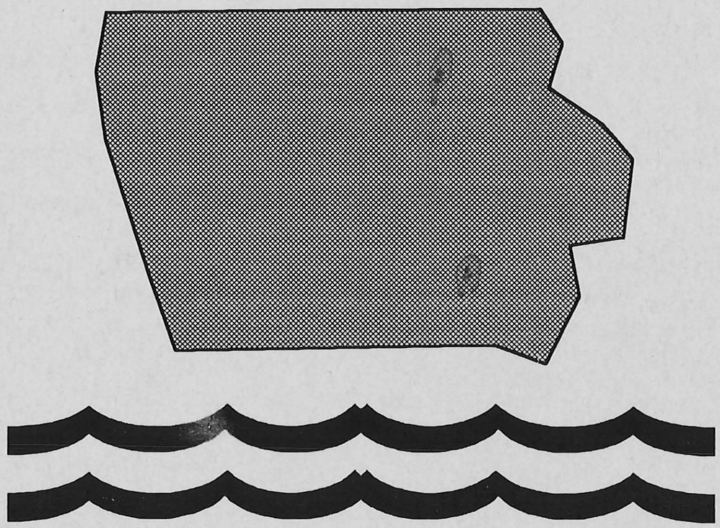
A Statewide Monitoring Strategy Supporting a Watershed-Based Approach in Iowa

Final Report



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Appendix A.
Example of Cost Estimate

Executive Summary

The watershed-based approach for waste load allocation and water quality management has many advantages over the traditional, fragmentary, point-source oriented way of dealing with water quality problems, that has historically been used in many states, including Iowa. The advantages of the watershed approach are potential efficiency gains through better coordination and prioritization, improved relationships with stakeholders, and the integration of point and non-point source management programs, which is a key to addressing many of today's prevailing water quality problems. Therefore, it is recommended that the state of Iowa adopts the watershed approach for its water quality management programs.

The key elements of the watershed approach include the integration of point and non-point sources in water quality monitoring and in the design of management strategies, the use of watersheds or river basins as geographic management units, planning and coordination of activities through a basin management cycle, and the involvement of interest groups or stakeholders in a watershed in the water quality management process. In this report, suggestions are made for a division of the state of Iowa into five major management units, drawn around large river basins, and for a five-year basin management cycle, to organize water quality management activities by basin and to balance the workload over time.

Water quality monitoring plays an essential role in the watershed approach. The objectives of a state-wide monitoring strategy for the watershed approach are to assess water quality conditions and trends and the degree to which designated uses are supported, to rank the severity of water quality impairments to enable prioritization, to identify sources of water quality standard violations, to collect data to support modeling for Total Maximum Daily Load (TMDL) development and waste load allocations, and to ensure compliance with permits and evaluating the effectiveness of water quality management strategies. Monitoring for assessment and prioritization purposes typically takes place in the first year of a basin management cycle, while more detailed and intensive monitoring is done in the third year to support modeling for TMDL studies and waste load allocations. Compliance monitoring is an ongoing activity.

In order to meet the diverse data needs originating from different water quality management activities, as described above, it is recommended that the state of Iowa includes the following elements in its water quality monitoring program.

- The existing fixed-station ambient monitoring network should be continued. It should be considered to include biological data as well as toxic chemicals in the parameters to be analyzed, and to expand monitoring to include some lakes.

- A rotational station should be established in each 8-digit USGS watershed (two stations in watersheds over 800 mi^2), that should be sampled once a month during one year out of every five years, according to the basin management cycle. Parameters to be analyzed should include channel characteristics and flow, water temperature and transparency, and concentration of relevant substances such as sediment, dissolved oxygen (DO), biochemical oxygen demand (BOD), nutrients, ammonia, toxic chemicals and heavy metals.

- In watersheds where critical water quality problems have been identified, intensive surveys will be carried out. These surveys will be tailored depending on the specific data needs for the problem under consideration.

- Data from intensive surveys could be used to support Total Maximum Daily Load (TMDL) studies. Procedures for TMDL studies will have to be designed in more detail by IDNR personnel.

- Ongoing studies at IDNR investigating the use of biomonitoring and the development of biological criteria, should be continued. Biological monitoring aims at assessing the overall condition of aquatic ecosystems, which reflects chemical and physical water quality parameters, as well as habitat quality. Therefore, biomonitoring could prove to be a valuable tool for signaling (especially non-point source related) water quality impairments. If the current studies yield positive results, biomonitoring should be incorporated into the regular fixed and rotational station monitoring programs.

- NPDES compliance monitoring is necessary for permit enforcement, and should therefore be continued.

- IDNR should investigate the practical and legal possibilities of requiring major NPDES permitees to provide IDNR with some in-stream water quality data. This would be an alternative for cost recovery of NPDES-related monitoring activities through charging substantial fees for NPDES permits, as is being done in some other states.

- IDNR should consider making more use of volunteer monitoring, in order to improve involvement of citizen' groups in water quality issues, and also to allow collection of larger amounts of ambient water quality data with a minimum of additional personnel cost. IDNR should provide proper equipment, training and guidance to volunteer monitoring groups, to coordinate data collection efforts with IDNR's own priorities, and to ensure basic quality control. Data collected by volunteers can not be used in legal enforcement issues.

In order to implement the various elements of the proposed monitoring strategy, including increased sampling frequency, IDNR will need to add approximately five more personnel at least to its water quality monitoring section. These include a basin planner (who would be coordinating watershed management activities in general), a database manager with knowledge of Geographic Information Systems (GIS), a monitoring professional, assisted by two or three technicians, and a volunteer monitoring coordinator. If IDNR hires a third party to carry out sample collection and analysis activities under contract, some of these people (in particular the technicians) would be working for the third party. In that case, the costs of IDNR's external contract would rise. In addition, IDNR should re-evaluate its hardware and software needs, in order to facilitate management of the increased amounts of data being collected. More resources may be needed to accomplish the goals and to obtain the benefits of the watershed-based approach.

An increased funding level for water quality monitoring activities in Iowa will be necessary. From a survey by ISU, it appeared that the expenditures on monitoring activities in many other states are substantially higher than in Iowa. The funding levels for water quality monitoring in some of Iowa's neighboring states are a factor two to twelve higher than in Iowa. The current monitoring budget of the state of Iowa is insufficient to provide the minimal information needed to support effective water quality management programs. Therefore, this budget needs to be expanded. It is recommended that IDNR investigates possibilities to obtain additional funding from a combination of in-state and federal sources. The costs listed in Appendix A are a preliminary estimate. More resources may be needed before the watershed approach could be fully implemented.

In the same survey mentioned above, states indicated the benefits they experienced after implementing a monitoring program on a watershed basis. These include better water quality assessments, improved data availability for waste load allocations, and greater efficiency. This accentuates the potential advantages of implementing such a program in the state of Iowa. While the watershed approach has benefits, including more efficient use of resources, the resources needed for implementing the approach would require a level of funding much higher than what currently is available in Iowa.

In order to guarantee a smooth transition from the current situation towards a fully implemented watershed approach, it is recommended that the proposed monitoring strategy be implemented in stages. In the first stage, the focus should be on implementing rotational monitoring and intensive surveys on a watershed basis, as well as improving stakeholder involvement. In the second stage, when more data should be available, more emphasis can be placed on non-point sources and TMDL development, and also on expanding volunteer monitoring programs. Priorities will have to be re-evaluated for each new cycle.

1. Introduction

This report presents the results of a research project conducted by Iowa State University (ISU) for the Iowa Department of Natural Resources (IDNR). The objective of the project is to develop a statewide strategy for monitoring water quality in Iowa's water bodies on a watershed basis, in order to support the implementation of a watershed approach to water quality management in Iowa.

In Part A of this report, the general concept of the watershed approach is reviewed, and a framework is developed for a watershed approach to be implemented in the state of Iowa. Key elements of the watershed approach, such as the basin management cycle and geographic management units, are discussed.

In Part B, a monitoring strategy to support the watershed approach in Iowa is developed. First, the monitoring needs for the watershed approach are identified. Then, a monitoring strategy is proposed, consisting of elements such as fixed stations, rotational stations, intensive surveys, biological monitoring and Total Maximum Daily Load (TMDL) studies. Also, the potential use of Geographic Information Systems (GIS) to support monitoring under the watershed approach is examined.

In Part C, the benefits of a monitoring strategy on a watershed basis are investigated, and the cost components of the proposed monitoring strategy are identified.

Finally, in Part D, recommendations are formulated for the design and implementation of a monitoring strategy on a watershed basis in the state of Iowa.

In a closely related research project, ISU is also investigating the possibilities of waste load allocation on a watershed basis for the state of Iowa. The results of that research are presented in another series of reports by the Surface Water Quality Research Group.

Part A.
The Watershed Approach

2. Review of the Watershed Approach in General[1]

2.1. Background

The Federal Water Pollution Control Act of 1972 (also called the Clean Water Act) established the national goal of restoring and maintaining the physical, chemical and biological integrity of the Nation's waters. Section 303 of this act laid a foundation for watershed protection with its provisions for intrastate water quality standards, comprehensive basin planning and establishment of Total Maximum Daily Loads (TMDLs).

However, the initial implementation of the Clean Water Act concentrated on the creation of a federal permitting program, the National Pollutant Discharge Elimination System (NPDES). The subsequent workload in handling NPDES permits overwhelmed many state water quality programs to the point where the primary focus became response to NPDES applications, establishment of point source waste load allocations, issuance of NPDES permits and NPDES permit enforcement. Program resources were rarely allocated to the evaluation of non-point source loads, such as those from overland runoff or transport of pollutants through groundwater flow into surface waters.

The most recent National Water Quality Inventory [305(b)] Report states that the Nation has not yet achieved its goal of restoring and maintaining the physical, chemical and biological integrity of its aquatic ecosystems. Major limiting factors are non-point source pollution and habitat degradation. Nowadays it is understood that a comprehensive approach is needed, which incorporates ecological principles and collaboration among agencies. Many agencies and programs at all levels of government are now embracing the idea of using the geographic boundaries of a river basin or a watershed as the basis for coordinating and integrating environmental management efforts. This is known as the watershed approach.

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[1] The material in this chapter is based on the "Statewide Watershed Management Course", EPA, 1995

2.2. The Watershed Approach

The watershed approach involves the integration of various natural resource management programs into a comprehensive watershed protection approach and the coordination of watershed protection efforts throughout a state. This is not a new approach, but rather a logical extension of basin planning provisions in the Clean Water Act. The watershed approach provides numerous benefits to agencies responsible for implementing water-related legislative mandates. Also, the approach is very flexible in that it can be adapted to the unique circumstances within each state.

Based on the experiences within various states, however, some common elements can be distinguished:

- <u>Geographic Management Units</u>
  Under a watershed approach, a state is divided into geographic management units, drawn around large river basins (see Figure 1.). These are used by the agencies involved as the geographic basis for coordination of their water resource management activities.

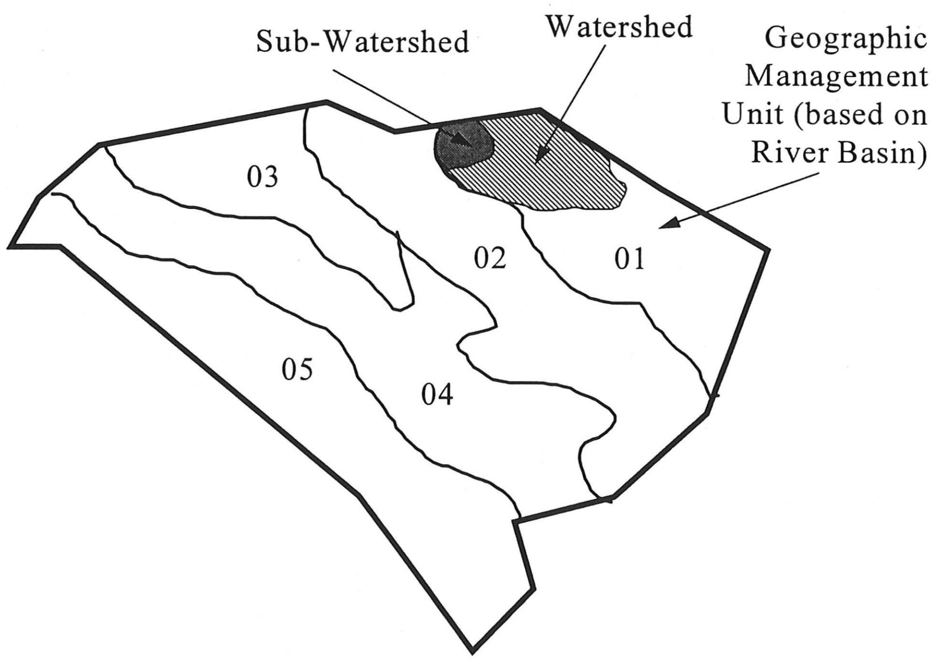

Figure 1. Example of Geographic Management Units :
Division of a state based on 5 major River Basins,
that can be subdivided into Watersheds and Sub-Watersheds

- Participants
  Under a watershed approach, participants are all agencies, organizations and individuals that are involved in or affected by water quality management decisions for a given basin. They can include, for example, regional offices of federal agencies, state natural resource management agencies, representatives of local (county or city) administrations, drinking water and wastewater utilities, industrial (NPDES) dischargers, representatives of the agricultural sector and citizen volunteer monitoring groups (see Figure 2.).

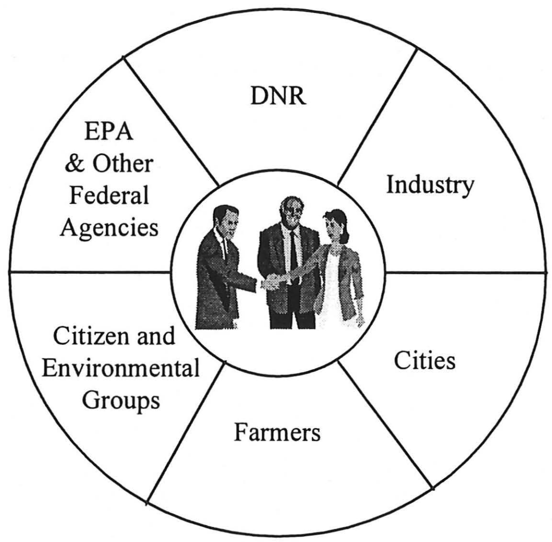

Figure 2. Example of Stakeholders in Basin Management

- Basin Management Cycle
  Under a watershed approach, various water resource management activities for a given basin are planned and coordinated through a basin management cycle. Many states have chosen a 5-year cycle for this purpose. Examples of activities that can be part of the cycle are (historic) data collection, assessment of water quality conditions, formulation of objectives, monitoring, modeling, NPDES permit issuance, and evaluation.

3. Framework for the Watershed Approach in Iowa

3.1. Need for the Watershed Approach in Iowa

Many States throughout the USA have already implemented the Watershed Approach for solving their water quality problems, and many others are planning to do so in the near future. This is not surprising, since this approach has many advantages over the traditional, fragmentary, point-source oriented way of dealing with water quality concerns. Two advantages of the Watershed Approach deserve some special attention:

<u>Non-Point Sources</u>
Many water quality problems are related to non-point sources. Examples are runoff from urban storm sewers and runoff from agricultural areas containing pollutants like sediment, nutrients and pesticides. This is especially important in Iowa, since the predominantly agricultural land use has a heavy impact on water quality conditions, and many water quality impairments can be subscribed to runoff from agricultural areas. Therefore, for many water bodies, the only way to achieve significant improvements in water quality conditions is to consider the combined effect of both point and non-point sources in the entire watershed.

<u>Prioritization and Coordination</u>
Most agencies responsible for water quality management must accomplish their mission with budgets that tend to be very restrictive. This is also the case for the Iowa Department of Natural Resources. Therefore, it is essential to address water quality issues in the most efficient way, by allocating scarce resources to the watersheds where they are most needed, and by cooperating with other parties involved, in order to combine forces and avoid overlaps. The Watershed Approach offers instruments for priority ranking of watersheds within a basin and provides a platform for cooperation with other parties involved.

3.2. Key Elements of the Watershed Approach in Iowa

Some of the key elements that need to be incorporated in the future Watershed Approach to water quality management in Iowa are discussed below.

- <u>Include Non-Point Sources</u>
  As is obvious from the previous paragraph, non-point sources, like agricultural practices and urban developments, need to be included in water quality analyses. An important constraint to implementing the Watershed Approach are the limited possibilities to measure the impacts of non-point sources, and the lack of water

quality standards specifically related to these sources. One way to approach this problem is the development of stream biocriteria, an activity that is currently being carried out by IDNR. However, it will still be necessary to devote a significant amount of attention to monitoring and controlling non-point sources, in order to make the Watershed Approach a success.

- Analyze the Entire Watershed
  In order to include non-point sources in a water quality analysis, and also to be sure that all point source discharges on a stream and its tributaries are taken into account, the entire watershed has to be considered.

- Address Basins in a 5-Year Cycle
  In order to improve water quality conditions in target watersheds in different basins over a multi-year period of time, planning will be needed. It needs to be decided how watershed management activities carried out by IDNR, like monitoring and permit issuance, will be scheduled in time and space. Two key decisions will have to be made:

  1) *Development of a Basin Management Cycle*
  A suitable planning framework, which is used by most other states implementing the watershed approach, is the basin management cycle. A workable cycle has to be developed, meeting the particular needs of IDNR.

  2) *Delineation of Geographic Management Units*
  It needs to be decided how Iowa can be subdivided into a number of major river basins or groups of basins, that will be used as units for the basin management cycle.

The first two points mentioned above have important implications for the watershed modeling approach chosen by IDNR. Therefore, they will be dealt with in the report on the Waste Load Allocation (WLA) project. The last point has more general implications for the way IDNR is organizing its water quality management activities. Therefore, it will be treated in more detail in the remaining part of this chapter.

3.3. Development of a Basin Management Cycle

The purpose of a Basin Management Cycle is to effectively and efficiently organize watershed management activities in time and space. This has to be done in a way ensuring coordination between various activities for one watershed and balancing the workload over time while addressing different watersheds.

Following this approach, various water quality management activities for a given watershed will take place in a cycle of a specified duration. Because of the 5-year time frame on NPDES permits, a 5-year cycle seems to be most appropriate for this purpose.

In this case, IDNR would group and sequence all watersheds in Iowa such that, during any given year, one-fifth of the watersheds is in the first year of the cycle, one-fifth in the second year, etc. (see also Figure 3.). In this way, any watershed management activity, such as intensive monitoring or issuing NPDES permits, is carried out in any given year for approximately one-fifth of the state's watersheds, thus balancing the workload for the personnel involved.

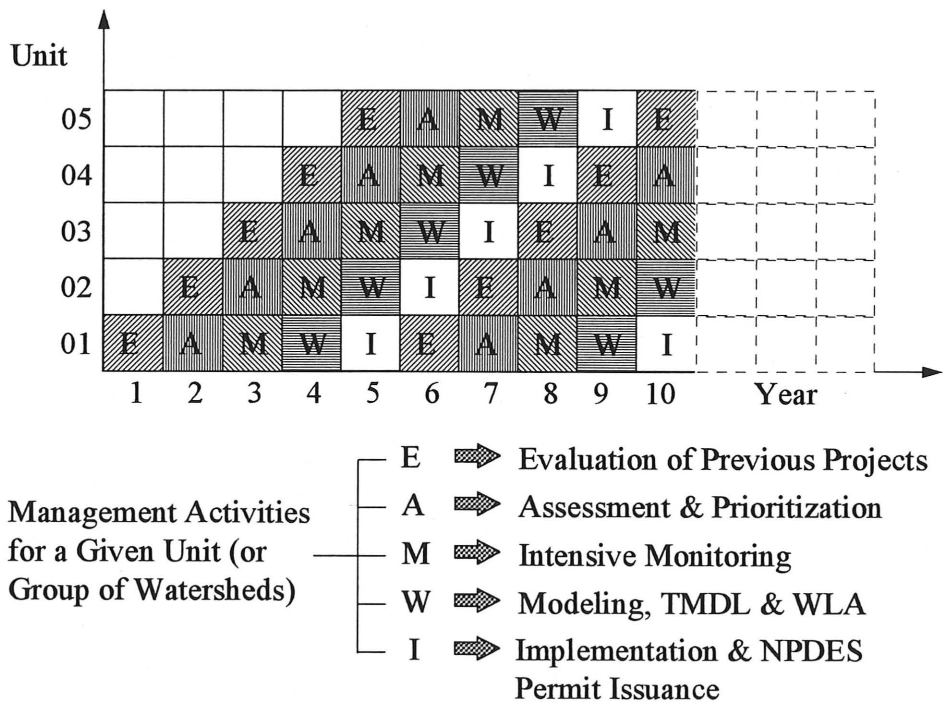

Figure 3. Example of 5-Year Management Cycle

The activities to be addressed in each year of the cycle are explained in more detail in the following:

Year 1

During the first year of the cycle for a given management unit, IDNR would be evaluating results of previous projects in the area (although this activity might be continuing over a more extended period of time). Also, IDNR would monitor the rotational stations located within the management unit, approximately one in each watershed. The stations being monitored each new cycle will generally be at the same locations, although it would be possible to adjust these locations or tailor the parameters to be monitored, dependent on the specific conditions of the watershed.

Year 2

Based on the results of the rotational station monitoring, IDNR would assess water quality conditions and designated use support in each of the watersheds within the management unit. Based on these assessments, water quality goals would be developed for the watersheds. These goals represent reasonable targets for water quality improvements in the respective watersheds. Therefore, goal setting is independent from the legislative process of designated use classification or setting water quality standards. The activities of water quality assessment and goal setting would involve meetings with the stakeholders, i.e. the agencies, organizations, local governments, industries and groups that have interests in water quality issues in the watersheds within the management unit. To the discretion of IDNR, these meetings could be organized for the management unit as a whole, or in case there is little relationship between the individual watersheds within the unit, on a watershed basis.

Based on the water quality assessment and goals, IDNR would set priorities to devote its attention to the most critical watersheds within the management unit. For the critical areas, an intensive monitoring plan will be developed.

Year 3

During the third year, IDNR will carry out the intensive monitoring, according to the plan that has been developed in year 2. The data obtained through the intensive monitoring studies will be processed, stored and analyzed.

Year 4

During the fourth year of the cycle, IDNR will use the data from the intensive monitoring studies for the calibration and verification of water quality models for the critical watersheds within the management unit. The calibrated models can then be used for development of Total Maximum Daily Loads (TMDLs) for the targeted watersheds, and for Waste Load Allocation (WLA) calculations. Also, in cooperation with the stakeholders, management strategies will be developed that are aimed at controlling both point and non-point sources. Non-point source control strategies could include, for example, incentive programs for farmers to adopt best management practices (BMPs).

Year 5
During the fifth and final year of the cycle, NPDES permits will be issued based on the Waste Load Allocations, and approved management strategies will be implemented. This will be done in close coordination with relevant stakeholders. Also, evaluation procedures will be developed and indicators will be defined to monitor if the selected management strategies actually lead to achievement of the desired water quality level. This information will be used in the first year of the next management cycle.

These activities are summarized in Table 1.

Table 1. Example of 5 Groups of Basin Management Activities

Year	Activity
1	• Evaluation of results of previous projects in the basin • Development of rotational station monitoring plan • Rotational station monitoring
2	• Water quality assessment* • Setting water quality goals* • Prioritization of intensive monitoring and modeling efforts • Design of intensive monitoring plan
3	• Intensive watershed monitoring • Data processing and analysis
4	• Water quality modeling • Total Maximum Daily Load (TMDL) development • Development of management strategies* • Waste Load Allocation (WLA)
5	• NPDES permit issuance • Implementation of management strategies* • Design of evaluation procedures / performance indicators*

(The activities marked with a * involve some form of stakeholder input or participation)

3.4. Delineation of Geographic Management Units

In order to effectively cover the entire State of Iowa in IDNR's water quality management program, it is recommended that Iowa be subdivided into river basins and watersheds. These will be used as units to efficiently organize water quality management efforts, like TMDL development and NPDES permitting, as described in the previous section.

Because of the 5-year duration of the water quality management cycle (which is based on the 5-year period for which NPDES permits are issued), Iowa should be divided into 5 basins or groups of basins, which will be called units. Every year activities like monitoring or permitting will be carried out in one of the 5 units, so that after 5 years all units, covering the whole state, have been addressed. Therefore, the workload should be more or less evenly balanced among the 5 units.

An important factor in determining the workload for a given unit is the number of NPDES permits to be issued in that area. Since this information cannot be easily obtained, a division will be proposed that defines five units with more or less equal land areas. It is assumed that the number of permits to be issued in these large areas is approximately of the same order of magnitude. As a basis for the division of Iowa into units, the USGS Hydrologic Unit Map has been used. However, the USGS hierarchy of regions and subregions has to be adapted in order to enable the designation of 5 units having an approximately equal area.

The following management units are proposed (see Table 2. and Figure 4.) :

Table 2. Example of Delineation of Geographic Management Units in Iowa

Unit	River Basin(s)	USGS Number(s)
I	Des Moines River	0710####
II	Skunk River South-Central Iowa North-Central Iowa	07080104 through 07080107 0711####, 102801## and 102802## 07020009
III	Iowa and Cedar Rivers	070802##
IV	Wapsipinicon River North-East Iowa	07080101 through 07080103 0706####
V	West Iowa	1017####, 1023#### and 1024####

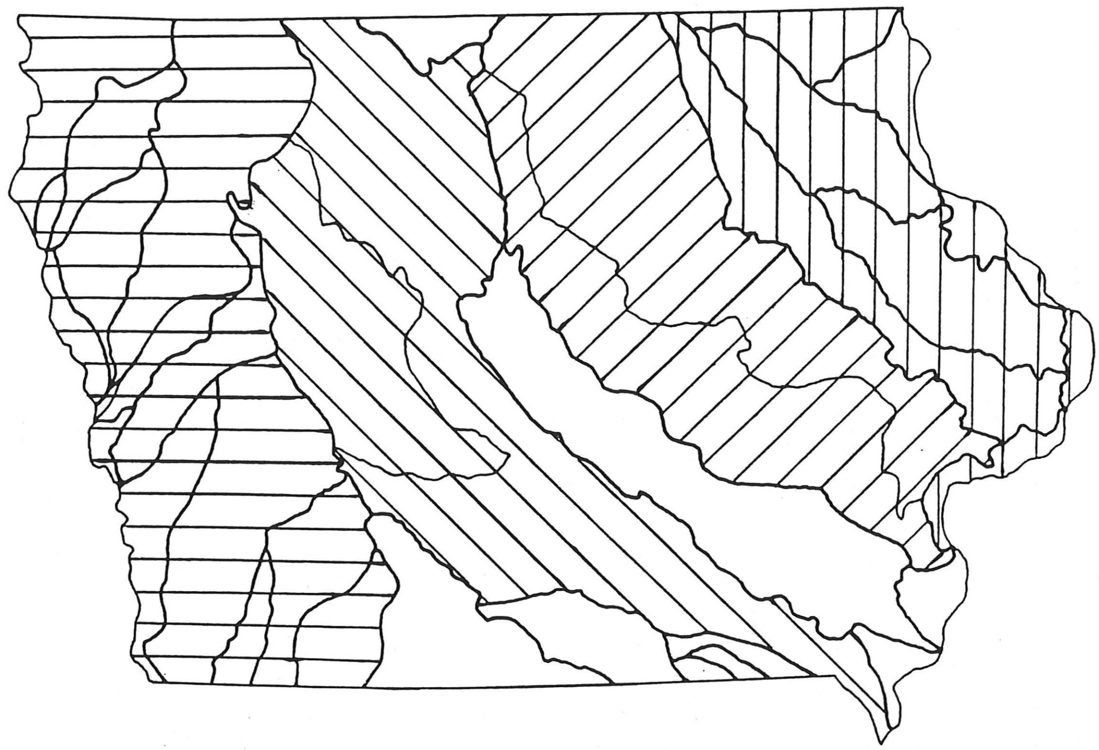

Figure 4. Example of Delineation of Geographic Management Units in Iowa

Part B.
Development of the Monitoring Strategy

4. Monitoring Needs for the Watershed Approach

4.1. Monitoring Objectives

The success of a statewide watershed management approach depends heavily on the availability of reliable environmental (water quality) data. Consequently, monitoring is a critical part of a Watershed Approach. The ongoing and new monitoring efforts have to be strategically coordinated by management unit to address various data needs. These data needs arise in different phases of the basin management cycle, including:

- Assessment of the present water quality conditions and trends (for both surface water and groundwater).
- Evaluation of the degree to which designated uses are supported.
- Ranking the severity of water quality impairments, which is necessary for prioritization within a basin.
- Identifying sources of water quality standards violations in targeted watersheds.
- Modeling to support both non-point and point source control programs, such as waste load allocations and NPDES permit issuance. Data is needed for model calibration and verification, for estimating background concentrations, and for predicting the effects of management strategies.
- Evaluating the effectiveness of management actions (by measuring performance indicators).
- Compliance monitoring.

Under a Watershed Approach, the monitoring needs are determined in a strategic monitoring plan. This plan describes the specific monitoring activities for each basin in a given year, as evolve from the basin management cycle, as well as the statewide ambient monitoring activities. For example, IDNR may maintain its statewide ambient network of fixed stations that are sampled monthly. In addition, there might be a network of rotating stations, that are sampled one year during each basin management cycle, to provide additional information for basin assessments. Compliance monitoring may be performed on a continuous basis regardless of the basin cycle.

4.2. Non-Point Source Monitoring

Monitoring non-point sources of pollution is a difficult task, due to the spatial distribution of these sources. The only way to estimate non-point source loads is indirectly, since their distributed nature makes it impossible to actually measure their exact magnitude. Regarding nonpoint source (NPS) pollution, physical alteration of aquatic habitats may be a more important factor in use attainability than chemical pollutants. As the NPS picture has not been well understood, long-term monitoring, including biological monitoring, may be needed to define the problems and set priorities.

However, as pointed out before, the control of non-point source pollution plays a key role in the watershed approach. Therefore, it is important to develop methods to monitor non-point source impacts. One possible approach, which is currently being tested by IDNR, involves the use of biological indicators to determine overall aquatic ecosystem impairment, rather than attempting to measure a multitude of individual chemical water quality parameters. The biocriteria approach could be complemented by estimates of various non-point source pollution loads, such as the rate of soil erosion, which can be obtained from analyzing spatial data (e.g. soil type, slope, and land use) with the help of a Geographic Information System (GIS).

Models to estimate the magnitude of various non-point sources (such as soil erosion) still require measured data for parameter calibration and model verification. Monitoring for these purposes generally takes place at the watershed outlet, so that the cumulative effect of distributed sources from the entire watershed can be measured. Parameters of special interest include suspended solids (sediment), nitrate, ammonia and phosphate. The critical time to measure non-point source pollution loads is during high-flow events. For modeling purposes, it is important that simultaneous weather data (esp. hourly rainfall records) are available for the watershed.

4.3. Point Source Monitoring

Some specific data requirements follow from the need for calibration of point-source simulation models, in order to obtain reliable modeling results. Ideally, these data requirements should be taken into account when designing a surface water monitoring strategy. The following specific data needs have been identified :

- Data requirements for pollutant load estimation :
    - At wastewater discharge points :
      Concentration of selected pollutants, Flow rate
    - At tributaries :
      Concentration of selected pollutants, Flow rate

- Data requirements for receiving water characterization :
  - Physical characteristics :
    Channel Section Length, Channel Width, Channel Depth, Flow Rate, Flow Velocity, Transparency, Water Temperature
  - Chemical characteristics (dependent on the parameters to be modeled) :
    - Dissolved Oxygen, BOD
    - Nutrients (Organic Nitrogen, Organic Phosphorus, NO_2, NO_3, NH_3, PO_4)
    - Toxic substances (various Organic Chemicals, Pesticides, Herbicides, Heavy Metals)
    - pH (a key parameter regarding the toxicity of ammonia)
    - Conductivity
  - Biological characteristics :
    - Pathogen concentration (e.g. e-coli)
    - Biomass
    - (Ecological health)
    - (Habitat quality)
      (Data on the last two parameters will be more qualitative in nature)

5. Monitoring Strategy for a Watershed Approach in Iowa

Based on the review of monitoring programs in states that have already implemented the watershed approach, recommendations by the ITFM, EPA guidelines, the monitoring objectives as discussed in chapter 4 of this report and the particular needs of the State of Iowa, it is proposed that the following elements be included in the monitoring strategy to support a Watershed Approach for the State of Iowa.

5.1. Fixed Station Ambient Monitoring Network

Iowa DNR's fixed station, ambient monitoring network is used to evaluate existing water quality conditions through regular, periodic sampling of selected water bodies over a long period of time. Ambient data can be used for many purposes, including documenting long-term trends in water quality, signaling water quality impairments, screening for existing and emerging problems, identifying water quality priorities, and evaluating the effectiveness of management controls. It is envisaged that IDNR will continue to monitor its current ambient fixed station network, because of the valuable long-term data series that are being collected. Under the proposed monitoring strategy, the fixed station, ambient monitoring program should emphasize the following aspects:

- The existing fixed stations (sampled monthly every year for basic physical and chemical parameters), should continue to be monitored.
- Biological monitoring on a regular basis should be initiated at representative locations, for example the stream reference sites that have been selected by IDNR personnel.
- It could also be considered to start monitoring key lakes in Iowa on a regular basis, for example twice annually, near the start and end of the growing season, or more frequently as desired.

5.2. Targeted Rotational Stations

Targeted rotational stations provide ambient monitoring data for watersheds that are being targeted in the basin management cycle. An important objective of these stations is to identify watersheds with water quality problems. Once a problem watershed has been identified, IDNR can focus more resources on that particular watershed. Intensive surveys could be carried out, to obtain more detailed water quality data and to gain a better understanding of the water quality problem. Depending on the magnitude of the problem, TMDL studies could be carried out, ranging from a simple mass balance to complex water quality modeling.

Targeted rotational stations are monitored in the first year of the Basin Management Cycle. This type of monitoring is conducted for a specified period of time (usually one year) and with a specified frequency (usually once a month), as needed for a particular watershed. Although not necessary, it would be useful to keep the rotational stations at the same location in a watershed for each subsequent cycle, in order to obtain a series of data points (with five-year intervals) at a fixed location. In some cases, multi-year sampling may be necessary to adequately define water quality characteristics.

5.3. Intensive Surveys

Intensive surveys are designed to collect detailed data on a particular water quality problem. They might also be done to characterize the extent of environmental and ecological degradation of a particular stream. Some specific purposes of intensive surveys include:

- locating and quantifying pollutant sources;
- measuring the fate and effect of pollutants;
- evaluating the ecological impacts of conventional and toxic pollutants in surface water, ground water, sediment, fish, and shellfish;
- providing data to support model calibration and verification.

The field work associated with intensive surveys could range from a few days to a few months, depending on the study objectives.

In the five-year watershed cycle, intensive surveys in a target watershed would be planned in year two and carried out in year three. Their specific form depends on the data needs for the problem being investigated. Intensive surveys generally support waste load allocation modeling or complement ongoing TMDL studies.

5.4. Total Maximum Daily Load (TMDL) Studies

TMDL studies employ a whole-watershed approach to determine the maximum load of pollutants which can be discharged to a water body without violating state water quality standards. TMDL projects assess the cumulative impact of multiple point and non-point source dischargers through intensive basin-wide surveys and computer modeling. The models simulate total waste load under different design conditions, which enables testing of alternative waste load allocation strategies aimed at reducing pollutant concentrations.

TMDL projects vary in complexity. Simpler projects may involve a single discharger, negligible non-point source loading, and a conservative pollutant. More complex projects could involve multiple dischargers, significant non-point source contributions, or pollutants which decay over time. TMDL monitoring spans one to two years, depending on project complexity and the availability of historical data and models.

5.5. Biomonitoring

A survey of several states, that have implemented the watershed approach, reveals that biomonitoring has become an important tool in determining surface water quality. IDNR has initiated a biological monitoring study, with the intent of developing biological criteria and stream reference sites. It is recommended that this work be continued and, if successful, expanded.

Studying a stream's fish community using various biotic indices is a quick and informative method of determining the relative health of a stream and any adverse impacts from point and non-point sources of pollution. By incorporating the resultant numerical index values from these biotic indices into water quality standards, a broader measure of a stream's biotic integrity will be available. The underlying principle is that the biological integrity of unimpacted waters may be measured and used as the standard with which other waters may be compared.

In the watershed management cycle, biomonitoring in a target watershed would be completed in year three of the five-year cycle.

5.6. Wastewater Discharge Compliance Monitoring

Industrial, municipal or agricultural operations that discharge wastewater into the surface waters of the state of Iowa must obtain a National Pollutant Discharge Elimination System (NPDES) permit to discharge. This applies to all public and privately owned wastewater treatment facilities. The NPDES permit sets limits for physical and chemical characteristics of the effluent of the facility, in order to protect the water quality of the receiving water body.

The purpose of the compliance monitoring program is to ensure that permitted effluent limitations are being met and properly reported to the state, to ensure proper operation and maintenance of wastewater treatment facilities, and to ensure that the public's concerns and complaints concerning wastewater dischargers are answered effectively. This type of monitoring encompasses the review of NPDES permit compliance schedules, review of NPDES self-monitoring data, inspection and evaluation of wastewater treatment facilities, and investigation of complaints concerning wastewater treatment facilities or stream quality throughout the state.

5.7. NPDES Discharger In-Stream Monitoring

IDNR should investigate the possibility of having NPDES permittees monitoring in-stream water quality in the stream in which they discharge. This would provide a large amount of reliable water quality data at a low cost to IDNR. However, the practical and legal possibilities and limitations of this proposal need to be carefully examined.

5.8. Volunteer Stream Monitoring

IDNR should consider initiating efforts to support volunteer stream monitoring. A first step to support volunteer monitoring projects in Iowa would be the creation of a position for a volunteer monitoring coordinator at IDNR, who would oversee the program. Both classroom and field demonstrations would have to be organized, to begin the process of incorporating standardized methods in a citizen volunteer monitoring effort. IDNR should coordinate data acquisition with volunteer stream groups to make optimum use of volunteer data in IDNR programs, provide equipment support to volunteer stream groups where possible, and continue efforts to meet one-on-one with interested volunteer groups to further coordinate activities.

Data collected by these volunteer monitoring groups could be helpful for IDNR to signal water quality impairments throughout the state. However, these data are unsuitable for use in legal NPDES permit enforcement, because of the lack of quality control.

6. Role of Geographic Information Systems (GIS) in Monitoring under a Watershed Approach

Geographic Information Systems (GIS) are increasingly being used as a tool for operational support of various water resources planning and management activities. GIS have been readily adopted as a planning tool, because they allow spatial information from diverse sources to be displayed in an interactive manner that is both readily comprehensive and visual.

Water quality monitoring data, both from fixed stations and from special studies, have traditionally been entered into the USEPA water quality data base STORET. Due to the complicated data retrieval procedures, this data base can only be accessed successfully by experienced personnel with prior working knowledge of the system. GIS has the potential to greatly facilitate data handling and management, and could provide easy access to important information for watershed managers and stakeholders. However, the possibilities to use GIS for this purpose are limited, because of constraints on the conversion of data from diverse sources to manageable GIS formats and media.

Under a watershed approach, GIS can be used to study impacts from both point and non-point source pollutants. Different geographic coverages such as land use, soil type, etc., could be used to identify critical areas contributing to non-point source pollution in a watershed. Possible sources of water quality impairments could include feedlots, modified stream channels, crop lands and impervious urban catchments. GIS can also be used to determine the location of stormwater outfalls and permitted municipal and industrial wastewater treatment facilities. Maps could be generated from each of the problem watersheds. These would depict the geographic distribution of critical non-point source pollutant contributing areas and identify the stream reaches that may be impaired as a result of these disturbances. The results from the GIS analysis could support the process of prioritizing watersheds, thereby ensuring an efficient allocation of the scarce resources available for water quality management.

Targeting high-priority water bodies or watersheds for TMDL development often involves more than just technical factors. It may also involve the evaluation of factors related to recreational, economic, and ecological values such as the risk to human health and aquatic life; the degree of public interest and support in protecting a water body; and its vulnerability or fragility as an aquatic habitat. Many of these factors contain spatial components and can be displayed on maps. Overlaying these maps on maps of potential pollutant yield would illustrate which water bodies are of special concern. Coupled with professional judgment, these maps could facilitate the prioritization and targeting of watersheds with the greatest need for TMDL development.

GIS could serve as a useful tool in the development of TMDLs for individual watersheds and in the modeling process. Many forms of GIS data, such as digital maps of soil types, land use, and annual average rainfall, are becoming more readily available for use on personal computers. These data are effective spatial indicators of physical processes, that are directly applicable to model use and development. Consequently, GIS data is well-suited for modeling purposes, both on the planning level and for implementation, because each GIS data layer directly represents certain spatially distributed, physical parameters, that are necessary as model inputs. Because GIS maps can be overlaid on top of one another almost exactly, there can be a high level of accuracy for matching of the associated sets of physical properties to a specified location.

The critical area maps generated by the GIS would serve as valuable watershed management tools. They would help to determine the Best Management Practices (BMPs) necessary in a particular watershed, tailored to the specific situation. BMPs could include no-till farming, nutrient management plans, pasture management and the removal of land from production. In addition, GIS output maps are useful as an educational tool. Landowner cooperation is sometimes a difficult issue in the implementation of BMP programs. These maps could be used by agricultural field personnel as visual means for promoting program cooperation.

However, some limitations of GIS applications need to be recognized as well. It is not always possible to identify straightforward relationships between spatial parameters (such as land use) and water quality impairments. Moreover, some vital data layers are not yet available at the appropriate level of detail for small-scale watershed studies. IDNR's Geological Survey Bureau is currently developing a land coverage data layer, but it is estimated that this effort will take at least two more years to complete. Once coverages have been developed, it is important to keep them up-to-date. These tasks present additional resource requirements, that need to be met if GIS is to play a substantial supportive role in the implementation of the watershed approach in Iowa.

Part C.
Benefits and Costs

7. Benefits of Monitoring on a Watershed Basis

Monitoring on a watershed basis is an essential part of the watershed approach. The watershed approach has several important advantages, which have been discussed in a preceding chapter of this report. Furthermore, monitoring on a watershed basis offers some specific additional benefits, which will be discussed in this chapter.

Tailoring of monitoring activities, depending on data needs for point source and non-point source management programs, as well as a better integration of monitoring programs for different types of sources, will provide more functional water quality data. Better data are anticipated to lead to more effective water quality management strategies, and thus, ultimately, to improved water quality in the state of Iowa.

Moreover, the proposed approach has the potential to enhance the administrative efficiency of water quality monitoring programs in Iowa. Increased awareness of priorities leads to increased efficiency of staff utilization. The watershed approach to monitoring will also improve coordination and communication between IDNR staff members, other agencies involved in water quality monitoring, and the general public.

Finally, more intensive involvement of stakeholders (such as various interest groups and citizen volunteer monitoring groups) in water quality monitoring programs, will increase public awareness and understanding of water quality issues. This is likely to result in a larger acceptance rate of environmental policy measures, thus making it easier for IDNR to implement water quality control programs.

Although these benefits are intangible, i.e. hard to express in a monetary value, they represent significant improvements over the current situation. This is confirmed by experiences from other states that have already implemented a monitoring program on a watershed basis. More states are currently considering to implement such a program, because of expected benefits. The benefits experienced or expected by some states that responded to a survey by Iowa State University's Surface Water Quality Research Group, are collected in Table 3.

Table 3. Benefits of Monitoring on a Watershed Basis

State	Benefits Experienced or Expected
Florida	"Better water quality assessments, improved data availability for waste load allocations and cost savings, if the approach is correctly designed."
Illinois	"It has allowed improvements in data availability and utilization for various program activities as a result of integrating point and non-point source programs, as well as water pollution control and drinking water programs."
Kentucky	"We expect better assessments and a pooling of monitoring resources of other agencies should lead to greater efficiency and ultimately better water quality."
Maine	"Better coordination of licensing."
Michigan	"The data is much more useable and used more in the rotating watershed approach - for NPDES and non-point."
Mississippi	"More efficient use of limited field staff for monitoring by targeting selected basins each year, better water quality assessments for each basin, especially for Total Maximum Daily Load (TMDL) development and 303(d)-list and 305(b)-report development."
Nebraska	"More intensive monitoring data in a given basin, enhanced ability to detect water quality problems and to accurately depict water quality conditions."
Nevada	"Better water quality assessments, improved data availability for waste load allocations and a greater potential for environmental improvements"
New Hampshire	"If we didn't monitor on a watershed basis, the data would only be representative of one instant in time, which is worthless."
Washington	"Better water quality assessments and improved data availability for waste load allocations"

8. Cost Estimate of the Monitoring Strategy

The total cost of implementing the proposed improvements of IDNR's water quality monitoring strategy is composed of several components, which include the following:

- Rotational Station Monitoring
  In the present situation, 11 rotational stations are being monitored 4 times a year, which adds up to a total of 44 samples per year. After implementation of the proposed watershed based approach, one station in all 8-digit USGS watersheds in one of the five major basins will be monitored 12 times per year. Since there are (on average) approximately 10 8-digit USGS watersheds in a major basin, this adds up to 12 times 10 equals 120 samples per year.

- Intensive Surveys
  In the present situation, the level of expenditure for intensive surveys is practically zero, since these surveys are seldom being conducted. If the proposed increase in these types of studies is being implemented, up to 8 intensive surveys might be performed in a given year, with up to 60 samples being collected for each of these surveys. This would result in a total of 480 samples per year to be collected and analyzed. However, this number is more flexible than the number of samples from rotational station monitoring, since intensive surveys are being designed and executed on a case-by-case basis, according to the needs and specifications of IDNR's monitoring personnel.

- Total Maximum Daily Load (TMDL) Studies
  Since the scope of TMDL studies can vary greatly, depending on the specific conditions in the watershed under consideration, no quantitative estimate has been obtained for the cost of carrying out such studies on a regular basis.

- Biological Monitoring
  Since IDNR personnel are already investigating the possibilities of collecting and analyzing biological data on a more regular basis, no attempt has been made in this report to recommend a specific funding level for biomonitoring activities.

- Volunteer Monitoring
  Employing volunteer labor to assist IDNR with collection of water quality samples might be a way for IDNR to obtain more data at a relatively low cost, and increase public awareness of water quality issues at the same time. This could be done as long as the data are not going to be used for legal enforcement purposes, and if the volunteers receive proper guidance, training and equipment. In order to

meet these volunteer coordination and training requirements, IDNR would need to have a position for a volunteer monitoring coordinator.

- General Staffing Needs
  In order to properly implement a monitoring program on a watershed basis, it is expected that IDNR needs to add approximately five more personnel at least to its water quality monitoring section. One of these people would be a basin planner, who would be coordinating all activities related to the watershed approach in general, including monitoring components. Additional personnel would include a database manager, who would be responsible for processing and storing the increased amounts of data being collected under the proposed approach, and a monitoring professional, with two or three technicians, who would be responsible for sample collection and analysis. More resources may be needed to accomplish the goals and to obtain the benefits of the watershed approach.

The total costs for all elements of the monitoring strategy suggested above are hard to estimate, because the scope of some of the proposed activities depends on choices to be made by IDNR, and because of uncertainty about personnel costs. However, a preliminary estimate of some of the above costs has been made, in order to provide an example. This is being presented in Appendix A. The costs are a preliminary estimate. More resources may be needed before the watershed approach could be fully implemented.

From a survey by Iowa State University's Surface Water Quality Research Group, it appeared that most of the states that have already implemented a watershed-based monitoring program, did not experience a significant increase in expenses as a result of the change. Improvements could be accomplished through a reallocation of funds within the monitoring program. In Iowa, however, the current level of funding for water quality monitoring activities is already perceived as being insufficient or even skeletal, as compared with other states.

This can be illustrated by a comparison of Iowa with two of its neighboring states. Since 1985, the state of Iowa has been spending a constant annual amount of $ 300,000 on its water quality monitoring program, without any correction for inflation. This entire amount has been supplied by EPA, without any contribution from the state itself. Only about $120,000 of it is on ambient monitoring (i.e. fixed and rotational stations). The remaining is for facility compliance sampling, field support, etc., which may be of limited value to the watershed-based monitoring. The state of Nebraska, which is much less populated than Iowa, spends an annual amount of $650,000 on its monitoring program, 15 % of which is being paid by the state itself. The state of Illinois spends an annual amount of $ 3.5 million on its monitoring program, 75% of which is being paid from state funds. This implies that, in order to implement the watershed approach in Iowa, an increased level of expenditure for water quality monitoring will be necessary.

Part D.
Recommendations

9. Design of the Monitoring Strategy

It is recommended that IDNR designs and implements a monitoring strategy to support the implementation of the watershed approach to water quality management in Iowa. Such a monitoring strategy should consist of the following elements:

9.1. Fixed Station Ambient Monitoring Network

A. Objectives

The objectives of the fixed station ambient monitoring network are to assess statewide water quality conditions and long-term trends, to signal emerging problems, and to provide general information on existing water quality impairments, long-term water quality improvements and designated use support.

B. Specific Recommendations

IDNR should continue to monitor the existing fixed station network. It is recommended that IDNR considers the possibilities for expanding the parameters to be analyzed to include biological parameters as well as toxic chemicals (especially pesticides and herbicides). IDNR could also consider the possibilities for initiating annual monitoring of some key lakes in Iowa.

9.2. Targeted Rotational Stations

A. Objectives

The objective of targeted rotational station monitoring by watershed is to collect data, in order to:

1. Assess the general water quality condition in each watershed in a river basin.
2. Evaluate water quality trends and designated use support.
3. Determine priorities for intensive surveys.
4. Evaluate the success of previously implemented water quality improvement strategies.

B. Specific Recommendations

1. Each (8-digit USGS) watershed should have (at least) one rotational station, to be sampled during one year in the course of a five-year basin management cycle.
2. Larger 8-digit USGS watersheds (more than 800 mi^2) should ideally have two rotational stations.
3. The rotational stations in all watersheds in one river basin will be monitored for one year every five years, according to the basin management cycle.
4. In the first year of the five-year cycle, available (historic) data will be reviewed, and a rotational station monitoring plan will be developed for the basin under consideration. In some cases, multi-year sampling may be necessary to adequately define water quality characteristics.
5. Subsequently, the actual monitoring of the rotational stations will take place. Sampling should take place once a month. Parameters to be sampled include channel characteristics and flow (only if this cannot be obtained from a nearby USGS gauging station), water temperature, transparency, and concentration of relevant substances such as sediment, Dissolved Oxygen, BOD, ammonia, nutrients, toxic chemicals, heavy metals, etc.

9.3. Intensive Surveys

A. Objectives

The objective of intensive surveys is to collect data, in order to:

1. Assess water quality in detail.
2. Investigate severe water quality problems and identify sources of water quality impairments.
3. Calibrate water quality simulation models to support TMDL development, Waste Load Allocation modeling and NPDES permit issuance.

B. Specific Recommendations

1. Data from the rotational stations and other studies, and additional information available from IDNR (e.g. NPDES permits, historic monitoring data, etc.), will be used to identify critical water quality problems for each river basin. Critical reaches within the river basin will be identified from the available information. Typical water quality problems might involve some of the following:
   - sediment
   - BOD / DO
   - nutrients (organic material, fertilizer)

- toxic substances (including agricultural chemicals, like pesticides and herbicides)
- heavy metals

2. During late year 2 or early year 3 of the Basin Management Cycle, an intensive monitoring plan will be developed for each of the critical reaches identified in step 1. This plan should include what to monitor, where, how, by whom, etc. Five to eight critical reaches per river basin are expected.
3. The actual monitoring will be a profile survey: a "photo image" of the water quality along a reach of the stream. For example, we may need data every 1 to 3 miles, over a reach of about 20 miles, downstream of a significant point source.
   Data will have to be collected both at low flow and at average or slightly above average flow (not floods). Seasonal variations in water quality problems should be considered in selecting the time for an intensive survey. For example, the critical time for non-point source pollution is often spring (mid April through June), and for point source pollution it is often fall (September or October), while the worst oxygen conditions often occur in winter, when water bodies are covered with ice.
   Data to be collected include:
   - Flow (along the reach)
   - Channel geomorphology (channel slope, width, depth, shape, roughness)
   - Boundary conditions upstream and downstream of critical area
   - Relevant water quality parameter concentrations:
     i.e. for oxygen: DO, BOD, NH_3, NO_2, NO_3, temperature, etc.
     i.e. for eutrophication: the above, plus PO_4, Chl a, etc.
   - At significant point sources, a DO profile will be needed, at one or two time periods.
4. Point source discharge data from existing NPDES permittees have to be collected and analyzed.
5. Intensive surveys can also be used to investigate special and unique water quality problems, such as high concentrations of a particular pollutant without a known source.

9.4. Total Maximum Daily Load (TMDL) Studies

A. Objectives

The objective of TMDL studies is to collect data, in order to:

1. Identify and assess all point and non-point pollutant sources in a watershed.
2. Establish Total Maximum Daily Loads for each watershed.

B. Specific Recommendations

1. The procedure for TMDL development, that is currently being developed by IDNR under contract with EPA, should be followed.
2. Rotational station monitoring and intensive surveys should provide most of the data on point sources that are needed for TMDLs.
3. Existing non-point source programs at IDNR should be continued or expanded. In this context, the monitoring component of non-point source programs is particularly important.

9.5. Biomonitoring

A. Objectives

The objective of biological monitoring is to assess the condition of aquatic ecosystems, which is thought to reflect chemical and physical water quality parameters as well as possible habitat impairments. Physical alteration of aquatic habitats may be a more important factor in use attainability than chemical pollutants. Regarding nonpoint source (NPS) pollution, long-term biological monitoring may be needed to define the problems and set priorities as NPS picture has not been well understood.

B. Specific Recommendations

1. Ongoing studies on the techniques, uses, and accuracy of biomonitoring for water quality management should be continued.
2. The possibilities of using biological criteria to signal water quality impairments should be investigated.
3. If biomonitoring proves to be a valuable tool for water quality assessment, it should be incorporated into the regular fixed and rotational station monitoring programs.

9.6. Compliance Monitoring

A. Objectives

The objective of compliance monitoring is to ensure that NPDES permittees act in accordance with the limits imposed by their permits.

B. Specific Recommendations

Compliance monitoring is necessary for permit enforcement and should therefore be continued.

9.7. NPDES Discharger In-Stream Monitoring

A. Objectives

The objective is to obtain additional data on in-stream water quality upstream and downstream of major NPDES wastewater dischargers. The philosophy behind this is that fees for NPDES permits in Iowa are relatively low, as compared to some other states, while IDNR has to make substantial expenses in order to obtain the data needed for waste load allocation modeling, which is necessary to determine appropriate permit levels.

B. Specific Recommendations

It is recommended that IDNR investigates the practical and legal possibilities of requiring major NPDES permittees to provide IDNR with some in-stream water quality data, upstream and downstream of their point of discharge.

9.8. Volunteer Monitoring

A. Objectives

The objective of the volunteer monitoring program is to allow expansion of the monitoring program with a minimum of additional personnel cost for sampling, and to assist in improving the relationship between IDNR and state and local volunteer groups.

B. Specific Recommendations

1. IDNR should consider using volunteer labor for both rotational station sampling and for intensive surveys.
2. IDNR must provide training and guidance for volunteers, in order to maintain sufficient quality control and coordinate data collection efforts.
3. In order to set up a volunteer monitoring program, IDNR will need a volunteer monitoring coordinator.

10. Implementation

10.1. Implementation of the Watershed Approach

A. It is recommended that IDNR adopts the watershed approach for its water quality management programs, because this approach offers a more integrated and effective management of point and non-point sources, improved relations with stakeholders, and potential efficiency gains.

10.2. Implementation of the Monitoring Strategy

A. It is recommended that IDNR adopts a watershed-based monitoring strategy, in order to support the implementation of the watershed approach. Recommendations for the design of this watershed-based monitoring strategy have been proposed in Chapter 9.

B. It is recommended that the proposed monitoring strategy be implemented in stages, that should coincide with the five-year periods of the basin management cycle.

1. In the first stage, the focus should be on implementing rotational monitoring and intensive surveys on a watershed basis, as well as improving stakeholder interest in and involvement with water quality management in general and the monitoring program in particular.
2. In the second stage, when more data should be available, more emphasis can be placed on non-point sources and TMDL development, and also on expanding volunteer monitoring programs.
3. These trends will continue in the following cycles. Priorities will have to be re-evaluated for each new cycle.

10.3. Funding and Staffing Considerations

A. In the current situation, the state of Iowa does not have sufficient resources allocated to water quality monitoring and management programs. With the current level of funding for monitoring activities, it is not possible to provide the basic information on water quality impairments that is:

1. necessary to support effective water quality improvement strategies, and
2. commonly found in most other states throughout the nation.

Therefore, it is strongly recommended that the funding level for IDNR's water quality monitoring activities be expanded.

B. In order to implement the proposed monitoring strategy, IDNR would need to increase staffing of its monitoring program with about five people at least.

1. In order to coordinate water quality monitoring and management activities in different watersheds, maintain contacts with stakeholders, and prepare monitoring plans and management strategies, it is recommended that IDNR creates a position for a basin planner / watershed coordinator.
2. In order to meet increased data management and analysis needs, IDNR would require one additional professional for data handling and data base management, with an emphasis on spatial and geographic data.
3. In order to carry out the increased number of intensive surveys and TMDL studies expected under a watershed-oriented monitoring program, IDNR would need one additional monitoring professional and 2 to 3 additional technicians for sampling and analysis work.
4. In order to make more use of volunteer labor for data collection, IDNR would need a volunteer monitoring coordinator.

C. It is recommended that IDNR investigates possibilities to obtain additional funding from EPA to meet the staffing requirements resulting from the implementation of a watershed-based approach.

10.4. <u>Computer Support</u>

A. It is recommended that IDNR re-evaluates its hardware and software needs, in order to support management of the increased amounts of data being collected under the proposed monitoring strategy. Specifically, an additional workstation might be needed, to serve as a platform for increased use of GIS.

Appendix A. Example of Cost Estimate

A preliminary cost estimate for recommended monitoring activities under the proposed monitoring strategy has been prepared. This estimate mainly includes the costs of carrying out an increased amount of intensive surveys.

1. Lab Analysis Costs for Intensive Surveys

a) Lab analysis cost per sample (based on ISU Analytical Services Lab):

• Suspended Solids	$ 10.85
• Dissolved Oxygen	$ 11.00
• BOD	$ 21.90
• Ammonia	$ 11.05
• Nitrate / Nitrite	$ 16.05
• TKN	$ 19.60
• Ortho P	$ 14.60
• Total P	$ 19.60
• Chl a	$ 17.35
Total per sample	$ 142.00

b) Number of samples for intensive surveys per year:

- 20 samples/profile * 3 profiles/site * 8 sites/basin * 1 basin/year = 480 samples/year

c) Total lab analysis costs for intensive surveys per year:

- $ 142.00 /sample * 480 samples/year = $ 68,200

2. Total Cost of Intensive Surveys, Including personnel costs for sample collection and data processing:

• Lab Analysis Cost / Year	$ 68,200
• Professional Engineer	$ 38,000
• 3 Technicians	$ 72,000
• Data Manager	$ 30,000
• Computer	$ 10,000
Total per year	$ 218,200

This figure does not include the increased frequency of rotational station monitoring, the collection of biological data at existing monitoring stations, the basin planner and volunteer monitoring coordinator positions, nor any other support cost.