MINNESOTA'S WATER QUALITY MONITORING STRATEGY

2004 TO 2014

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Minnesota Pollution Control Agency

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INTRODUCTION

Minnesota has an abundance of water resources – more surface waters than any other of the 48 contiguous states. Minnesota boasts an estimated 92,000 miles of streams, 12,000-plus lakes, 10.6 million acres of wetlands and more than one billion gallons of ground water. This abundance of water presents both opportunities and challenges. Minnesota's $10 billion-a-year tourism industry is based on its water resources, and water is important to a healthy agricultural and business economy. At the same time, the sheer abundance of waters results in greater challenges in monitoring, preventing degradation and restoring polluted waters.

The Minnesota Pollution Control Agency (MPCA) and its partner organizations currently conduct a variety of surface and ground water monitoring activities to provide information about the status of the water resources, potential and actual threats, options for addressing the threats and data on how effective management actions have been. Overall, the MPCA and its partners are striving to provide information to assess – and ultimately to restore or protect – the integrity of Minnesota's waters.

To be effective in conducting monitoring that will meet Minnesotan's needs for information, Minnesota needs to have an overall guiding strategy for its monitoring. This report is intended to pull together and document all of the elements of our monitoring program strategy for both surface and ground water and for all monitoring types. While intended to satisfy the requirement of the U.S. Environmental Protection Agency (EPA) for preparing a monitoring program strategy, its greatest benefit will be in guiding monitoring programs for the future.

TYPES OF MONITORING

The MPCA categorizes its environmental monitoring efforts by the purpose for the monitoring and how the information is assessed and used. In general, water monitoring efforts can be grouped into three "use" categories as follows:

- *Condition monitoring:* This type of monitoring is used to identify overall environmental status and trends by examining the condition of individual waterbodies or aquifers in terms of their ability to meet established standards and criteria. Condition monitoring may include chemical, physical or biological measures. The focus of condition monitoring is on understanding the status of the resource, identifying changes over time, and identifying and defining problems at the overall system level. Examples include routine surface water monitoring, basin monitoring, TMDL listing activities, and the ambient ground water network.

- *Problem Investigation Monitoring:* This monitoring involves investigating specific problems or protection concerns to allow for the development of a management

approach to protect or improve the resource. Problem investigation monitoring is used to determine the specific causes of impairments to water or ground water and to quantify inputs/loads from various sources. It is also used to determine the actions needed to return a resource to a condition that meets standards or goals. Examples include Clean Water Partnership and Section 319 projects, TMDL development, site assessment, and investigation of specific ground water issues, such as pesticides.

- *Effectiveness Monitoring:* This is used to determine the effectiveness of specific regulatory or voluntary management actions taken to remediate contaminated water. Effectiveness monitoring allows for the evaluation and refinement of the management approach to ensure it is ultimately successful. Examples include implementation monitoring for TMDLs, CWPs and 319 projects, and monitoring associated with a particular best management practice. Another example of effectiveness monitoring is effluent monitoring done to assess the compliance of a facility with a permit, rule or statute (i.e. compliance tracking) and to provide information on the effect of regulatory actions on inputs to water bodies (not the effects on the waterbody itself).

While there are similarities among the three monitoring types and the definitions are not meant to be exclusive and rigid, the definitions do help to distinguish between the various purposes for monitoring. Perhaps the greatest area of overlap is found between effectiveness and condition monitoring. In this case, the difference between the two is largely a matter of scale. Effectiveness monitoring is done at the management scale, to evaluate particular management actions. In contrast, condition monitoring can be used to track the system-wide effectiveness of environmental protection efforts. In discussing the elements of the monitoring program strategy, it will be important to distinguish among the three types of monitoring, since many elements are different depending on the type of monitoring.

Special Studies Monitoring: It is also important to note that some monitoring activities do not neatly fit into the three types of monitoring discussed above. This is especially true of special studies monitoring. This category includes a number of different lake and stream studies that are more research-focused. Examples of special studies monitoring includes monitoring related to emerging issues (pharmaceuticals, wastewater compounds, etc.); monitoring related to critical toxic pollutants such as mercury; monitoring focused on specific areas; and monitoring focused on a specific problem or to answer a specific question. This type of monitoring is generally characterized by a very narrow focus and a study of relatively short duration.

ORGANIZATION OF THE STRATEGY

The strategy is organized broadly by media – surface water and ground water. Within each media, we discuss Minnesota's strategies for the three monitoring types – condition, problem investigation and effectiveness. The appendices contain additional documentation of the strategy elements. A timeline for implementation of the surface water strategy is attached as Appendix 1.

SECTION 1: SURFACE WATER

SECTION 1.1
GOALS AND OBJECTIVES

Minnesota has several sets of goals and objectives related to monitoring. MPCA has adopted three strategic goals to drive its water quality protection and restoration efforts (both point and nonpoint) and achieve its vision of clean, fishable and swimmable surface waters. For nonpoint source pollution, a consortium of federal, state and local organizations have adopted water monitoring goals, as part of the 319 planning process.

1.1.A MPCA'S STRATEGIC GOALS FOR WATER QUALITY PROTECTION AND RESTORATION

- Goal W.1. Assess the chemical, physical and biological integrity of lakes, streams and wetlands to identify if designated uses are being met, and to provide information on the condition of waters.

- Goal W.2. Maintain and enhance the chemical, physical and biological integrity of Minnesota lakes, streams and wetlands so that water quality standards and designated uses are met and degradation is prevented.

- Goal W.3. Restore the chemical, physical and biological integrity of Minnesota lakes, streams and wetlands that do not support designated uses.

Each of the goals contains several specific, measurable objectives to set direction for all of the agency's surface water quality work, including monitoring. While the monitoring objectives for Goal W.1 are clearly articulated, the monitoring components of the other two goals are implied:

Goal W.1. Assess the chemical, physical and biological integrity of lakes, streams and wetlands to identify if designated uses are being met, and to provide information on the condition of waters.

Objectives[1]:

W1a) By December 31, 2014, gather water quality data and increase assessment of streams and rivers to 33 percent, in comparison to the 2003 level of 5 percent (includes tracking progress of studies and grants related to emerging contaminants).

W1b) By December 31, 2014, gather water quality data and assess 100 percent of the lakes larger than 500 acres

[1] The MPCA adopted its goals and objectives prior to convening the Stakeholder process for impaired waters. Because of that, some of the specific numeric objectives may not be consistent with the recommendations of the Stakeholder group. These objectives will be changed in future strategic plans.

W1c) By December 31, 2014, gather data and increase monitoring so that 25 percent of the state's depressional wetlands are assessed.
W1d) By December 31, 2008, assess Minnesota's contribution to identified regional, national and international water pollution problems[2].
W1e) Ensure data is readily available to the public within one year of season it is collected.

Goal W.2. Maintain and enhance the chemical, physical and biological integrity of Minnesota lakes, streams and wetlands so that water quality standards and designated uses are met and degradation is prevented.

Conduct monitoring, as needed, to support the following objectives[3]:
W2a) By December 31, 2005, ensure that discharges from all permitted point sources are in significant compliance with state and federal limits 95 percent of the time for major facilities and 90 percent of the time for regular facilities.
W2b) By December 31, 2006, prevent 1.2 million tons of sediment from reaching surface waters annually from construction activities in comparison to an estimated 2003 level of 600,000 tons.
W2c) By December 31, 2004, ensure that feedlots with NPDES permits meet state and federal requirements 90 percent of the time.
W2d) By December 31, 2004, develop and implement an evaluation system for measuring progress in attaining basin/watershed goals.
W2e) By February 1, 2004, improve understanding of phosphorus loading in Minnesota by identifying the amounts and sources of phosphorus entering state waters. *
W2f) By October 1, 2005, 90 percent of the feedlot facilities enrolled in the open lot program meet interim correction measures and by October 1, 2010, 90 percent of these facilities meet water quality effluent standards.
W2g) By December 31, 2005, and every 3 years thereafter, review Minnesota's water quality standards to incorporate changes to the standards to reflect current science and information.

Goal W.3. Restore the chemical, physical and biological integrity of Minnesota lakes, streams and wetlands that do not support designated uses.

Conduct monitoring, as needed, to support the following objectives:
W3a) Complete impaired waters list according to EPA requirements.
W3b) Complete TMDL studies within 13 years of initial listing.
W3c) Within one year of EPA approval of each TMDL study, implementation plans will be approved and initiated.

[2] The MPCA will draft a monitoring needs assessment to evaluate Minnesota's contribution to hypoxia, turbidity, temperature change and other water pollution problems. The draft needs assessment will be complete by July 1, 2004, and the plan developed as a result will be appended to this strategy.
[3] The objectives included in Goals W.2. and W.3. contain both program objectives and environmental objectives. It is important to note that the underlying assumption in the objectives is that realizing the program objectives will result in pollutant reductions. It is also important to note here that, for Goals W.2. and W.3., monitoring is not the focus but monitoring activities provide support for reaching the goals and objectives.

W3d) By July 1, 2005, obtain Legislative approval of an impaired waters program.

In general, Goal W.1. is focused on condition monitoring, while Goals W.2 and W.3 include both problem investigation and effectiveness monitoring.

1.1.B MINNESOTA'S NONPOINT SOURCE (NPS) MANAGEMENT PLAN MONITORING GOALS

NPS 1. Develop baseline data necessary to allow establishment of good status and trend information relative to surface water and ground water at the state/regional level.

NPS 2. Establish reference conditions, criteria or standards for those waterbody types or types of measurement for which such references do not currently exist.

NPS 3. Improve monitoring designed to characterize NPS contributions to water quality problems.

NPS 4. Promote effective use of BMP's through assessing the improvement in water quality relative to specific NPS reduction actions.

NPS 5. Design monitoring programs to meet management information needs concerning identified geographic areas or issues of concern, then use information obtained for resource management decision-making.

NPS 6. Improve communication linkages both between state and local resource managers, as well as among the various local, state and federal agencies within the State for purposes of expanding the water quality monitoring database and enhancing accessibility to it.

Clean Water Act monitoring objectives are reflected within Minnesota's goals and objectives in Table 1:

Table 1. Relationship of Minnesota's Goals and Objectives to Clean Water Act objectives:

Clean Water Act Goals	**Found in Minnesota goals:**
Establishing, reviewing and revising water quality standards	MPCA W.2. and Objective W.2.g; NPS 2
Determining water quality standards attainment	Goals W.1. and W.2.; NPS 1 and 5
Identifying impaired waters	Objectives W.1.f and W.3.a; NPS 1
Identifying causes and sources of water quality impairments	Objective W.3.b; NPS 3
Supporting the implementation of water management programs	Goals W.1., W.2, and W.3; NPS 5
Supporting the evaluation of program effectiveness	Goals W.1 (on a system level) and W.2 and W.3 (on a project/program level); NPS 4

1.1.C GOALS AND OBJECTIVES WITH A GEOGRAPHIC FOCUS

Minnesota has additional monitoring goals targeted more specifically for geographic regions. As part of MPCA's basin planning process, each basin adopts monitoring goals for the basin. Currently, basin plans have been adopted or are in draft for the Minnesota, Red, Lower Mississippi/Cedar, Upper Mississippi, Rainy and Superior basins. The monitoring goals found in the basin plans can be found on the MPCA's website: http://www.pca.state.mn.us/water/basins/index.html. Lake Superior's Coastal Nonpoint Program also includes information on monitoring activities related to nonpoint source management in the Lake Superior Basin at: http://www.pca.state.mn.us/water/basins/superior/coastalnp.html

Local units of government (counties, watershed districts and watershed management organizations) also undertake water planning in Minnesota. As part of those planning processes, goals and objectives for monitoring programs are adopted, based on the information needs and priorities of the local government. These local goals play an important role in development of basin plans by the MPCA.

SECTION 1.2
CONDITION MONITORING STRATEGY

Minnesota's condition monitoring strategy was developed by a broad-based stakeholder group, composed of representatives of state government, environmental organizations, citizen organizations, local government, business, cities and agriculture. The stakeholder recommendation for the monitoring strategy discussed below is based on agreement that Minnesota needs to completely assess its lakes and streams over a ten-year timeframe. A copy of the Stakeholder report and recommendations is attached as Appendix 2.

Monitoring for Prevention and Impairment

Minnesota's assessment strategy is based on completely assessing its lakes and streams on a 10-year cycle. While assessment is often thought of in terms of identifying impairments, it's important to remember that assessment also is intended to identify water bodies that are meeting standards.

The stakeholder group recognized the importance of prevention and noted in the opening paragraph of its report:

While not the program's primary objective, protection of non-impaired waters would be viewed as a legitimate use of program resources.

In the view of the stakeholders and MPCA, protection and restoration are both part of Minnesota's strategy.

1.2.A LAKES AND STREAMS

As indicated earlier, condition monitoring is used to identify overall environmental status and trends by examining the condition of individual waterbodies in terms of their ability to meet established standards and criteria. Condition monitoring may include chemical,

physical or biological measures. The focus of condition monitoring is on understanding the status of the resource, identifying changes over time, and identifying and defining problems at the overall system level. The MPCA's condition monitoring goals and objectives are largely found in Goal W.1. and its objectives.

Minnesota's statewide surface water quality assessment strategy has four data collection components: 1. MPCA stream and lake monitoring; 2. stream and lake data collected by other organizations; 3. remote sensing; and 4. citizen monitoring. Each of these components contributes important data to the system that results in both geographic coverage and data confidence.

For both lakes and streams, the MPCA considers this four component strategy of data collection to be sufficient for fully assessing streams and lakes in Minnesota over a 10-year cycle, given the abundant surface water resources contained within Minnesota's borders. This strategy is considered complete, in that it builds on a foundation of citizen monitoring, remote sensing, and other information to direct attention to waters that may be changing or indicating impairment for further assessment. Section 1.12 discusses the funding necessary to implement this strategy.

1. MPCA Stream and Lake Data Collection: The MPCA will ensure that the data collected meets the quality requirements of the 303d/305b assessment process. A 10-year data collection cycle ensures the data is current enough to meet federal requirements.

Streams: Over the 10-year cycle, MPCA will:

- conduct 'continuous' flow and chemistry measurements at 86 sites, providing comprehensive data for key sites in each major watershed. The flow monitoring will be conducted in cooperation with USGS and/or the Department of Natural Resources. Continue chemistry monitoring at existing Minnesota milestone sites (many have been monitored for 50+ years), thus providing statewide trends over time. Collecting stream flow and chemistry data at the outlets of each major watershed and the Minnesota milestone sites provides information to better understand loading contributions and trends over time, both of which will help in later steps of the TMDL process and in targeting additional monitoring.

- conduct integrated monitoring (biological, chemical and physical) at 680 sites per year, rotating through watersheds providing composite assessment and coverage. Each year the MPCA will select a portion (10-20%) of the stream sites based on previous citizen monitoring, remote sensing or other data that indicate a need for further assessment. The integrated monitoring uses both a probabilistic design, to provide confidence in applying information to a larger area and a progressive design in which the agency systematically, watershed by watershed, moves upstream from the mouth to identify impaired areas. The probabilistic design allows the Agency to use data from a small number of randomly selected sites to make statistically valid statements about stream conditions in a larger area. The progressive design, used in Ohio, represents the upstream reaches at a 25-square-mile scale, without monitoring each and every stream reach. Biological monitoring, itself, provides data on resource

impacts over time, since fish populations, for example, indicate changes in the resource over a 2 to 5 year period. Together, use of probability-based and progressive designs, and biological monitoring of fish provide for comprehensive coverage of stream condition across the state. By combining this professional monitoring with citizen monitoring and remote sensing, which provide a higher level of monitoring frequency and geographic coverage, the result is a complete picture of streams and their condition across the state.

Lakes: Over the 10-year cycle, the MPCA will:

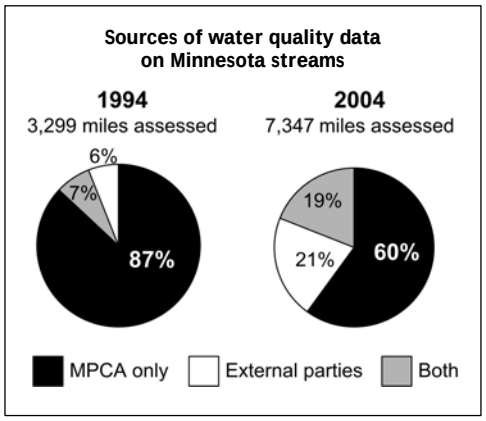
- monitor 100 lakes per year, focusing first on all lakes over 500 acres (approximately 800 lakes) and selected lakes between 100 and 500 acres (approximately 4000 lakes) based on results of citizen monitoring and remote sensing. Again, the MPCA will select a portion (10-20%) of the lakes based on the need for further assessment identified through other monitoring, including citizen monitoring and remote sensing, which will provide complete geographic coverage of the state's 12,000 lakes.

For lakes, this level of data collection will provide information on lakes over 100 acres, at the level of confidence needed to conduct 305b/303d assessments. Given the large number of lakes in Minnesota, focusing on the largest is the most practical approach, since they represent the attention for fisheries management, public access and use. Other monitoring and sources of information, including citizen monitoring, local water planning and remote sensing can be used to target additional smaller lakes for assessment, which will provide confidence that important lakes are adequately assessed.

2. Lake and Stream Monitoring by Other Organizations: Organizations external to the MPCA (e.g., USGS, Metropolitan Council, some watershed districts, citizen volunteers) collect data that the MPCA uses in assessments. As long as the data collected meets assessment requirements (number of samples, use of certain techniques for collection and analysis, and data provided to MPCA), the MPCA will use it in assessments. More information on data quality requirements for use in assessments can be found in MPCA's *Volunteer Surface Water Monitoring Guide* (see Appendix 3).

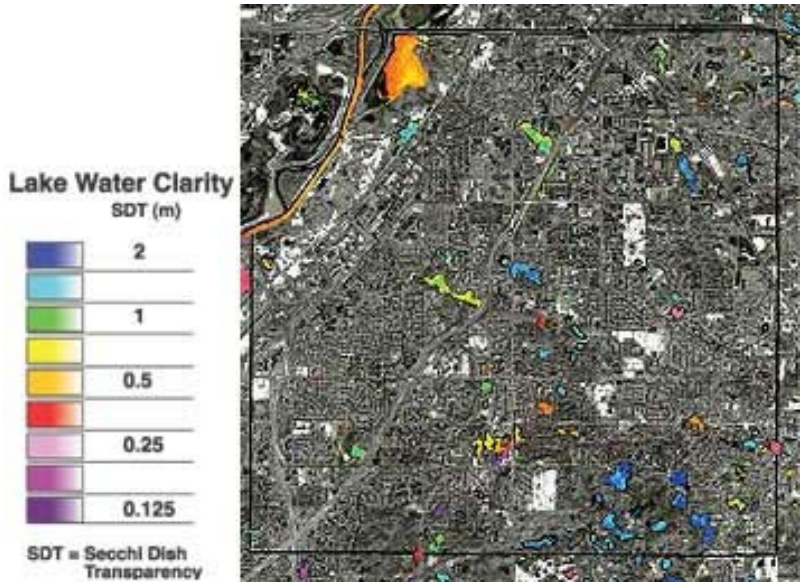
MPCA's use of other organizations' data is increasing, and MPCA wants to use that data in assessments, where it meets criteria. The use of such data has increased significantly over the last several assessment cycles.

Figure 1. MPCA use of external data: 1994 – 2004



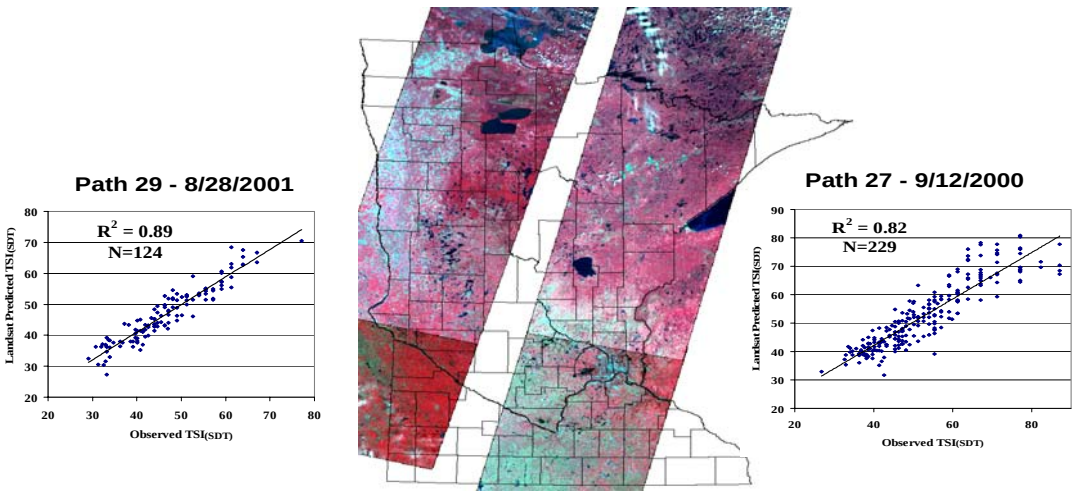
In addition, MPCA may choose to contract with some of these contributing organizations to provide information for other parts of Minnesota's strategy. For example, MPCA may contract with USGS, Department of Natural Resources (DNR) or other organizations to provide flow data as part of this strategy. MPCA is also working on an interagency agreement with the Minnesota Department of Agriculture (MDA). When complete, this agreement will outline the responsibilities of each agency in monitoring the state's water resources, and will further describe how the two agencies will coordinate their activities.

Figure 2. Remote Sensing: Map of lake water clarity for City of Eagan, Minnesota, a suburb of Minneapolis/St. Paul.



3. Remote Sensing: The MPCA will work with the University of Minnesota and DNR to conduct statewide remote sensing (aerial photos and satellite imagery) every five years to provide information to prioritize and direct its more rigorous data collection activities. Figure 2 provides an example of the remote sensing the MPCA is currently undertaking, and Figure 3 shows the relationship between Landsat imagery and lake water clarity.

Figure 3. Landsat Imagery and Lake Clarity. University of Minnesota Remote Sensing Lab analysis showing the close correlation between satellite predicted transparency in meters (y-axis) and secchi disk observations converted to the Trophic Status Index (x-axis).



Remote sensing provides the highest level of geographic coverage for lakes and streams and at a very low cost, but it does not meet the requirements for assessment data. Remote sensing will be used as a targeting tool every five years, to identify lakes and streams that may be changing or impaired and warrant more comprehensive monitoring. Remote sensing will also provide a five-year check, to help provide more complete geographic coverage.

4. Citizen Monitoring:

Citizen monitoring is a cost effective way to gather data on a large number of water bodies annually. The strategy involves citizen monitoring of streams at 3600 sites across the state using T-tubes. Additionally, stream chemistry data will be collected at 10 sites in each of the 81 major watersheds. For lakes, citizen monitoring will occur with secchi disks at all lakes over 100 acres, with chemistry collected at 300 lakes per year of lakes in the 100 to 500 acre size.

Using citizen monitoring as a screening tool fills a critical time gap in the state's 10-year cycle of monitoring and fills in geographic coverage. The easy to use and low cost T-tubes have a high correlation with total suspended sediment, turbidity and nutrients (and possibly mercury) in streams. The easy to use and low cost secchi disk has a high correlation with phosphorus and chlorophyll a. This provides cost-effective means of getting broad coverage which can identify streams and lakes where there is a need to take a closer look or to re-monitor sooner than the 10 year cycle. The addition of chemical and/or biological measures builds an even stronger foundation of data to indicate change and/or impairment that directs priority for additional assessment. Citizen monitoring also provides data necessary to calibrate the remote sensing system.

In order for MPCA to use citizen monitoring to screen and prioritize, citizen monitoring will need to be conducted consistent with the guidelines identified in MPCA's *Volunteer Surface Water Monitoring Guide* (Appendix 3). The manual was developed in 2003 by a broad based group of stakeholders and includes guidelines for all of the planning aspects, as well as use of equipment. An LCMR pilot project is currently providing citizen training following the manual's recommendations. The project will result in learning on how to deliver training and support for effective citizen monitoring (see Section 1.6.A).

How the strategy components fit together

The four components of the monitoring strategy rely on each other mutually to provide the "complete monitoring picture." Detailed data collection by the MPCA and other organizations will provide the scientific rigor to ensure confidence in the data collected. The fixed station sites (Milestone sites, sites at the outlets of watersheds and monitoring by other organizations) provide the information necessary to assess trends. The integrated monitoring provides the probabilistic system that provides confidence that the information is representative and will demonstrate the percentage of waters assessed. The lake monitoring part of the strategy assures a focus on Minnesota's largest lakes.

Citizen monitoring and remote sensing, on the other hand, will provide the geographic coverage and monitoring frequency needed to ensure appropriate targeting and priority-

setting. This will allow Minnesota to ensure that it is not missing smaller, yet important resources. Citizen monitoring and remote sensing provide a statewide look at our water resources. A portion of MPCA's more rigorous monitoring will be targeted to resources identified through citizen monitoring and remote sensing.

The four components, coupled with the MPCA's rotating basin approach to monitoring, will ensure that the condition monitoring program embodies a comprehensive picture in which Minnesota can have confidence, within a ten-year cycle. The system will provide reports on the status and trends of the state's waters, for use by decision-makers at all levels.

Figure 4. Minnesota's Condition Monitoring – the complete picture

MPCA data collection • 81 major watersheds/yr. • 680 integrated sites/yr. • 100 lakes/yr.	+	**Data collection by other organizations** • Detailed data on additional lakes and rivers	=	**Data confidence on 10-year cycle**
Remote sensing • Full coverage • Every 5 yr.	+	**Citizen monitoring** • Streams: 3,600 T-tubes, 800 chemistry sites • Lakes: 4,000 with Secchi, 300 with chemistry	=	**Geographic coverage and monitoring frequency; targeting and priority-setting**

1.2.B WETLANDS

MPCA has been developing an Index of Biological Integrity (IBI) as a tool for using macroinvertebrates and aquatic plants as indicators of wetland health since the 1990s, as well as developing sampling protocols and analytical tools. In 1995 and 1999, the aquatic invertebrate IBI process was refined for depressional wetlands in the Central Hardwood Forest Ecoregion of Minnesota and is currently being refined for other areas of the state. It is possible that the same methodology could be applied for monitoring the health of lakes as well as other types of wetlands. For aquatic plants, the MPCA developed and validated ten plant metrics for wetlands in the North Central Hardwood Forest Ecoregion. The MPCA has also developed seven preliminary metrics and a proposed IBI for riparian wetlands in East-central Minnesota within the St. Croix basin.

In addition to work on the IBIs, Minnesota is in the process of developing a comprehensive wetland monitoring strategy, through a grant from U.S. EPA. The strategy will be used to track status and trends in wetland quantity and quality statewide in Minnesota. The first phase of this project will involve three components: 1) developing a comprehensive wetland monitoring and assessment strategy to assess status and trends in wetland extent and quality state-wide; 2) continue development of wetland indices of biological integrity (IBIs); and 3) field testing and calibration of the revised Minnesota Routine Assessment Method (MnRAM, Version 3.0). The Board of Water and Soil Resources (BWSR), the Department of Natural Resources (DNR) and the Minnesota Pollution Control Agency (MPCA) will jointly develop the monitoring

strategy. The MPCA will be chiefly responsible for completion of component 2. The Department of Natural Resources, Division of Ecological Services will be chiefly responsible for completion of component 3.

Completion of the project will result in the following outcomes:

- Development of a state comprehensive wetland monitoring plan
- Initiation of a coordinated multi-agency approach to monitoring status and trends in wetland quantity and quality
- Integrated (quality and quantity and multi-agency) assessment results from three geographically focused pilot areas
- Prototype database structure for data capture, storage, retrieval and analysis
- Completed statewide coverage of plant and invertebrate IBIs for depressional wetlands
- Statewide reference wetland network for depressional wetlands
- Tested and validated digital MnRAM suitable for statewide use by wetland professionals
- Recommendations for improved wetland mitigation based on initial use of MnRAM

The strategy is being developed through a planning process involving a Steering Committee, Policy Committee, Technical Advisory Group and Stakeholder Group. The Steering Committee will provide ongoing direction to the project as issues arise. The Policy Committee will manage and support the development and implementation of a statewide wetland monitoring and assessment strategy. The Technical Advisory Group provides technical expertise and direction to project staff. Finally, the Stakeholders Group provides ongoing direction and support; disseminates project information to stakeholder groups; generates support for funding for future on-going implementation of the monitoring strategy; and identifies potential funding sources.

The strategy in development is envisioned to be similar to the MPCA rivers and lakes strategy with several tiers of monitoring and assessment done on a periodic basis.

- State-wide remote sensing is being considered on a 10 year timeline with the intent of updating the location, size and type of wetland. New remote sensing technologies are being explored to determine the quality of the wetlands. This monitoring would primarily inform Minnesota's goal of "no net loss" in quantity managed through the Wetland Conservation Act.
- Professional "in-the-wetland" sampling would continue to determine the condition and trends in quality. Random sampled plots or random wetland basins sampling designs are being considered. Sample parameters would consist of plant and/or invertebrate indicators depending on wetland type. Focus for condition sampling would be directed by remote sensing, volunteer monitoring, and wetland vulnerability. This information would determine impaired wetlands for restoration.
- Volunteer monitoring or rapid assessment techniques are also being considered to fill in gaps in time and target professional sampling.

Currently, the goal of the wetland tiered strategy is to have a statewide inventory every 10 years. In addition, sampling of 25% of the states' vulnerable depressional wetlands is desired. This would be expanded to other types of wetlands as resources and technology allow. The strategy is planned for completion in 2005 and will be incorporated into this overall monitoring strategy when it is finalized.

SECTION 1.3
PROBLEM INVESTIGATION MONITORING STRATEGY

Problem investigation monitoring, as discussed earlier, is used to investigate specific problems or protection concerns in order to develop management approaches for improving or protecting the resource. Such monitoring also is used to identify specific causes of problems and inputs or loads from various sources – both point and nonpoint. The MPCA's problem investigation monitoring goals and objectives are found in Goals W.2. and W.3., reflecting the need for both restoration and prevention.

Minnesota's problem investigation monitoring strategy is built on two cornerstones – the impaired waters program and the basin management planning process – and includes monitoring by a variety of entities, depending on the purpose.

Currently, the agency's problem investigation monitoring strategy is driven by the impaired waters program, the agency's highest priority. Under the program, monitoring will be conducted to identify sources of impairments (NPDES facilities and nonpoint sources) and allocate loads so that water quality standards and designated uses are met and degraded waters can be restored. The state's TMDL list and the priority-setting process developed by the Impaired Waters Stakeholder Team (see Appendix 2) are used as a tools to target areas that are impaired and the monitoring that is needed. The projects range from those

A Great Lake

Minnesota shares one Great Lake – Lake Superior – with its neighbors Wisconsin, Michigan and Canada. Minnesota's monitoring for Lake Superior is focused on several activities.

- Beach monitoring
- Using fish and invertebrate community indicators to assess the quality of wadable streams.
- Two years of intensive monitoring of nutrient and sediment loadings on six representative North Shore Streams
- A Lake Superior Basin Plan
- A remote sensing project examining forest age, land use and impervious surface changes over time

Minnesota's focus in the Lake Superior Basin is on prevention, thus monitoring is focused on studying landscape characteristics which affect water quality of inland lakes and streams and of Lake Superior itself. For this reason, MPCA conducts little open-lake monitoring in Lake Superior (see Section 1.12). The lake has been, however, assessed and listed as impaired for aquatic consumption, and the harbor listed for aquatic life.

Minnesota also cooperates on monitoring projects with other states and Canada through its participation on the Lake Superior LaMP and through other Great Lakes wide organizations.

as small as a single reach to those encompassing an entire basin. As such, for the foreseeable future, priority for problem investigation monitoring will be driven by the needs of the impaired waters program.

Minnesota also has adopted a basin management process for planning and managing activities within a geographic area – the basin. The basin approach allows monitoring data to be used to inform management programs within a basin through a continuous planning process. Basin water quality planning in Minnesota is being done under the direction of the Minnesota Pollution Control Agency. It is a geographically-based approach to water quality protection and restoration. The approach focuses on the state's 10 major drainage basins and is designed to 1) identify water quality problems, 2) work with local governments to establish shared goals and priorities, and 3) develop pollutant reduction strategies.

Basin plans are intended to be five-year plans, continuously updated every five years. The goals, objectives, and targets they specify are to be at least partially achievable within the five-year life span of the plan. Basin monitoring plans reflect both basin-scale and project-scale monitoring needed to measure progress in attaining basin/watershed goals. Basin coordinators and monitoring staff work together to prioritize problem investigation efforts and effectiveness efforts in each basin.

Within these two cornerstones – the impaired waters program and the basin management process – the problem investigation monitoring work is accomplished. Minnesota's strategy relies on a variety of partners to conduct problem investigation monitoring:

- monitoring by regulated parties for most of its regulatory programs (NPDES),
- a mix of MPCA and MPCA-contracted monitoring for its TMDL studies,
- local monitoring for locally-identified problems or protection concerns (through Clean Water Partnership, county water planning, local lake associations, etc.),
- MPCA monitoring to fill gaps, for special projects (fish kills, wasteloads, etc.),
- monitoring by other organizations for additional needs (USGS, Metropolitan Council Environmental Services).

SECTION 1.4
EFFECTIVENESS MONITORING STRATEGY

Effectiveness monitoring is used to determine the effectiveness of specific regulatory or voluntary management actions taken to remediate contaminated water. Effectiveness monitoring allows for the evaluation and refinement of the management approach to ensure it is ultimately successful. Effectiveness monitoring can occur at the project scale and at the systems scale. Much like problem investigation monitoring, the state's effectiveness monitoring strategy relies on monitoring activities by a variety of parties. On an individual BMP and project scale, regulated parties, local implementers, MPCA contractors, other organization and MPCA conduct effectiveness monitoring to evaluate

specific management practices or groups of practices in a specific area. And, as in problem investigation monitoring, project-scale effectiveness monitoring will be targeted to the priorities of Minnesota's impaired waters list, as those projects are implemented. The Impaired Waters Stakeholder Group in its recommendations called out the need for effectiveness monitoring during the restoration phase of the impaired waters process:

> "Completed restoration efforts must have an effectiveness monitoring component to ensure water quality standards are being met and for the purposes of delisting. Effectiveness monitoring data should also be captured to report on the status of ongoing restoration activities. Individual implementation measures need to be monitored for their effectiveness in achieving water quality goals for the impaired water body. Effectiveness monitoring can be supplemented by physical, chemical and biological monitoring and needs to be coordinated between local governmental units and state agencies."

The MPCA also identified a need for effectiveness monitoring for each TMDL implementation plan. Templates would ensure that monitoring plans meet minimum agency standards and are consistent across the state.

MPCA also includes effectiveness monitoring in some cases as part of its ongoing project-level activities, such as Clean Water Partnership and 319, as well as its regulatory management programs. Most recently, MPCA is developing an effectiveness monitoring system for its stormwater program (a description is attached as Appendix 4) and an effectiveness monitoring framework (which will be incorporated into this strategy when complete). Ongoing discussions are also occurring to identify the types and scales of effectiveness monitoring underway at MPCA and to develop a strategy for filling the gaps. As part of those discussions, MPCA has developed a draft "picture" of types and purposes, etc. (see Table 2).

Results from effectiveness monitoring activities are used to evaluate individual management activities and suites of management activities, and make changes where necessary. For example, the stormwater effectiveness monitoring activity will investigate the effectiveness of a variety of stormwater BMPs. This information will be used by permittees in choosing and implementing BMPs at their sites, and is being conducted in lieu of compliance monitoring at individual sites. In the Clean Water Partnership/319 programs, effectiveness monitoring is used by projects to evaluate implementation plans and to adapt plans as needed. As Minnesota has more experience with implementing TMDL projects, effectiveness monitoring will provide the critical check on whether projects are being implemented and whether the water is being cleaned up, as well as providing effectiveness information to future TMDL implementation projects.

At the systems scale, Minnesota's condition monitoring strategy will provide effectiveness monitoring. The four-part condition monitoring strategy will not only provide data for surface water assessments, but will also provide data over the course of subsequent monitoring cycles to evaluate effectiveness, where implementation plans have

been implemented. This monitoring will also provide the data necessary for delisting of impaired waters.

Table 2. Draft MPCA Effectiveness Monitoring Matrix: types, scales and purposes

Common to all types of effectiveness monitoring:

- There is always comparison in effectiveness monitoring (before/after, comparison to a standard, above/below, paired, reference sites).
- For effectiveness monitoring we need: a network of scales, baseline information (land use included), reference sites, and communication among scales.
- Effectiveness monitoring examines cause and effect (and the reason for it) and is used to adjust (at various scales).
- Uses statistical methods/approaches.
- $$$

Cautions and Questions:

- We need to get enough implementation in place to detect change (experts suggest ~60%)
- Design is important; effectiveness monitoring should be designed to answer a specific question
- What's the role of modeling and the relationship of remote sensing?

Scale	Description	Answers the questions:	Focus	Examples
Plot Scale Effectiveness	Research-level monitoring directed at individual practices in controlled setting.	Does the BMP work? What's the effect of implementing the BMP?	Focus on inputs and outputs for a single practice. Uses statistical methods, replicates and controls.	U of M, USDA Ag Research Service efforts. Usually not MPCA.
Field Scale Effectiveness	Monitoring directed at single or sets of practices in a "real world" setting. Compliance monitoring could be considered a subset	Do the BMPs work in an uncontrolled setting? Do the practices result in facility compliance?	Focus on physical and chemical changes related to single or sets of practices; need to know land use/land use changes, wet/dry cycles	Compliance monitoring, BMP effectiveness monitoring
Project/ Program Scale Effectiveness[4]	Monitoring directed at sets of practices or activities implemented over a larger area with multiple landowners and operators. Ranges of things used to evaluate effectiveness.	How much was spent? How many regulations enforced, BMPs adopted? Are behaviors changing (social changes)? Are the cleanup plans working? Is water quality getting better?	Focus on environmental (physical, chemical, biological), program and social indicators; measures aggregate effects and outcomes; need to know land use/ land use changes, wet/dry cycles	Whitewater River, Clean Water Partnership projects (e.g., Lake Shaokatan), TMDL implementation plan, 319 project monitoring.
System (resource) Scale Effectiveness	Monitoring directed at environmental conditions within major watersheds, basins or statewide	Are water quality goals and standards being met? Is the water quality getting better or worse (trends)?	Focus on environmental (physical, chemical, biological) indicators	Condition Monitoring with long-term flow in major watersheds, Basin Assessments (e.g., Upper Mississippi River)

[4] We could add a "Small Watershed" scale between Field Scale and Project/Program Scale. The small watershed scale would address multiple practices and multiple landowners, and answer the questions related to how many practices were adopted?, was this enough to show changes in water quality?, etc. The focus of small watershed scale monitoring is either that of field scale or project/program scale. An example might be monitoring associated with wetlands restoration in Chain of Lakes.

SECTION 1.5
MPCA SURFACE WATER MONITORING PURPOSES, DESIGNS AND INDICATORS

This section addresses the varying purposes of the MPCA's monitoring activities, the monitoring designs used and the indicators chosen. Section 1.6 provides information on the surface water quality monitoring activities of organizations external to the MPCA.

The MPCA currently operates a variety of monitoring activities for a variety of purposes. A brief description of each of the current activities by type of monitoring – condition, problem investigation, and effectiveness – is provided in the following section.

1.5.A MPCA SURFACE WATER MONITORING ACTIVITIES

The following descriptions provide information on the primary MPCA condition, problem investigation and effectiveness monitoring activities. Each description provides information on the activity start date, purpose, monitoring design used to meet the monitoring purpose and indicators.

MPCA Condition Monitoring Activities – Rivers and Streams

- **MPCA Milestone Monitoring:** (1953 at some sites[5]). A fixed station design with periodic grab sampling for a suite of conventional chemical/physical parameters. Samples are collected monthly for ten months of the year. Currently there are 80 sites, with 32 sites monitored each year on a rotating basin basis. Almost all sites now have some type of flow measurement available. Purpose of the monitoring is to compare basic water chemistry to water quality standards, looking at trends at a consistent set of sites. *Parameters: Dissolved oxygen, temperature, pH, nitrite/nitrate nitrogen, ammonia nitrogen, conductivity, turbidity, and fecal coliform bacteria and/or E. coli (collected for special projects and when sample holding times can be met); when continuous flow data is available: total phosphorus, chlorophyll-a, pheophytin 5-day biochemical oxygen demand, residue, total non-filterable (total suspended solids), suspended volatile solids.*

- **MPCA Integrated Monitoring in Streams**, with DNR: (1990). A statistically-based design with random site selection. Periodic grab samples collected for integrative biological, physical, and chemical parameters. Currently sampling at 200 sites per year, on a rotating basin basis. Plan to include a progressive design

[5] While there have been changes in sites over time, for many of the current Milestone sites the period of record starts with 1953. From 1953-1967, monitoring was done under the Water Pollution Control Commission, the predecessor of the MPCA. In the early 1990s, MPCA chose for continuing monitoring a consistent set of sites for which it had the most years of data. The name of the program was also changed to Minnesota Milestone Monitoring, reflecting that a major purpose of this program was trends over time.

component (following the Ohio model) that will systematically move up individual watersheds, providing greater confidence that streams are being assessed without cost-prohibitive levels of monitoring. Information used for biocriteria development, trend monitoring, 305(b) and 303(d) assessments and reporting, evaluation of water quality permit limits, and evaluating water quality standards. *Parameters: composite index of fish and invertebrate community characteristics; dissolved oxygen, conductivity, nutrients, turbidity, stream flow, bottom type, bank stability.*

- **MPCA River Nutrient Studies** with USGS (1999): A fixed station design with periodic grab sample, physical/chemical parameters. Samples are collected at about 20 river sites and combined with USGS flow records. Data is used to provide basis for standards, nutrient criteria. Also used for research, model development. *Parameters: Nutrients, chlorophyll-a and related data.*

- **MPCA Trace Metals in Streams** (1996): Fixed station design with samples collected on a rotating basin basis. Samples are collected at locations to represent basin characteristics. Basin-focused measurement of metals in whole water and dissolved-phase of streams. Data is available for six basins to date. Information is used for waterbody assessments, including 305(b) use assessments and 303(d) listing, assist in the development of water quality standards and effluent limits, and to estimate typical metal concentrations in surface waters of the basin. *Parameters: Hg, As, Cd, Cr, Cu, Pb, Ni, Zn and hardness in whole water and dissolved-phase of streams.*

- **Citizen Stream Monitoring Program** (1998): A self-selected volunteer effort, with periodic sampling. Focus is citizen monitoring of river water clarity using a transparency tube. Currently, there are approximately 500 volunteers; the strategy calls for citizen monitoring at 3,600 stream sites. Citizens monitor the transparency of MN rivers and streams for baseline conditions, goal setting, trend identification and targeting more intensive monitoring. *Parameters: Transparency, with chemistry at selected sites.*

- **MPCA Basin Assessments** (2002): Basin assessments are condition monitoring activities conducted as a component of basin management. Upper Mississippi River initiative is currently underway. A fixed station with continuous (automated) monitoring, with 28 stations in the basin. The overall purpose is to assess condition of basin tributaries and main stem rivers, and the information is used to identify trends and exceedences of standards. This monitoring supports the calculation of loadings of solids and nutrients for major tributaries in the basin. Basin assessments also serve as effectiveness monitoring on a basin scale. *Nonpoint parameters: nutrients, TSS, BOD, fecal, TDS and turbidity for all sites and chlorophyll a, periphyton, chloride and suspended volatile solids at some sites.*

MPCA Condition Monitoring Activities – Lakes

- **MPCA Intensive Study Lakes,** with DNR and MDH (fish tissue sampling began in 1968): MPCA collects predator fish and one-year-old panfish for mercury and other contaminant analysis. Sampling is focused on 100 lakes, monitored approximately every five years. The information is used to identify trends in fish-tissue mercury concentrations and is also used for 305b and 303d assessments. *Parameters: Mercury*

- **MPCA Lake Trend Analysis** (1985): An ecoregion-based monitoring design using fixed-station reference lakes. Lakes are chosen based in part on Citizen Lake Monitoring Program trends. The monitoring purpose is to characterize trophic status for each ecoregion in Minnesota. The information is used to develop status and trend reports for Minnesota lakes, and also for 305b and 303d assessments and to develop water quality criteria for lakes. *Parameters: pH, conductivity, Secchi disk, temperature (profile), dissolved oxygen (profile), total phosphorus, total Kjeldahl nitrogen, nitrate/nitrite nitrogen,residue, total non-filterable (total suspended solids), alkalinity, chloride, color, turbidity, chlorophyll-a.*

- **MPCA Lake Assessment Program**, with local lake associations (1985): A fixed station design with monthly sampling from May-September, with more than 160 studied since 1985. The information is used to develop status and trend reports for Minnesota lakes and for 305(b) reporting, as well as to recommend actions for local lake management efforts. *Parameters: Secchi disk transparency, nutrients, chlorophyll a, solids, pH, color, plus a depth profile of oxygen and temperature. Fisheries and lake level measures provided by DNR.*

- **Citizen Lake Monitoring Program** (1973): A self-selected volunteer effort, with periodic sampling. A network of Citizen monitoring of lake water clarity using Secchi disk, with about 1200 volunteers; the strategy calls for monitoring lakes greater than 100 acres (about 4,000). Limited chemistry is collected at selected sites. Information is used to monitor the transparency of MN lakes for baseline conditions, goal setting and targeting, and trend identification. *Parameters: Secchi disk transparency, chemistry at some sites.*

MPCA Condition Monitoring Activities – Wetlands

- **MPCAWetland Monitoring** (1996): MPCA samples wetland aquatic plants and invertebrates to develop an Index of Biotic Integrity (IBI) for each wetland. The

current focus is on developing IBIs for depressional wetlands statewide before attempting to focus on other types of wetlands. An IBI is a good indicator of the condition of Minnesota's wetlands. The information will be used for status and trends, as well as for problem investigation and effectiveness monitoring. In the future, the information can also be used in permit issuance and possibly in the TMDL process.[7] *Parameters: Aquatic plants, aquatic invertebrates to the species level, general chemistry, sediment toxicity.*

- **Wetland Health Evaluation Program** (1996): A self-selected volunteer effort, with periodic sampling in two metro-area counties (Dakota and Hennepin). MPCA provides annual training. The data is used in water resource and city planning decision making. *Parameters: Aquatic plants, aquatic invertebrates to the family level.*

MPCA Problem Investigation Monitoring Activities

- **TMDL reports** (1999): Monitoring associated with completing TMDL studies, i.e. the TMDL itself. The monitoring conducted by local groups, contractors and the MPCA, with designs varying by parameter. The monitoring is used to develop the TMDL allocations. *Parameters: dependent on impairment, fecal coliform, turbidity, dissolved oxygen, ammonia, chloride, pH, temperature, impaired biota, excess nutrients, mercury and PCB in water, mercury and PCB in fish tissue, various toxics in the St. Louis River.*

- **Clean Water Partnership Phase I** (1987): Clean Water Partnership supports locally-based monitoring projects, funded through MPCA. Projects involve flow-based monitoring of watershed inputs to a lake, river or wetland to determine loadings in areas of local concern. The information is used to determine the major sources of a water quality concern, develop goals and identify strategies for achieving goals. Monitoring data is also used to provide input data for models. Currently Clean Water Partnership is in transition, and funds are used solely for implementation. In the future, as funding is identified for impaired waters, Clean Water Partnership funds may again be used for diagnostic work and TMDL development. *Parameters: Project dependent, most common are those related to runoff – nutrients, nitrogen, phosphorus, sediment, flow and hydrological modifications.*

- **Fishkill investigations and discharge violations** (1950s): This monitoring involves case-specific designs, usually with upstream and downstream sampling

[7] A note on wetlands: Minnesota has 10.6 million acres of wetlands. Currently, the MPCA is not assessing wetlands for TMDL listing purposes. To meet its newly-established goal of assessing 25% of the state's depressional wetlands by 2014, the MPCA will begin with a dual approach. By June 30, 2005, the MPCA will sample 50 to 75 depressional wetlands on forested land, from which an IBI report will be developed. The MPCA will also work with its partner agencies to develop a long-term monitoring plan for Minnesota wetlands. This plan will be completed by June 30, 2005 and will include a focus on wetland inventory needs using remote sensing techniques. The plan will be attached to the final strategy.

and sampling of candidate cause, if suspected. Sampling includes water quality and released material collection, with fish and wildlife collections made in conjunction with DNR. The data is used for incident response, water quality impact documentation and enforcement case development (supporting emergency response, NPDES and feedlot programs). *Parameters: case-specific; for manure & wastewater releases: general chemistry (pH, conductivity, TSS, turbidity, chloride, sulfate, BOD5), nutrients, metals, and fecal coliform; for manure, fecal strep; for industrial or releases of unknown origin, most of above plus more comprehensive metals, VOCs, SVOCs and pesticides; others as case requires.*

- **Waste Load Allocations to Support NPDES Program** (1977): The MPCA monitors chemical or physical parameter of concern on selected streams and rivers receiving discharges from municipal wastewater treatment plants. The monitoring typically consists of two, 2 to 3 day surveys under low-flow conditions. Approximately 100 surveys at 500+ stations have been conducted to date. The data is used to determine appropriate effluent limits for a discharge so that water quality standards are maintained and the designated uses protected, with effluent limits incorporated into NPDES permits. *Parameters: Diurnal DO, temperature, pH, flow, time of travel, physical measure of stream channel, CBOD, nutrients, chlorophyll a, TSS, turbidity, conductivity, alkalinity, chloride, sometimes metals. Also composite sampling of wastewater effluent.*

- **MPCA Lake Superior Beach Monitoring Project**, with MDH and local organizations (2003): MPCA conducts tiered monitoring at 36 Lake Superior beaches for bacteria.[8] The information is used to assure safe and healthy aquatic recreation and inform the public about risks of contracting waterborne diseases from exposure to contaminated water. *Parameters: Fecal coliform and E. coli*

- **Fluvial Geomorphology**: This is an emerging monitoring activity, only beginning to be developed at the MPCA. The information can be used to assess water bodies by considering physical conditions.

MPCA Effectiveness Monitoring Activities

- **Stormwater Monitoring** (2004): Monitoring design under development. The data will be used to evaluate effectiveness of MPCA's stormwater permitting programs and best management practices. *Parameters: Flow and chemistry.*

- **Monitoring associated with TMDL implementation plans** (2003): Monitoring by local groups or MPCA to evaluate effectiveness of TMDL implementation plan/BMPs and ultimately to delist a particular water body. At a minimum, the monitoring will meet the delisting guidance in MPCA's *Guidance for Assessing*

[8] Tiered monitoring involves ranking Lake Superior beaches into three tiers based on a variety of factors including primary contact recreational use, extent of use, known pollution sources, potential risk and public input. A monitoring design is then developed for each tier identifying monitoring frequency, sampling location, depth of samples, etc.

Water Quality Impairments. In addition, monitoring design is customized, based on parameter or BMP implemented. In cases where a pesticide TMDL is implemented, MDA monitoring program efforts will play a large role, and may need to be enhanced to satisfy the TMDL requirements. *Parameters: Dependent on impairment: Fecal coliform, turbidity, dissolved oxygen, ammonia, chloride, pH, temperature, impaired biota, excess nutrients, mercury and PCB in water, mercury and PCB in fish tissue, or various toxics in the St. Louis River.*

- **NPDES effluent monitoring** (1970s): Monitoring by permittees for parameters required in permits. Frequency varies by parameter, by size and type of facility, from continuous to a few samples per year, and includes tile-line discharge monitoring at NPDES feedlots. The data is used for compliance determination, standards development and enforcement. *Parameters identified in individual permits. Typical parameters for domestic wastewater include: flow, CBOD, TSS, pH, Phosphorus, DO Fecal coliform, chlorine residual. For industrial: flow, TSS, temperature. May be additional parameters based on situation.*

- **Up/down stream monitoring to support NPDES permit program** (ongoing): Approximately 110 permittees conduct this monitoring, at 270 stations. Designs are based on permit issues, frequency of sampling ranges from once per week to conditional monitoring during low-flow conditions. The data is used to evaluate effluent limits for an NPDES permit, compliance determination, requirement of variance process. *Parameters: dependent on situation (about 30 total for all permits); typically includes DO, temperature, pH, ammonia, phosphorus.*

- **Monitoring associated with feedlot regulatory activities:** Case-specific monitoring design as part of enforcement case development. The data is used to verify information for enforcement cases. *Parameters: Fecal and BOD.*

- **Monitoring associated with ISTS regulatory activities** (1980s): Occasional monitoring at cluster systems or large, multi-party drainfield systems in shoreland areas. The monitoring is required as part of the specific permit. Data is used to determine impact of system on water body. *Parameters: Phosphorus*

- **Monitoring to evaluate Clean Water Partnership implementation projects, 319 projects, etc.** (Late 1980s): Locally-based projects, jointly funded through MPCA and external organization. The monitoring designs vary by project and BMPs implemented. An example is the Whitewater River Watershed National Monitoring Project.[9] The information is used to assess the effectiveness of nonpoint source water-pollution-control efforts. Although some projects include monitoring for effectiveness, most do not and effectiveness monitoring needs to become a standard component within projects. *Parameters: Depends on project.*

[9] In *2003 Annual Report to the U.S. Environmental Protection Agency on Clean Water Act Section 319 and Clean Water Partnership Projects in Minnesota* (attached as Appendix 5).

Most common are those related to runoff – nutrients, nitrogen, phosphorus, sediment, flow and hydrological modifications.

- **Basin Assessment**s (2002): See "Condition Monitoring". The information is used to evaluate basin-scale effectiveness of implementation projects.

As the descriptions indicate, the MPCA operates a number of monitoring activities, for a variety of purposes. Each monitoring activity has one or more designed objectives, although in most cases the data is also used for one or more secondary purposes. Tables 7 – 9 provide an overview of the monitoring activities and the major Water Quality Management Program areas they support. MPCA's priority information needs are related to the Impaired Waters Program: 305b/303d assessments; TMDL allocations; and effectiveness monitoring related to TMDL implementation.

1.5.B MPCA SURFACE WATER MONITORING DESIGNS

Minnesota currently uses a mix of monitoring designs to address its variety of purposes and information needs. Monitoring designs differ in terms of at least three variables: how the site is selected (fixed, random, self-selected); how often the sampling occurs (periodic, continuous, or targeted); and which parameters are sampled.

In general, Minnesota's strategy uses a combination of designs in its condition monitoring – fixed stations with periodic sampling for assessing trends; probabilistic-based sampling and a progressive design for integrative biological sampling to ensure comprehensive coverage and a high degree of confidence; and self-selected periodic sampling as a targeting tool. Remote sensing will be added to this mix, to provide additional targeting assistance.

Table 3. MPCA Condition Monitoring Design Types and Examples

Design Type	MPCA Monitoring Activity Example	Comments
Fixed station	Milestone sites, Lake Trends	MPCA uses for status and trend information; contains long-term information
Probabalistic	Integrated streams	MPCA uses random design to provide confidence in applying information to a larger area
Self-selected	Citizen Lake Monitoring Program, Citizen Stream Monitoring Program	Provides great degree of geographic coverage; combined with other information can be used for a variety of purposes, including as a targeting tool

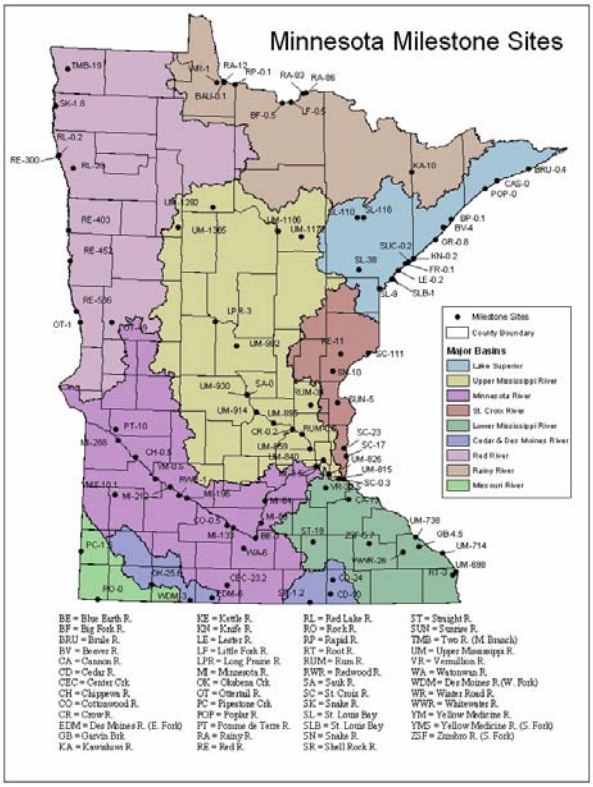
The MPCA also uses a rotating basin approach for its primary stream monitoring activities (Milestone monitoring, integrated monitoring, and trace metals monitoring. Table 4 below identifies the rotating basin approach for Milestone monitoring and Trace Metal monitoring for the next ten years. Figure 4 identifies the Milestone sampling sites, some of which have been sampled for more than 50 years and provide information on long-term trends.

Table 4. Rotating Basin Schedule for Milestone and Trace Metal Monitoring

Basin	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Red	M T	M T		M			M		M		
Superior		M			M		M			M	
Minnesota	M T		M			M		M			M
Upper Miss	T	M		M			M		M		
Lower Miss			M		M			M		M	
St. Croix	M	T	T	M T		M			M		M
DesMoines	M		M			M		M			M
Missouri	M T		M			M		M			M
Cedar	M		M			M		M			M
Rainy		M			M		M			M	

M = Milestone monitoring T = Trace Metal monitoring

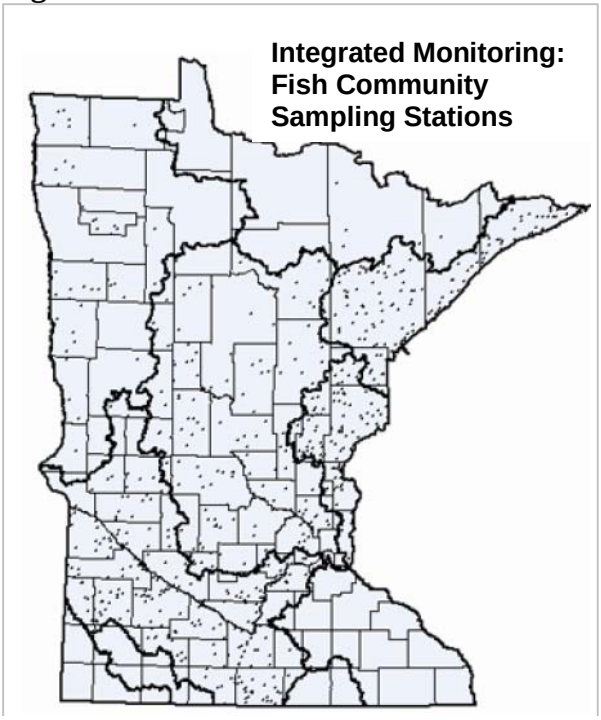
Figure 5. Milestone sampling sites



Design for Integrated Monitoring

MPCA's integrated monitoring uses a probabilistic design, which, under the strategy, will be coupled with a progressive approach to provide complete assessment of Minnesota's lakes and streams. All approaches will be conducted on a rotating basin basis (see Table 5). Sampling sites for fish sampling to date are shown in Figure 6.

Figure 6.



For the random design, sites are randomly selected for condition monitoring as part of the Environmental Monitoring and Assessment Program (EMAP). Latitude and longitude coordinates (x-site) are provided by EPA, Corvallis. A stream information sheet is supplied for each site which contains locational information and a stream trace, making it possible to determine the location of the site on a USGS 7.5" topographic map and the state DeLorme atlas. This statistical method requires sampling approximately 50 locations to make valid scientific statements about the condition of the whole basin.

Added to the random design, the MPCA's integrated monitoring activity will also include a progressive watershed approach. The approach uses a geometric sampling design, modeled after work underway in Ohio. Ohio EPA[10] describes this approach as follows: "This design utilized both a linear approach and a stratified approach. In the linear approach, sites are arranged to achieve distance from each other and in relation to known potential pollution sources. In a stratified approach, sites are characterized by similarities and levels of particular interest are selected for study." With geometric site selection (stratified approach), basins are sequentially subdivided into sub-basin areas. Sites which most closely match these stratifications are selected for inclusion in the study. This provides coverage of rivers and streams to the 25 square mile scale resolution, without monitoring each and every stream reach. This approach is particularly good at locating impaired sites.

By using this two-part sampling design, MPCA believes that its strategy will provide complete coverage of Minnesota's streams. In addition, citizen monitoring and remote sensing will provide even greater geographic coverage, targeting additional sites for assessment.

[10] Ohio Environmental Protection Agency. 2000. *Biological and Water Quality Study of Sugar Creek 1998.*

Currently, the rotating basin schedule for the MPCA's integrated monitoring (Table 2b) is in draft. The draft schedule is based on a 10 year repeat cycle for trend analysis. It is important to note that the IBI development (targeted monitoring) is near completion, and MPCA will use 2006 to conduct any targeted site sampling that may be needed to complete the data needs for a statewide IBI.

The random site sampling will be designed for a new view of basin conditions and for trend analyses. MPCA will continue its discussions with EPA in the near future to statistically design for time trend analyses using random site selection.

The progressive monitoring component with geometric site selection will focus on progressive monitoring in two basins in 2006 and 1 basin in each of the following years through 2014. Major basins will be chosen for progressive monitoring based on the needs of the TMDL program.

Table 5. Rotating Basin Schedule for Integrated Monitoring

Basin	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Red		T R								R	
Superior					R						
Minnesota							R				
Upper Miss	T R					R					
Lower Miss								R			
St. Croix				R							
DesMoines	T R								R		
Missouri	T R								R		
Cedar	T R								R		
Rainy		T R									R
Statewide			T								

T = Targeted (IBI development) R = Random

For problem investigation monitoring, designs are generally fixed station sampling targeted to certain conditions: high flow; low flow; rain events; etc. For nonpoint source projects, streamflow monitoring is part of the design to estimate the pounds of pollutants being generated from watershed sources. Effectiveness monitoring designs at the system level is often similar to condition monitoring and at the project level often involves continuous monitoring.

1.5.C MPCA SURFACE WATER MONITORING INDICATORS

Much like monitoring designs, the indicators used in MPCA's monitoring activities also vary by monitoring purpose. Condition monitoring for rivers and lakes are routinely analyzed for a standard set of chemicals and water quality characteristics, as described in the summaries of MPCA monitoring activities above. Other monitoring efforts will sample for additional chemicals consistent with the purpose of the monitoring.

For assessing water bodies, MPCA uses a core set of indicators, supplementing them with other parameters depending on the situation. The parameters included in the core indicators are different for streams and rivers, wetlands and lakes. The core indicators are used in most of the MPCA's monitoring activities, although fish and invertebrate IBIs are only used in the MPCA's integrated monitoring and aquatic consumption data is collected by the Minnesota Department of Natural Resources.

Table 6. Core indicators for assessing the condition of Minnesota's waters

Indicator	Streams	Lakes	Wetlands
Aquatic Life	Fish and invertebrate IBI Toxics (ammonia, chloride) Dissolved oxygen pH Temperature Turbidity[11] Atrazine and other agricultural pesticides[12]	Evaluating feasibility of using DNR's fish IBI	Plant and invertebrate IBI
Aquatic Recreation	Fecal bacteria[13]	Nutrients Transparency Chlorophyll	
Aquatic Consumption[14]	Fish PCBs Fish mercury Mercury in water column	Fish mercury Fish PCBs	
Drinking water	See page 60	See page 60	

At all of its integrated monitoring sites, the MPCA also considers physical indicators (flow, bottom type, bank stability). While these physical indicators are considered in assessing the condition of water bodies, MPCA does not list waters impaired for habitat, and thus these indicators do not appear on the table above. In addition, at other sites, MPCA is exploring the use of geomorphology to assess the condition of streams. Using geomorphological indicators is an emerging activity at MPCA.

[11] Currently turbidity data is used for assessing aquatic life use; in the future, turbidity may be moved to the aquatic recreation category.
[12] Data provided by Minnesota Department of Agriculture and used principally as a secondary parameter for further diagnosis.
[13] MPCA expects to use *E coli* in the future.
[14] The Minnesota Department of Natural Resources collects this data, in cooperation with the Departments of Agriculture and Health, and MPCA.

As MPCA develops its bioassessment capacities, the agency expects to rely more and more on fish and invertebrate IBI for its aquatic life assessment and rely less on toxics and other parameters. These parameters will likely become secondary parameters in many situations, used for stressor identification, to diagnose problems identified through bioassessment. The parameters will continue to be used for other purposes, such as at Milestone sites to track trends over time.

In addition to the core indicators, MPCA monitoring programs may consider other parameters of concern. For example, lake assessments (individual lake reports) require greater detail, and the MPCA includes watershed characteristics, lake level, fishery composition, description of the plant communities, user perceptions and other parameters. Temporal trends in lakes are assessed based upon current and historic trophic status data. For criteria development, a high degree of detail is needed with information on how the indicators relate to each other and influence the condition of the water body.

Similarly in streams, monitoring programs may include additional indicators, depending on the particular purpose or need. As an example, on the Lower Mississippi River, and interstate water, MPCA uses PCBs in the water column to assess for aquatic consumption. In this case, the State of Wisconsin has identified the need and provides the data for use in Minnesota's assessments. Examples of differing purposes requiring additional indicators can also be found in stream nutrient criteria development. To develop nutrient criteria for streams, data on nutrients and solids in streams is necessary, requiring monitoring programs to add such indicators beyond the core.

Problem investigation and effectiveness monitoring also require different indicators and parameters because the monitoring activity is focused on particular chemicals of concern or in cases where load calculations are needed. Loadings of nutrients and solids are also evaluated as part of problem investigation nonpoint source projects to identify contributions to the tributary, as well as contributions of the tributaries to the main stem of the river. In this manner, MPCA makes decisions on which indicators are needed beyond its core indicators based on the particular purpose of the monitoring.

MPCA is currently exploring how to use transparency as an indicator in stream assessments. MPCA uses transparency data from secchi disks as a factor in the assessment of lakes, and MPCA would like to find a similar way to use transparency tube data as part of its stream assessment. As volunteer monitoring increases under Minnesota's monitoring strategy, it will be important to identify ways to use the transparency data in the assessment process.

At a programmatic level, the MPCA tracks another set of indicators to evaluate the effectiveness of its monitoring program. Programmatic indicators used for surface water monitoring include: percent of stream miles assessed; percent of lakes assessed; use of data external to the MPCA; lakes and streams monitored by citizen volunteers; and number of lakes and streams impaired. By tracking these programmatic indicators over time, MPCA can assess Minnesota's progress in monitoring its waters.

In the future, MPCA may consider developing additional indicators for such things as emerging issues, as well as consider diagnostic indicators, microbial stressors, methods comparability studies, biological condition/human disturbance gradient, etc. It is important to note that MPCA staff are currently involved in two methods comparability studies – one related to total suspended solids (TSS) and total phosphorus and another related to coliform. Both studies were begun because of widely divergent analytical results from different organizations sampling at the same sites or sites within close proximity. The methods being targeted are for parameters that help determine TMDLs, and are fundamental to determining whether a lake or stream should be included on the 303(d) list. The TSS/TP study is currently underway, and the coliform study is complete.

As time goes on and monitoring activities mature, MPCA will be in a better position to assess the need for such additional indicators.

Table 7. Relationship of MPCA Condition Monitoring Activities to Major Water Quality Management Program Areas

	Basic Reporting		**WQS Program**					**Watersheds/NPS**		**TMDL/303d/ 305b**		**NPDES/Other Permitting**						
	Status	Trends	Tiered Uses	UAA	Refined WQC	Anti-deg	Site-specific Crit.Mod	NPS/BMP/ Local issues	Hab-itat	List/ Delist	TMDL Dev.	WQ BELs	Priority Setting	Storm-water I & II	WET limits/ Cond.	Sever-ity/ Extent	Enforce-ment	Promote water steward-ship
Milestone Sites	❶	❶		❷	❷	❷	❷	❷		❷	❷	❷						
Integrated Stream Monitoring	❶	❶	③	③	❷		❷	❷	❷	❶	❶	③						
River Nutrient	❶				❶													
Trace Metals in streams	❶				③					❶	❷	❷						
CSMP	❶	❶						❶		③	❷							❶
Basin Assmts	❶	❶						❶										
Intensive Study Lakes	❶	❶			❶					❶	❶	❷						
Lake Trends	❶	❶			❶		③	❷		❶	❶	❷						
Lake Assmt Prog	❶	❶						❶		❶	❷	❷						❶
CLMP	❶	❶						❶		❷		❷						❶
Wetland Monitoring	❶	❶								③		❷		❷				❷
Wetland Health Eval Prog	❶							❶										❶

❶ = Design objective
❷= Secondary use
③ = Planned/potential future use

Table 8. Relationship of MPCA Problem Investigation Monitoring Activities to Major Water Quality Management Program Areas

	Basic Reporting		**WQS Program**					**Watersheds/NPS**		**TMDL/303d/ 305b**		**NPDES/Other Permitting**						
	Status	Trends	Tiered Uses	UAA	Refined WQC	Anti-deg	Site-specific Crit.Mod	NPS/BMP Diagnosis	Hab-itat	List/ Delist	TMDL Dev.	WQ BELs	Priority Setting	Storm-water I & II	WET limits/ Cond.	Sever-ity/ Extent	Enforce-ment	Promote Water Steward-ship
Monitoring assoc. w/ TMDL reports								❶		❷	❶	❶	❷			❷	❷	
CWP Phase I								③		❷	③							❶
Fishkill investigations and discharge violations																❶	❶	
Waste Load Allocations					❷		③			❷	❷	❶				❶		
Basin Assmts								❶			❷							
Lake Superior Beach Monitoring	❶	❷								❷								

❶ **= Design objective**
❷ **= Secondary use**
③ **= Planned/potential future use**

Table 9. Relationship of MPCA Effectiveness Monitoring Activities to Major Water Quality Management Program Areas

	Basic Reporting		**WQS Program**					**Watersheds/NPS**		**TMDL/303d/ 305b**		**NPDES/Other Permitting**						
	Status	Trends	Tiered Uses	UAA	Refined WQC	Anti-deg	Site-specific Crit.Mod	NPS/BMP Effec.	Hab-itat	List/ Delist	TMDL Dev.	WQ BELs	Priority Setting	Storm-water I & II	WET limits/ Cond.	Sever-ity/ Extent	Enforce-ment	Promote Water Steward ship
Storm water monitoring								❶						❶				
Monitoring in TMDL implem. plans								❶				❶	❶				❷	
NPDES effluent monitoring					❷	❷	❷					❶	❷		❶	❶	❷	
Up/down stream NPDES monitoring					❷	③	❷					❷	❷	❶				
Feedlot regulatory monitoring																	❶	
ISTS regulatory monitoring								❶										
CWP implement 319 proj.								❶		❷								❶
Basin assessmt.								❶		❷								

❶ **= Design objective**
❷ **= Secondary use**
③ **= Planned/potential future use**

SECTION 1.6
EXTERNAL ORGANIZATION MONITORING

As discussed earlier, Minnesota's monitoring strategy is made up of a four-pronged approach which includes data collection by other organizations and citizen monitoring.

The following provides a brief description of the monitoring purposes, designs and activities of other Minnesota organizations involved in surface water quality monitoring: Minnesota Lake Association, Rivers Council of Minnesota and Rivers Network; Minnesota Department of Agriculture; Minnesota Department of Natural Resources; U.S. Geological Survey; Metropolitan Council Environmental Services; and University of Minnesota Water Resources Center.

This section will be expanded to include monitoring activities of other organizations as needed.

1.6.A VOLUNTEER CITIZEN MONITORING: MINNESOTA LAKES ASSOCIATION, RIVERS COUNCIL OF MINNESOTA AND RIVER NETWORK SURFACE WATER QUALITY MONITORING ACTIVITIES

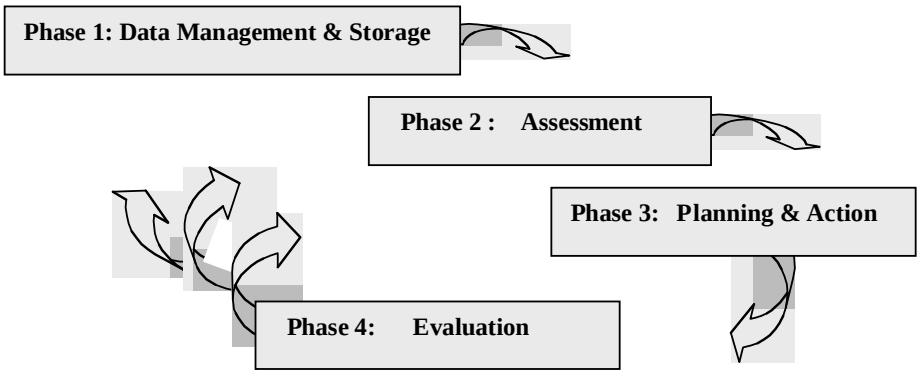
Minnesotans are interested in water quality monitoring across the state. Numerous individuals and groups undertake monitoring activities at many levels – through basin groups; county water planning; lake associations; and on an individual basis because they care about their lakes. The Rivers Council of Minnesota (RCM), the Minnesota Lake Association (MLA) and the River Network (RN) work together to encourage and empower citizens to engage in water quality monitoring and to ensure that citizen data is used in water management decision-making.

In 2002, the organizations for the McKnight Foundation conducted an evaluation to (1) explore if, how and by whom citizen volunteer monitoring data is used to guide surface water resource management decisions and actions in Minnesota; (2) identify the barriers and opportunities to using citizen volunteer monitoring data to guide decisions and/or take action at various levels; and (3) use this information to recommend how to make citizen monitoring more effective in Minnesota. A full copy of the report is attached as Appendix 6.

The evaluation found that the top three intended data users for citizen monitoring data are the MPCA, local organizations (most often local and quasi-local governments), and the monitoring groups themselves. The evaluation demonstrated that citizen monitoring groups produce outcomes – increasing understanding of water body conditions, changes in attitudes, changes in behavior and changes in the condition of the water body due to restoration or protection. Additional findings included that many citizen monitoring groups lack monitoring plans that specify intended users and uses and how they intended to gather the data (Figure 7); that the "data pathway" (Figure 6) is key to understanding how data is used; that there are barriers at various points along the pathway or within the system; and that there are key ingredients for program success, starting with strong leadership, funding, keeping volunteers informed and

motivated and having clear monitoring objectives to establishing partnerships with data users, data collection with a definite purpose and use, help in interpreting data, and having local data users.

Figure 7: Generic Data Pathway



Phase 1: Data Management and Storage - compiling, entering, validating, and storing the data.
Phase 2: Assessment – summarizing and analyzing the data to determine patterns and comparing the monitoring data to known benchmarks (such as reference conditions or state water quality standards) to see if the water body(s) are healthy.
Phase 3: Planning and Action – reporting and presenting the data to the intended users, developing protection and/or restoration plans, and carrying out the actions in the plan.
Phase 4: Evaluation – comparing intended and actual uses of the data with the outcomes they produced to see if the actions worked.

Based on these findings, the Rivers Council of Minnesota, Minnesota Lake Association and the Minnesota River Network identified the following conclusions and recommendations:

General Conclusions

- Minnesotans really care about their lakes and streams and are willing to put in a lot of time and effort to monitor and protect them.
- Like the lakes, streams and watersheds of Minnesota, citizen volunteer monitoring programs are complex and unique from place to place.
- Citizen volunteer groups' data are frequently not used by their intended users.
- Citizen volunteer programs that are successful in having their data used by their intended users have a few common key ingredients: strong leadership; partnerships with clearly identified local data users; and informed, involved and motivated volunteers.
- The pathways from raw data to its use to attain healthy waters are complex and need to be clarified.
- Volunteer monitoring has been an effective tool in producing "learning-based" outcomes and even restoration and protection actions. It has been less effective to date in measuring the resulting positive changes in the condition of water bodies.
- Support services for citizen volunteer monitoring groups are not consistently available and, where they are available, groups are not taking full advantage of them.
- Given the reality of reduced public and private funds, fewer dollars will be available to support volunteer monitoring. A new funding approach is needed.

General Recommendations

- Every citizen volunteer monitoring group (including CLMP and CSMP) should prepare a monitoring plan that is designed to provide information useful to achieve its specific outcomes. These plans should specify: Intended uses and users of the data, along with their data requirements; monitoring activities (indicators, sites, frequency, etc.) that will meet those requirements; how the data will be managed, summarized, and assessed; and quality assurance measures.

- Clear and user-friendly guidance should be produced by data users and state service providers that identify different monitoring program options and their associated data requirements. This guidance should include: the data and data quality requirements of state and local data users; a standardized monitoring design process; a few standardized monitoring plans geared to different data uses and users, water body types, purposes, etc. These should include recommended indicators. Acceptable sampling/analysis methods, procedures for demonstrating the comparability of alternative methods, and guidance for site selection and frequency, data reporting formats, etc. and meta data needed: basic information about the data set – e.g. program name, who collected and analyzed, the samples, site location info, etc.

- RCM and MLA should continue to build and coordinate a statewide service network that provides technical, organizational, and networking services. In order for successful development of a coordinated network to happen, there needs to be players providing guidance, advice, training, networking, consultation, and coordination in a variety of content areas:

Organizational Development Topics	Technical Topics
Fundraising	Monitoring Plans
Program and strategic planning	Monitoring Techniques
Leadership development	Data Interpretation
Volunteer recruitment, etc.	Quality Assurance
	Data to Action

  Other services include advocating for citizen volunteer groups and conducting needs assessments.

  This support network should exist at state, regional, and local levels and include all of the players involved, such as: an overall coordinator, citizen volunteer groups, non-profit and for profit service providers, data users, agency service providers, and funders. Not all services and funding need go through the network. Existing relationships among the pieces would be supplemented, not replaced by, the network.

- A collaborative process should be convened to design a statewide volunteer citizen monitoring network and develop a supporting funding strategy by potential funders and network participants. This process should result in a plan that: develops a long-term funding strategy for the network; maximizes efficiency of the delivery of services; assures the long-term viability and capacity of the monitoring groups; provides support for individual groups

to buy services and supplies; and funds different levels of service providers to provide certain services free of charge.

That approach will have added benefits of providing more consistent training, both quality and content, and enabling a larger number of groups to participate in training sessions, and creating economies of scale.

- Additional research needs identified:
  - The evaluation should be repeated periodically to benchmark progress, assess needs of service providers and monitoring groups, and address new/different needs involving citizen volunteer programs.
  - A more detailed look and evaluation of existing monitoring plans – including what they look like in Minnesota and other states), how they are developed and implemented, and document specific outcomes in the program and how they correlated to the plan.
  - A more systematic look at actual versus intended data uses that are defined by citizen volunteer monitoring groups.
  - A better understanding of professionally gathered data (especially at local levels) how it relates to citizen volunteer monitoring programs and the data pathway barriers and successes to make these efforts most effective.

Citizen Monitoring: Next steps

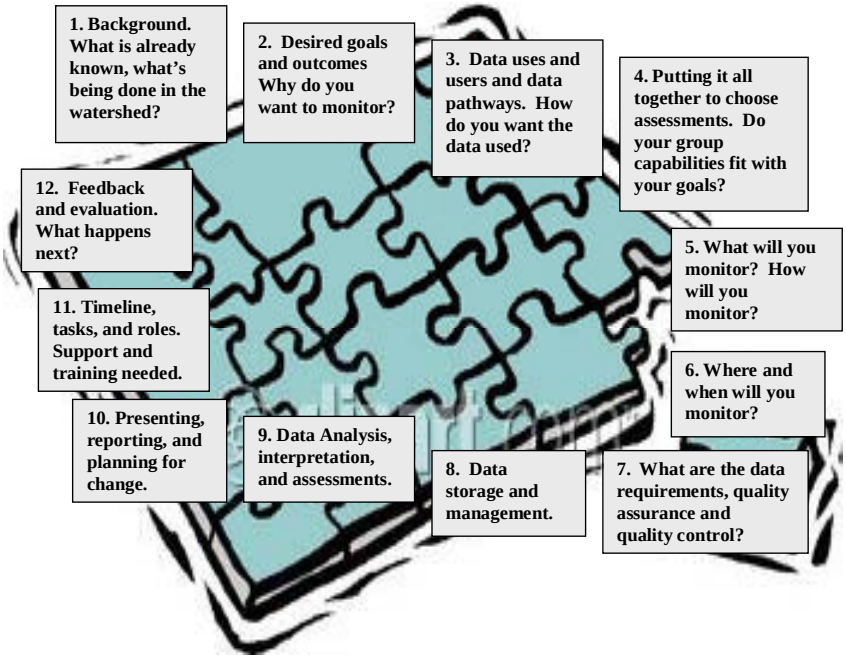
As a followup to the recommendations in this report, the MLA, RCM and RN received funding from the Minnesota Legislative Commission on Minnesota Resources for training, technical support, education and communications for individuals and organizations interested in volunteer lake and stream monitoring. The components of the funded plan include developing a *Monitoring Plan Pilot Training and Workbook* for citizen water quality monitoring programs. The research had indicated that many citizen monitoring programs collect data – but often stumble when it comes to using data. The training program is designed to help groups focus their goals and create a plan that makes citizen volunteer monitoring programs more efficient and effective.

A monitoring plan is a document and a process which is made up of a logical series of choices about the why, what, where, when, who and how of water quality monitoring programs, emphasizing that preparing a monitoring plan may be the most important step in organizing the whole monitoring effort. A monitoring plan:

- encourages groups to focus on what they are trying to accomplish with the monitoring programs;
- helps prevent waste of time and money on equipment and procedures that are inappropriate for particular groups or goals;
- allows groups to select the most appropriate monitoring strategy to address the issues that are important to the community;
- helps to make sense of data, preparing for how it will be turned into useful information;
- allows everyone who might use the data to assess the quality of the results since sampling and analysis methods and quality assurance procedures are clearly documented;

- minimizes the impact of changing personnel on the continuity of monitoring activities because anyone can read the monitoring plan and "pick up the threads;"
- allows groups to re-evaluate their monitoring studies every year in an orderly manner and make changes as needed; and
- provides some of the information needed for a "Quality Assurance Project Plan," which is required when using federal funds to monitor waters.

Figure 8. Monitoring Plan Steps



The Monitoring Plan is a sequence of strategic choices that will focus decisions to meet the goals, time, and capabilities of the group. The 12 steps (listed above) are intended to move groups from a set of issues and concerns, through deciding on the outcomes they want, to the technical design of a system to gather information needed by people who make decisions that affect watershed health.

Training workshops are designed for leaders and their team involved in citizen monitoring programs. It guides them through the process of developing a monitoring plan during two sessions, with individual assistance from the trainers between training dates. When finished, groups have a completed written monitoring plan that meets the needs and capabilities for their citizen monitoring program. Through the LCMR[15] recommended funds, the groups in the pilot program received up to $3000 for monitoring plan implementation.

[15] "Funding for this project was recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund." The goal of this grant is to enhance and expand the ability of citizen volunteers to collect water quality data that will be useful for lake and stream assessments and management. Minnesota Lakes Association and Rivers Council of Minnesota, with assistance from River Network, will work collaboratively to provide training, technical support, education and communications for individuals and organizations statewide interested in volunteer lake and stream monitoring

MLA, RCM and RN piloted the training program with seven citizen volunteer monitoring groups, and provided partial funding for implementation of the plans. Following evaluation of the initial training, RCM, MLA and RN will hold an additional round of pilot training with seven additional volunteer monitoring groups. To further expand and enhance volunteer monitoring projects, the organizations will develop and deliver eight training sessions designed to build specific skills for up to 20 existing Citizen Volunteer Monitoring Groups, who will develop and implement project plans to enhance or expand their current programs

In addition, the organizations will hold a lake and rivers conference in 2004, which will include a series of workshops, training and plenary sessions that form the agenda of a Monitoring Congress held concurrently with the Conference It will be targeted for 250-300 citizen volunteers, local governments, schools, and local natural resource professionals. The workshops and sessions will designed to improve understanding of key water resource issues and enhance monitoring skills of citizen volunteers.

1.6.B MINNESOTA DEPARTMENT OF AGRICULTURE (MDA) SURFACE WATER QUALITY MONITORING ACTIVITIES

It is the overall goal of the MDA water quality monitoring program to provide detailed information on the impacts of the routine use of pesticides on the quality of Minnesota's ground and surface water. Objectives of the program are four fold and encompass the full range of concerns associated with pesticide impacts on water. The four primary objectives are listed below:

1. Measure the occurrence of, and the long-term trends in, the detection and concentration of pesticides in the state's water resources.

2. Provide analysis of land use, pesticide use, nutrient use, and hydrologic factors that may lead to or prevent ground water impacts.

3. Provide the information needed to determine the effectiveness of pesticide management plans and recommended best management practices.

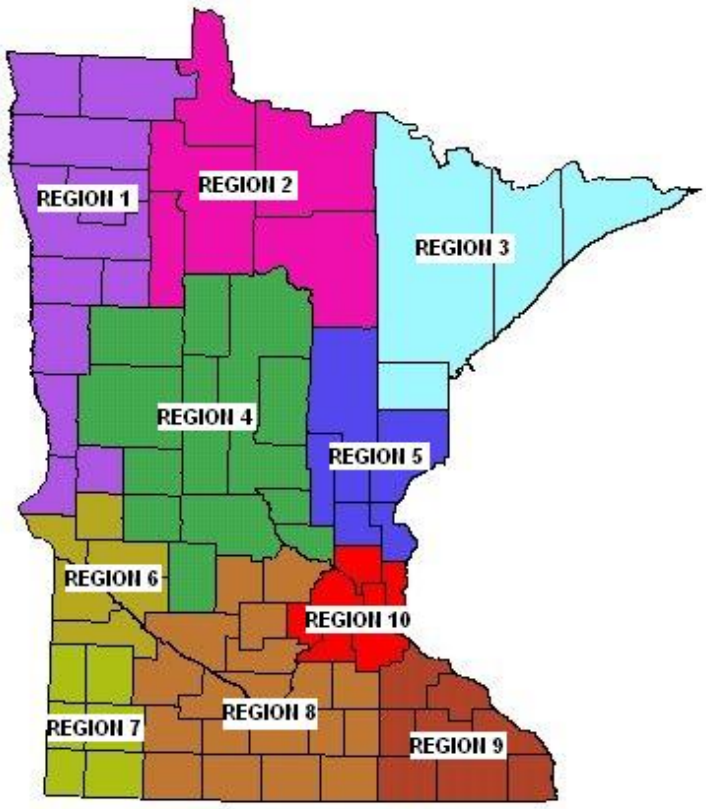
4. Distribute the information developed by the monitoring program to farmers, policy makers, scientists, and other citizens of the state so that they may make informed decisions.

For the purposes of water quality monitoring the MDA has divided the state into 10 water quality monitoring regions (Figure 5). These 10 monitoring regions are considered preliminary, as the MDA is currently working on an EPA funded project that will result in a detailed analysis of regional delineation options. The preliminary regions are as indicated in the accompanying figure and were delineated based on rough geological, climatological and agricultural similarities. The agroecoregions of Minnesota were also utilized in determining the rough

boundaries. For ease of implementation, county political boundaries were used in establishing the final proposed monitoring region boundaries.

The MDA monitoring regions are intended to correspond to future potential Pesticide Management Areas (PMAs). A PMA is an area of the state with similar agricultural practices and for which similar pesticide best management practices would be developed, promoted and evaluated. The PMA concept is the primary driver of the MDA Monitoring Regions since monitoring activities are required to evaluate the need for, and effectiveness of, BMPs in each PMA.

Figure 9. MDA Water Quality Monitoring Regions[16]



Continuous monitoring installations containing computer controlled auto-sampling devices are installed in watersheds in southeastern and south central Minnesota. The auto-samplers are programmed to turn on when stream flow increases in response to rainfall. The samplers collect water during the course of the storm and composite it into a single container for laboratory analysis. Between storm events one-liter "grab" samples are collected from streams

[16] As noted in the text, MDA has divided the state into 10 proposed regions for agricultural chemical monitoring purposes. The regions should be considered preliminary at this time, as MDA works with EPA on delineation. It should also be noted that the proposed 10 regions are not the same as the basins used by MPCA in its monitoring programs. MDA's monitoring focuses on water quality impacts in Minnesota's agricultural regions, which do not directly match basin boundaries.

instrumented with auto-samplers. Additional "grab" samples are collected during May, June and July from streams that do not have auto-samplers installed. All samples are analyzed for a suite of chemicals that include several herbicides and insecticides, and a small number of pesticide breakdown products.

In addition to the auto-sampling stations, 15 to 20 stream sites across the state that have flow data associated with them are sampled once each two week period from May 15 through July 15. The samples are analyzed for the same compounds included in analyses for the automated continuous stations. The program targets at least one site for each monitoring region with significant agricultural production. The agency's goal is to continue sampling these sites for many years so a broader estimate of trends in pesticide impacts on surface water may be completed.

The program develops a full report on the monitoring results every year. These reports are made available on the MDA web page (http://www.mda.state.mn.us/appd/ace/maace.htm) and are shared with the Minnesota Pollution Control Agency, Minnesota Department of Health, and other interested agencies, organizations or individuals.

1.6.C MINNESOTA DEPARTMENT OF NATURAL RESOURCES (DNR) SURFACE WATER QUALITY MONITORING ACTIVITIES

The DNR Waters Division administers state water law relating to regulation of work in public waters, control the appropriation and use of water, ensure the safety of dams, and conduct water resource surveys, investigations, and studies. Surface-water monitoring is described below.

Stream Hydrology

The Stream Hydrology Program collects data and provides information on stream flows in Minnesota which is needed to effectively carry out DNR Water's statutory responsibilities and water management programs. Primary clientele are Waters staff who use stream flow information to make permit decisions, as well other DNR staff, state agencies, local governments, consulting engineering firms, and members of the public who need stream flow information for water planning and management decisions.

Primary products provided by the Stream Hydrology Program include:

- production and distribution of weekly statewide stream flow conditions reports during the open water season (typically April through October)
- production of stream discharge and stage hydrographs
- technical reports analyzing hydrology for special projects
- technical guidance materials explaining stream flow measurement techniques
- production/distribution of daily stream flow condition reports during droughts and floods

Services include interpreting data from more than 100 USGS cooperative program stream flow network gages during the open water season; taking miscellaneous stream flow measurements at key locations during drought and flood events; and making periodic stream flow measurements,

and establishing and maintaining stream elevation-discharge curves for special projects and the 37 Flood Forecast/Warning System Network gages. In addition, the program maintains more than 40 stream flow gages and provides data under contract to MPCA and local Clean Water Partnership project sponsors; provides information on low flow conditions to the DNR staff for use in decisions regarding suspensions of certain surface water appropriation permits; provides historical stream flow information, river stage information, and flow statistics; and applies hydrologic models to problems involving surface/ground water interactions.

The Stream Hydrology Program currently relies on the U.S. Geological Survey (USGS) *WATSTORE* database and *ADAPS* data processing software for management of the data from the streamflow gages in the USGS cooperative streamflow program network. By agreement, the USGS maintains an Internet site providing access to the Flood Forecasting/Warning System Network river stage data "http://mn.usgs.gov/rt-dnr-cgi/gen_tbl_pg" displayed in the same format as river stage and flow data from the streamflow gages in the USGS cooperative streamflow program network "http://waterdata.usgs.gov/mn/nwis/rt".

Examples of information available from Stream Hydrology staff include:

- streamflow gage location, site characteristics, reader, type of gage, and drainage area
- manual staff gage readings and electronic gage readings
- stage/discharge rating curves and equations
- stream flows
- hourly headwater and tailwater readings
- flow statistics
- flood damage stages

Lake Hydrology

The Lake Hydrology Program supports the DNR Waters Division by maintaining a statewide water information system to gather, process and distribute data on lake levels and other lake characteristics that are needed to effectively carry out DNR Waters statutory responsibilities and management programs. This includes development and maintenance of the *Lake Level Minnesota* monitoring network and the *Lakes-DB* electronic database. Specifically, state law makes the DNR Commissioner responsible for determining control elevations of public waters.

The Program has a network of over 700 citizen volunteers and local government partners who record lake levels and forward the data to DNR Waters. DNR field hydrologists help enlist support of volunteer lake gage readers at the local level, including some officials and employees of local governmental units. With its existing staff complement, *Lake Level Minnesota* has the potential to effectively manage a network of about 1,000 lake gages.

Primary clientele groups are DNR Waters technical staff, engineering firms, representatives of lake associations, and local units of government. Approximately 20% of the monitoring sites are managed under cooperative agreements with local units of government. Requests to add new lakes to the gaging network generally come from DNR Waters field hydrologists, who recruit local volunteers to read lake gages on lakes where fluctuating levels are a concern. Getting a lakeshore resident involved in data collection can help strengthen the working relationship between the DNR and the local lake association.

Lake level data supports many DNR Waters hydrologic and hydraulic analyses. DNR Waters field hydrologists often ask for lake level and precipitation data to be combined on a single graph, to help explain lake level fluctuations to concerned property owners. Volunteer gage readers ask for similar technical assistance in developing information for their lake associations.

Products provided by the Lake Hydrology Program include:

- individual lake level reports including graphs, tabular lists, summaries of lake information
- statewide summaries of recorded lake levels
- hydrologic and hydraulic modeling and analysis
- access to electronic lake bottom contour map images for about 4,000 lakes
- annual gage run reports listing each gage in the network, along with its elevation datum, location, and other information
- an informational brochure, *Lake Level Minnesota*

Services include training and technical assistance for local units of government conducting lake level monitoring; development and maintenance of a statewide lake information database capable of continuous updating and usable as a resource management tool; installation of temporary lake level staff gages at locations convenient to volunteer readers; creation of customized graphs combining lake level data with precipitation or other related information; making special queries of Lakes-DB to answer specific statistical questions; and generation of custom data sets for use in GIS or other DNR wide systems.

The Lake Hydrology Program manages the DNR Waters computer database for lake information called *Lakes-DB. Lakes-DB* provides a tool for storing/retrieving data on hydrological and physical characteristics of Minnesota's lake basins. All lake level readings and date taken are entered into *Lakes-DB,* which contains information on many other lake data elements, including:

- lake name and identification number
- gage reader name and address
- gage location
- county
- nearest city
- township, section, and range location
- quadrangle map numbers and names
- major and minor watershed numbers/names
- shoreline length
- maximum and median depth
- secchi disc readings
- shoreland dwellings, resorts, resort units
- shoreland ownership
- 10-year and 100-year flood elevations
- survey benchmarks/hydrographic drawings
- references to flood studies
- type, location, and elevation of outlet
- ordinary high water level
- contributing watershed area/lake surface area
- ice out dates
- fish management classification
- ecological management classification
- game lake and trout lake designations
- scientific and natural lake designation
- names and addresses of DNR area field staff
- ecological management classification

DNR Waters Surface Water Program Priorities

Because DNR Waters budget depends on the State General Fund, monitoring programs are subject to the state economy and, ultimately, Legislative action. The following table shows how the Stream and Lake Monitoring Programs would be affected by increased or decreased funding.

Table 10. Stream and Lake Monitoring with funding scenarios

Level of funding	*Stream Monitoring*	*Lake Level Monitoring*
Current funding	▪ continue providing timely stream flow information, technical analysis, and streamflow gaging assistance to customers ▪ expand and improve stream gaging through increased collaboration with other agencies, local governments, and watershed organizations ▪ maintain communication/coordination with DNR staff doing instream habitat research ▪ develop stage/discharge relationships at Flood Forecasting/Warning System Network gage sites	▪ maintain a lake gaging network of approximately 1000 gages ▪ continue providing timely and high quality technical support services to DNR staff and outside customers ▪ continue to improve Lakes-DB by gradually expanding the use of new tools such as scanned imagery and GIS technology ▪ expand data availability/data storage methods via the Internet
Increased funding	▪ gaps in the existing streamflow monitoring networks could be filled ▪ greater expertise in stream geomorphology could be developed ▪ additional gaging assistance could be provided to local governments, watershed organizations, and Clean Water Partnership project sponsors ▪ methods for extrapolating gage data to ungaged sites could be improved. ▪ stage/discharge relationships could be developed and maintained at more Flood Forecasting/Warning System Network gage sites	▪ the lake gage network could be expanded to include additional significant lakes ▪ development and application of new tools to enhance Lakes-DB could be accelerated ▪ automated lake level monitoring equipment could be installed on key lakes ▪ additional data from hard copy lake files could be captured and added to Lakes-DB
Decreased funding	▪ additional USGS streamflow gaging sites in the cooperative network would be shut down ▪ technical services to customers would be reduced ▪ maintenance of the Flood Forecast/Warning System Network gages would be reduced ▪ stage/discharge relationships would be maintained at fewer Flood Forecasting/ Warning System Network gage sites	▪ lake gaging network would be reduced ▪ technical services provided to field staff would be diminished ▪ development and application of new tools to enhance Lakes-DB would be delayed

Minnesota Fish Contaminant Monitoring (a multi-agency partnership)

Minnesota's Fish Contaminant Monitoring provides essential information for science-based fish-consumption advice, programs on mercury cycling, trends analysis and water quality standards development, and evaluating the potential harm of newly identified bioaccumulative pollutants. The monitoring is conducted through a partnership of the DNR, MDA, MDH and MPCA. The agencies jointly select lakes and rivers for fish collection and analysis, with DNR responsible for fish collection, processing and data analysis, DNR and MDA responsible for chemical analysis, MDH responsible for public health evaluation and MPCA responsible for analysis and research.

Testing of contaminants in fish began in 1967, and currently fish are monitored for mercury and PCBs, as well as for special studies to assess other chemicals present in fish tissue. Information from the monitoring is used for fish consumption advisories, identifying impaired waters, understanding mercury cycling and determining long-term trends. A fact sheet on Minnesota's fish contaminant monitoring is found on MPCA's website at http://www.pca.state.mn.us.

1.6.D METROPOLITAN COUNCIL (MCES) SURFACE WATER QUALITY MONITORING ACTIVITIES

The Environmental Monitoring and Assessment Section of the Metropolitan Council Environmental Services (MCES) conducts water quality monitoring of rivers, streams, lakes, and wastewater treatment plant discharges in the Minneapolis-St. Paul seven-county Metropolitan (Metro) Area. Monitoring is conducted through several programs as described below.

Large River Monitoring

The large river monitoring program originated in 1927 when a predecessor agency began assessing the water quality of the Mississippi River after it had been declared a public health hazard. The monitoring program has evolved over the years to reflect changing needs and water quality issues. Today, monitoring is conducted to meet NPDES permit requirements, assess the performance and effectiveness of MCES wastewater treatment plants, measure compliance with state water quality standards and criteria, determine the biological health of large river ecosystems, and obtain information on the sources and water quality impacts of nonpoint source pollutants. The large river monitoring program is comprised of several sub-programs as described below.

- Automatic Monitoring - The automatic monitoring network was initiated in 1973 as a cooperative program with the United States Geological Survey (USGS). The network consists of 6 monitors located along the Mississippi (UM 836.8, above the Metro Plant; UM 831.0 at Newport; UM 826.7 at Grey Cloud Island; and UM 815.6, above Lock & Dam No. 2), Minnesota (MI 3.5 at Fort Snelling), and Vermillion Rivers (VR 15.6, below the Empire Plant). MCES currently operates this program. The monitors continuously measure and record the dissolved oxygen content, temperature, pH and specific conductance of the river water. Turbidity is also measured at Fort Snelling only. These variables are good indicators of river quality, the effectiveness of treatment plant operations, and problems caused or aggravated by diurnal (24-hour cyclic) phenomena.

- Conventional Monitoring - Conventional pollutant monitoring is conducted to complement automatic monitoring. On a weekly to biweekly basis, river samples are manually collected at additional fixed sites between the automatic monitoring stations and are analyzed for numerous variables that cannot be measured by the automatic monitors. Conventional monitoring more fully characterizes water quality and helps to determine specific sources and levels of pollution. Analyses are conducted in the field as well as in the MCES laboratory.

  Along the Mississippi River, 11 conventional monitoring sites are located between Anoka on the north end and Lock and Dam No. 3 near Red Wing on the south end of the Twin Cities Metro Area. The Minnesota River is monitored at 5 locations, beginning at Jordan near the western boundary of the Metro Area and ending at Fort Snelling near the confluence with the Mississippi River. The St. Croix River is monitored at 2 locations, upstream of the St. Croix Valley Plant at Stillwater, MN and near the river mouth at Prescott, WI. Three sites are monitored on the Vermillion River, to gauge the impact of

the Empire Plant, and 1 site is monitored on the Rum River just prior to its confluence with the Mississippi River in Anoka.

- Toxics Water Monitoring – On a bimonthly to annual basis, river water samples are collected from 7 sites on the Mississippi River, 3 sites on the Minnesota River, and 2 sites each on the St. Croix and Vermillion Rivers for analysis of toxic contaminants, including 14 trace elements (metals) and numerous organic compounds. Results of these analyses help determine the extent and nature of any toxics problems that may exist, and also help determine the effectiveness of the MCES Industrial Waste Control (Pretreatment) Program. Since concentrations of trace elements and organic compounds in river water tend to be an order of magnitude lower than concentrations of conventional variables, detection and analysis of these toxic compounds is more difficult.

- Biological Monitoring - Biological monitoring serves as a useful screening tool for assessing the integrated effects of water pollution on aquatic organisms. The composition of the biological communities reflects water quality and is indicative of the various stresses to the ecosystem. On an annual basis, 9 biological stations are monitored on the Mississippi River, 2 each on the Minnesota and St. Croix Rivers, and 1 on the Vermillion River. Four organism groups are monitored, with each representing a different portion of the riverine community. Taxonomic identification, organism counts, and diversity index calculations are performed on these four biological groups, which include phytoplankton, periphyton, zooplankton, and macroinvertebrates.

- Riverbed Sediment Monitoring, Biological - At selected river monitoring sites on an occasional basis, riverbed sediment samples are obtained to measure the toxicity of contaminants to sediment-dwelling organisms. Sediment toxicity testing is conducted in the laboratory with chironomids and amphipods, which are placed in beakers with riverbed sediment samples for a ten-day period. Mortality rates of these aquatic organisms are determined. Sediment samples are also collected for the purpose of counting and identifying the indigenous species of sediment macroinvertebrates. Chemical monitoring (see below) of the sediment is conducted in conjunction with toxicity testing and biological monitoring. The combination of toxicity testing, biological monitoring, and chemical monitoring is referred to as the sediment quality triad approach for evaluating the impacts of contaminants that accumulate in riverbed sediment.

- Riverbed Sediment Monitoring, Chemical – Concurrent with the collection of riverbed sediment samples for toxicity testing and biological analysis, riverbed sediment samples are also collected for chemical analysis of trace elements (metals) and organic compounds (acids, base-neutrals and pesticides). With the development by EPA of numeric sediment quality criteria for trace elements and organic compounds, guidance will soon be available on the contaminant levels in sediment that are protective of sediment-dwelling organisms. In the meantime, biological monitoring (see above) is also conducted to determine sediment toxicity.

Stream Monitoring

Stormwater runoff in both urban and rural areas carries nonpoint source pollutants from diverse and widely scattered sources to Metro Area streams and rivers. To determine the extent of nonpoint source pollutant loading from tributaries to the Mississippi, Minnesota, and St. Croix Rivers, to provide the information necessary for development of target pollutant loads for these tributary watersheds, and to evaluate the effectiveness of watershed best management practices for reducing nonpoint source pollution and improving water quality in streams and rivers, 27 streams are monitored in the Metro Area. These streams are monitored during significant runoff events, such as snowmelt and heavy rainfalls, and during baseflow conditions, to help determine the sources and extent of nonpoint sources of pollution. Several streams and rivers in the Minnesota River Basin near Mankato, MN are also monitored as a part of this program. Six monitoring stations are located on the Minnesota, Le Sueur, and Blue Earth Rivers, as well as on two small streams. Automated measurements of water stage, in conjunction with rating curves, are used to estimate flow rates in all streams. During runoff events, automated water samples and occasional grab samples are obtained for analysis of a wide variety of nonpoint source pollutants. During baseflow conditions, grab samples are obtained for water quality analysis.

- Automatic Monitoring - Continuous automatic monitoring of stream flow, stage height, conductivity, and temperature is conducted at 31 stream stations and 3 Minnesota River stations.

- Automatic Sampling - Conducted at the same stations and as a complement to the automatic monitoring, automatic sampling occurs when automated samplers are triggered by a runoff event and subsequently collect a composited water sample during the course of the event hydrograph, for analysis of a wide variety of nonpoint source pollutants. These samples are analyzed in the MCES laboratory.

- Grab Sampling - Grab samples are also collected at the stream monitoring sites and supplement the information obtained from automatic monitoring and sampling. Grab samples are collected to characterize water quality during both baseflow and runoff event conditions. These samples are analyzed in the MCES laboratory.

- Precipitation Monitoring - Continuous precipitation monitoring is conducted at all stream and Minnesota River automatic monitoring stations and at three additional stations: one near Farmington, MN in Dakota County, one in western Carver County, and one near Lake Minnetonka in Hennepin County. These three additional stations help determine the precipitation amounts reaching some of the southern- and western-most Metro Area watersheds.

- Volunteer Stream Monitoring – The Volunteer Stream Monitoring Partnership (VSMP), with funding provided by MCES, is coordinating and expanding a citizen stream monitoring program in the Metro Area. Macroinvertebrate samples are collected in Metro Area streams and analyzed by citizen volunteers (identification and counts). The volunteers also collect some grab samples for chemical analysis in the MCES laboratory. The volunteer data will be added to the MCES Environmental Information Management System (EIMS) and made available to interested parties through the internet.

Lake Monitoring

The Metropolitan Council has conducted water quality monitoring of Metro Area lakes since 1980. Both MCES staff and citizen volunteers have been obtaining the monitoring data. The MCES Citizen-Assisted Monitoring Program (CAMP) has been very successful at involving citizens in lake monitoring efforts and greatly expanding the number of lakes with water quality data. The long-term goal of the MCES lake monitoring program is to obtain and provide information that enables cities, counties, lake associations, and watershed management districts to better manage Metro Area lakes, thereby protecting and improving lake water quality.

- MCES Monitoring - MCES staff conducts bi-weekly monitoring (April-October) of approximately 12-14 Metro Area lakes per year, on a rotating schedule. Lakes are monitored for a variety of trophic status indicators (total phosphorus, chlorophyll-a, Secchi transparency, dissolved oxygen, etc.), to determine the lakes' basic ecology, to assess possible water quality trends, and to help quantify lake responses to management efforts by cities, counties, and watershed districts. Information from the MCES lake monitoring program (such as a lake's degrading water quality trend) can lead to a more intensive lake and watershed study (see Special Lake Monitoring Projects below).

- Citizen-Assisted Monitoring - The Citizen-Assisted Monitoring Program (CAMP) is an MCES-managed program where citizen volunteers monitor the water quality of Metro Area lakes. One hundred thirty CAMP lakes were monitored in 2003. On a bi-weekly basis (April-October), each volunteer collects a surface water sample for laboratory analysis of total phosphorus, total Kjeldahl nitrogen, and chlorophyll-a, obtains a Secchi transparency measurement, and provides some user perception information about the lake's physical and recreational condition. The main purpose of CAMP is to provide lake and watershed managers with water quality information that will not only help them properly manage these resources, but will also help document water quality impacts and trends. An added benefit of the program is the volunteers' increased awareness of their lakes' condition, which has fostered local efforts to protect lakes and promote support for lake management.

- Special Lake Monitoring Projects - Special MCES research projects are conducted on individual lakes in an attempt to answer pre-determined questions. Additional monitoring may include in-lake plankton analyses and macrophyte surveys and assessment of water quality, water quantity, and land use within the watershed. This information may subsequently be used for in-lake and watershed computer modeling of pollutant sources, loads, and impacts on water quality. For example, an emphasis of a special project may be the determination of nutrient sources and loads to a lake, thereby providing valuable information for lake management efforts. Some examples of recent special projects include:
  - The Lake McCarrons Project: a continuing project studying the influences of a constructed wetland treatment system on the water quality of an urban lake.
  - The Cedar Lake Project: a study determining the water quality of a rural Metro Area lake, its ability to support certain recreational uses, and the feasibility/cost of upgrading water quality to support those recreational uses.

– The Square Lake Clean Water Partnership Project: an in-depth study of a high-quality rural Metro Area lake, with an emphasis on maintaining current water quality conditions as growth occurs in the watershed.

- Special Monitoring - Special monitoring is conducted on Metro Area lakes on a "as-needed" basis. Special monitoring may include such things as coliform bacteria tests on lakes affected by sewer breaks or algal analysis on lakes causing illness in domestic animals.

Wastewater Treatment Plant Monitoring

Performance monitoring of all 8 MCES wastewater treatment plant discharges is conducted annually to meet NPDES Permit requirements and to assess the quality of treated wastewater discharged to the large rivers in the Metro Area. Both biological and chemical monitoring are conducted on the wastewater treatment plant discharges. In addition, the chemical characteristics of groundwater in the vicinity of some MCES wastewater treatment plants are measured through a network of monitoring wells.

- Effluent Toxicity Testing, Biological – Biological toxicity testing consists of a set of tests that are conducted in a controlled environment to determine the biological effects of a substance, factor, or condition on living organisms. It is valuable to conduct such tests to help determine the toxicity of numerous chemicals contained in wastewater treatment plant effluents, and to determine the effects of these effluent discharges on aquatic organisms in Metro Area receiving waters. The MCES toxicity testing program began in 1979 in response to both federal and state laws prohibiting the discharge of toxic materials in toxic amounts. Two types of toxicity tests are conducted: acute and chronic. Acute tests are short-term (1-4 day) mortality tests that determine the immediate toxicity of the effluent and also indicate whether or not additional testing is required. Chronic tests are longer-term (7 day) tests that measure the potential long-term toxic effects of the effluent on test organism survival, growth, and reproduction. Effluent toxicity testing began as a self-monitoring tool; however NPDES Permits for MCES treatment plants have required toxicity testing since 1988.

- Effluent Toxicity Testing, Physical/Chemical - Physical and chemical monitoring of wastewater treatment plant effluents is conducted concurrently with biological toxicity testing, to characterize levels of toxic substances in the effluents, and to identify those substances that may be causing any biological effects evident during toxicity testing. Physical and chemical effluent analyses include: temperature, dissolved oxygen, pH, specific conductance, alkalinity, hardness, ammonia, metals, and organic compounds.

- Effluent Suspended Sediment Toxics Monitoring – Monitoring of toxics associated with the suspended sediment in Metro Plant effluent has been conducted since 1990, as required by the Metro Plant NPDES Permit. Ninety-day composite samples are collected quarterly in the Metro Plant effluent channel and at an upstream control site in the Mississippi River. The suspended sediment samples are analyzed for 36 contaminants of interest, including 7 metals and 25 pesticides, seven of which are various aroclors of polychlorinated biphenyl (PCB).

- Groundwater Monitoring - MCES and its predecessor agencies have been monitoring groundwater at various treatment plant locations since 1975, to determine the impacts of past biosolids disposal practices on local groundwater quality. Groundwater monitoring has been conducted for planning purposes, and to meet NPDES and State Disposal System Permit requirements of the MPCA and local governments. The EMA Section began monitoring groundwater in 1984 and maintains a database containing all existing MCES groundwater monitoring data. Routine groundwater monitoring is conducted quarterly at the Metro and Seneca Plant ash disposal facilities, and data are reported to the MPCA as required by solid waste permits. Quarterly groundwater monitoring is also conducted at the Metro Plant ash lagoons and the Empire Plant landspreading area.

  Since some groundwater de-watering is necessary at the Seneca Plant to maintain the structural integrity of the treatment tanks, the Seneca NPDES Permit also requires measurement of surface water flows and groundwater elevation monitoring in the nearby Nichols Fen. This monitoring is conducted in cooperation with the Minnesota Department of Natural Resources and the City of Eagan.

Data Management and Assessment

In support of the Water Monitoring Programs summarized above, the Environmental Monitoring and Assessment Section manages water data and information via the MCES Environmental Information Management System (EIMS), interprets and reports water quality data and information, conducts water quality modeling to support MCES facility planning, participates in local, state, and federal water resource planning and management efforts, and provides assistance with public education and community outreach efforts.

1.6.E UNIVERSITY OF MINNESOTA WATER RESOURCES CENTER (WRC) MONITORING ACTIVITIES

Volunteer Stream Monitoring Partnership

The Volunteer Stream Monitoring Partnership (VSMP) has been coordinating volunteer monitoring throughout the Twin Cities Metropolitan area since December 2000. Many of the groups currently involved have been monitoring since the mid 1990s. VSMP's initial goal was to standardize data collection, management, and analysis so that all volunteers were using the same protocols. The program concentrates on biological monitoring, with a focus on macroinvertebrates. Sample collection protocols are based on the EPA's Rapid Bioassessment Protocols using the multi-habitat approach to all types of metro streams. There are several levels of QA/QC including field sampling and sample preparation and identification. Professional entomologists at the University of Minnesota conduct the final level of taxonomic QA/QC checks. All of the data are housed in an online database, which will eventually accommodate volunteers entering their own data, generating reports, and conducting analyses.

1.6.F U.S. GEOLOGICAL SURVEY (USGS) WATER QUALITY MONITORING ACTIVITIES

The USGS conducts a variety of surface water, as well as ground water, monitoring activities in the state. Many of its activities and investigations are conducted in cooperation with other organizations and support the work of other organizations. As an example, its flow gaging work on major rivers is used by a variety of federal, state and local agencies. MPCA uses USGS flow data in its effluent setting process, to calculate loadings of solids and nutrients and to help interpret observed changes in chemical or biological measures.

Below is a brief description of the various surface and ground water monitoring projects currently underway by Minnesota's USGS. More information on the Minnesota office of USGS can be found at: http://mn.water.usgs.gov/index.html

USGS Surface-Water Quality Monitoring Projects

- **Effects of Highway 169 expansion on the water-quality of tributaries to Mille Lacs Lake** (USGS, MNDOT)—Water-quality and bed-sediment monitoring in stream and wetland tributaries to Mille Lacs Lake is being conducted prior to and will continue during the expansion of Highway 169 adjacent to Mille Lacs Lake. Analyses include nutrients, suspended and bed sediment, major ions and trace metals, (and semivolatile organic compounds in wetland sediments). Two real-time telemetered monitoring stations for streamflow, water temperature and specific conductance will be installed. Project may include ground water at later date.

- **Support for water-quality modeling of the Lower Minnesota River Basin** (USGS, Metropolitan Council, Lower Minnesota Watershed District)—The USGS is providing technical support for the Metropolitan Council's water-quality modeling. Longitudinal river surveys for streamflow and physical parameters are being conducted and a stream-gaging station near Fort Snelling that uses acoustic Doppler technology to measure streamflow in real-time during backwater.

- **Characterization of bed sediment and invertebrates in Sturgeon Lake, Prairie Island** (USGS, Prairie Island Indian Community)—The objective of this two-year study is to characterize bed sediment chemistry (emerging contaminants) and size, and the invertebrate community composition in Sturgeon Lake.

- **Elm Creek water-quality monitoring in the northwest metro** (USGS, Elm Creek WMO)—Manual and automated samples are collected during runoff and approximately monthly for analysis of nutrients, total and volatile suspended solids, and chloride. These data and streamflow have been collected since 1988.

- **Suspended-sediment monitoring at the Minnesota River at Mankato** (USGS, MPCA)—Sediment has been collected since 1967. Data are used to determine daily suspended-sediment loads in the Minnesota River.

USGS Surface-Water Monitoring Projects

- **USGS-cooperative stream gaging program**—The USGS operates approximately 90 continuous streamflow, 13 river stage, 14 lake stage, and 83 crest-stage gaging stations in Minnesota through cooperative agreements with State, Federal, local agencies. The status of a few gages is in doubt due to budget cuts. Two new gages were installed in the Kawishiwi River Basin as part of Federal Energy Regulatory Commission requirements.

- **Geomorphic characterization of streams in Duluth** (USGS, City of Duluth)—This two-year study will characterize the geomorphology of streams in Duluth. Data will provide the city with a basis for evaluating stream reaches proposed for preservation.

- **Rush River Watershed stream gaging support** (USGS, Rush River Clean Water Action Plan)—the USGS is developing stage-discharge relations at five sites in the Rush River Basin to help the CWP determine nutrient and sediment loads.

USGS Water-Quality/Biological Monitoring Projects

- **Amphibian Research and Monitoring Initiative** (DOI) a multi-agency, Department of the Interior, initiative with the objectives of (1) starting long-term monitoring to determine trends in amphibian populations, and (2) conducting research into causes of amphibian declines and malformations. Water-quality samples were collected at 10 frog-monitoring sites in Voyageurs National Park, St. Croix National Scenic Riverway, and Upper Mississippi River National Wildlife and Fish Refuge.

- **National Fish Mercury Modeling project** (USEPA): This project uses USEPA's National Listing of Fish and Wildlife Consumption Advisories data and statistical methods to estimate spatial and temporal variations in mercury concentrations of standardized fish tissue samples across the US. Original mercury data and model predictions will be served from a public website.

USGS Ground-Water/Surface-Water Quality Monitoring Projects

- **Glacial Ridge hydrology and water quality** (USGS, Red Lake River Watershed District)—This multi-year project is investigating fluxes of ground water, surface water, and water quality, to document the hydrologic status of The Nature Conservancy's Glacial Ridge Project area prior to restoration of wetlands and prairies. Fifty ground-water wells and six stream gages will be used to determine water quantity before restoration begins. Ten ground-water wells and all stream sites and will be sampled for major ions, nutrients, and suspended sediment (surface water). Several wells have real-time telemetry.

- **Landscape Indicators Project** (USGS, USEPA)—This project will explore relations between hydrologic landscapes in the upper Midwest, and pesticides, nutrients, toxic chemicals, and aquatic invertebrates in streams during base flow conditions. Monitoring will be conducted during 2004.

- **Decorah Edge Effect** (USGS, Rochester Public Utilities)—This project is monitoring ground-water and wetland water quality to evaluate (1) causes for the loss or removal in

nitrate-nitrogen in wetland areas along the Decorah Shale edge near Rochester, Minnesota in waters that recharge the underlying St. Peter-Prairie du Chien-Jordan aquifer and (2) the effects of changing land use on water quality along the Decorah edge. Monitoring will be conducted in 2003-2005.

- **Emerging contaminants** (USGS, MDH, MPCA, selected Drinking Water Facilities)—The objective of this project is to determine the occurrence and concentrations of pharmaceuticals and other organic contaminants associated with wastewater in drinking water, wastewaters, and selected surface and ground water throughout Minnesota. Most of the field collection was completed during 2000-2002. A report is underway. Low-level field activities may occur in 2004.

- **National Water-Quality Assessment Program, Upper Mississippi River Basin** (USGS)—This project is in its low intensity phase, with reduced sampling of three streams (Mississippi River, Little Cobb River, and Shingle Creek) and several ground-water wells. The project begins its second high intensity phase in 2005.

- **Rain gardens** (USGS, Metropolitan Council)—Rain gardens are increasingly being used across the Nation as a Best Management Practice to temporarily store, filter, and reuse runoff water while providing attractive landscaping. This project is designed to determine the potential benefits of selected rain gardens to remove contaminants from the runoff and thereby mitigate adverse effects on shallow ground-water quality. This project will be completed during 2004.

- **Mercury flux chamber** (USGS, USEPA)—The objective of this project is to establish an improved method of determining the rate of ground-water seepage into and from lakes. A chamber is being evaluated that can monitor the ground-water seepage rate and can be used to collect water-quality samples.

USGS Ground-Water/Surface-Water Monitoring Projects

- **Recharge estimates in the Upper Mississippi River** Basin (USGS)—The primary objective of this study is to quantify recharge to unconfined sand and gravel aquifers in the Upper Mississippi River Basin using several methods at a variety of scales. Existing ground-water level data primarily will be utilized in this study, including data from the MDNR observation well network, soil moisture and other data from the USGS Bemidji crude-oil spill research site, and the USGS Integrated Research Initiative project near Williams Lake. Water samples have been collected from about 20 wells for SF6 analysis to estimate recharge rates.

- **Evaluating lake-level trends in Long Lost Lake** (USGS, White Earth Indian Reservation)—Long Lost Lake is a 480-acre land-locked lake located in Clearwater County of northwestern Minnesota. The water level (stage) of Long Lost Lake has risen about 12 feet since about 1992. This study involves understanding the cause and effect relations that have resulted in the stage increases. Water level data are being collected from a network of a lake stage and ground-water monitoring wells. The project is planned to run through 2006.

Geographic Information Systems/Surface Water

- **Basin Characteristics** (USGS, MDOT, MDNR)–The objective of this project is to create hydrologically enhanced Digital Elevation Model for use in an automated basin characteristics (drainage area, area of lakes and wetlands, stream length and stream slope) program that will generate 2, 5, 10, 25, 50, and 100 year estimated peak-flows on unregulated streams in Minnesota.

- **Stream Slope Research** (USGS, MDOT)—The objective is to analyze the differences between the observed method of determining stream slope and an automated method using hydro enhanced DEMs. Changes in processing and programming procedures will be evaluated for improvements in slope estimation and compatibility with ArcHydro Data Model and StreamStats web based stream and watershed information.

- **National Hydrography Dataset Project** (USGS, MPCA)–The National Hydrography Data set 1:24,000 (http://nhd.usgs.gov/) comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order.

SECTION 1.7
MONITORING QUALITY ASSURANCE

Nearly all decisions about remediation, issuing permits, monitoring surface and ground water quality, and site investigations are based on one thing -- the data gathered from the site. That's why the Minnesota Pollution Control Agency (MPCA) has quality assurance/quality control standards for this data.

The MPCA's Quality Assurance/Quality Control Coordinator oversees data collection, including the agency's selection of laboratories, collection of data, selection of parameters to be measured, consistency of data analysis and confidence in data quality. In addition, anyone submitting data for 305b/303d use is required to submit a Quality Assurance Project/Program Plan, as well as to follow the data collection, management and reporting requirements specified in "Attachment D," *Volunteer Surface Water Monitoring Guide* (attached as Appendix 7). It is important to note that MPCA approves its own Quality Assurance Project/Program Plans, rather than having EPA approval required.

The MPCA's Quality Management Plan is approved by the U.S. EPA, and is currently being revised. The 2004 Plan is attached as Appendix 7. For monitoring projects, the MPCA and its partners follow the Quality Management Plan in implementing monitoring protocols.

To enhance and expand the ability of citizen volunteers to collect water quality data that will be useful for lake and stream assessments and management of water resources, the Minnesota Lake Association and Rivers Council of Minnesota, with assistance from the River Network, have jointly developed training for volunteer monitoring, as part of a Legislative Commission on Minnesota Resources (LCMR) pilot project (see Section 1.6.A).

SECTION 1.8: DATA MANAGEMENT

As noted in the Goals and Objectives discussion, the MPCA has established an objective of ensuring that data is readily available to the public within one year of the season in which it is collected, for all types of monitoring. All data will be entered into STORET with a few exceptions. Biological (streams and wetlands) data is available in MPCA local databases and currently not available in STORET. Biological data is a developing field and currently, STORET does not readily accommodate biological data. Reports on MPCA's wetland monitoring data are available on MPCA's website; stream biological data can be accessed through the Environmental Data Access project.

Continuous chemistry and flow monitoring data are additional examples of data not currently included because STORET is not well-suited for such data. MPCA is currently researching possible software to use for flow and continuous chemistry data, and will consider possible means of linking to STORET. In the summer of 2004, MPCA and the Minnesota Department of Natural Resources have agreed to use Hydstra software to store flow and continuous chemistry data and to allow for greater ease in data analysis.. Following extensive training, MPCA staff will begin entering current and past data into the software. MPCA will also evaluate the types of Hydstra data summarizations which can be made available via STORET. Within the next few years, MPCA expects to have this data publicly accessible.

Developing a system for wetland and biological data that links to STORET remains a future challenge.

In addition to MPCA data, MPCA is working with its partner organizations to include external monitoring data in STORET. Currently, data from the following organizations is entered into STORET and used in Water Quality Assessments, as well as for other purposes Upper Mississippi River Headwaters Board, Big Fork River Watch, Hennepin County Conservation District River Watch, South Dakota Environment and Natural Resources Department, North Dakota Health Department, Wisconsin Department of Natural Resources, Western Lake Superior Sanitary District, National Forest Service and others. Metropolitan Council Environmental Services and USGS data is used in assessments although stored in other databases and not duplicated in STORET. Prior to conducting assessments, the agencies provide a file of their data which is then merged with STORET data. The process is designed to allow opportunities for MCES and USGS to review their data with respect to appropriateness for assessment purposes. Managing data in this way eliminates duplication yet allows the data to be used in assessments.

A collaborative effort between MDA and MPCA is underway to ensure data collected by the MDA's pesticide water quality monitoring program is also transferred to STORET.

To work toward ensuring all MPCA-funded external data goes into STORET, the MPCA includes language in its contracts for TMDL studies: "The [contractor] shall organize and make available to the MPCA data collected as part of this project for entry into USEPA's STORET database. The [contractor] shall provide location information needed for all monitoring stations which MPCA will use to establish the stations in STORET. All lab work must be done by a lab certified by the state of Minnesota for the parameter being measured." MPCA also has dedicated one staff person with sole responsibility for data management for MPCA-funded external projects, to ensure data is entered into STORET.

In addition to working toward entering data into STORET, the MPCA has developed the Environmental Data Access Initiative, which allows the public to view the data in STORET in a user-friendly fashion (a front-end system for STORET data). The Environmental Data Access initiative is described in Section 1.10.

Relative to the use of the Assessment Data Base (ADB), the MPCA is using a recent version of the ADB from EPA and has submitted its 2004 305b/303d integrated report using this database. MPCA is incorporating as much 303d information as is available into the ADB.

SECTION 1.9
DATA ANALYSIS

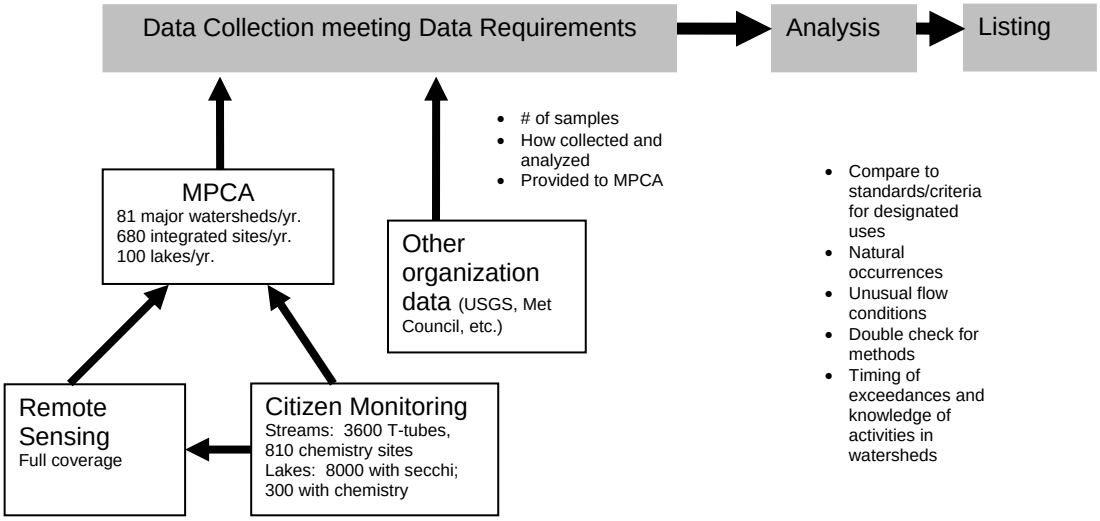
Data analysis occurs at various levels and to various degrees of sophistication – from analysis of data on a specific project or lake to the rigorous data analysis used in the 305(b) and 303(d) processes. This section contains a description of the principal data analysis efforts at the MPCA for condition monitoring: comparison to standards and trends, as well as analysis methods used in problem investigation monitoring.

1.9.A COMPARISON TO STANDARDS (305B/303D)

As part of its integrated 305(b)/303(d) process, Minnesota assesses data for the use supports of aquatic life, aquatic consumption, and aquatic recreation The integrated assessment process requires a quality rating be assigned to the data used to make these use support assessments. The rating options available in the Assessment Database Version 2.1 (ADB) are low, fair, good, or excellent for each type of data (physical/chemical, biological, pathogens, etc.) Minnesota, in an effort to use "all available data" in the integrated process, conducted a public call for data in 2002 to obtain data from stakeholders who normally do not provide the State with monitoring data. Collected data were incorporated in with data from the MPCA and from other groups who routinely provide data, and were used for the 2004 integrated assessment process.

Under Minnesota's condition monitoring strategy, described in Section 1.2, all usable data will be included in the assessment process. Figure 9 illustrates the relationship among the types of data used, based on a 10-year monitoring cycle. Appendix 8 provides a view of the overall assessment process.

Figure 10. Data to be used in Minnesota's Assessment Process (10-year cycle).



MPCA has established a formal process for assessments as part of 305(b) and 303(d) efforts – the professional judgment team. The process recognizes the value and necessity of including professional judgment as a "formal" step in assessments since no assessment guidance and protocol, no matter how detailed, can address all the unforeseen aspects of the multi-step assessment process. Under the process, a professional judgment team is formed for each basin. The team is made up, for example, of regional MPCA basin coordinators knowledgeable about local water quality issues, MPCA monitoring and data assessment staff, and staff from organizations outside the MPCA whose data were used in the assessments, if appropriate. The professional judgment teams meet to review how the data were used and interpreted, and whether outside data were used appropriately. They determine whether the data (possibly data combined from more than one source) are adequate and appropriate for making statements about use-support and about causes of impairment (such as low dissolved oxygen or high phosphorus, etc.).

MPCA staff and a professional judgment team compare monitoring data from all sources to the water quality standards for a specific stream reach or lake to assess protection of beneficial uses. If data are available to assess more than one type of standard that protect the same beneficial use, exceedance of any applicable standard normally indicates impairment. This concept is called "independent application". In general, independent application means that a water body should meet multiple assessment tests (standards) to be considered un-impaired for a given use. This is consistent with the national and state goal to protect the "chemical, physical and biological integrity" of surface waters, and it is consistent with EPA guidance. EPA's discussion of independent application is the integration of assessments of, 1) chemical-specific data, 2) biological assessments, and 3) whole effluent toxicity testing (EPA 1991). The independent tests must apply to the **same beneficial use**. Independent application does not apply when assessing

different uses, such as aquatic life (toxicity), fish consumption (human health), swimming or aesthetics. Assessments for different uses are carried out separately.

The professional judgment team's first step in making impairment decisions is to review the results of an "automated" pre-assessment of the available chemical and biological data. The pre-assessment is a computerized screening of the data which identifies waterbodies meeting minimum data requirements, appropriate periods of record, and showing the necessary exceedances of impairment thresholds. Following a review of the pre-assessment results, the team considers a wide range of factors that can affect water quality, and use impairment. For examples the team may consider:

- The quality and quantity of all available data,
- The magnitude, duration and frequency of exceedances,
- Timing of exceedances,
- Naturally occurring conditions that affect pollutant concentrations and toxicity,
- Weather and flow conditions,
- Consistency of the preliminary assessment with information on other numeric or narrative water quality standards,
- Known influences on water quality in the watershed, and
- Any changes in the watershed that have changed water quality.

Based on all the relevant information, a final impairment decision is made regarding a given water quality standard and the associated beneficial use. These decisions are based on a "**weight of evidence**" concept; which simply means that when all the readily available data and information is considered together, and in the appropriate context (e.g., ecoregion, known pollution sources, etc.), a convincing pattern emerges on the condition of the waterbody.

The MPCA assembles the professional judgment teams and chairs the meetings; and the MPCA takes responsibility for all team decisions regarding impairment. While consensus of opinion on impairment decisions is the goal, and is normally achieved, if consensus can't be obtained, the MPCA will make the final decision. All professional judgment decisions are recorded on a *Professional judgment group transparency form for assessed streams.* Summaries for the data used by the Professional Judgment Groups are described in Tables 11 and 12, for pollutants with numeric standards and narrative standards, respectively.

Table 11. Summary of Data Needed for Water Quality Assessments for 305(b) Report and 303(d) List for Use Support and Impairment Determinations, for Pollutants with Numeric Standards.

Pollutant Category **305(b) Report, or 303(d) List**	**Minimum Number of Values*, and Data Treatment**	**Exceedance Thresholds:** • **Number or Percent Exceedances of Chronic Standards** **Use Support or Listing Category**		
Pollutants with Toxicity-based Standards	Number of Exceedances →	≤ 1	na	≥ 2
305(b)	5 values in 3 years	Fully supporting	na	Not supporting
303(d)	5 values in 3 years	Not listed	na	Listed
Pollutants with Human Health-based Standards	Number of Exceedances →	≤ 1	na	≥ 2
305(b)	5 values in 3 years	Not assessed for 305(b)	na	Not assessed for 305(b)
303(d)	5 values in 3 years	Not listed	na	Listed
Conventional Pollutants and Water Quality Characteristics	Percent Exceedance →	< 10 %	10 – 25 %	> 25 %
305(b)	10 values in 10 years	Fully supporting	Partially supporting	Not supporting
303(d)	10 values in 10 years	Not listed	Listed	Listed
Fecal Coliform, Step 1 200 orgs./100 ml	Percent Exceedance →	< 10 %	≥ 10 %	na
305(b)	10 values in 10 years	Fully supporting	Step 2	na
303(d)	10 values in 10 years	Not listed	Step 2	na
Fecal Coliform, Step 2 200 orgs./100 ml	*Number of months with Exceedances* → (geometric mean)	No months	1 or 2 months	> 2 months
305(b)	Geometric mean of 5 values over 10 years for each month	Full supporting	Partially supporting	Not supporting
303(d)	Geometric mean of 5 values over 10 years for each month	Not listed	Listed	Listed
Fecal Coliform, Step 2 2000 orgs./100 ml	Percent Exceedance →	< 10 %	10 – 25 %	> 25 %
305(b)	10 values in 10 years	Full supporting	Partially supporting	Not supporting
303(d)	10 values in 10 years	Not listed	Listed	Listed

* Values are individual or single data points. Exceedance thresholds are of individual values unless noted otherwise.
na = not applicable. There is no "partially supporting" or "review" category for toxics and fish tissue contaminants, no "not supporting" or "listed" category for step 1 of fecal coliform assessments, and no specific minimum data requirements for biological and fish tissue contaminant assessments.

Table 12. Summary of Data Needed for Water Quality Assessments for 305(b) Report and 303(d) List for Use Support and Impairment Determinations, for Pollutants with Narrative Standards.

Pollutant Category **305 (b) Report, or 303(d) List**	**Minimum Number of Values*, and Data Treatment**	**Exceedance Thresholds:** • **Eutrophication Guideline values** • **IBI Scores** • **Contaminant Levels in Fish Tissue** **Use Support or Listing Category**		
Eutrophication (lakes) Northern Lakes and Forests Ecoregion	Total phosphorus →	< 30 µg/L	30 – 35 µg/L	> 35 µg/L
	Chlorophyll-a →	< 10 µg/L	10 – 12 µg/L	> 12 µg/L
	Secchi disk →	≥ 1.6 meters	1.6 – 1.4 meters	< 1.4 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed
Eutrophication (lakes) North Central Hardwood Forests Ecoregion	Total phosphorus →	< 40 µg/L	40 – 45 µg/L	> 45 µg/L
	Chlorophyll-a →	< 15 µg/L	15 – 18 µg/L	> 18 µg/L
	Secchi disk →	≥ 1.2 meters	1.2 – 1.1 meters	< 1.1 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed
Eutrophication (lakes) Northern Glaciated Plains and Western Corn Belt Plains Ecoregions	Total phosphorus →	< 70 µg/L	70 – 90 µg/L	> 90 µg/L
	Chlorophyll-a →	< 24 µg/L	24 – 32 µg/L	> 32 µg/L
	Secchi disk →	≥ 1.0 meters	1.0 – 0.7 meters	< 0.7 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed

* Values are individual or single data points. Exceedance thresholds are of individual values unless noted otherwise.
** Assessment of mercury fish tissue data not limited to most recent 10 years.
na = not applicable. There is no "partially supporting" or "review" category for toxics and fish tissue contaminants, no "not supporting" or "listed" category for step 1 of fecal coliform assessments, and no specific minimum data requirements for biological and fish tissue contaminant assessments.

It should be noted that there are a few uses and waterbody types for which Minnesota does not currently undertake assessments – drinking water standards; aquatic life standards for lakes; and wetlands – for the reasons described below. In general, however, because of Minnesota's large number of surface waters, the priorities reflected in Minnesota's strategy will be the focus of assessment activities in the future. While we may consider broadening our assessment to other uses and waterbody types, our focus and resources will be directed to our current strategy.

Drinking water: While MPCA does not currently assess surface water for drinking water standards, aquatic life standards may be more stringent than drinking water standards for the pollutants for which the MPCA has surface water data (mercury and other

metals) or the pollutants may not be relevant to drinking water (dissolved oxygen, ammonia, excess nutrients). Minnesota has twenty-four surface-water-based community water supplies, and MPCA is continuing conversations with the Minnesota Department of Health and public water suppliers to determine the considerations necessary for assessing surface waters for drinking water standards.

Aquatic life standards for lakes: MPCA does not currently have good metrics to assess aquatic life in lakes. Existing dissolved oxygen (DO) standards are not particularly useful for this purpose as lakes routinely exhibit a range of DO concentrations over depth (from surface to bottom) during stratification. MPCA does, however, include chlorophyll-a, a measure of primary productivity, and semi-qualitative assessments of algal forms in our individual lake assessments. An additional consideration is that fish stocking may also pose problems since the species that are stocked may not be native to that particular lake and the water quality and habitat may be only marginally suitable for the species (e.g., walleye stocking) or some of the species may not naturally reproduce in the lake in which they are placed (e.g. stream trout). In this case, also, MPCA is also closely monitoring the Department of Natural Resources' development of an IBI for lakes and the University of Minnesota's algal IBI development work, for consideration of use in assessments in the future.

Wetlands: MPCA is not currently assessing wetlands for 305b and 303d, as it completes its Index of Biotic Integrity. Wetlands may be included for assessment in the future. Similarly for this topic, Minnesota is working to complete its IBI for wetlands as its current priority action, and assessment of wetlands may occur once this is completed.

Detailed information on MPCA's assessment process can be found in *Guidance Manual for Assessing the Quality of Minnesota Surface Water*, attached as Appendix 9.

1.9.B LAKE SECCHI TRANSPARENCY TRENDS

Secchi transparency measurements provide a basis for assessing current water quality, estimating trophic status (overall health and productivity) and documenting water quality trends over time. It is a measure of water clarity and varies greatly among Minnesota's lakes. In most Minnesota lakes, Secchi transparency provides an indirect measure of the amount of algae in the water; however, suspended sediments (soils), or color due to dissolved organic materials, can limit transparency as well.

Detecting trends in water quality over time is a primary goal for many lake programs. For MPCA analysis, detecting trends requires taking a minimum of 4 readings each summer for 8 to 10 years. Secchi transparency is one of the best parameters for determining a lake's overall health (trophic status) and assessing trends in Minnesota lakes. Transparency is a preferred parameter for many reasons: low cost, easily incorporated in existing lake monitoring programs, and it allows for the collection of a large number of samples in a given sampling period on many different lakes. Transparency of a lake may vary from year to year in response to changes in amounts of algae, watershed runoff, precipitation and many other factors. It is important to

consider all of these aspects when determining if any significant long-term changes have occurred, or if changes are random in nature.

All available Secchi transparency data from STORET (U.S. EPA's national water quality database) are used in the annual assessments. The majority of the data collected is from volunteer lake monitors in the MPCA's Citizen Lake-Monitoring Program (CLMP). This program began in 1973, and involves the voluntary participation of citizens who live and recreate on Minnesota lakes. These volunteers provide the state and many others with valuable information on the water quality of Minnesota's lakes. In fact, for many lakes, CLMP data is the only water quality information available. This program continues to be a cost-effective mechanism for obtaining good, basic water quality data on many Minnesota lakes.

For the trend analysis, MPCA used Kendall statistical tests using WQ Stat Plus™ software on lakes with 4 or more transparency readings per summer (June – September) and 8 or more years of data. We used a probability (p) level of $p \leq 0.1$. At this p-level, there is a 10 percent chance of identifying a trend when it does not exist. In 2001, there were 667 lakes in Minnesota that met the minimum requirements for trend analysis. Of the 667 assessed lakes, 214 of them exhibited a statistically significant improvement in transparency over time. In contrast, only 45 lakes exhibited a statistically significant decline in transparency. The majority (61 %) of the assessed lakes (408 lakes) exhibited no change in transparency over time.

In addition to providing trend analysis for individual lakes, the secchi lake transparency data is used to target lakes in Minnesota for the more detailed Lake Trend Analysis monitoring activity.

1.9.C TRENDS IN STREAMS: MILESTONE SITES

The MPCA has analyzed trends for the 80 sites and six water quality parameters for which good, long-term data exists. The "Minnesota Milestone" monitoring sites are spread throughout the state, and, on a rotating basis, are monitored by the MPCA monthly through most of the year. The six parameters with data suitable for long-term trends analysis are biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform bacteria, ammonia, total phosphorus, and nitrite/nitrate. The data covers the last approximately 40 years, on average, and is stored in STORET (USEPA's national water quality database).

A combination of parametric and non-parametric statistical methods are used to analyze the data. Over the period of record, the large majority of sites show a decreasing pollutant trend for BOD (89% of sites), fecal coliform bacteria (82%), ammonia (83%), and total phosphorus (78%). Almost all of the sites not showing a decrease show no trend. On the other hand, only 42% of the sites show a decreasing trend for TSS, with 54% showing no trend, and fully 75% of the sites show an increasing trend for nitrite/nitrate, with 23% showing no trend.

1.9.D CALCULATING LOADINGS OF NUTRIENTS AND SOLIDS

In its problem investigation monitoring in Clean Water Partnership projects and TMDL studies, the MPCA uses a regression approach to computing pollutant loads. Regression approaches develop a relationship between concentration and flow based on the samples taken, then use the relationship to estimate a representative concentration for the days not sampled, usually using the mean daily flow as input to the regression equation. MPCA uses FLUX, an interactive program developed by the U.S. Army Corps of Engineers, for estimating the loadings of nutrients or other water quality components passing a tributary sampling station over a given period of time. These estimates can be used in formulating nutrient balances over annual or seasonal averaging periods. Data requirements include: 1) grab-sample nutrient concentrations, typically measured at a weekly frequency 2) corresponding flow measurements 3) a complete flow record for the period of interest (mean daily flows).

Flow is usually determined by routinely measuring the stage, or water height, while simultaneously measuring discharge over a wide range of flow conditions. A rating curve (mathematical equation(s)) is then computed to convert stage to discharge. Once a gaging station is established, stage measurements are made using automatic equipment and converted to flow by computer programs. Once a rating curve is developed, flow measurements are taken every four to five weeks to verify the integrity of the curve and to account for shifts in the curve (i.e. deposition or scour of bed material).

Ideally, 15 to 25 grab samples are collected each season at each monitoring site. Sample collection is systematic with the largest proportion of the samples collected during the time period(s) when the majority of the flow occurs. During low flow conditions, samples are collected less frequently but frequent enough to characterize changes in the concentration/flow relationship.

Using six calculation techniques, FLUX maps the flow/concentration relationship developed from the sample record onto the entire flow record to calculate total mass discharge and associated error statistics. An option to stratify the data into groups based upon flow, date, and/or season is also included.

SECTION 1.10
DATA REPORTING

To make its water quality monitoring data accessible to stakeholders and the public, the MPCA has designed a downloadable web page containing water quality data from monitoring sites located in Minnesota, as well as surface water conditions (assessments), where available. Currently, more than a dozen local, state and federal organizations have collected data that is available through the web page. All data included is thoroughly quality assured before it is made available on the site. The Environmental Data Access Initiative can be viewed on the web at: http://www.pca.state.mn.us/data/eda/index.html and a description is attached as Appendix 10.

The data web page was designed with considerable input from MPCA's monitoring partner stakeholders (local government and citizen monitoring groups). As a result, the web page addresses the most critical information need identified by those stakeholders – making the MPCA's data accessible. The web page will be expanded in the future to include data from other media (air and groundwater) as well as to include some level of data analysis (turning the data into information).

In addition, the MPCA provides a variety of reporting mechanisms for a variety of audiences, ranging from fact sheets on current topics to EPA-required reports to web-based reporting. Highlights of MPCA's surface water quality reports based on monitoring data follows, with web links where available:

Minnesota Water Quality: Surface Water Section Report to Congress: This 305b report reflects water body assessments for each basin, from which MPCA has developed its 303d list. The report and list are submitted to EPA in April of even-numbered years.
http://www.pca.state.mn.us/water/basins/305briver.html
http://www.pca.state.mn.us/water/basins/305blake.html

Minnesota Nonpoint Source Management Program Plan: Report to EPA required under Section 319 of the Clean Water Act. Provides information on nonpoint source pollution and strategies for improving water resources. http://www.pca.state.mn.us/water/nonpoint/mplan.html

To report on the effectiveness of Minnesota's nonpoint source efforts, *Watershed Achievements, 2003 Annual Report to the U.S. Environmental Protection Agency on Clean Water Act Section 319 and Clean Water Partnership Projects in Minnesota*, describes Minnesota's efforts to protect, maintain and improve the state's waters by reducing nonpoint source water pollution. The report is submitted annually to EPA (Appendix 5) and is excerpted as needed for use in providing information to Minnesota's legislature and other decision-making bodies.

Fact sheets on *Clean Water Partnership/Clean Lake Projects, North Shore Land Use Issues, Citizens' Guide to Monitoring Surface Water*, and other water topics. These fact sheets are made available at community meetings, in discussions with monitoring partners, and are used in discussions with legislators, county board members, etc.
http://www.pca.state.mn.us/water/pubs/factsheets.html

A *Volunteer Surface Water Monitoring Guide* (Appendix 3) is distributed to interested citizen monitoring organizations and is used by the Minnesota Rivers Council/Minnesota Lake Association in their ongoing volunteer monitoring training program.

A variety of status and trend reports as part of the Lake Assessment Program and Lake Assessment Reports by Minnesota County. The Lake Assessment Program is operated in partnership with local lake associations; thus the assessments are conducted at the request of the association and the information resulting is used by associations in planning their lake protection and remediation activities. Also, like the fact sheets, the reports are distributed to other interested parties through community meetings and are used in discussions with legislators, county board members, etc. http://www.pca.state.mn.us/water/lakequality.html

A variety of reports on Minnesota rivers and streams for scientific or technical audiences including the River Nutrient Study *Establishing Relationships Among In-stream Nutrient Concentrations, Phytoplankton and Periphyton Abundance and Composition, Fish and Macroinvertebrate Indices, and Biochemical Oxygen Demand in Minnesota USA Rivers* and *An Assessment of Representative Lake Superior Basin Tributaries 2002*. The technical reports are distributed within the Minnesota monitoring community through conferences, seminars and technical organization newsletters.

Annual reports of the Citizen Lake Monitoring Program and Citizen Stream Monitoring Program on the transparency of Minnesota lakes and streams. The reports are distributed to monitoring partners, citizen participants, local officials, etc. http://www.pca.state.mn.us/water/clmp-publications.html http://www.pca.state.mn.us/water/csmp-reports.html

For scientific and technical audiences, MPCA's *Environmental Bulletin* series, designed to highlight environmental outcomes and results of scientific studies the MPCA and its partners conduct in air, water and waste management. An upcoming Environmental Bulletin will focus on MPCA's North Shore Streams monitoring study. The bulletins are distributed to this specialized audience at technical meetings and conferences and through a mailing list of approximately 100 organizations in Minnesota and western Wisconsin including colleges and universities, libraries, trade associations, environmental groups, etc. http://www.pca.state.mn.us/publications/environmentalbulletin/index.html

For more general audiences, *Minnesota Environment*, a quarterly magazine, highlights environmental topics in each issue and has a readership of greater than 25,000. Past issues have been devoted to impaired waters, toxics, Minnesota lakes, hypoxia, and water quality impacts of sprawl. http://www.pca.state.mn.us/publications/mnenvironment/index.html

A web-based reporting method, *Indicator of the Month*, provides a learning tool to highlight important or emerging environmental issues and inform decision making. Past indicators discussed have included harmful exotic species, reduction of key pollutants in the Minnesota River, Lake Superior, Soil loss, assessing Minnesota rivers and streams for aquatic life and swimming use, and water transparency in Minnesota lakes. Information from Indicator of the Month is sometimes picked up for use in other venues. As examples, one of the ground water indicators was republished in Minnesota's Ground Water Association newsletter, and the indicator on soil loss was developed into a fact sheet for use at meetings and events. http://www.pca.state.mn.us/programs/indicators/iom.html

A series of *Reports on the MPCA's Index of Biotic Integrity* work highlights biological monitoring in streams and wetlands. The reports focus on geographic areas or specific issues involving fish, aquatic invertebrates and algae monitoring in streams and plant and invertebrate monitoring in wetlands. The reports are shared with researchers and others interested in biological monitoring through conferences, seminars, meetings and newsletters. http://www.pca.state.mn.us/water/biomonitoring/index.html

The MPCA's *Basin Information Documents* detail the conditions of each basin, and compile monitoring data and information for each basin. Monitoring data from all of the stakeholder groups in the basin is included. Basin information documents are used by basin teams

throughout the basin planning process (basin teams include MPCA staff, local government, other state and federal agencies, and citizens). http://www.pca.state.mn.us/water/basins/index.html

Each Clean Water Partnership and Section 319 project submits a final report on the work done, including the results of monitoring and the effectiveness of management activities undertaken. These reports are shared with interested parties and the information in them is used in determining the overall effectiveness of the programs.

Finally, for internal decision making, MPCA's *Environmental Information Report* provides an easy to use guide to information on air, water and land issues, using data summaries to identify risk and priority of various environmental problems. A copy of the report is attached as Appendix 11 and is available at http://www.pca.state.mn.us/publications/ei-report.html

SECTION 1.11
PROGRAMMATIC EVALUATION

In 2002, MPCA conducted a comprehensive evaluation of all of its monitoring programs. The report assessed MPCA's monitoring projects to identify needs and gaps, opportunities and ways to make the projects more efficient and effective. The report included a series of recommendations that applied across the media and recommendations for surface water monitoring. Copies of the report and a status update are included as Appendices 12 and 13. A description of the evaluation process undertaken in 2002 is included in the report, and MPCA plans to repeat this comprehensive evaluation, using a similar process, every 5 years. The next evaluation will be undertaken in 2007.

A primary need identified in the monitoring evaluation (and the evaluation's first recommendation) was the need for an annual process for identifying and coordinating annual monitoring efforts (a planning process). The Monitoring Leadership Team (supervisors and managers involved in all three types of monitoring, responsible for coordinating surface water monitoring at a strategic level) has authorized development of a prototype database for use in planning and coordination for annual monitoring activities. Monitoring staff will enter their monitoring plans into the database annually, which then will be available to staff and management for planning and coordination purposes. This will serve as a first step in establishing an annual planning process, and will be evaluated for effectiveness.

SECTION 1.12
GENERAL SUPPORT AND INFRASTRUCTURE PLANNING

In 2003, the MPCA convened a broad-based stakeholder group to design and identify funding for Minnesota's Impaired Waters efforts. The stakeholder group has developed its recommendations, including a funding source, to Minnesota's Governor and Legislature. The recommendations focus on monitoring for both prevention and restoration. For the condition

monitoring portion of Impaired Waters (data collection for assessments), the stakeholder group is recommending the four-part approach identified in the strategy section of this document: data collection by MPCA, data collection by other organizations, remote sensing and citizen monitoring. The group is recommending an assessment scenario that will provide complete coverage and confidence in the data over a 10-year cycle. Funding for this recommendation is provided in Table 10, with a comparison to current funding.

A detailed description of the impaired waters proposal is included as Appendix 2. Approval and funding from the Minnesota State Legislature will be necessary for Minnesota's monitoring strategy to be implemented in the 10-year time-frame.

For problem investigation and effectiveness monitoring, the stakeholder group is also recommending a broad-based approach. Problem investigation monitoring (TMDL studies) will be conducted by a variety of entities, including contractors and local governments. To judge the effectiveness of the implementation plans, the ten-year assessment cycle will provide this information at the watershed scale, while local monitoring will be used to judge the effectiveness of project level management practices.

1.12.A IDENTIFIED NEEDS

Implement Minnesota's strategy for complete assessment of its waters. At this time, funding to implement Minnesota's surface water monitoring strategy has not been identified. While the strategy exists, the means to implement all parts of it does not. In order to implement the four-component approach of the strategy, a funding source will need to be identified and adopted. The lack of funding affects not only MPCA's part of the monitoring strategy, but also the other three components – citizen monitoring, remote sensing and monitoring by other organizations in Minnesota (see Table 13).

Table 13. Statewide Assessment of Surface Water Quality and Trends -- Costs

	MPCA's Current Monitoring		Scenario for Comprehensive Monitoring	
Components	**Annual Funding**	**Activity**	**Annual Funding**	**Activity**
Streams	5% coverage		"Full" coverage in 10 years	
Chemistry & Flow Monitoring	$330,000	32 of 80 MN Milestone sites each year (on a rotating basis); 20 flow sites	$1,320,000	32 of 80 MN Milestone sites each year (on a rotating basis); 86 flow sites (20 existing + 66 new)
Integrated Monitoring (biological, chemical, physical)	$400,000	100 sites/year	$2,720,000	680 sites/year (100 existing + 580 new) to provide progressive monitoring to 25 mi^2 resolution
Remote Sensing	--	--	$30,000	Statewide remote sensing every 5 years ($150,000 every 5 yrs)
Volunteer Monitoring	$90,000	Citizen t-tube monitoring at 500 sites	$2,172,000	Citizen t-tube monitoring at 3600 sites, with partial chemistry monitoring at 10 sites in each of 84 major watersheds
Lakes	12% coverage		"Full" coverage of lakes > 100 acres in 10 years	
Lake Assessment Monitoring	$160,000	40 lakes/year	$450,000	100 lakes/yr (40 existing + 60 new) (20 lakes/yr are a follow-up of remote sensing)
Remote Sensing	--	--	$30,000	Statewide remote sensing every 5 years ($150,000 every 5 yrs)
Volunteer Monitoring	$100,000	Citizen Secchi disk monitoring at 1200 sites	$1,050,000	Citizen Secchi disk monitoring on all lakes > 100 acres, with partial chemistry monitoring on 300/yr of lakes 100-500 acres
Data Management	N/A	--	$520,000	Management of additional data
TOTAL	**$1,080,000**		**$8,292,000**	

-- Current annual funding includes monitoring-staff, equipment, and lab costs, but not supporting infrastructure costs.

-- Stream and lake percent coverages are based on impaired waters assessments (rather than 305b assessments, which may require less data). Lake percent coverages are of total lake numbers (rather than acres).

-- Full coverage of streams would be achieved through MPCA assessment (50%), remote sensing, and citizen monitoring providing screening and targeting of further monitoring where evidence of impairment. Full coverage of lakes > 100 acres would be achieved through MPCA monitoring of all lakes > 500 acres, remote sensing to help target the agency's assessment efforts for lakes between 100 and 500 acres, and volunteer monitoring of all lakes between 100 and 500 acres.

-- LCMR has funded a project that is providing support for IBI development, application and development of remote sensing, and training of volunteer monitors.

Develop and implement a framework for effectiveness monitoring for TMDLs. The MPCA and the stakeholder process recognized the need for effectiveness monitoring as an integral part of TMDL implementation plans. A strategic approach for such monitoring at the project and watershed level needs to be developed to address this need.

Consider assessing all waters for all uses. Currently, the MPCA does not assess surface waters for drinking water, aquatic life standards in lakes, and wetlands. While MPCA considers its strategy for assessing water bodies complete due to the use of probabilistic and progressive monitoring for streams, remote sensing and citizen monitoring for targeting both lakes and streams, the strategy does not provide for assessment of 100% of the individual water bodies in Minnesota. Because of Minnesota's vast number of surface water bodies and the resources that would be necessary to assess all water bodies for all uses, the MPCA has established priorities for its monitoring program, reflected in its strategy. Minnesota intends to continue its discussions to consider the feasibility of including drinking water, aquatic life standards for lakes, and wetlands in its assessment process, however, its focus remains on the priorities in its strategy outlined in this document.

MPCA recognizes Lake Superior monitoring as a related need. The MPCA has assessed Lake Superior in the past, and would like to do so again in the future. MPCA will discuss with its partner organizations what an appropriate monitoring activity for Lake Superior might involve, considering the lake's 191 year residence time, size and existing activity in the basin.

Support MPCA partners on their monitoring needs. MPCA monitoring partners – citizen volunteers, lake associations, watershed districts, county-led monitoring organizations, other regional, state and federal organizations, higher education institutions, and others – are a critical part of Minnesota's monitoring strategy. Each of those organizations has individual monitoring plans and associated needs. The MPCA needs to work closely with these organizations to ensure that all needs are considered in developing a state monitoring system.

SECTION 2: GROUND WATER

SECTION 2.1
AGREEMENT
TO OPERATE
AN INTEGRATED GROUND WATER QUALITY MONITORING SYSTEM
FOR THE STATE OF MINNESOTA

The Minnesota Department of Agriculture, Minnesota Pollution Control Agency and Minnesota Department of Health (Agencies) agree that the attached document *Integrated Ground Water Quality Monitoring Strategy*, dated February 11, 2004, represents the Agencies' joint plan for conducting ground water quality monitoring on a statewide basis in Minnesota.

The plan outlines the Agencies' different purposes, goals and roles in ground water quality monitoring based on their individual state and federal authorities and requirements.

The plan identifies how the monitoring conducted by the Agencies will be conducted in an integrated fashion providing a comprehensive, statewide assessment of ground water quality resources for the future. The plan also establishes inter-agency cooperation in shared monitoring design, sample collection, sampling location selection, evaluation of sensitive areas, and data management to ensure efficiencies in the system.

The plan provides for an annual review of the ground water quality monitoring system to allow for modifications, along with a five-year evaluation, at which time this agreement will be updated.

By signing this agreement, the Agencies commit to fulfilling the monitoring activities outlined in this plan in cooperation with the other agencies. An individual agency may choose to terminate its participation in this agreement with 30 day notice to the other Agencies.

Signed,

Gene Hugoson **Commissioner** **Department of Agriculture**	**Sheryl A. Corrigan** **Commissioner** **Pollution Control Agency**	**Dianne M. Mandernach** **Commissioner** **Department of Health**
Date	Date	Date

SECTION 2.2
Integrated Ground Water Quality Monitoring Strategy: Minnesota Department of Agriculture, Minnesota Department of Health and Minnesota Pollution Control Agency February 11, 2004

Three agencies – the Minnesota Department of Health, Minnesota Department of Agriculture and the Minnesota Pollution Control Agency – have primary responsibility for monitoring the quality of ground water statewide. This document represents an overall strategy for conducting statewide ambient ground water quality monitoring, and is agreed to by the three agencies to represent their operational plan.

2.2.A MONITORING PURPOSES, GOALS AND ROLES

Among the three agencies there are different, yet very closely related, purposes for conducting ground water monitoring. All three agencies use monitoring data to provide information necessary to assess – and ultimately restore or protect – the quality of Minnesota's ground water and drinking water resources.

The three agencies also share a common mission to share data with each other and other entities that manage ground water resources, and to share information from monitoring to educate the public about threats that ground water contamination presents to Minnesotans.

Beyond these general purposes for conducting ground water monitoring, each agency has individual, more specific purposes, based on the agency's statutory mandates (see table).

The Minnesota Department of Agriculture monitors to provide information on the impacts of the routine use of agricultural chemicals (pesticides and fertilizers) on the quality of Minnesota's water resources. The Department's monitoring goals/objectives are:

- to measure the status and trends in occurrence and concentration of pesticides and nutrients (from fertilizer) in water resources of the state;
- to evaluate attributes associated with ground water quality conditions that may cause or reduce ground water degradation by pesticides and nutrients;
- to provide scientifically and legally defensible information from which the efficacy of pesticide and nutrient management plans and practices may be determined; and
- to investigate the causes of agricultural chemical contamination and evaluate the effectiveness of Best Management Practices (BMPs) and any necessary Water Resource Protection Requirements (WRPRs).

The Minnesota Department of Health monitors to ensure all Minnesotans have safe drinking water and to understand current contaminant levels and trends in water quality that may pose significant health concerns for those drinking it. The Department's monitoring goals/objectives are:

- to assess public water supplies to ensure contaminants are below levels that present a human health threat;
- to assess private water supply wells to ensure that new wells meet minimal water quality standards and that the owners of private wells understand the health risks associated with contaminants that are detected in their well water;
- to evaluate the risk to human health arising from the presence of human-caused and naturally-occurring contaminants in groundwater; and
- to assist local health departments with addressing the human health impacts related to the contamination of public and private water supply wells.

The Minnesota Pollution Control Agency monitors to provide information on the impacts of non-agricultural chemicals on water resources. The Agency's monitoring goals/objectives are:

- to assess the status and trends of Minnesota's ground water system for non-agricultural impacts;
- to determine specific causes of impairments and to quantify inputs from sources;
- to investigate specific problems, and to design management approaches to protect or improve ground water resources; and
- to evaluate the effectiveness of regulatory or voluntary management actions.

The differences in monitoring purposes and goals result from the three agencies' differing roles in ground water quality monitoring. Those roles are set by a variety of state and federal statutes governing ground water. Table 1 identifies the different roles.

Table 1. State and Federal Ground Water Monitoring Authorities, by Agency

STATE AUTHORITIES MDA	MDH	MPCA
MS 103H: requires MDA to monitor the use and effectiveness of agricultural best management practices	MS 144.83: grants MDH authority to ensure that public water supplies are safe to drink and adopts federal Safe Drinking Water Act monitoring requirements	MS 103H: requires MPCA to monitor the use and effectiveness of non-agricultural best management practices
MS103H: requires MDA (for agricultural chemicals) to conduct monitoring following pollution detection to evaluate pollution frequency and concentration trend	MS 103I: grants MDH authority over the construction of water supply wells and to require testing to ensure potability of newly constructed wells	MS 103H: requires MPCA (for non-agricultural chemicals) to conduct monitoring following pollution detection to evaluate pollution frequency and concentration trend

MS 18B: requires MDA to determine impact of pesticides on the environment	MS 115B: grants approval for MDH to use solid waste funds to test private water supply wells that may be impacted by municipal waste disposal sites	MS115A: authorizes MPCA to investigate the extent, character and effect of the pollution of waters; to gather data for administration of pollution laws
MS 18B; 18C; 18D; 18E; 115B : authorizes MDA to undertake monitoring to investigate agricultural point-source pollution releases		MS115B: authorizes MPCA to undertake monitoring to investigate non-agricultural pollution releases
FEDERAL REQUIREMENTS **MDA**	**MDH**	**MPCA**
Federal Insecticide Fungicide and Rodenticide Act (FIFRA): Delegates pesticide programs to MDA and requires monitoring as part of FIFRA cooperative agreements	40 CFR 141 and 142 requires that public water supplies meet potability standards and grants states primacy rights to enforce federal drinking water regulations	Federal environmental programs delegated to MPCA require monitoring as part of clean up and regulatory programs

2.2.B TYPES OF MONITORING

For purposes of this document, we will discuss the three agencies' monitoring efforts in terms of three categories as follows:

- *Condition Monitoring:* This type of monitoring is used to identify overall environmental status and trends by examining the condition of individual water bodies, airsheds, or aquifers in terms of their ability to meet established standards and criteria. It may include chemical, physical or biological measures. The focus of Condition monitoring is on understanding the status of the resource, identifying changes over time, and identifying/defining problems at the overall system level.
- *Problem Investigation Monitoring:* This monitoring involves investigating specific problems to allow for the development of a management approach to protect or improve the resource. Problem Investigation monitoring is used to determine the specific causes of impairments to water or air and to quantify inputs/loads from various sources. It is also used to determine the actions needed to return a resource to a condition that meets standards or goals.
- *Effectiveness Monitoring:* This is used to determine the effectiveness of specific regulatory or voluntary management actions taken to remediate environmental problems. Effectiveness monitoring allows for the evaluation and refinement of the management

approach to ensure it is ultimately successful. Another example of Effectiveness monitoring is effluent or emissions monitoring done to assess the compliance of a facility with a permit, rule or statute (i.e. compliance tracking).

Note that there are connections between the three monitoring types. These definitions are not meant to be exclusive and rigid; there are gray areas and transitions. However, the definitions do help distinguish between the various purposes for monitoring. Perhaps the greatest area of overlap is found between Effectiveness and Condition monitoring. In this case, the difference between the two is largely a matter of scale. Effectiveness monitoring is done at the management scale to determine whether a particular management action is working. In contrast, Condition monitoring can be used to track the system-wide effectiveness of environmental protection efforts.

This strategy and operating agreement focuses primarily on Condition and Effectiveness monitoring. Also included is a brief discussion of the three agencies' Problem Investigation monitoring efforts.

2.2.C CONDITION MONITORING DESIGNS

To assess the status and trends of ground water quality, the three agencies have developed three individual monitoring designs that are interdependent and rely on close cooperation among the agencies, but reflect the three distinct missions of the agencies (pesticides and nutrients, nonagricultural chemicals and drinking water). An overview of these inter-relationships is shown in the table below, followed by a more detailed discussion of each agency's effort.

Table 2. Relationships among Condition Monitoring Designs

MDA Pesticide/Nutrient Ambient Monitoring	**Drinking Water Supply Monitoring**	**MPCA non-agricultural chemical ambient monitoring system**
• Uses MPCA GWMAP wells, MDH non-community public supply wells, as available. • Also uses dedicated monitoring wells and naturally occurring springs • Collects non-agricultural chemical samples for MPCA along with MDA samples	• Uses community and non-community public water supply wells • Assists in collecting non-community well samples for MPCA and MDA ambient networks • Assists with developing water quality data for private wells	• Uses existing wells from remediation sites and MDH public water supply wells, as appropriate • Collects pesticide and nutrient samples in urban areas for MDA, when funding or laboratory capacity is available

1. Assessing pesticides and nutrients in agricultural areas

MDA has established a statewide ambient drinking water survey to evaluate if and to what extent people may be consuming pesticides from drinking water wells across the state. The project targets sampling of drinking water wells that are vulnerable to pesticide contamination. The project focuses on pesticides present in sampled wells, frequency of presence and concentrations present. The data will be used to determine areas of the state that may need additional, more detailed monitoring or development of best management practices. A detailed discussion of the methods, uses of data, design and data analysis is included as Ground Water Attachment 1.

The network is based on a random 100 point grid where drinking water wells are selected. Sampling occurs once per year, and may not be repeated every year. The network is statewide, with the exception of the northeastern part of the state which has limited agriculture. With each sampling effort, a new random grid will be used. MDA will choose wells for the network from MPCA's former Ground Water Monitoring and Assessment Program (GWMAP) well set, MDH's non-community public water supply wells, and where the previous are not available, wells from the County Well Index.

MDA will sample the wells for nitrate, base neutral pesticides, and some degradates of these pesticides. Over time, the pesticides chosen for analysis may change, based on the Department's knowledge of pesticide use, new pesticide registrations and as methods are developed for additional degradates. In addition, for the first round of sampling MDA will collect samples from its network wells for MPCA, and MPCA will analyze those samples for its suite of non-agricultural contaminants. MPCA and MDA will consider the need for this additional sampling in future sampling rounds. For the non-community public water supply wells that are used, MDH will assist in securing the necessary samples, gaining permission to sample, and in screening wells for geologic sensitivity. In this way, the three agencies will be assisting each other in sample collection, resulting in a system that is efficient and comprehensive.

2. Assessing non-agricultural chemicals in urban areas

The MPCA is establishing a monitoring network to provide information on the quality of Minnesota's ground water and to identify trends. This network will build on the previous work done by the Ground Water Monitoring and Assessment Program. The monitoring network will focus on two areas: the presence and concentration of fuel oils, industrial solvents and other commercial and industrial organic chemicals in urban areas and concentration of nitrate in ground water beneath residential areas, particularly those serviced by septic systems.

Wells used for this network will include 100 to 150 shallow monitoring wells along with 100 to 150 deeper drinking water wells. All wells targeted will be in vulnerable aquifers. Shallow wells provide an early warning network in which we first expect to see changes in water quality. The deeper wells provide information about the quality of water that people are drinking and allow us to determine if there is a correlation between water quality trends in shallow and deep ground water. The wells used will be located in St. Cloud, the Twin Cities' area and Rochester, and the information will be used to understand ground water quality in other areas of the state as

well. In addition, annually, the MPCA will sample approximately 40 wells (20 shallow, 20 deep) from locations outside these study areas.

MPCA will analyze the samples for nitrate, volatile organic chemicals and chloride. MPCA will collect samples for MDA, when requested, to analyze for urban pesticides. Wells used for this network will include upgradient wells at existing remediation sites, wells drilled by the MPCA and MDH's non-community public water supply wells.

3. Assessing Drinking Water Quality

At a system scale, MDH's public water supply monitoring system evaluates drinking water quality in the state's public water supplies. The network includes 2,600 community water supply wells and 11,000 non-community public water supplies. The wells are sampled on varying schedules from daily to every 6 years, depending on the type of water supply and the contaminant. All wells are sampled for bacteria and nitrate. Community and non-transient non-community wells are also sampled for volatile organic chemicals and synthetic organic chemicals.

Most community public water supply systems are sampled after the water is treated, so these wells are least appropriate for use by MPCA and MDA monitoring networks. MDH monitors raw water at most non-community water supplies, so some of these wells will be used in the MPCA and MDA networks. In those cases, MDH will assist in collecting the samples.

MDH also works with county health agencies to collect and interpret water quality data from private water supply wells. The purposes for this are to 1) inform the public about health risks related to contaminated private water supplies, 2) identify areas where special well construction practices are needed to prevent contamination from entering water supply wells, and 3) to identify areas of ground water contamination that may present a risk to public health. Private well testing may assist MPCA and MDA in expanding their assessment activities into areas where ground water quality presents a risk to public health and to the environment in general.

2.2.D EFFECTIVENESS MONITORING DESIGNS

1. MDA regional ground water assessment program for pesticides

The MDA has established 10 water quality monitoring regions and is either currently, or will soon begin, monitoring in six of the 10 regions.

The purpose of the MDA's regional assessment program is to determine regionally specific pesticide or fertilizer best management practice needs and to measure the effects of changes in pesticide and nutrient management on ground water quality on a regional basis. The monitoring network will monitor existing wells in four regions of the state (northwest, west-central, southwest and south-central) using a random grid design in each region, with well sampling in winter and summer at a minimum of 10 wells in each region. For this program, MDA will use the most appropriate available existing wells in each of the regions. One additional regional assessment has been underway in the central sands since January 2000. The central sands

regional network utilizes specifically designed and installed monitoring wells and is located in one of the state's more sensitive ground water areas. In southeastern Minnesota the MDA is evaluating pesticide impacts by sampling springs emerging from the sedimentary bedrock formations.

Information from this network will be used to establish regional baseline conditions and to develop time trend data sufficient to evaluate the success of pesticide management changes in reducing pesticide impacts. Network information may further be used to determine the need for new approaches and refinement of existing practices in pesticide management; evaluate the need for water resource protection requirements; evaluate natural factors that impact pesticide movement to sensitive ground water; and evaluate BMPs for the need for specific modifications. Additional details on this network are attached in Ground Water Attachment 1.

MDA also conducts Effectiveness monitoring at a project level for point sources at its pesticide remediation sites across the state.

2. MDH Compliance Monitoring System

MDH's Public Water Supply monitoring network also serves as an Effectiveness monitoring system at a project scale. Each public water supply in the state is monitored on a routine basis for compliance with standards, as required by federal and state law. In addition, MDH also operates a compliance monitoring system for new private wells statewide, which requires one-time monitoring for bacteria and nitrate at time of drilling, to ensure compliance with standards.

MDH also requires effectiveness monitoring in special well construction areas to ensure that mandated well construction practices offset the movement of contamination into private water supply wells.

3. MPCA Effectiveness Monitoring

On a project level, MPCA conducts Effectiveness monitoring at each of its remediation sites across the state and at some of its regulated facilities (e.g., certain wastewater spray irrigation sites, certain feedlots, etc.). However, a system-level evaluation of the effectiveness of non-agricultural management practices needs to be developed.

2.2.E PROBLEM INVESTIGATION MONITORING

Problem Investigation monitoring by the three agencies is likewise tied to the differing roles and authorities. MDA conducts Problem Investigation monitoring at point source sites where agricultural chemical releases have occurred. MPCA conducts Problem Investigation monitoring at a variety of sites – Superfund sites, voluntary cleanup sites, landfills, and other regulated sites, as well as for nonpoint pollution through the Phase I diagnostic studies in the Clean Water Partnership program. MDH investigates a variety of ground water quality problems that may affect drinking water quality and human health, including monitoring around old dump sites, monitoring to study the occurrence of arsenic in drinking water systems and diagnostic monitoring as part of the Wellhead Protection Program.

2.2.F QUALITY ASSURANCE, DATA MANAGEMENT, DATA ANALYSIS AND REPORTING

Each agency will follow its respective Quality Assurance and Data Analysis processes required for the respective type of chemical. These methods and plans are available from each agency.

For data management and reporting, the ambient network data from MPCA and MDA will be entered into STORET, a federally-driven database. This data can then be accessed through the MPCA's Environmental Data Access Initiative, which allows users to view and use the data via a GIS-based system. For the future, MPCA will work toward entering current and historic remediation ground water data into STORET. MDH will consider the use of STORET for its public water supply data, depending upon resources.

Each agency will use their data, as well as the data from other agencies, to prepare reports based on their statutory requirements and the need for sharing information with stakeholders and the public. On issues where there is mutual interest, the Agencies will coordinate interpretation of data and presentation of results to stakeholders and the public. MPCA will continue its role of coordinating a biennial report to the legislature on the status and trends in ground water quality.

2.2.G PROGRAMMATIC EVALUATION

Annually, the three agencies will review their monitoring plans for Condition and Effectiveness monitoring, and make adjustments, as necessary. On a five year cycle, the agencies will update this operating agreement to reflect changes made to the monitoring systems over the five year period.

2.2.H GENERAL SUPPORT/INFRASTRUCTURE PLANNING

This strategy represents what the Agencies believe to be an implementable coordinated ground water quality monitoring system in Minnesota, given current resource constraints. Any additional resource reductions that should occur will impact the ability of the Agencies to implement this plan.

GROUND WATER ATTACHMENT 1

MINNESOTA DEPARTMENT OF AGRICULTURE
2003 MONITORING NETWORK EXPANSION FRAMEWORK

1. Statewide ambient drinking water evaluation program

a. Purpose: evaluate to what extent people may be consuming pesticides from drinking water wells across the state.

This project targets sampling of drinking water wells for pesticides and attempts to collect samples from sites that exhibit a vulnerable condition. This is a general survey to determine if, and to what extent, the water that is developed and consumed as potable supplies may be impacted by pesticides.

b. Information need: pesticides present; frequency of presence; concentrations present

Pesticides present
We want to know what pesticides might be reaching drinking water sources. A pesticide is determined as present through laboratory analysis where the compound is qualitatively identifiable through Gas Chromatography and Mass Spectrometry analysis.

Frequency of presence
When pesticides are found to be present in drinking water, are they found at single or multiple sites? This will be determined by simple counts of samples where a pesticide is determined as present versus those where pesticides are absent.

Concentrations present
When pesticides are found in drinking water, how much is there? Where pesticides are found at quantifiable levels, those levels will be reported and compared among samples and sites.

c. Use of data: focus additional work including common detection determination; additional monitoring; and implementation of BMPs

Focus additional work including common detection determination
Data collected through this effort will be valuable for informing decision making regarding future activity, priority setting, and resource allocation. The use of the data incorporates the protection of ground water and primary decisions directing actions to affect the protection of ground water.

Additional monitoring
Data collected through this effort may be used to evaluate and direct priorities for future monitoring efforts. Monitoring needs may be identified by evaluating geographical extent and intensity of pesticide impact to drinking water sources.

Implementation of BMPs
Data collected may provide additional focus for the need for BMP implementation and evaluation efforts. The first action for ground water protection under the ground water protection act is the development, promotion, implementation and evaluation of BMPs. The statewide sampling effort may identify areas where implementation actions should be accelerated.

d. Basic design: random grid of size to result in 100 nodes across the state (excluding the northeast); closest well to grid nodes selected when determined to represent a vulnerable condition; samples collected once per year, and may not be repeated every year.

A randomly initiated, randomly aligned grid will be generated over the area of the state of interest [all of the state except the north east and north central regions] with a density such that 100 grid nodes lie within the designated area. The grid nodes will occur at a regular interval which meets the above criteria. The point of each node will identify the geographic point to be used to initiate a search for the nearest available well for potential sampling. Well owners will be asked for permission to sample. Each identified well will be characterized at the time of sampling. Characterization will include identification of surrounding land use (i.e. agriculture, urban/suburban, rural residential, etc.); well information including, depth, diameter, use, construction, etc.)

e. Data analysis and presentation: percent detection of any pesticide; percent detection of specific pesticides; averages and ranges of pesticide concentration; location of detections; changes in above items over time

Percent detection of any pesticide:
Percentage of samples in which one or more pesticides were detected.

Percent detection of specific pesticides:
A list of pesticide analytes and the percentage of detections for each of those analytes.
Averages and ranges of pesticide concentrations:
Central tendency will be evaluated against the data distribution. Median and mean values will be reported for each detected analyte. Range will be reported directly for each analyte. Additional distribution information such as the interquartile range and standard deviations may also be reported when supported by the data.

Location of detections
Wells with detections will be highlighted on a map showing all sampled well locations. GPS readings will be collected at the time of sampling to facilitate this effort if not already collected by another entity.
Changes in percent detections or concentrations over time:
Will be evaluated over future repeated sampling efforts.

f. Implementation target date: October 2003
g. Anticipated first report of results: January 2005

2. Regional ground water assessment program

h. Purpose: measure the effects of changes in pesticide management on ground water quality on a regional basis.
i. Information need: trends in frequency of detection of specific pesticides; trends in concentration of specific pesticides (looking for trends that are long-term small magnitude to be protective); detection of new pesticides in ground water
j. Use of data: measure success of pesticide management changes at reducing pesticide impacts; determine need for new approaches and refinement of existing practices in pesticide management; evaluate need for water resource protection requirements; evaluate natural factors that impact pesticide movement to sensitive ground water; evaluate BMPs for the need for specific modifications
k. Basic design: focus on four regions (northwest, west central, southwest and south central); use central sands design paradigm of randomly established appropriately sized grids; use statewide paradigm of selecting existing wells closest to grid node; sample wells biannually (Winter, Summer); select a minimum of 10 wells per region (select replacement wells if wells become unavailable for sampling); maintain program for at least 20 years. Preference toward publicly owned wells.
l. Data analysis and presentation: detection of any pesticide; percent detection of specific pesticides; averages, ranges, quartiles of pesticide concentration; location of detections; trends in above items over time
m. Implementation target date: January 2004
n. Anticipated first report of results: January 2005

APPENDICES

APPENDIX 1

SURFACE WATER MONITORING STRATEGY IMPLEMENTATION TIMELINE

Ongoing	Work with state agencies, EPA and others to evaluate the feasibility of assessing waters for all uses.
Ongoing	Continue to identify MPCA and partner organization needs for surface water quality monitoring
Early 2004	Establish database for annual monitoring planning process
March 2004	Establish effectiveness monitoring design for stormwater program
April 2004	Submit 303d list and 305b report to EPA (integrated report) Begin development of effectiveness monitoring framework for 319 and the impaired waters program
July 2004	Identify parts of strategy to proceed in absence of funding Finalize revised Quality Management Plan and submit to EPA Draft needs assessment on monitoring data needed to assess Minnesota's contribution to hypoxia, turbidity, temperature change and other regional and national pollutants
September 2004	Impaired Waters Coordinating Council established (dependent on legislation) MPCA monitoring strategy approved by EPA MPCA effectiveness monitoring framework submitted to EPA
By end of 2004	Approve monitoring strategies for 15 TMDL implementation plans
July 2005	Secure funding for surface water monitoring assessment strategy and TMDL studies; begin implementation of strategy Multi-agency wetland strategy developed 650 stream sites monitored by volunteers 1450 lake sites monitored by volunteers Begin stormwater effectiveness monitoring Conduct monitoring to support completion of 36 TMDLs (from 9/03 to 6/05) Evaluation of monitoring needed to assess state's contribution to hypoxia, turbidity, temperature change, other water pollution problems First round of remote sensing completed for lakes

	Development of remote sensing completed for streams Water Quality Standards Revision, with process articulated for requesting use attainability classification changes
September 2005	Sampling for Index of Biotic Integrity Report completed
By end of 2005	Approve monitoring strategies for 21 TMDL plans
April 2006	Submit 303d list and 305b report to EPA
By end of 2007	Complete 5-year evaluation of state's monitoring programs
April 2008	Submit 303d list and 305b report to EPA
By end of 2008	Water Quality Standards Revision, with tiered aquatic life standards Assessment of state's contribution to identified regional national and international water pollution problems complete
2010	Second round of remote sensing completed
2011	Water Quality Standards Revision
By end of 2012	Complete 5-year evaluation of state's monitoring programs
2014	First 10-year cycle (complete coverage) of surface water assessments completed 4000 lakes with ongoing citizen monitoring 3600 streams with ongoing citizen monitoring Assessment complete on 25% of state's depressional wetlands