4.0 Reporting Monitoring Results

4.1 Audience Definition

The audience for RLWD water quality reports will be broad, covering many levels of education and understanding of water quality issues. This audience includes, but is not limited to other water quality professionals, RLWD staff members, the RLWD Board of Managers, local decision makers, technical advisory committee members, and lake associations. The report should be complete and technical enough to be referenced by other water quality professionals. It should be understandable enough so that decision-makers that are not necessarily water quality experts can still understand the main points within the reports. When creating tables and graphs, they should summarize data as much as possible so that there aren't just pages and pages of time series plots. For example, instead of including many pages of time series plots for the reader to interpret, the writer of the report can summarize these plots in a table that describes the trends for each parameter at each site. This way, the document is more useful as a reference to the reader and a hundred pages of information can be summarized into one or two pages. Great care should be taken in ensuring the accuracy of the results reported within the document. These reports will likely be used as references in water quality discussions, studies, reports, decision making, etc (the 2004 report already has been frequently used in this fashion).

4.2 Report Format

A standard water report format was developed for the RLWD as part of the Red River Watershed Assessment Protocol Project. The first report in this format was completed in July of 2004. A similar report will be completed once every two years. The general outline of the report is organized in the following manner:

1.0 Executive Summary
2.0 Program Description
       2.1 History and Reasons for Initiating the Program
       2.2 Overview of RLWD Monitoring Locations
       2.3 Purpose of the Report
3.0 Monitoring Goals and Objectives
       3.1 Organization of the Program
       3.2 Goals by Program Aspect (long-term, special studies, investigative)
4.0 Statistical Analysis Methods
       4.1 Frequency Distributions of the Data
       4.2 Transformation Methods
       4.3 Data Censoring Methods
       4.4 Trend Detection Methods
5.0 Status of Water Quality Within the District
       5.1 General Comparison
           5.1.1   Comparison of mean concentrations between sites and by region
           5.1.2   Comparison to MPCA "minimally impacted streams"
           5.1.3   Comparison to background levels
       5.2 Trend Analysis
           5.2.1   Annual Concentrations
           5.2.2   Annual Loads
           5.2.3   Annual Yields
6.0 Recommendation for Future Monitoring Activities
       6.1 Modifications to Goals and Objectives
       6.2 Modifications to Monitoring Network
       6.3 Future Monitoring Costs
       6.4 Potential Funding Sources
7.0 References

4.3 Submitting Data to STORET

The EPA **STORET (STOrage and RETrieval**) data base houses environmental data from the entire United States of America and is used by states for water quality assessments. The data can also be used by anyone who needs it. STORET data can be downloaded from the STORET website (http://www.epa.gov/storet/) or from the MPCA's **Environmental Data Access** (EDA) web page (http://www.pca.state.mn.us/data/edaWater/index.cfm). The MPCA's EDA website features an interactive map and displays data from search results in a spreadsheet to

makes finding and acquiring data relatively easy. Because the data in STORET is used to assess the state's waters, groups and agencies that are conducting monitoring programs should place a high importance on getting data into STORET. The most common way data is entered into STORET in Minnesota is by sending data to the MPCA. Usually, there is a member of the local MPCA staff that is responsible for collecting data for entry into STORET. Because the data entered into STORET needs to meet certain quality assurance qualifications, there are some things that need to be sent with data. Two types of forms also need to be completed before data can be entered into STORET. These are the **project establishment form** and the **station establishment form**. A **lab establishment form** is also required but it isn't necessary for each monitoring entity to fill out one of these sheets since the MPCA already has lab establishment forms for the major Minnesota Department of Health Laboratories.

Data entered into STORET is usually entered under a particular project. All data entered under a project name should have been collected and analyzed according to the laboratory and sampling methods that were submitted to the MPCA for the project. The **project establishment form** (Appendix B) is used to submit information about the project such as **the project ID, project name, project purpose, start date, planned duration, project manager, data manager, laboratory information, field procedure information, sample collection methods and gear, field measurements collected, a list of monitoring stations, and data format**. All water quality data entered into STORET needs to be collected using approved methods, so a set of sampling and analysis plans or standard operating procedures (SOP) needs to be sent to the MPCA with the project establishment form. The RLWD uses the *Standard Operating Procedures for Water Quality Monitoring in the Red River* Watershed for this purpose. Other organizations may also use this manual as their SOP so they don't have to write their own. Also, laboratory analysis needs to be conducted by a Minnesota Department of Health certified laboratory, so the MPCA will need to know which laboratory was used for the sample analysis. This lab information needs to be included on the project establishment form and will need to be updated if there is a change in testing methods or reporting limits at the lab, or a switch of laboratories. RLWD lab information is shown in Appendix C.

A **station establishment form** is needed for each monitoring site. The information needed for this document includes the **name of the project for which the site is being monitored, a station ID, STORET station ID, station name, station type, station description, GPS coordinates and methods, state, county, HUC code, and RF1 river reach**. The first step in completing a station establishment form is to search the STORET database to determine if there is already a site established at the location of your monitoring site. If there is, than you can use the site information to enter the station ID and station name into their appropriate blanks. If there are no sites established at the location of your monitoring site, leave the station ID blank and create a good station name and description for the monitoring site. The EPA will create a station ID for a new monitoring station. The HUC code is a number identifying the watershed in which the site is located. For example, the HUC codes for the major subwatersheds in the RLWD are 09020302 for the Red Lakes subwatershed, 09020303 for the Red Lake River

subwatershed, 09020304 for the Thief River subwatershed, 09020305 for the Clearwater River subwatershed, and 09020306 for the Grand Marais Creek/Red River subwatershed. RF1 river reach data is not essential to the completion of the form, but can be found with the help of information and GIS data available on the EPA's river reach index website: http://www.epa.gov/waters/doc/rfindex.html.

There are several **tips** that can help the STORET entry process go smoother.

1. First of all, project and station establishment sheets should be submitted prior to sampling. Since project and station establishment can be a lengthy process, getting sites established early will help facilitate faster entry of monitoring data into STORET once it has been submitted. The forms are available for download on the MPCA's STORET webpage (www.pca.state.mn.us/water/storet.html).

2. If one of your monitoring sites is already an established site in the STORET database, you don't need to complete a station establishment form for that site. What you do in this case is to look up the STORET Station ID and include it in the project establishment form. To see if your site has a STORET Station ID:

   a. The easiest way is to use the Minnesota Pollution Control Agency's Environmental Data Access website. There is a map-based search tool that makes locating established monitoring sites very easy (http://www.pca.state.mn.us/data/edaWater/index.cfm).

   b. The MPCA also has lists of established sites available on its STORET webpage (http://www.pca.state.mn.us/water/storet.html).

   c. In other states, you may need to use the EPA's STORET website to find established sites.

3. The MPCA conducts assessments of the states waters every odd year and lists of impaired waters are completed in even years. Data should be submitted in a timely manner so that updated data is available for each assessment.

4. Submit updated project establishment forms if there is a change in staff, laboratories, methods, sites, etc.

5. Use correct station Ids, project names, and site names.

6. Check data for errors. STORET will reject data that does not fall into an acceptable range. So, for example, if a pH reading of 7.5 is entered as 75, STORET will reject the data and it will be returned to you so that the errors can be fixed. If you use a Microsoft Access database, you can create allowable ranges for each cell that will prevent out-of-range data to be entered.

7. Use column headings that match the ones on templates provided by the MPCA or, at least, include the parameter's units.

   a. See Appendix E for one example spreadsheet that was provided by the MPCA.

   b. Download a template from the MPCA's website (http://www.pca.state.mn.us/publications/wq-s5-04.xls).

8. Flag codes (also known as remark codes) are used to mark data that is higher than the maximum detectable level, below the detection limit, etc. Flag codes for a parameter are placed in a column directly to the right of the column containing data. See the example spreadsheet in Appendix E. Using flag codes that match those used by the MPCA will help your data get entered into the database more quickly.

   a. **D** = Actual value is known to be less than the method detection limit given by the lab [Below Detection Limit (BDL)]

   b. **E** = Actual value is known to be less than the reporting limit given by the lab (< Reporting Limit)

   c. **~** = estimated value

   d. **Q** = Exceeds holding time

   e. **>** = Greater than the maximum measurable value.

      i. This will be used for transparency tube readings that are greater than 100 cm (the maximum length of tubes are either 60 cm or 100 cm), fecal coliform levels that are too numerous to count, and turbidity readings that are off the charts.

9. Visit the MPCA's STORET website for the most recent information, forms, and templates. http://www.pca.state.mn.us/water/storet.html.
10. Contacts:
    a. Local MPCA representative
       i. Mike Vavricka, Michael.Vavricka@state.mn.us, 218-846-0776
    b. Data manager at the MPCA Headquarters
       i. Jennifer Oknich, Jennifer.Oknich@state.mn.us, 651-297-8466
    c. RLWD Staff
       i. Corey Hanson, coreyh@wiktel.com, 218-681-5800

5.0 Monitoring Network Design

A monitoring plan should be a written document that includes a clear statement of the goals and objectives of the program, potential uses of data, a description of the area to be studied, background information, descriptions of monitoring sites, which water quality aspects will be measured, the frequency and timing of sampling, project partners, a budget, quality assurance and quality control measures, any training needed, necessary equipment, and a project schedule. The following sections will explore the monitoring network design process in further detail.

5.1 Agencies Involved in Data Collection

The Red Lake Watershed District works with other agencies and citizen monitoring programs when choosing monitoring sites. In addition to the RLWD monitoring program, other agencies and groups collecting water quality data within the RLWD include the Minnesota Pollution Control Agency, Soil and Water Conservation Districts, River Watch, United States Geological Survey, volunteers, cities, and Red Lake Department of Natural Resources. The MPCA's monitoring program is entitled the Red River Basin Monitoring Network and monitors several sites along the main-stem of the Red River of the North and also monitors the major tributaries of the Red River within the State of Minnesota. The Soil and Water Conservation Districts within the RLWD that have conducted water quality monitoring include the Marshall-Beltrami SWCD, Marshall County SWCD, Beltrami County SWCD, Clearwater SWCD, Pennington County SWCD, and the Red Lake SWCD. The Red Lake DNR monitors Upper and Lower Red Lakes, the rivers and streams that flow into them, and the beginning of the Red Lake River at the Lower Red Lake outlet. The RLWD sponsors River Watch programs at schools within the RLWD. The schools participating in the River Watch program within the RLWD include Clearbrook-Gonvick, Red Lake County Central, Grygla, Red Lake Falls, Crookston, Fisher, Win-E-Mac, Sacred Heart, East Grand Forks, Fosston, Red Lake, and Bagley. Additional schools may participate in the future.
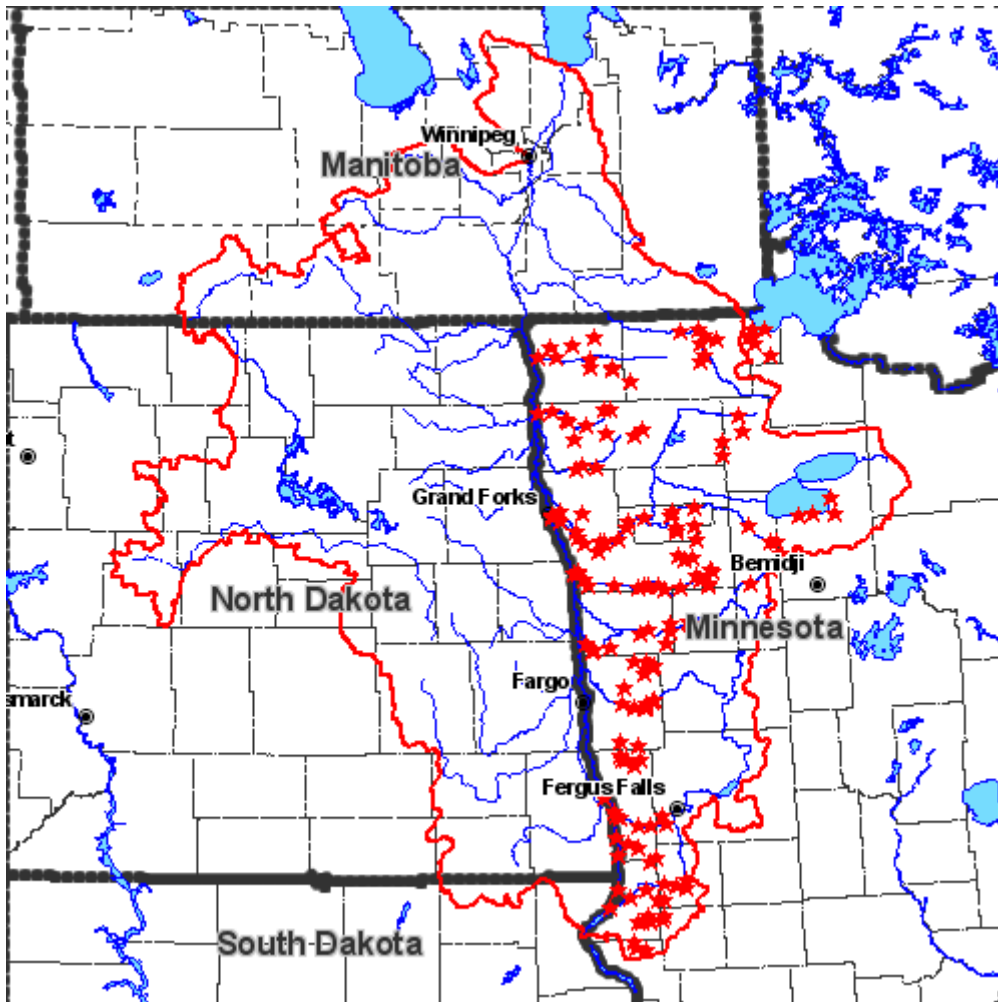
Figure 34. River Watch Monitoring Sites in the Red River Basin.

5.2 Setting Monitoring Goals and Objectives

A water quality and/or water quantity monitoring program is a large investment. Therefore, it should be well-planned. Before monitoring sites are selected, the goals of a monitoring program should be clearly stated. There are many different reasons for initiating a water monitoring program. A water monitoring program may be designed to collect data for baseline characterization purposes, planning and policy-making, public education, management and operational information, regulation and compliance, resource assessments, response to an emergency, and other uses.

The RLWD Water Quality Coordinator is in charge of designing the RLWD monitoring program and making sure that correct sites get monitored at the correct times using the correct methods. Monitoring plans created by the Water Quality Coordinator should be approved by the RLWD Administrator and the RLWD Board of Managers. The Water Quality Coordinator is a member of the Red River Basin Monitoring Advisory Committee (RRBMAC) and the Red River Basin Water Quality Team (RRBWQT). The

RRBMAC focuses on coordinating monitoring efforts throughout the Red River Basin. These meetings are held at the Sand Hill Watershed District in Fertile. The committee directs projects such as the MPCA's Red River Basin Monitoring Network and the River Watch program. Reports and updates are shared among the members of the committee. Through this committee, the RLWD can work with other agencies to prioritize potential monitoring sites, share information, coordinate efforts, and prevent duplication of efforts.

The RRBWQT committee is a meeting of minds on water quality issues. The group serves as an advisory committee for the Red River Basin Water Quality Plan. The group discusses strategies for improving water quality, monitoring programs, and project funding opportunities. It has also taken on a role as the directing committee for a turbidity TMDL study on the Red River and its tributaries.

When setting monitoring goals and objectives, there are several points to consider:

1. Determine what questions the monitoring program should be able to answer.

    a. Which streams, rivers, and lakes in the watershed are impaired?

    b. Which streams are safe for swimming, boating, and other forms of recreational uses?

    c. What is the effect of a project on water quality, habitat, or water quantity?

    d. What are the overall water quality trends in the watershed?

    e. To what extent are the designated uses of the water body being threatened?

    f. How does water quality/quantity or habitat quality change over time?

Table 15. Sources and Associated Pollutants for Volunteers to Consider Monitoring (from MPCA *Volunteer Surface Water Monitoirng Guide*).

Source	Associated pollutants and conditions
Cropland	Turbidity, nutrients (phosphorus, nitrite + nitrate), temperature, total suspended solids, changes in the biological community (macroinvertebrates, fish, plants)
Construction	Turbidity, temperature, dissolved oxygen, total suspended solids, changes in the biological community
Forestry harvesting	Turbidity, temperature, total suspended solids, changes in the biological community
Grazing and feedlots	Fecal bacteria, turbidity, nutrients (phosphorus, nitrite + nitrate), total suspended solids, temperature, changes in the biological community, stream bank stability
Industrial discharge	Temperature, conductivity, total suspended solids, pH, changes in the biological community
Property development/ lakeshore urbanization	Total suspended solids, total phosphorus, changes in shoreline vegetation, changes in aquatic vegetation
Septic systems	Fecal bacteria, nutrients (phosphorus, nitrite + nitrate), dissolved oxygen, conductivity, temperature, changes in the biological community
Sewage treatment plants	Dissolved oxygen, turbidity, conductivity, nutrients (phosphorus, nitrite +nitrate), fecal bacteria, temperature, total suspended solids, pH, changes in the biological community
Urban runoff	Turbidity, nutrients (phosphorus, nitrite + nitrate), temperature, conductivity, dissolved oxygen, changes in the biological community

Table 16. Water Quality Problems and Monitoring Parameters for Volunteers to Consider (from MPCA *Volunteer Surface Water Monitoirng Guide*).

Problem/concern	Water body type	Parameters
Eutrophication (i.e., nutrient enrichment)	Lakes and streams	Nutrients (phosphorus and nitrogen), Secchi transparency (lakes), turbidity/transparency tubes (streams), chlorophyll-*a*, dissolved oxygen, temperature, flow, and changes in the biological community (fish, plants, macroinvertebrates, etc.)
Habitat loss	Lakes, streams and wetlands	Macroinvertebrate biosurveys, habitat, temperature, aquatic plant surveys, shoreline surveys and flow
Low oxygen levels	Lakes and streams	Dissolved oxygen, nutrients (phosphorus, nitrogen), temperature, chlorophyll-*a*, flow and macroinvertebrate biosurveys
Sedimentation	Streams and wetlands	Total suspended solids, turbidity/transparency tubes, habitat, macroinvertebrate biosurveys and flow

¹Additional advanced parameters may be helpful for characterizing some problems such as biochemical oxygen demand and ammonia for diagnosing low oxygen levels.

2. Cooperation with other agencies should be considered.

3. A nationwide goal of the United States Environmental Protection Agency (EPA) is the assessment of waters. This goal not only applies to water quality

assessments, but also applies to biological assessments of wadeable streams. Providing data for statewide assessments of streams, rivers, and lakes are becoming increasingly important. Local input to the assessment process can come from local monitoring programs. Methods should be used that meet the data quality requirements of these assessments. Data should be submitted to a local representative of the Minnesota (or other respective state's) Pollution Control Agency so that it can be entered into the EPA STORET database for use in assessments.

4. Completeness is a goal that can be applied to the selection of monitoring sites, selection of parameters, and collection of data.

5. A monitoring program may be designed to locate problem areas so that projects can be implemented to address correctable problems.

6. Specific projects can have an impact on a monitoring program. Some may need their own separate water quality monitoring plan (stormwater projects). They may also influence frequency of sampling, site locations, parameters monitored, and project partners.

7. Accuracy should be a major goal of a monitoring program.

8. A monitoring program should have goals/objectives of providing some form of public education or scientific report based upon the sampling results.

9. A goal of a monitoring program may be to monitor a body of water that has a unique value, such as a trout stream, or a lake that is well-known for its good fishing. Long-term monitoring of these resources can be part of a water quality protection plan for the water body. Any alarming changes in water quality can be documented and corrective actions can be taken by local agencies if necessary.

10. Monitoring of a specific stream reach or lake may also be one of the main goals of a monitoring program if it has been negatively impacted in some way. Lakes that are suffering from increased eutrophication, streams that are experiencing heavy erosion in their watersheds, and streams that receive water from a wastewater treatment plant are some examples of bodies of water that have been negatively impacted. Monitoring results from these sites may be of great interest to the general public as well. To assess the impact of a pollution source, there should be a site located upstream as a reference site, another site immediately downstream of the potential problem to determine the amount of impact it is having on water quality, and another further downstream of the potential problem to evaluate how well the stream is recovering from the impact of the potential source of pollution. This can be referred to as bracketing the problem for impact assessment.

11. If a water quality monitoring program will be focusing on a river, assessment of the impact of its tributaries on water quality should be incorporated into the monitoring program.

12. How frequently will monitoring sites be sampled? The answer to this question may depend on how the data will be used. MPCA assessments, for example, have data requirements for each parameter. Assessments for most parameters require a certain number of samples, and some even recommend a particular sampling frequency (fecal coliform). Greater number of samples can allow for greater accuracy in assessments.

13. Which parameters will be monitored?

14. Consider the audience that will be viewing water quality monitoring results during the planning process. The EPA publication, *Volunteer Stream Monitoring: A Methods Manual*, lists potential users of water quality monitoring data may include state agencies, county agencies, local groups and agencies, the monitors themselves, fisheries biologist, universities, school teachers, environmental organizations, parks and recreation staff, local planning and zoning agencies, state environmental agencies, state and local health departments, soil and water conservation districts, federal agencies such as the U.S. Geological Survey and the U.S. EPA. The level of QA/QC measures that are implemented may depend upon who will be using the data. Higher quality data is needed if it will be used for assessments of impairment based upon water quality standards, proof of compliance (or non-compliance) with regulations, and planning decisions.

A water monitoring program may include other types of monitoring in addition to water quality monitoring. One of these other types is biological monitoring. There are many biological indicators of water quality. Negative effects of pollution and habitat losses are often evident through biological monitoring. Bioassessments can also be used to measure the success of habitat improvement projects.

Another type of monitoring that can be conducted on rivers, streams, and lakes is physical monitoring. This can involve habitat assessments, watershed surveys, and stream classifications. Habitat assessments of streams and rivers examine characteristics such as in-stream habitat, pool substrate, pool variability, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, vegetative stream bank protection, and riparian vegetative zone width. Watershed surveys look at land use patterns, past and present sources of pollution, water uses, diversions, and stream obstructions. Geomorphic stream classification is used to predict a stream's behavior based upon its appearance, develop hydraulic and sediment relationships for a stream, provide a method to extrapolate site specific data to other sites with similar characteristics, and to provide a frame of reference when communicating the morphology and condition of a stream. The Rosgen classification system is the standard method for stream classification. Surveyed cross sections can be used to monitor physical changes in a channel over time.
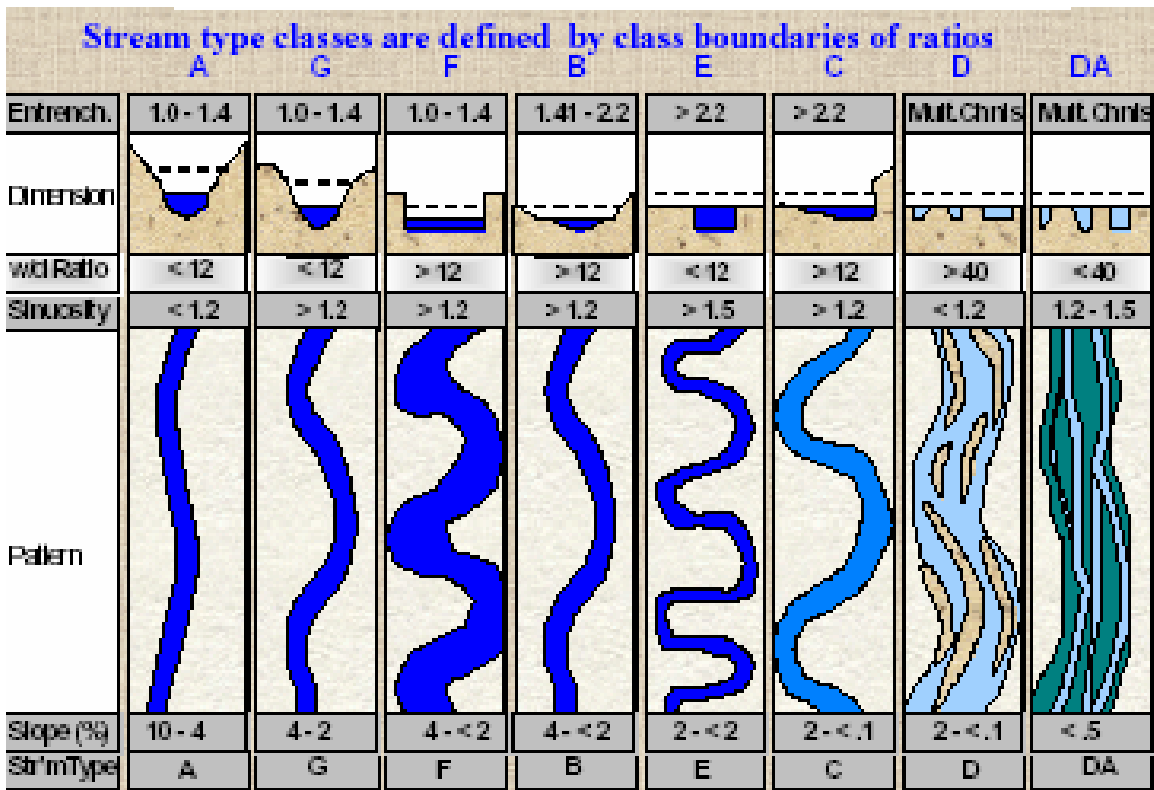
| Stream type classes are defined by class boundaries of ratios | | | | | | | |
A	G	F	B	E	C	D	DA
Entrench. 1.0-1.4	1.0-1.4	1.0-1.4	1.41-2.2	>2.2	>2.2	Mult.Chnls	Mult.Chnls
w/d Ratio <12	<12	>12	>12	<12	>12	>40	<40
Sinuosity <1.2	>1.2	>1.2	>1.2	>1.5	>1.2	<1.2	1.2-1.5
Slope (%) 10-4	4-2	4-<2	4-<2	2-<2	2-<.1	2-<.1	<.5
Str'm Type A	G	F	B	E	C	D	DA

Figure 35. Stream Type Classes of the Rosgen Classification System.

5.3 Network Design Techniques

Designing a monitoring network is not always an easy task. There usually are a large number of potential monitoring sites, but only limited funds for a monitoring program. Prioritization of monitoring sites is often necessary. A monitoring program may need to cover a large watershed, or it may focus on one reach of a stream or river. The scope of projects can vary greatly. The following paragraphs provide some ideas and advice for anyone designing a monitoring network.

Before selecting sites, create a map of the major and minor subwatersheds of the watershed you are monitoring. For broad-scale condition monitoring, a goal may be to monitor what is coming from each of the streams within the monitoring area. A goal of a water-quality monitoring program may be condition monitoring in streams to see what is coming from watersheds. To meet this goal, a monitoring site should be located at the end of the watershed, most likely at the last road crossing before the stream empties into another body of water.   Even distribution of monitoring sites should be considered in a large watershed such as the RLWD for long-term monitoring programs. Travel time, however, may also need to be considered when choosing monitoring sites. Monitoring on a smaller scale can be much more intensive. A monitoring site could be located at nearly every crossing of a river if the study is intensive enough. The intensity of a localized monitoring program can depend upon the number of potential monitoring points,

potential sources of pollution, funding, and time. One type of short term, intensive monitoring is investigative monitoring. Investigative monitoring sites may be located upstream and downstream (and ideally, one more site further downstream) of a suspected source of pollution in order to assess its impact.

The goals and monitoring activities of other agencies should be considered when choosing monitoring sites. Find out what locations are currently being monitored and which sites have been monitored in the past. Monitoring a site with historical data may be beneficial. The locations of current projects should be considered when choosing the locations of monitoring sites if knowing the effects of the projects on water quality is desirable. Choose monitoring sites and sampling frequencies that can facilitate a proper assessment of the streams and rivers to be monitored. Know which water bodies have been assessed by the state pollution control agency (Minnesota Pollution Control Agency).

A more detailed analysis of the watershed to be monitored may aid in choosing monitoring sites. Sites should be typical and representative of the stream reach in which they are located. Land use, stream order, elevation, slope, soils, and pollution sources can all change throughout a watershed. Choosing site locations that can detect changes in water quality with changes in the features of the watershed should be considered when choosing monitoring sites. If a stream has a designated use, monitoring sites should be located where these uses occur (swimming, canoeing, fishing…). If there is a location that can be used as a reference site, it should be monitored. A reference site is a site that has been impacted by human development to a very minor extent, if at all. Data from these sites can be useful in estimating the extent to which other sites have been impacted. Choosing sites that monitor waters with a unique value may be desirable. These could include trout streams and other areas that provide habitat for sensitive species.

The feasibility of each monitoring site should be evaluated when designing a monitoring network. Sites should be chosen where accurate stage, water quality, and flow measurements can be collected. There should be a good relationship between flow and stage. Beaver dams near the site, especially downstream can make flow estimations based on stage and can affect the natural water quality conditions in the river. A permanent structure or gauge from which to measure stage is helpful in collecting reliable stage measurements. Note whether or not debris in the channel may hinder the collection of water quality or flow measurements. Choose sites that are accessible and can be safely monitored. Use bridges or culverts if possible. If no staff gauges are present, being able to measure down to the water from a set location (benchmark) on these structures allows for reliable and accurate stage measurements.

The degree of impact of a tributary on a river may be a question that can be answered through a water quality monitoring program. The number of monitoring sites needed to do this can vary based upon desired accuracy. If water quality in the main river is already being monitored sufficiently, a monitoring site near the mouth of the tributary may be sufficient. Water quality on the tributary can be compared with water quality on the main river to get a general idea of whether the impact of the tributary is positive or negative.

This method was applied when the MPCA was choosing sites for the Red River Basin Monitoring Network. Main-stem monitoring sites were located along the Red River of the North. Primary monitoring sites were then chosen for the main tributaries of the Red River. These sites were located near the mouth of these tributaries. Secondary sites were also chosen near the mouths of streams that were tributaries to the main tributaries of the Red River.

If a goal is to estimate the impact of the tributary as accurately as possible, as many as four sites can be used for each tributary. There should be a site near the mouth of the tributary itself, but not so close that backwater can have an effect on the site. A site on the main river located just upstream of the tributary will assess the quality of water before it is influenced by the tributary. Results from this site can be compared with results from a site downstream of the tributary to determine its impact. A fourth site may be located further downstream to assess how well the river recovers from any impact the tributary might have had on water quality.

5.4 Resources

There are many informational resources available that can be utilized when designing a monitoring program and monitoring network. This document has utilized a large number of these. Information from these sources has been combined to produce as robust a document as possible. Although this document contains much information on the creation and management of a water monitoring program, there is no end to the additional knowledge available from the multitude of water quality resources that are available. Many of these resources are available for free over the internet. Some come in the form of textbooks or other documents that must be purchased. Two excellent sources of free information are the United States Environmental Protection Agency and the Minnesota Pollution Control Agency. They provide manuals for differing levels of monitoring including local volunteer monitoring, intensive TMDL studies, and statewide monitoring programs. Most of these are available online. There also are guidance documents available relating to monitoring methods. The monitoring of lakes, rivers, and streams can involve more than just water quality monitoring. Biological monitoring is a good way to measure the overall health of an aquatic ecosystem. It is also a very good educational tool when it is part of a volunteer monitoring program. Biological monitoring methods are also available from both the USEPA and the MPCA.

Many of the manuals and guides listed in the **References and Further Reading** section of this document provide information useful for the creation of a monitoring plan, design of a monitoring network, and selection of sampling methods. Since most of these are available online, their respective website addresses are included in the citations. Below is a listing of the titles of some of the most useful resources.

- MPCA Website: http://www.pca.state.mn.us/
- EPA Website: http://www.epa.gov/
- USGS Website: http://www.usgs.gov/

- Minnesota Department of Natural Resources (DNR) Website: http://www.dnr.state.mn.us/index.html
- EPA: *Guidance for Quality Assurance Project Plans.*
- EPA: *EPA Requirements for Quality Assurance Project Plans.*
- EPA: *The Volunteer Monitor's Guide to Quality Assurance Project Plans*
- EPA: *Volunteer Stream Monitoring: A Methods Manual.*
- MPCA: *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment – 305 (b) Report and 303(d) List.*
- World Health Organization/United Nations Environment Programme: *Water Quality Monitoring – A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes.*
- River Watch Network: *Testing the Waters: Chemical & Physical Vital Signs of a River.*
- MPCA: *Volunteer Surface Water Monitoring Guide.*
- USGS: *National Field Manual for the Collection of Water-Quality Data.*

Other resources that may be useful when designing a monitoring network are reports and studies from other agencies or groups. The monitoring plans for previously conducted studies can be used as examples when a new program is being created. Often, when designing a monitoring plan, using methods similar to those used by other monitoring programs within the same area will allow for comparison of results from multiple studies. For nearly all project reports and other documents created by or related to the RLWD, see the RLWD projects website at http://www.redlakewatershed.org/projects.html or the RLWD water quality page at http://www.redlakewatershed.org/h2oquality.html.

6.0 GIS, Database Design, and Website Development

6.1   GIS Software Recommendations

At the time that the majority of this document was written (winter 2004-05), the RLWD was using ArcView 3.1 for GIS work. This version is commonly used for the general creation of maps for the RLWD. Many natural resources professionals are familiar with this program. By creating a well organized project with multiple views for different projects and areas, maps can be created relatively quickly and easily. This program can also be used for spatial analysis, for example, finding the area of a complex polygon.

A newer version of ArcView is also available. The RLWD has begun using ArcGIS 9.1, but is still in a transition period. This version allows the user to do things not possible with version 3.1, 3.2, or 3.2a. For example, ArcGIS 9.1 allows users to view data from different projections with the same view. It is also more user-friendly, has tools for better data management, has more intuitive controls, allows the use of a scroll button, provides more options for editing the appearance of maps, provides additional tools to improve and ease the process of making layouts, along with many other features. A central database, ArcGIS-based ditch inventory, and an easy-to-use GIS interface are being

developed as part of the RLWD Ditch Inventory Project, which is being funded by a Minnesota Board of Soil and Water Resources Challenge Grant.

There are some tricks of the trade for ArcView 3.x that are included in this manual even though it is not the latest version. It is still a widely used version of ArcView.

Basically, the georeferenced data that can be pulled into ArcView includes shapefiles (lines, points, and polygons) and image files (aerial photos and scanned topographic maps). These themes can be layered on top of one another to create maps. New shapefiles can be created by the user. Shapefiles can be created and used to mark features on the landscape. Each shapefile has a query database associated with it. The area of polygons can be calculated. The RLWD uses the DNR ArcView tools extension for calculation of area. This is available at http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/tools/tools.html. The main resource for GIS data in Minnesota is the DNR Data Deli website: http://deli.dnr.state.mn.us/. 2003 color orthophotos (aerial photos) are available on the Data Deli website and the Land Management Information Center (LMIC) website: http://www.lmic.state.mn.us/chouse/airphoto_usda.html#fsa.

Sometimes it is desirable to know the GPS coordinates of a set of points. In ArcView 3.x, there is a quick and easy way to **add UTM coordinates** to the attribute table of a point shapefile. Make the theme you will be working on active by clicking on it. Open the **attribute table** for the theme. Make sure the table is in the editing mode. Add two fields to the table. One should be named **latitude or X** and the other should be named **longitude or Y**. In the add field window, make sure there are enough characters to fit the coordinates, make sure it is a number field, and tell it to display 4 decimal places. After both fields have been created, select one of the fields and make sure that no records are selected (they will be highlighted in yellow if they are). Click on **field**, and then **calculate** in the pull-down menu. The **calculate** window will now be showing. If you have selected the latitude field, double click on the word **[shape]** in the upper left corner box in the window. The word [shape] will appear in the **(name of field)**= box. Then **type .getx** after the word [shape]. For the longitude field, do everything the same except that the formula will be [**shape].gety** instead of **[shape].getx**.

Creating and saving a project that contains several often used views can save the user a great deal of time. Maps can be created much quicker once a project is established because most of the necessary GIS data is already loaded into the project. Theme legends and color schemes are already configured the way the user wants them, so editing legends doesn't have to be done every time a map is to be made. Each view can be of a different project area or can include a different set of themes. Views may be of a particular county, city, or subwatershed. Multiple views with different themes may be created for the same area. ArcGIS 9.x offers some improvements related to this process as well through the creation of layer files that include legend information in the file so that the file looks the same (desired) way every time it is loaded into a new project. In 3.x, shapefiles that are loaded into a new project are given a random, default color shceme that seldom looks the way you want it to. It is necessary to change the legend around or load a saved legend file

every time the file is loaded into a new project unless the project establishment method described earlier in this paragraph is used.

The organization of GIS data is very important. Whenever an ArcView project is created and saved, it remembers where each theme within it is located. Therefore, organization is crucial to efficient utilization of GIS technology. Storing GIS files in a sensible hierarchy within a central GIS folder is highly recommended. Before adding new GIS files to a project, save them in a place that will be permanent and makes sense. If GIS files are moved to a new location on a computer, existing projects won't be able to find them. Another advantage to placing all GIS data and project files within the same folder (in sensibly organized subfolders), is that a GIS project can be moved from one computer to another this way.

Another technique for GIS data management that some offices use is to store the majority of GIS data on one computer (particularly large files). ArcView users can access this data over a local area network (LAN). In order for ArcView to browse a network for files, mapping a network drive is necessary. This is done by clicking on the **Tools** menu in **My Computer**. Click on the words: **Map Network Drive**. When the **Map Network Drive** window is visible, choose the letter you wish to assign to the drive. Click the **Browse** button, then find and highlight the folder located on another computer that you wish to access using ArcView. Click **Finish** to add the drive. Now, when you add a theme to ArcView, you will be able to add a theme that is stored on another computer to your project.

6.2 Website Development and Procedures

The RLWD website was developed by Houston Engineering. The website has nine major sections: home, about RLWD, permits, projects, water quality, maps, contacts, related sites, and watershed plan update. The first three sections are mainly informational, although the permits section will feature a permit database in the future as part of a separate project. The projects section contains a list of RLWD projects and links to any available reports associated with these projects. There currently are 19 project reports available on this page. The water quality page includes links to annual water quality reports, *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*, and water quality data search tools (text and interactive map). Website visitors can use the text form to find a water quality monitoring site based on site ID, site name, county, subwatershed, or ecoregion. The interactive map tool can be used for the creation of maps, but also can be used to find water quality data. Clicking on the identify () button, clicking on a star marking a monitoring site (or click and drag to select a larger area or several sites), and then clicking on the site ID link (combination of latitude and longitude in blue) in the results window will bring you to the set of webpages for that particular monitoring site. There are five pages for each site. A report card page compares fecal coliform, total phosphorus, total suspended solids, and dissolved oxygen levels at that site to other sites within the same subwatershed, the entire Red Lake River watershed, and minimally impacted stream data form the same ecoregion. A site information page displays information on the location of the sampling site along with

pictures of the site. The third page displays all the data for the site. The "Analyze or Download Data" page allows users to create summary statistics, create time series graphs, use the StatCrunch data analysis software, download data, and download quality assurance information.

7.0 Standard Operating Procedures and Quality Assurance Project Plan Development.

7.1 Standard Operating Procedures Manual Description

To ensure that the assessments and decisions made from data results are accurate, following proper procedures during project planning, implementation, and assessment is very important. These procedures should be documented in a Quality Assurance Project Plan (QAPP), set of Standard Operating Procedures (SOP), and/or a Sampling and Analysis Plan The rigorous application of standard protocols ensure that the river, stream, lake, and wetland data collected for a project is accurate, precise, and comprehensive, and representative. The application of a set of uniform methods also ensures continuity in methodology and comparability of results among projects administered and carried out among different agencies. Bringing data together from multiple sources can improve efficiency, coordination, and assessment.

The *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* document was created to provide the benefits described above to monitoring projects taking place in the Red River Basin, and anywhere else. The creation of this SOP is part of the Red River Watershed Assessment Protocol Project. A BWSR Challenge Grant and matching funds from the Red Lake Watershed District provided the funding for this project. The overall purpose of this project is to provide a model for water quality monitoring activities throughout the Red River Basin. The SOP has been reviewed by individuals from the Minnesota Pollution Control Agency, United States Environmental Protection Agency, United States Geological Survey, Red River Basin Board, University of Minnesota Crookston, University of North Dakota, City of Grand Forks Environmental Laboratory, Red Lake Department of Natural Resources, Red River Basin Monitoring Advisory Committee, and the Red River Watershed Assessment Protocol Technical Advisory Committee. The SOP was composed using existing standard methods, existing standard operating procedures, manuals, and the experience of those involved with its creation.

The *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* document is available online at http://www.redlakewatershed.org/waterquality/Entire%20SOP%20Document.pdf.