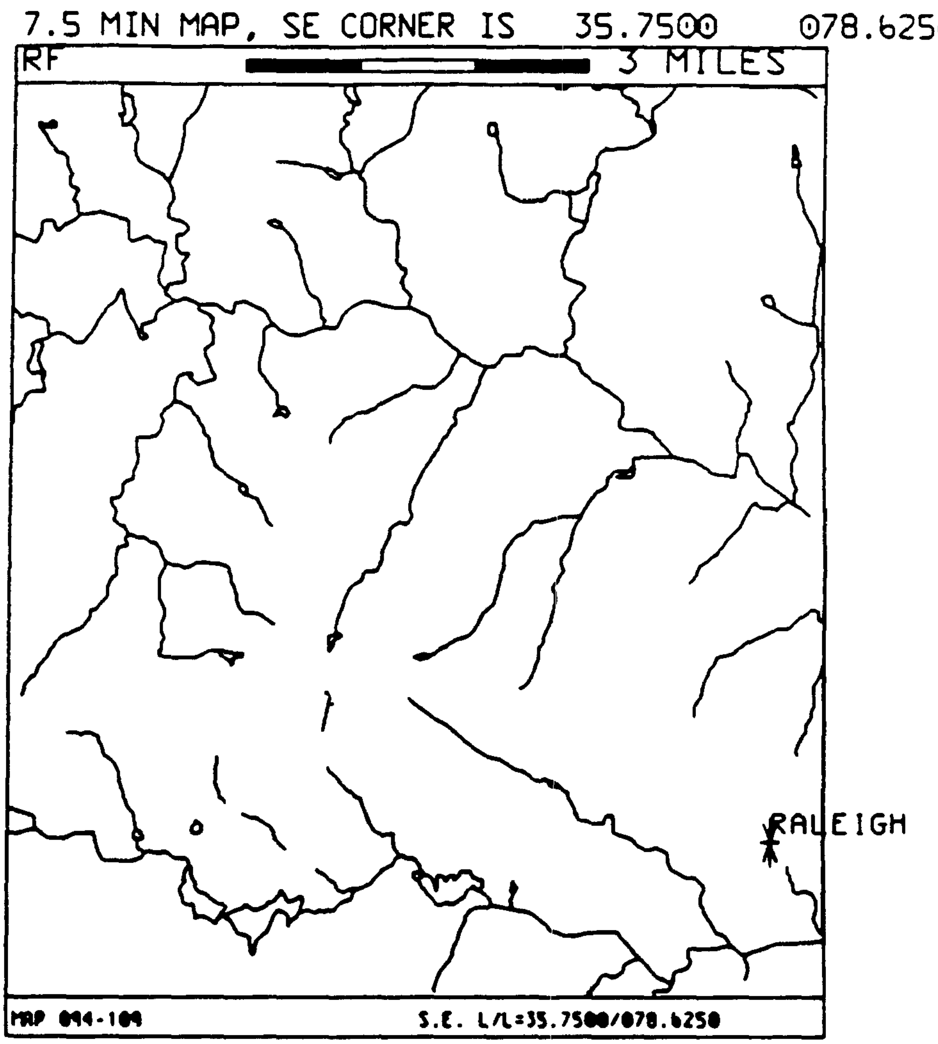
The DLG database would produce the same printout of hydrologic traces.

PF KEYS

2 SAVE MAP-REPRT
3 EXIT
4 CITIES
5 SHIFT
6 ENABLE STA LOC
7 N/A
8 N/A
9 N/A
10 ENABLE RCH LOC
11 ROUTE REACHES
12 TAGS
13 7.5
14 WATERBODY

CITY DATA
CITY : RALEIGH
CITY
CNTY,ST: WAKE
, NC

LAT : 35.7713
LONG : 078.6330



Ohio sees one drawback to WBS in that the system treats all levels of data in the same way; i.e., it does not address the relative power levels or levels of confidence in different data types. Ohio feels very strongly about recognizing the strengths and weaknesses of the data, and ultimately, the information used in decision making. They also highly recommend that a 386 or 486 based computer be used for the WBS.

As described in Table 5-1, until recently Indiana has planned to use the PC version of WBS for the 1992 305(b) assessment cycle. However, at this time it appears that staff resource limitations will prevent data entry this 305(b) cycle. Indiana has no existing system for assessment tracking, and using WBS would save the State considerable development costs. Indiana now has the computer hardware needed and is in the process of designating waterbodies throughout the State for entry into WBS.

Michigan is considering switching from their RBASE tracking system to WBS after the 1992 305(b) cycle. Wisconsin used WBS for lakes in 1990, and staff are redesignating all stream waterbodies and entering data into us WBS by sub-watershed and individual streams.

Illinois and Minnesota have had customized 305(b) tracking databases for years and do not see the need to convert to WBS. Each State's database contains some information that would be lost upon conversion unless additional data fields were added to WBS. (PC WBS can be modified somewhat to suit specific State needs, although this is not commonly done).

5.2.3 Other Findings

In addition to limitations resulting from lack of training, hardware limitations and policy still limit the effective use of data systems in some States. Wisconsin staff cannot use the mapping and graphical capabilities of STORET because of hardware limitations. In Indiana, Division policy and lack of inexpensive hardware limit the access of those responsible for 305(b) assessments to the national data systems. Requests for retrievals must be communicated to a data management group in another part of Indianapolis, resulting in delays and reducing the usefulness of STORET in particular.

States have high expectations for the accuracy of data in national data systems. As an example, a 5 percent error rate in discharger location data in the Industrial Facilities File might be acceptable for national level screening of potential toxics problems. However, State agencies want such location data to be nearly 100 percent correct because they must deal with the dischargers themselves. This finding has implications for State acceptance of national systems, because States must invest staff resources to update such data.

Also, some States expressed concern over their lack of involvement in, and knowledge of, the STORET modernization effort at Headquarters.

Table 5-1. State Use of WBS and RF3

Use of the Waterbody System (WBS)	Locational Data for use in WBS	Will State use RF3?
Illinois Illinois uses its own dBASE system for 305(b) assessment tracking. Illinois' system includes capabilities beyond those required for 305(b) reporting, including a system for prioritizing how State dollars for construction grants will be spent. IL's system also related STORET stations to specific waterbodies, which WBS does not The 1990 assessment data have been transferred to the national WBS.	•Each waterbody is associated with a station number •Reach numbers are given, but they are often the number for the nearest reach in RF1. Waterbodies typically include parts of more than one reach.	At this time they have no plans to use RF3. Unless IL switches to the EPA WBS (a major effort), using RF3 may not be desirable because RF3's capabilities could not be fully utilized.
Indiana RTI installed PC WBS software and demonstrated WBS and RF3 during this project. IDEM has hired a data entry person and waterbody designation is underway by IDEM staff.	Not yet clear. WBS is not yet implemented. Reach indexing cannot be done until waterbodies are designated and stored.	Not yet clear. Staff must first implement WBS.
Michigan Michigan's Surface WQ Division used their own RBASE file for the 1990 report. A Michigan-provided ASCII file was uploaded to WBS in 1990. The Division is considering switching to EPA WBS.	•USGS Cataloging Unit numbers	Yes, resources permitting. There is a lot of interest in linking together multiple databases with RF3. First, however, Michigan must delineate its waterbodies. EPA support may be necessary.
Minnesota Minnesota uses its own SAS files for assessment data. RTI has uploaded these files to the National WBS, but WBS is not used for 305(b) reporting.	•Rivers: hydrologic unit codes and segment numbers •Lakes: lake id. numbers developed by MNDNR	Minnesota personnel are interested in using RF3 but are reluctant to commit to it until they know more about its capabilities and resource requirements
Ohio Ohio uses PC version of WBS for entering and updating assessment information of waterbodies. Data are also uploaded to mainframe version of WBS.	•Waterbody id no. •5 digit river code number and segment description	RF3 will be cross-referenced with Ohio's existing waterbody definitions. Although Ohio will reach index their waterbodies, they plan to keep existing waterbody sizes as the scale for reporting, trend assessments, etc.
Wisconsin Wisconsin personnel used WBS for lake assessments in 1990, and are redesignating stream waterbodies using WBS for streams also. Prior to this, they considered a watershed to be one waterbody. 1990 data were uploaded to the Natioal WBS.	•River Mile System uses: section/ township/ range and river mile •STORET stations have lat/long	Wisconsin personnel may need assistance from EPA to complete implementation of RF3 by the next 305(b) cycle. They hope it will provide better linkage between databases.

It was beyond the scope of this project to determine the extent to which the national data systems could be used to support management decisions in the States. WBS currently is used mainly for compiling data and assisting with 305(b) report preparation. However, the WBS also has potential as an information management system for water resource planners and managers.

5.3 Recommendations

The following recommendations follow from the State interviews and a review of readily available materials about State data systems. No systems analysis was done; such an analysis would result in more detailed, State-specific recommendations.

- Indiana and Michigan could benefit from using the EPA WBS and should proceed with its implementation. These States do not have comparable systems, and WBS should meet most or all of their assessment tracking requirements. Illinois and Minnesota already have fully implemented State systems with some capabilities not offered by WBS.

- The PC WBS should be modified, as needed, for specific State needs. Also, the availability of STORET and other datasets in CD-ROM format (for multiple platforms such as UNIX, Mac-OS, and DOS/Windows) would substantially increase the number of users.

- Assuming the two States listed above are successful in implementing WBS, they should receive technical support, as needed, to accomplish reach-indexing in a timely fashion. This would encourage the use of consistent geographic locators throughout much of the Region.

- Hardware should no longer limit access to the mapping and graphical capabilities of EPA's national water data systems. For only about $2000, a PC can be upgraded to simulate a graphics terminal on the EPA/NCC mainframe.

- Water quality analysts need direct access to data systems as tools of their trade. Impediments to such access should be removed wherever possible.

- States requested additional training, user-friendly documentation, and user support for their national water data systems. Onsite training or EPA-subsidized travel to training sites was suggested because of State travel restrictions. The Waterbody System's package of support--a Users Group that makes suggestions for system improvements, a newsletter, telephone user support, and the *User's Guide*--was cited as a good example.

- EPA should prepare a report or brochure, with examples, on the potential applications of the combined RF3/WBS/WQAS systems to State water quality planning and management. The report should also discuss State obligations for system implementation.

- The EPA Regions should take steps to ensure that all appropriate State personnel receive reports and documentation to counteract the likelihood that only computer specialists will hear about the capabilities of the national data systems.

- The level of State involvement in STORET modernization should be increased.

- A followup study is recommended to identify opportunities for increased use of WBS, RF3, and other national systems in management decisionmaking. Two or three representative States should be selected, preferably from Region 5, to save data gathering costs.

6. OPPORTUNITIES FOR DEVELOPING AND USING ENVIRONMENTAL INDICATORS

6.1 Overview

Water resource policy is undergoing important changes at the Federal, State and local levels that reflect a fundamental shift in the approach to environmental protection and management.[1] The new approach emphasizes risked-based decision-making that relies more heavily on scientific information and pollution prevention. While this new approach offers the opportunity for more effective environmental protection, it also poses new information needs for water resource planners and managers.[2] Comprehensive implementation of watershed planning and management requires significant resource commitments and coordination among Federal, interstate, State, and local organizations.

Four overall recommendations from this study and related projects and initiatives include:

1. EPA and States should develop a tiered classification scheme for environmental indicators that relates basic characteristics of indicators (e.g., spatial and temporal coverage, scientific defensibility, and relationships to environmental impact) with basic planning and management objectives. For example, some indicators, such as designated use support, are best suited for overall water resource evaluation. Others, such as water column chemistry, sediment chemistry, and tissue contamination provide more detailed information related to cause-effect mechanisms.

2. EPA and States should develop a long-term, plan for integrating environmental indicators across water resources, including surface water, ground water and ecological resources. Once environmental indicators are developed for specific water resource categories (e.g., rivers and streams, wetlands), the plan should address how resource-specific and generic indicators can be developed and implemented, taking into account factors such as technical feasibility, costs and presentation value.

3. EPA, other Federal Agencies, interstate organizations and States should take advantage of shared and complementary interests related to water resource planning and management. States, in particular, must have the basic capabilities for assessment activities such as site-specific studies (e.g., assimilative capacity/TMDL development), assessment of program success over wide geographic areas, and

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[1]See discussion of *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* in introduction, pp. 1-9 to 1-13.

[2]See discussion of *Surface Water Monitoring: A Framework for Change* in Introduction, pp. 1-6 to 1-9.

development of protective standards such as biocriteria and other geographically stratified criteria. These groups should continue and improve upon their working relationships to ensure that monitoring and assessment programs support planning and management objectives, both collectively and independently. Pilot projects could be excellent mechanisms for improving State capabilities and fostering the much needed coordination.

4. EPA should conduct studies in other EPA Regions that are similar or identical to the Region 5 project.

The remainder of this chapter provides specific discussion and recommendations related to four primary planning and management objectives:

1. Water resource evaluation

2. Problem identification and characterization

3. Management strategy development, implementation, and evaluation

4. Communication of results to the public and legislators.

6.2 Water Resource Evaluation

States collect data that can be used to assess the status of a water resource, whether or not the status has changed over time, and the sources and causes affecting the water resource quality. Recommendations for improving this data collection and management are summarized below.

6.2.1 Water Resource Status

Region 5 States rely heavily on aquatic life designated use attainment as the primary indicator of surface water resource status. However, the States vary in the emphasis placed on the data used to assess designated use attainment (Figure 3-2 and 3-3). States have historically relied upon chemical monitoring to assess use attainment, but are establishing stronger biological community survey capabilities to complement their chemical and toxicological programs. Substantial improvement in the collection and analysis of the biological data as well as more thorough integration of the biological and habitat information with the existing programs must continue.

To improve the assessment of the status of the quality of water resources, we recommend the following:

1. Attainment of aquatic life designated uses for rivers, and streams, and lakes must include direct measures of the aquatic life to supplement the existing chemical and toxicological approaches.

2. The direct measures applicable to aquatic life use attainment for rivers and streams must include multiple assemblages (e.g., fish and benthos) assessed with a multiple metric approach for fish (e.g., IBI) and benthos (e.g., RBPs), and include a numeric habitat evaluation (e.g., QHEI).

3. Methods and approaches for determining aquatic life use attainment should be consistently applied within a State and among States, while allowing for consideration of distinct regional and State-specific characteristics.

4. EPA and the States must re-evaluate their current selection of designated uses in State water quality standards to ensure that aquatic life uses are specifically represented and that numerical assessment methods are linked to the attainment or non-attainment of those aquatic life uses.

5. EPA must work more cooperatively with the States on implementing biological criteria in the State programs and should re-evaluate some existing policies which tend to be barriers towards biocriteria implementation.

6.2.2 Water Resource Trends

Water resource trend assessment has emerged as an essential, but neglected, activity at the State level. The focus of State programs towards improving the quality of the water resource by site-specific measures without consistently demonstrating how the quality has improved on a larger geographic scale (State-wide trends) prompted new program development by Federal agencies such as the USGS's NAWQA (National Water Quality Assessment) program and USEPA's EMAP (Environmental Monitoring and Assessment Program). NAWQA is designed to provide data/information on a basin scale while EMAP will provide statistically-based random sampling geared for regional and national perspectives. Enhanced versions of EMAP may be applicable towards Regions or even States. However, both NAWQA and EMAP are long-term programs.

The following general recommendations are intended to identify areas which need to be addressed in the short-term to facilitate trend assessments of the water resource quality.

1. The importance of statistically-based trend assessments using a random sampling approach, as opposed to trend assessments based on existing, non-random sampling data, should be clarified. In addition, the spatial and temporal scales necessary to conduct useful trend assessments at the State, Regional, and National levels should be determined.

2. States may not need to strictly utilize a statistically-based time series trend analysis to evaluate temporal changes in water resource status. Depending upon the data, status assessments at specific time intervals will also provide substantial information on tracking environmental progress.

3. EMAP should provide the opportunity to expand efforts to identify reference sites and conduct basin assessments based upon faunal and ecoregional boundaries rather than State political boundaries.

4. EMAP should assist with the development and implementation of more consistent approaches to determining aquatic life use attainment and better utilization of specific environmental indicators.

6.3 Problem Identification and Characterization

Region 5 States rely heavily on best professional judgment, supported by both monitoring and evaluative data, to identify and characterize sources and causes of surface water impairment. This step provides a valuable link between water resource evaluation and management strategy development. Incomplete or inaccurate problem identification and characterization can contribute to fragmented and ineffective management strategies. In general, all Region 5 States expressed interest in improving their methods for identifying and characterizing problems, but expressed concerns over the availability of tools (e.g., GIS technologies), resources, and data.

6.3.1 Problem Identification

Region 5 States use a variety of data to detect problems with water resources, such as: changes in biological community and habitat data, exceedances of water-quality standards (predominately chemical), citizen complaints, discovery of fish kills, point and non-point source monitoring and land-use surveys.

However, it is unclear how this information is used to assess designated use attainment of waterbodies, since the States rely on the judgment of individual professionals. All of the States expressed a high level of interest in developing and improving upon their data acquisition, management, and analysis by using GIS, trend analysis, and remote sensing tools. At least a few of the States expressed an interest in improving the ability to use forecasting tools forecasting trends within watersheds to help identify and prevent future problems. The following recommendations are intended to improve the quality and consistency of problem identification:

1. EPA and States should jointly develop guidance and training for identifying water resource problems, including procedures for detecting potential sources and causes

before water resources are significantly impacted. The guidance and training should help ensure more effective and consistent procedures are implemented within and among States.

2. EPA should ensure that States have adequate resources and training for utilizing new technologies, such as geographic information systems and remote sensing.

3. States should document their procedures for identifying problems to provide data on the reliability of results and to help ensure the reproducibility of procedures. The State 305(b) reports, EPA Waterbody System, and State-Compatible systems, should be modified to accommodate data related to problem identification methods.

4. In the long-term, EPA and States should develop the capacity to identify and anticipate problems caused by sources or causes originating within and outside watersheds that have measurable impacts on water resources. Examples of problems that may arise outside individual watersheds include atmospheric deposition of contaminants, interbasin transfers of effluent and solid waters, and human-induced climate change.

6.3.2 Problem Characterization

Problem characterization should provide the following types of information important to decision-makers and planners: the degree of human health, ecological and welfare risks, the spatial extent, temporal characteristics (e.g., new vs. old problem, trends, persistence), cause-effect relationships, and identification of pathways through which the environment is affected. This information could help States develop response strategy, prioritize problems, target resources to areas of greatest risk and areas of greatest risk-reduction potential, and communicate program needs to legislators and the public.

Region 5 States use a variety of tools for characterizing water resource problems, including intensive, integrated basin-wide surveys, facility inspections, basin wide waterload allocation modeling, effluent toxicity testing, and intensive special studies (e.g., Illinois' Pesticides Survey). As part of the 305(b) process, States characterize problems by reporting a variety of narrative and graphical information for different water resource categories. These include: state-wide causes and sources of nonattainment, basin-wide water quality summaries, contaminant-specific and general data on public health/aquatic life concerns, waterbody-specific data on sources and causes of nonattainment, documentation of methodologies, and summaries of monitoring and assessment programs. The following recommendations are intended to improve problem characterization:

1. Historically, EPA and States, have tended to focus their monitoring and assessment programs to support permitting and enforcement related to point sources. As a consequence, problem characterization of nonpoint sources has not been adequately

supported, even though these problems are often the dominant sources and causes of water resource degradation within watersheds. EPA and State monitoring and assessment programs should be developed or modified, with sufficient funding and resources, to provide the necessary data for comprehensive problem characterization.

2. A long-term, national strategy should be developed to integrate numerous activities conducted by Federal, interstate, State, and local organizations that support problem characterization. Pilot studies at the watershed, State and Regional levels could provide valuable feedback to support the development of this strategy, including the identification and testing of potential environmental indicators and analytical tools (see descriptions of the EPA's EMAP and the USGS's NAWQA programs in Introduction).

3. EPA and States should consider monitoring and assessment approaches that more fully integrate monitoring and evaluative data collected in the field with information management technologies such as GIS, remote sensing and geopositioning techniques. For example, land use and land cover data that is correlated with intensive field surveys within selected watersheds could be used to assess or predict conditions in other watersheds. The use of an ecoregion approach, rather than a traditional hydrologic unit approach, would provide a strong framework for integration. Potential benefits include more effective targeting of monitoring resources and management actions, reduction in monitoring and assessment costs, broader spatial and temporal characterization of problems, and more accurate geographic referencing of assessment data.

4. Recognizing the real and large differences in stream size that exist is an important first step towards more realistic aggregation of data. In the long-term, EPA and State's should identify or develop mechanisms for linking quantitative and qualitative water resource data. For example, a watershed map that illustrates water quality conditions of streams by color and stream size (e.g., annual average flow in cubic feet per second) by thickness or width on the map could be a useful decision-making and communication tool for watershed planners and managers.

6.4 Management Strategy Development, Implementation and Evaluation

Since the early 1970s, the focus of State and EPA surface water protection and management programs has been directed to control large, obvious point sources such as municipal sewage treatment plants and industrial facilities. Given statutory mandates and resource constraints, EPA and the States have not until recently paid sufficient attention to new problems or the development of new management strategies. Further, it has been difficult or impossible in many instances for EPA and States to adequately evaluate their programs. Today, EPA and State programs broadly recognize the need for better information to support integrated, anticipatory planning and management on a watershed-basis. It is important to note that some of the Region 5 States have been at the forefront of this shift in water resource policy. The following recommendations highlight important opportunities for developing and using environmental indicators to support management strategy development, implementation and evaluation:

1. The success of watershed planning and management depends, to a large extent, on the ability to identify, access, manage, and use relevant information. It is particularly important to provide linkages between environmental indicators, quantitative resource data, program plans, management activity measures, and data on environmental stresses. EPA, other Federal agencies, and States should jointly develop a computer-based tool that provides central, user-friendly access to the above types of information to support watershed planning and management. The tool should be designed to take full advantage of recent modernization efforts in data and information systems (e.g., Waterbody System, Reach File Version 3, and STORET), both within and outside EPA. Selected watersheds throughout the U.S. could be used to pilot test the tool to ensure its usefulness and flexibility. Computer-based planning and decision-making, using the 305(b) process as a framework, could dramatically improve the development, implementation and evaluation of management strategies.

2. Federal, State and local budget deficits are encouraging water resource planners and managers to seek innovative, more effective solutions, particularly those oriented toward pollution prevention. To support these policies, pollution prevention indicators should be identified and used to provide feedback, via environmental monitoring results, for strategy development, implementation and program evaluation. Examples of potential indicators include per capita water consumption, water and fertilizer application rates for various crops, and waste/product ratios for industrial processes.

6.5 Communication of Results to Public and Legislators

Measures of success in our environmental programs will only be recognized if we can effectively and accurately communicate the results. Although we have many communication vehicles available, the biennial State 305(b) reports remain the primary structure through which most water quality information is conveyed. Various environmental agencies are working with citizens groups to make more data available and to facilitate the proper use of the information that is provided given to the public and the legislators.

6.5.1 State Biennial 305(b) Reports

Unfortunately, information included in current 305(b) reports does not support status and trend assessments at the National, Regional, and State levels. There are very large inconsistencies among States in how water quality data are collected, analyzed and reported. States assess different subsets of their waters from one year to the next. Moreover, States have considerable discretion in developing their own water quality standards. As a result of these differences among States in the type of information reported in 305(b) reports, national comparisons of status and trend assessments are essentially impossible. In addition, the inconsistencies in sampling design from year to year make it difficult to assess trends even within individual States. EPA's National 305(b) Consistency workgroup has revised the 305(b) guidance to reduce some of the problems with the reports. Inconsistences will, however, still exist in the State reports. Therefore, 305(b) Consistency efforts should be continued and accelerated.

To ensure that regional and national 305(b) consistency efforts continue on an accelerated time table to support State and EPA environmental indicators programs, we recommend the following:

1. The 305(b) reporting process must be viewed as a continual process and not merely as a State effort every two years. States should assign 305(b) coordinators and dedicate resources necessary to sustain that position with EPA support.

2. The States must fully document all decision-making processes in the 305(b) reports to allow for detailed reviews and understanding on how each State determines designated use attainment for aquatic life protection.

3. The National 305(b) Consistency Workgroup should formalize a schedule for reviewing and revising the 1994 305(b) report guidelines shortly after the 1992 reports are submitted. This workgroup must ensure that State guidelines are finalized at least one year before the reports are due (April 1, 1993 should be the deadline for the 1994 Guidelines).

4. EPA must provide States with incentives to increase use of the WaterBody System as well as Reach File 3 Indexing for program management and decision-making. These incentives must include dedicated funding for qualified personnel, training for State and Regional staff, contractor support for reach indexing and entering in current and historical information into the WaterBody System, and funding for the necessary hardware to fully utilize our information management systems.

5. EPA must ensure that data, information management and communication systems are fully functioning, finalized, and available to all States and Regions prior to requiring their use for any particular 305(b) cycle. Information management

systems and communication tools (e.g., videos, interactive graphics) should be designed to be user friendly, dynamic and flexible to accommodate to diverse background and interest of potential users.

6.5.2 Citizen Monitoring Activities

Citizen monitoring activities generally fulfill two needs: (1) education of the public and our legislators, and (2) collection of additional water quality information. Citizen monitoring programs have been tremendously successful throughout the country and within Region 5; however, they should never be viewed as a substitute or replacement for State monitoring programs. State-wide citizen lake monitoring in Illinois, Minnesota, and Wisconsin are nationally recognized for their excellence and the data generated from these programs are used in the 305(b) process. Citizen lake monitoring data from Indiana are also widely used.

Stream citizen monitoring programs have lagged behind the lake programs since the data collection for lakes has been relatively simple compared with biological data needs for the stream programs. However, the Ohio Department of Natural Resources operates an exceptional program for Scenic Rivers that has achieved national recognition. Michigan has maintained strong basin-specific stream monitoring programs (e.g. Rouge River), and Illinois Department of Energy and Natural Resources has recently initiated a State-wide program for streams which Illinois EPA intends to support. Wisconsin is attempting to initiate a streams program while Indiana and Minnesota have not committed to initiating such programs.

Citizen and volunteer monitoring programs need to achieve greater recognition and utility by EPA and the States. The Office of Water has been sponsoring citizen monitoring activities including the upcoming Third National Citizen's Volunteer Water Monitoring Conference in March 1992. To facilitate responsible cooperation among EPA, States, and citizen monitoring organizations we recommend the following.

1. Each State should inventory citizen monitoring activities, with support from the Regions.

2. Each EPA Region should identify lake and stream citizen monitoring coordinators to work with the States in interacting with the citizen monitoring groups.

3. The intent (data quality objectives) of each citizen monitoring group and program should be made clear to ensure that the program will not require participants to perform tasks for which they are not properly trained.

4. Quality assurance program plans must be completed and approved by the States and EPA for citizen monitoring program data to be utilized by States in Section 305(b) reporting.

5. EPA and the States should develop technical guidelines and provide training for citizen monitoring programs.

6. EPA and the States should develop strategies, which include modern information technologies, for more effectively capturing, managing and disseminating citizen monitoring data.

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