Thief River Watershed Sediment Investigation Work Plan

2007 – 2009 Clean Water Partnership Project

Revision 1

August 2007

Thief River Watershed Sediment Investigation

Organization: Red Lake Watershed District

Project Start Date: February 12, 2007 Project End Date: February 12, 2011

Work Plan Submittal Date: August 28, 2007

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Watershed, Lake or Water Body: Thief River Watershed (HUC 09020304)
Latitude/Longitude for center of project area: 48° N/96° W

Counties: Marshall, Beltrami, and Pennington Counties

Project Funding Type (check one): _X_CWP Diagnostic	___CWP Implementation
___319 Implementation	___319 Non-implementation
Grant Amount: $96,500	Proposed Cash Match Funds: $63,400
Proposed Inkind Match Funds: $37,100	Total Project Costs: $197,000

Project funded by:

Minnesota Pollution Control Agency Clean Water Partnership Resource Investigation Grant, Red Lake Watershed District, Red River Watershed Management Board

In-Kind Contributions from:

Marshall County Water Plan, United States Fish and Wildlife Service, Pennington County SWCD, Minnesota Department of Natural Resources

Other Project Partners:

United States Geological Survey, Energy and Environmental Research Center

Local Units of Government in the Project Area:

Counties:	1.Marshall	2.Beltrami	3.Pennington	4.
Townships:	1.Thief River	2.East Valley	3.Excel	4.North
	5. Moose River	6. Linsell	7. Whiteford	8. Hollis
	9. Veldt	10. Mud Lake	11. Eckvoll	12. Valley
	13. Benville	14. Agder	15. Grand Plain	16. Moylan
Cities:	1.Thief River Falls	2.Grygla	3.	4.
Agencies:	1.Red Lake Watershed District	2.Marshall County Water Plan	3.Marshall-Beltrami Soil and Water Conservation District	4.Pennington County Soil and Water Conservation District
Organizations:	1.Red River Watershed Management Board	2.	3.	4.
Other:	1.Energy and Environmental Research Center	2.	3.	4.
State Senate Districts: 01, 02				
State House Districts: 01A, 01B, 02B				

MPCA Representatives/Advisors:

Pete Fastner, Regional Division, St. Paul Office
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Hard copies of this document are available at the RLWD office.
This document may be downloaded from the RLWD website as well:
www.redlakewatershed.org

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1. STATEMENT OF PROBLEMS AND EXISTING CONDITIONS

The Thief River Watershed Sediment Investigation is intended to diagnose the impact of hydrologic modification as well as other anthropogenic and natural factors influencing water quality in the Thief River watershed. The watershed is heavily managed with more than 30 impoundments and many miles of channelized streams and man-made ditches. Some of the impoundments were built to address flooding concerns but most are operated primarily for wildlife habitat management. The drainage-related hydrologic modification made farming possible within this area. Headlines in a 1909 edition of the Minneapolis Journal proclaim "Net-Work of Ditches and Laterals Reclaims Vast Area in Thief River Valley" (sic) and "THIEF RIVER BOTTOMS TO BECOME A GARDEN."

Because it is home to Agassiz National Wildlife Refuge and Thief Wildlife Management Area the area is productive and important for waterfowl, shorebirds, and migrating birds. The watershed also features productive and important farmland.

The Thief River flows to the Red Lake River, which is a drinking water source for the cities of Thief River (just downstream of the confluence), East Grand Forks, and Grand Forks. It most directly affects the Thief River Falls Reservoir and water supply. The Minnesota Department of Health has developed source water plans for Thief River Falls and East Grand Forks.

Figure 1. Sediment plumes from the Thief River at its confluence with the Red Lake River in Thief River Falls

Monitoring by the Red Lake Watershed District led to designation of three reaches on the 2006 303(d) List of Impaired Waters. The impaired reaches in the Thief River Watershed are:

1. Thief River, Agassiz Pool to Red Lake River, 09020304-501, Low Oxygen
2. Thief River, Agassiz Pool to Red Lake River, 09020304-501, Turbidity
3. Thief River, Thief Lake to Agassiz Pool, 09020304-504, Ammonia
4. Moose River, Headwaters to Thief Lake, 09020304-505, Low Oxygen

Discharges from the larger pools have been shown, at times, to negatively influence water quality for the system (Red Lake Watershed District monitoring data). On the other hand, research conducted by Houston Engineering and the Pennington SWCD indicates that two-thirds of the sediment flowing into the Refuge's main pool is deposited there. A study by the NRCS found that 63% of the sediment yielded to streams in the Thief River Watershed comes from streambank and ditchbank erosion. The current long-term monitoring effort, although sufficient for identifying general problem areas, is insufficient (only 4 samples/year/site) to identify the causes of problems. More specific questions about the movement of sediment into and out of impoundments, contributions from agricultural ditches, current monitoring efforts (adequacy), channel erosion, and other issues have made this intensive study necessary.

This project has developed from discussion about water quality problems in the Thief River that have been found by the RLWD and Marshall County Water Plan water quality monitoring programs. The monitoring that has been done includes:

- Twenty years of quarterly monitoring by the RLWD
- Three years of monthly monitoring by the Marshall County Water Plan
- Recent investigative water quality monitoring by the RLWD

This discussion initially took place at Marshall County Water Plan meetings. Steps to address soil erosion, sedimentation, and other water quality issues were incorporated into the Marshall County Water Plan. The issues identified in this planning process were:

1. Streambank failure/ditchbank slumping in the watershed
2. Sediment in ditches/streams
3. Water quality impairments
4. Flooding – upstream? Downstream?
5. Drinking water at Thief River
6. Sediment in Thief River Reservoir.

An intensive study on the Thief River was also incorporated into the latest Red Lake Watershed District 10-Year Comprehensive Plan. The Marshall County Water Plan Task Force then teamed up with Molly MacGregor's (Red River Basin Coordinator, Detroit Lakes MPCA Office) Red River Basin Water Quality Team for several meetings focused on identifying and addressing water quality issues on the Thief River. The team came up with several recommendations and questions.
The meetings revealed that there was a need for a better understanding of how impoundments are operated in the watershed. A meeting was held on December 15, 2005 to address this need. The meeting was open to the public. All three agencies (RLWD, USFWS, MN DNR) that operate impoundments within the watershed gave presentations. After the presentations, small group discussions yielded lists of issues and questions about problems within the watershed.

- Coordination among impoundments and timing of water releases
- Coordinating impoundment water releases with downstream water levels
- Uncontrolled runoff
- Understanding the dynamics of sediment movement from ditches to impoundments

  - Need continuous monitoring
  - Need sediment budget for each impoundment
  - Flow and sediment monitoring would be necessary
- Sediment loads
- Source of sediment is not just from impoundments
- Long-term plan is needed
- Ditches – scheduled maintenance and design
- Land uses – land coming out of CRP
- Management conflicts
  - Differences in goals
- Cooperation among agencies
- Manage impoundments to benefit landowners
- The large amount of water storage in the Thief River watershed relative to other areas.
- Does water management create the sediment problem? Are the artificial ditch banks on the Thief River a sediment source?
- What is the rate of flow that produces sedimentation?

See Appendixes 2 through 7 for more information.

2. STATEMENT OF PROJECT GOALS AND OBJECTIVES

2. A. Overall Resource Goals

This investigation will help develop impaired waters studies for the listed reaches, create a common understanding of the true causes of water quality problems in the watershed, make recommendations for improving management of water, and protect drinking water.

Some reaches of the Thief River are impaired by turbidity, dissolved oxygen, and un-ionized ammonia. A goal of this project will be the identification of the true sources of these water quality problems. Recommendations and priorities established by this study will guide future project implementation activities within the watershed.

The Thief River has been found to have periodic turbidity levels greater than the state standard of 25 NTU. Fortunately, no turbidity readings with a HACH 2100P portable turbidimeter (a widely used portable instrument for turbidity measurements) have been greater than 50 NTU. The mean turbidity reading for the most recent 10 years of data through the 2006 monitoring season was 19.16 NTU. Also, when Index of Biotic Integrity (IBI) scores were calculated from fish sampling results for the Red River Basin Stream Survey Report – Red Lake River Watershed 2004, the monitoring site on the lower reach of the Thief River had a better IBI score than any other monitoring site in the study, including sites on the trout stream reach of the Clearwater River. So, the goal of meeting the state standards for aquatic life support is quite likely within reach for the Thief River.

2. B. Water Quality Characterization Goals

This study will perform investigative water quality monitoring at a minimum of 11 sites throughout the watershed to verify the impairments. Flow and sediment monitoring will be conducted in order to develop sediment budgets (FLUX modeling) for the impoundments. Water quality monitoring results will be used to calibrate the Soil and Water Assessment Tool (SWAT) to model contributions from various sources, estimate pollutant loads and evaluate pollutant reduction strategies. Data will be entered into the EPA STORET database and a comprehensive final report will be written, published by the RLWD, and made available on the RLWD website (www.redlakewatershed.org).

Data will also be used to verify impairments and sources of sediment in the watershed. A very important outcome of this project will be an understanding of the timing of water and sediment movement through this complex watershed. This grant-funded project will allow us to collect the continuous monitoring data needed to understand this timing.

Although not originally budgeted in the study, the possibility of conducting some form of an erosion assessment within the watershed will be explored. The rigor of such a study may initially be limited to a simple inventory of erosion sites in the watershed. A channel stability assessment will be needed to determine the proper course of addressing these erosion problems.

2. C. Preliminary Quantitative Goals

The participating agencies have worked cooperatively to develop long-range plans. However, serious questions about the source of sediment (and flooding problems) in the system remain and can be divisive. An objective examination of the system is needed to develop a shared understanding.

The current quarterly sampling schedule conducted throughout the RLWD is sufficient for discovering potential problems and trends, but is generally insufficient for diagnosing the specific sources of problems. The RLWD's regular sampling schedule is random in respect to flow. Still, it is easier for a sampling scheme with only 4 samples per year to be biased by high flow periods. One sample collected during a storm event can have a greater impact on water quality assessments than it should.

One quantifiable goal of the study will, of course, be the quantity of data collected. Monthly water quality samples will be collected at the monitoring sites included in this study. Field measurements will be collected more frequently through maintenance related site visits. There are 11 monitoring site planned for the CWP portion of the study. There will be 4 additional monitoring sites within Agassiz NWR as part of a "piggyback" study. Continuous water quality monitoring for turbidity, dissolved oxygen, pH, temperature, and water level will be conducted at 5 of these sites. Continuous stage monitoring will be conducted at the other sites. Over the three-year span of the study, a minimum of 20 samples will be collected at each CWP monitoring site. Monitoring results will be used in the next MPCA statewide water quality assessment. The data will provide for a more reliable and representative assessment than what has been possible to date. It will either confirm or disprove that an impairment actually exists.

Turbidity measurements will be compared to the current MPCA standard of 25 NTU. The Thief River will need to exceed the 25 NTU standard in fewer than 10% of the measurements collected in the most recent 10 years of monitoring in order to officially be considered to be fully supporting of aquatic life.

Dissolved oxygen readings will be compared to the MPCA state standard of 5 mg/L. The water quality in the Thief River will need to meet this standard in 90% of the measurements collected in the most recent 10 years of monitoring in order to officially be considered to be fully supporting of aquatic life.

2. D. Information and Education Goals for Citizens in the Project Area

There is a need within this watershed to develop an awareness of the value of a healthy river system. There are some that only view this river as a ditch or a means of carrying water away from the flood plain that they are attempting to farm. As with any river system, it is important for people to realize that what they do to the river (increasing flow or pollutants) effects other people located downstream, including an entire city of people in Thief River Falls that rely on water from the Red Lake and Thief Rivers for their drinking water supply.

There is much heated debate in this watershed over who is causing flooding and water quality problems. Not all the opinions are based upon fact. This CWP project will provide the project partners the opportunity to focus upon this watershed, collect data, and obtain the facts. We need to be certain that water managers understand the issues in the watershed, causes of problems, and viable solutions to these problems. Once the scientists and natural resource professionals have a clearer understanding of the watershed, then more can be done to provide public education. The report that is created for this study will be written in an understandable format. It will need to be useful not only to water resource scientists, but to many different people with varying educational backgrounds. It is important for everyone to have a good understanding of the facts behind the real and perceived problems within the watershed in order to avoid misinformation and make wise decisions.

Summaries of project (this and other projects) findings and recommendations should be made available. The RLWD has a website (www.redlakewatershed.org) that can be used for dissemination of information, but online distribution of information alone is not enough. The will need to be some form of outreach as well. Strategies for this will be discussed as part of the project.

3. PROJECT ORGANIZATION AND RESPONSIBILITY

The watershed is intensely managed through hydrologic modification. This fuels disagreements between resource agencies and citizens. This project aims to develop a platform of shared understanding between farmer, wildlife manager and local government. Multiple stakeholders will be involved in order to help us achieve this goal.

3. A. General Responsibilities

The lead agency for the project will be the Red Lake Watershed District, which manages several of the impoundments and conducted the water quality monitoring that discovered impairments. The U.S. Fish and Wildlife Service manages Agassiz National Wildlife Refuge, the older of the impoundments. The Minnesota Department of Natural Resources manages several smaller wildlife management areas. Also involved are the County Water Planners for Marshall and Pennington Counties, the Minnesota Pollution Control Agency, the Board of Water and Soil Resources and the Red River Watershed Management Board. The Energy and Environment Research Center at the University of North Dakota has completed a hydrologic SWAT model for the Red River Basin and will be able to use this model for water quality modeling for an estimated cost of $45,000 for each major subwatershed. The Red Lake Watershed District Board of Managers, Red River Basin Water Quality Team, and Marshall County Water Resource Advisory Committee will be the primary stakeholder advisory and decision-making groups for the project, but there will be a need for stakeholder advisory meetings that involve more of the public. Public meetings will need to be well advertised in advance through newspaper, phone calls to known interested individuals, and maybe even radio interviews.

3. B. Specific Responsibilities

SWAT water quality modeling will be performed by the Energy and Environment Research Center at the University of North Dakota. The Marshall County Water Planner will be conducting water quality monitoring at the seven northernmost sites being monitored for the CWP project. The Marshall-Beltrami SWCD District Technician will assist with this monitoring. The RLWD Water Quality Coordinator will be responsible for monitoring the 4 southernmost sites of the CWP project, storm-related monitoring at all sites, continuous water quality monitoring, continuous water level monitoring, project administration and reporting, organizing meetings, and more. The RLWD Administrator and Board of Managers will be in charge of making official The USFWS will monitor sites in and around Agassiz National Wildlife Refuge twice weekly. They have acquired funding for the purchase of additional continuous monitoring equipment and augmentation of the Thief River Watershed Sediment Investigation through intensification of the amount of monitoring in and around the Refuge.

3. C. Project Organization

These groups meet together through the county local water planning effort or through the MPCA's Red River Basin Water Quality Team. In addition, the agencies meet annually to review operation of the impoundments.

- RLWD Board of Managers
    - Myron Jesme – Administrator
        - Corey Hanson – project planning and coordination, sampling, monitor installation/maintenance, report writing, data analysis
        - Engineering Technicians – flow monitoring
            - Loren Sanderson

        - Gary Lane
- Minnesota Pollution Control Agency
    - Jim Courneya - Official Project representative
    - Molly MacGregor (key part of project initiation)
- Agassiz NWR
    - Maggie Anderson, Manager – project coordination
    - Gregg Knutson
    - John Braastad
    - Student worker(s)
        - 2007 - Kristin Fritz, Maria Fosado
- USGS – Stream Gauging, project advisors
    - Gregg Wiche, *North Dakota Water Science Center Director*
        - Jason Lambrecht, *Supervising Hydrologist*
        - Rochelle Nustad, *Civil Engineer*
        - Paul Scarpari, *Hydro Tech*
    - Lan Tornes, *Water Quality Specialist*
- Marshall County – water monitoring – project sponsor
    - Marshall County Water Planner – Jan Kaspari
    - Marshall-Beltrami SWCD – Lisa Newton
- Pennington County – stakeholder/advisors
- City of Thief River Falls - stakeholder/advisors
- Minnesota Department of Natural Resources - stakeholder/advisors

3. D. Staff and Governing Board Directory

Project Staff Directory

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4. IDENTIFICATION AND SUMMARY OF PROGRAM ELEMENTS

Water Quality Monitoring

This will consist of sampling and field measurements. This data will be used for comparisons and correlations with continuous data, for modeling, and to provide quality data for stream assessments. The water quality concerns addressed by this project are excessive turbidity, fecal coliform bacteria, ammonia nitrogen, low oxygen, phosphorus, and suspended solids.

The goal of this project is to develop an understanding of a complex system of hydrologic modification (ditches, channelization, and impoundments) upon water quality. This project will analyze water quality through investigative monitoring, model results and estimates of sources and loading. Data will be used for statewide water quality assessments. The RLWD has been monitoring water quality for 22 years and has successfully completed many intensive water quality studies and water quality improvement projects. This study will be used to guide water quality improvement efforts so the state water quality standards can be met. The monitoring schedule may be subject to future adjustment to meet the data requirements of MPCA statewide water quality assessments and/or model calibration.

Equipment

One of the most important elements of this study will be the ability to collect continuous water quality data at key locations in the watershed. This will be accomplished using water quality and water level logging sensors and multiprobes deployed at key locations throughout the watershed. Hardware and materials will be needed to construct protective structures for these sensors. The Eureka Manta water quality multiprobes will need a new set of batteries once every four weeks. All other equipment purchases will be made to improve the quality of data collected during the study (barometer and stand for dissolved oxygen calibrations, steel tape for stage measurements, etc.). A portable sonde (Eureka Manta/Amphibian combo) already owned by the RLWD will be used to collect field water quality measurements during site visits and to validate the quality of data collected from the deployed instruments. The Marshall County Water Planner uses a YSI (Yellow Springs Instruments) multiprobe on loan from the Minnesota Pollution Control Agency. All of the agencies conducting monitoring for the study will also be using HACH 2100P portable turbidimeters for standardized measurements of turbidity. The USFWS will be using a Hydrolab Datasonde 4 and Surveyor 4 combo that is already owned by the RLWD. The USFWS has purchsed their own HACH 2100P portable turbidimeter.

Equipment will be purchased at the beginning of the project. Cooperative planning among the RLWD, Agassiz NWR, USGS, Northwest Regional Sustainable Development Partnership, and Minnesota Department of Natural Resources has been used for equipment selection and for the purchasing of additional equipment.

Equipment Calibration and Maintenance

Diligent equipment calibration and maintenance will be needed to ensure that the continuous and spot measurements are reliable. All water quality equipment will require regular maintenance during the course of the study. The minimum frequency of the calibration and maintenance of continuous monitoring equipment will be a two-week interval of site visits. Sampling equipment will need to be cleaned to avoid sample contamination. Water quality sondes used for spot measurements of water quality are calibrated regularly based on the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*.

A student worker will provide assistance with this process, although most of this calibration will be performed or supervised by the RLWD Water Quality Coordinator. Calibration of profiling sondes will be conducted in accordance with the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed.* Although the deployed and portable multiprobes are calibrated similarly, additional quality assurance procedures will be established for the maintenance and calibration of the deployed multiprobes. These procedures are covered in the Quality Assurance Project Plan in Appendix 1. Dissolved oxygen probes on profiling sondes will be calibrated each day before monitoring begins. Conductivity and pH will be calibrated monthly on the profiling sondes. The pH, conductivity, dissolved oxygen, and turbidity probes of the continuous monitoring sondes will be calibrated according to manufacturer recommendations and data validation results. Calibration schedules may be intensified if needed. The USGS *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting* and the British Columbia Ministry of Environment's *Continuous Water-Quality Sampling Programs: Operating Procedures* will be used to guide the continuous monitoring process. The technology being used for the continuous monitoring part of this project was not widely accessible at the time that the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* document was produced, in 2003. So, additional methods manuals such as these will be utilized for the project.

In order to ensure data quality, deployed water quality equipment will be brought in to the RLWD office for cleaning, calibration, and data validation within a stable laboratory environment. Although this will create larger gaps in data sets than field calibration, it will allow for greater confidence in data through data validation/grading, more accurate calibrations, better cleaning capabilities, and more efficient maintenance. The accuracy of the deployed sondes (and comparability to portable sondes) will be verified bi-weekly and calibrated as needed. Field measurements will be collected in-situ during removal and replacement of the deployed sondes.

There will be a total of 9 continuous monitoring stations used for this study. The original Thief River Watershed Sediment Investigation funds five and Agassiz National Wildlife Refuge has found funding for 4 additional monitors as part of a "piggyback" project. During each visit to a continuous monitoring station, data will be downloaded. Then, the monitors will be cleaned and calibrated. Data validation checks against a portable sonde in a bucket of stream water (at the lab) will be conducted before cleaning, after cleaning, before calibration, and after calibration.

Flow Monitoring

Flow monitoring will be essential for successful FLUX modeling and estimation of sediment budgets for the project,. Stage will be recorded using Onset HOBO water level loggers and a USGS gauging station. A barometric pressure logger deployed behind the Quonset at the Agassiz NWR headquarters will be used to improve the accuracy of the data collected from the deployed HOBO Water Level Loggers. Manual stage measurements will be used to convert continuous water depth data into a continuous record of river stage. When sufficient flow measurements are available to create a reliable flow rating curve, the equation for the curve can be applied to the continuous stage data to create a continuous record of flow. Pivot tables can then be created to summarize data and create daily average flow records for FLUX modeling. Continuous stage/flow records can be used to examine storm runoff events. Continuous water quality monitoring multi-probes will also include a water level sensor.

The Red Lake Watershed District will conduct a sufficient number of flow measurements at the project's monitoring sites to develop reliable rating curves. These rating curves will be used to convert the continuous water level record into a continuous record of flow. RLWD water quality and engineering staff will collect flow measurements over a range of flows. The higher flows will be measured mostly during spring runoff. Most of the work done for this project in the spring of 2007 will focus on work plan development and equipment installation; so spring flow measurements will mostly be collected in 2008 and 2009.

Agassiz NWR has contracted with the USGS to conduct a set of 3 flow measurements at the four monitoring sites within the refuge along with site #140. The United States Geologic Survey, using Acoustic Doppler technology, has collected several accurate high flow measurements around Agassiz National Wildlife Refuge for use in this study. These flow measurements are being conducted in the spring of 2007. The USFWS may be receiving additional funding for further collection of flow measurements and water quality samples.

Data and Information Collection

This program element includes all the data entry that will be needed for the project. This will be conducted by all project partners and will be submitted to the RLWD for the purpose of data analysis and report writing. The RLWD will submit data to the MPCA for entry into the EPA's STORET water quality database. Data should be submitted to STORET no later than November 15th of each year. Site establishment forms for new sites and updated project establishment forms should be completed and submitted to the MPCA in the spring of each year.

Develop Sediment Budget

FLUX modeling will used to balance inflows and outflows of sediment to and from the Thief Lake and Agassiz NWR impoundment areas. It will also be used at the other monitoring sites on the main stem of the Thief River and contributing ditches.

Sediment rating curves will be developed, if possible, by looking for a relationship between total suspended solids concentration and flow rate data.

Water Quality Modeling

The Energy and Environmental Research Center has used SWAT to create a hydrological model for the Red River Basin. A water quality component will be added to the existing hydrologic component for the development of a SWAT water quality model for the Thief River watershed. A contract will be established between the RLWD and the EERC for the completion of this program element. BMP implementation and water management scenarios will be modeled to determine the best strategies for improving water quality in the watershed.

Data Analysis and Assessment

The RLWD will analyze all the data collected for the study for the purpose of creating a final report. Project partners will also review the results of this analysis.

Review/assess the outcomes of the study

An advisory group composed of project partners will review project progress and outcomes on regular basis. This may be a new group, or we could use existing groups such as Water Resource Advisory Committees (Marshall and Pennington Counties), Red River Basin Water Quality Team, and the Red River Basin Monitoring Advisory Committee.

Assess Results

Project partners and/or advisory groups will assess the outcomes of the water quality monitoring, water quality modeling, flow monitoring, and any other data collection that is part of the study.

Make recommendations

An important part of this study will be the recommendations made for future project implementation and strategies for achieving water quality goals. The final report from the project will need to include:

1. A list of problem areas
2. Erosion assessment results
3. Public input/comments
4. Descriptions of implementation methods

Report

Write and Review Report

The Red Lake Watershed District Water Quality Coordinator will write the majority of the report during the third and fourth years of the project. All project partners will review the final report for this project. Project partners and other stakeholders will develop recommendations included in the report. The report will be started at the beginning of the project. This Microsoft Word document, and perhaps others, will be used to track and document the progress of the project. It will be important to have a central location/document in which to store the findings and other information gathered during the course of the project. For example, news of road construction may either be written down on a notepad and lost, or documented in a section of a first-draft project report. The latter of these two options is definitely the preferred choice.

The RLWD Water Quality Coordinator will document project activities throughout the project in semi-annual progress reports to the MPCA as well as in a section of the monthly RLWD water quality program progress reports that are written to keep the RLWD Board of Managers well informed and to serve as a reference for future report writing. Updates on this project will also be included within the 2006, 2007, 2008, 2009, and 2010 RLWD annual reports.

The semi-annual progress reports and workplan development will be tracked separately on the semi-annual expenditure reports. The RLWD keeps track of expenditures by using project and work type codes. The project number extablished for this project is 168. Existing work type codes from other projects will be used where appropriate to separate expenditures into the different objectives of the project. New numbers will be added when necessary. The following table shows these associations.

Table 1. Objectives and corresponding work type codes

Objective	Work Type
Development of a project workplan and admin.	**7**
Equipment purchases	**N/A**
Equipment calibration and maintenance	**1**
Water quality monitoring	**19**
Flow monitoring	**46**
Data entry and reduction	**54**
Develop sediment budget	**55**
Water quality modeling (SWAT contract)	**N/A**
Assess results	**52**
Make recommendations	**53**
Write and review report	**59**
Publish report	**17**
Develop impaired waters work plans	**69**
Assisting Agassiz NWR with parallel study (Separate from CWP Grant and Match reporting)	***8***

Publish Report

The Red Lake Watershed District will publish the report. The RLWD office has the capability of printing bound copies of reports. An indefinite number of copies will be made of the report to ensure that a sufficient number of copies are always available for distribution to interested parties. The report will also be available for downloading in PDF format from the RLWD website: www.redlakewatershed.org. An expectation of this project report is that it should serve as a reference that can be used for understanding the watershed and planning future projects.

Develop Impaired Waters Study Work Plans

A work plan and budget will be developed for each reach in the watershed that is listed on the Minnesota Pollution Control Agency's 303(d) List of Impaired Waters. The work plan will consider all the data and findings that are produced by the Thief River Watershed Sediment Investigation. Each reach will be considered separately (unless the same type of impairment extends upstream to other reaches) to allow flexibility in funding of TMDL studies by the MPCA. The MPCA's *TMDL Work Plan Guidance* (January 2006 or more recent version) document will be used to guide this project.

MILESTONE SCHEDULE

Equipment

Activity	Time Frame	Responsibility
Purchase continuous water quality monitoring equipment	January – March 2007	RLWD
Purchase continuous water level monitoring equipment	April 2007	RLWD
Build stilling wells for water quality monitoring equipment	April –May 2007	RLWD
Install continuous water level monitoring equipment	May-June 2007 March-April 2008 March – April 2009	RLWD
Install continuous water quality monitoring equipment	May-June 2007 March-April 2008 March – April 2009	RLWD
Purchase other equipment and batteries as needed	April 2007 – October 2009	RLWD

Equipment Calibration and Maintenance

Activity	Time Frame	Responsibility
Purchase Calibration Standards	April 2007, as needed	RLWD
Continuous monitoring equipment Calibration	2007 – 2009 Bi-weekly while equipment is installed	RLWD, Agassiz NWR
Continuous monitoring equipment cleaning and maintenance	2007 – 2009 Bi-weekly while equipment is installed	RLWD, Agassiz NWR

Water Quality Monitoring

Activity	Time Frame	Responsibility
Water quality sampling	2007 – 2009 Monthly (at least) during open water	Marshall County Water Plan
Water quality sampling	2007 – 2009 Monthly (at least) during open water	RLWD
Continuous Water Quality monitoring	Open water months of 2007 – 2009 (April through October)	RLWD, Agassiz NWR, Student worker

Flow Monitoring

Activity	Time Frame	Responsibility
Installation of structures to house continuous stage monitoring equipment	April-May 2007	RLWD
Continuous stage monitoring at all sites	Open water months of 2007 – 2009 (April through October)	RLWD, Agassiz NWR
Flow Measurements	Open water months of 2007 – 2009 (April through October) – particularly during high flows	RLWD, USGS
Rating Curve Development	Fall 2009	RLWD, USGS

Data Entry and Reduction

Activity	Time Frame	Responsibility
Data entry	Throughout the entire project (2007-2009)	RLWD, Marshall County Water Planner, Agassiz NWR
Preliminary data assessment	November – December of 2007 and 2008	RLWD
Final Data Analysis	October 2009 -	RLWD

Develop Sediment Budget

Activity	Time Frame	Responsibility
FLUX Modeling	November 2009	RLWD
Analysis of modeling results	December 2009	RLWD

Water Quality Modeling

Activity	Time Frame	Responsibility
Collecting data	Late 2009 – Early 2010 (with extension)	EERC, RLWD
Calibrate and run model	Early 2010 (with extension)	EERC

Assess Results

Activity	Time Frame	Responsibility
Yearly data review	November through March of 2007, 2008, and 2009	RLWD
Final data analysis	November 2009 – March 2010	RLWD
Write Report	2009 through 2010 (with extension)	RLWD, stakeholder agencies

Make recommendations

Activity	Time Frame	Responsibility
Decision making and recommendations from project partners (meetings)	December 2009	All project partners
Stakeholder meetings	November 2009, December 2009, or January 2010	Organized by MPCA and RLWD – involves stakeholders (landowners and agency representatives)

Write and Review Report

Activity	Time Frame	Responsibility
Draft report	End of 2009 or 2010	RLWD
Review of draft	Dec 2009 or Nov 2010	All project partners
Final report	January 2010 or December 2010 (dependent upon project extension)	RLWD

Publish Report

Activity	Time Frame	Responsibility
Printing	December 2010	RLWD
Distribution of Hard Copies	December 2010 and as needed	RLWD
Posting on RLWD Website	December 2010	RLWD
Press Release	November 2010	RLWD
Public Information Meeting	December 2010	RLWD

Develop Impaired Waters Study Work Plans

Activity	Time Frame	Responsibility
Create workplan	November 2010	RLWD, MPCA
Approval of work plan by the MPCA	December 2010 – early 2011	RLWD, MPCA

MONITORING AND MODELING PLAN

Monitoring Objectives

Sufficient data will be collected to confidently characterize water quality and processes affecting water quality within the Thief River watershed. One of the most important driving factors for the development of this study was the need for continuous monitoring to determine how the watershed behaves during a runoff event. Making sure that this data is as reliable as possible is a crucial part of this study. Also, spot measurements will need to be collected frequently enough to provide data of sufficient quality for modeling the watershed (FLUX and SWAT). Flow measurements will need to be sufficient to create reliable rating curves. Although there will be regular gaps in data sets from calibration and maintenance monitoring staff will strive to compile as complete a dataset as possible during the open water monitoring season. They will also need to be complete for the open water periods during which they will be deployed.

Previous Water Quality Studies

The participating agencies have worked cooperatively to develop long-range plans. However, serious questions about the cause of problems about the source of sediment (and flooding problems) in the system remain and can be divisive. An objective examination of the system is needed to develop a shared understanding.Summaries of previous studies can be found in the appendices of this workplan.

Monitoring Network

Site Selection

Sites will be selected based on the following questions:

1. Is the site located strategically within the watershed
    a. Measuring inflow and outflow from impoundment areas
    b. Accurately measures contribution from a ditch
    c. Will the site provide us with information that will help fulfill the goals of the project?
2. Is flow at the site influenced by downstream characteristics?
    a. Avoid backwater if possible.
3. Is it safe to conduct monitoring at the site?
4. Is there existing data from the site?
    a. Water quality
    b. Stage
    c. Flow measurements
5. Is it already part of an existing monitoring program?

Site selection is based on reviewing maps and also visiting each site to determine whether or not monitoring is feasible.All sites will have continuous stage monitoring. At least nine sites (Agassiz NWR and RLWD combined) will have continuous water quality monitoring.

Site Descriptions

RLWD and Marshall County Water Plan Sampling Sites

X4

- SH 54; Culvert 10 miles N. of Grygla in Sec. 1 of Veldt Twp.

15/X5 (Moose River)

- Moose River at SH 89; Bridge 4.5 miles NE of Gatzke in Sec.35 of Moose River Twp. Samples are collected from the upstream side of the bridge, within the thalweg. An Onset HOBO Water Level Logger will be installed at this site to collect and store water level readings once every 30 minutes.

98/T1 (Thief River)

- Thief River at CR 49 near the Thief Lake Outlet
- Vertical staff gauge on downstream side of Thief Lake Dam
    - SE headwall of outlet structure
    - Gage reads from 0 to 16.94, which is 1161.5 ft mean sea level
- Drainage area = 215.2 mi^2
- Benchmark: chiseled square on south side of Thief Lake Dam
- Elevation on NE headwall of bridge by Thief Lake Headquarters = 1163.54

140 (Thief River)

- Thief River at the northern boundary of Agassiz NWR
- Marshall County, T157N R41W Sections 8/17
- Benchmark: Painted bolt, top of curb, south side @ center of channel
    a. BM elevation = 100’ assumed elevation
- The Eureka Manta water quality logger for this site is installed on the downstream side of the bridge in a vertical PVC deployment tube.

757/D6 (Mud River)

- SH 89; Bridge 7 miles NW of Grygla in Sec 24 of Eckvoll Twp.
- Reference Point: Upstream side of bridge, painted point above thalweg.
- Stage: Measure down from reference point during low-water periods. There also is a staff gauge on one of the northwest pillars of the bridge.
    - This site is part of the Red Lake Watershed District's long term monitoring program.
- Eureka Manta logging water quality multiprobe installed in a fixed-angle deployment tube under the bridge.

40/T2 (Thief River/State Ditch 83)

- CSAH 7; Bridge 6 miles E. of Holt in Sec. 29 of East Valley Twp.

- Vertical staff (Corps of Engineers gage) on east face, S end of center pier of bridge at SW corner of Agassiz NWR
- Tape downs from center of upstream side of bridge (bottom rail) when vertical staff gauge is unreadable
- Benchmark: Chiseled square on S. end of east headwall of bridge over Thief River at SW corner of Agassiz Wildlife Refuge on Marshall County Road #7. Elev. From Marshall Co. Hwy Dept: 1141.05
- Eureka Manta logging water quality multiprobe installed in a fixed-angle deployment tube on the upstream stream side of the bridge on the west wingwall.

6 (Branch 200 of Judicial Ditch 200)

- Ditch 200, a little over 1 mile upstream of its confluence with the Thief River and approximately 1 mile downstream of the Farmes Pool/Elm Lake outlet.
- Samples and tape down measurements are taken from a painted X on the upstream side of the box culvert.

RLWD Sampling Sites

2 (Thief River/State Ditch 83)

- Thief River at the Rangeline Road (CR12)
- Tape-down measurements are made from the upstream bridge rail over the thalweg. This point is marked with paint.
- An Onset HOBO Water Level Logger is installed in a 1 1/2 inch PVC pipe on the downstream side of the bridge along the south river bank.

41 (County Ditch 20)

- CD20
- Stage is measured from the painted mark on the upstream (E) side of the bridge. Water quality measurements and samples are taken on the downstream side of the bridge. There is a difference between the two sides of the bridge. The upstream side is calm/flat for measurements of stage, but is not well mixed at times because of two road ditches that enter just upstream. The water flows over rocks under the bridge that help ensure that the stream is reliably mixed. Cross-section water quality surveys will be conducted to verify this.
- Eureka Manta logging water quality multiprobe installed in a fixed-angle deployment tube on the downstream side of the bridge.

156 (Thief River/State Ditch 83)

- Thief River at CR44 Crossing
- Tape down measurement on the upstream side of bridge. The water quality and tape-down measurement point is marked with paint over the thalweg of the stream.
- An Onset HOBO water level logger will be installed near one of the bridge pillars under the north side of the bridge.

760 (Thief River)

- Hillyer Bridge USGS gauging site #
- Real time water level and flow data is available at: http://waterdata.usgs.gov/nwis/uv?05076000
- A Eureka Manta continuous monitoring multiprobe is installed under the bridge in a fixed-angle deployment tube supported by one of the northern set of pillars under the bridge.

RLWD Continuous Water Quality Monitoring Stations

This list is a subset of the RLWD and Marshall County Water Plan sampling sites.

1. 140 (Thief River/State Ditch 83)
2. 757/D6 (Mud River/Judicial Ditch 11)
3. 40/T2 (Thief River/State Ditch 83)
4. SG41 (County Ditch 20)
5. 760 (Thief River)

Agassiz NWR Sampling Sites (Also Continuous Monitoring Sites)

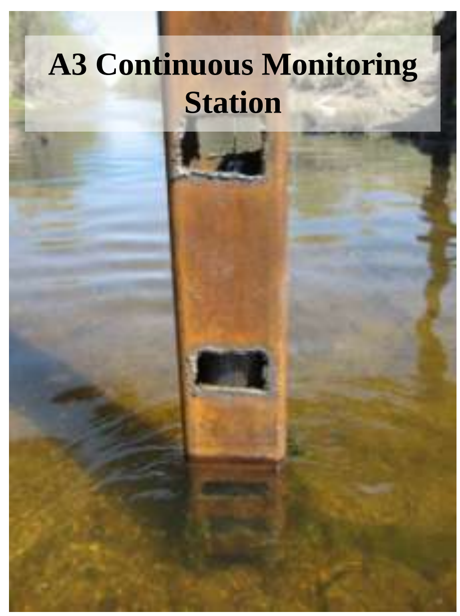
A1

- Branch 1 of Ditch 11
- Culvert crossing
- Eureka Manta logging water quality multiprobe is installed in a metal pipe on the downstram side of the crossing. It is installed at an angle along the ditchbank.

A2

- Outlet of Agassiz Pool
- Located at radial gates (pictured to the right)
- Eureka Manta logging water quality multiprobe deployed on the upstream side of the structure.

A3



- Wooden bridge over Ditch 11 at the Agassiz National Wildlife Refuge Boundary
- Eureka Manta installed in a vertical metal pipe on the donstream side of the bridge.

A4

- Ditch 200 at the southeast corner of Elm Lake
- Eureka manta logging water quality multiprobe installed within a fixed-angle deployment tube downstream of the road crossing.

Once monitoring sites are selected, it will be necessary to establish methods for measuring stage and water quality. Stage measurements will need to be collected in the same way each time. There are many sites within the RLWD from which stage and flow measurements have been collected in the past. These are referred to as "stream gauge sites." There currently are 155 of these sites at river, stream, and ditch crossings throughout the Red Lake Watershed District. For each site, there is a file describing benchmark elevations and stage measurement methods. This file will be referenced when describing the stage measurement locations at each of this study's monitoring sites. Benchmarks used for taking tape-down stage measurements will be clearly marked to avoid confusion and variation during the course of this study. They will either be marked with a chiseled square on the bridge rail, or they will be marked with paint. At the continuous monitoring sites, it will be necessary to choose an installation location and depth that is representative of the mean water quality conditions within the stream. Identifying the location of this mean will be accomplished through cross-section stream water quality surveys at each monitoring site. A field sheet like the one below will be filled-out at the site and entered into an Excel spreadsheet at the office.

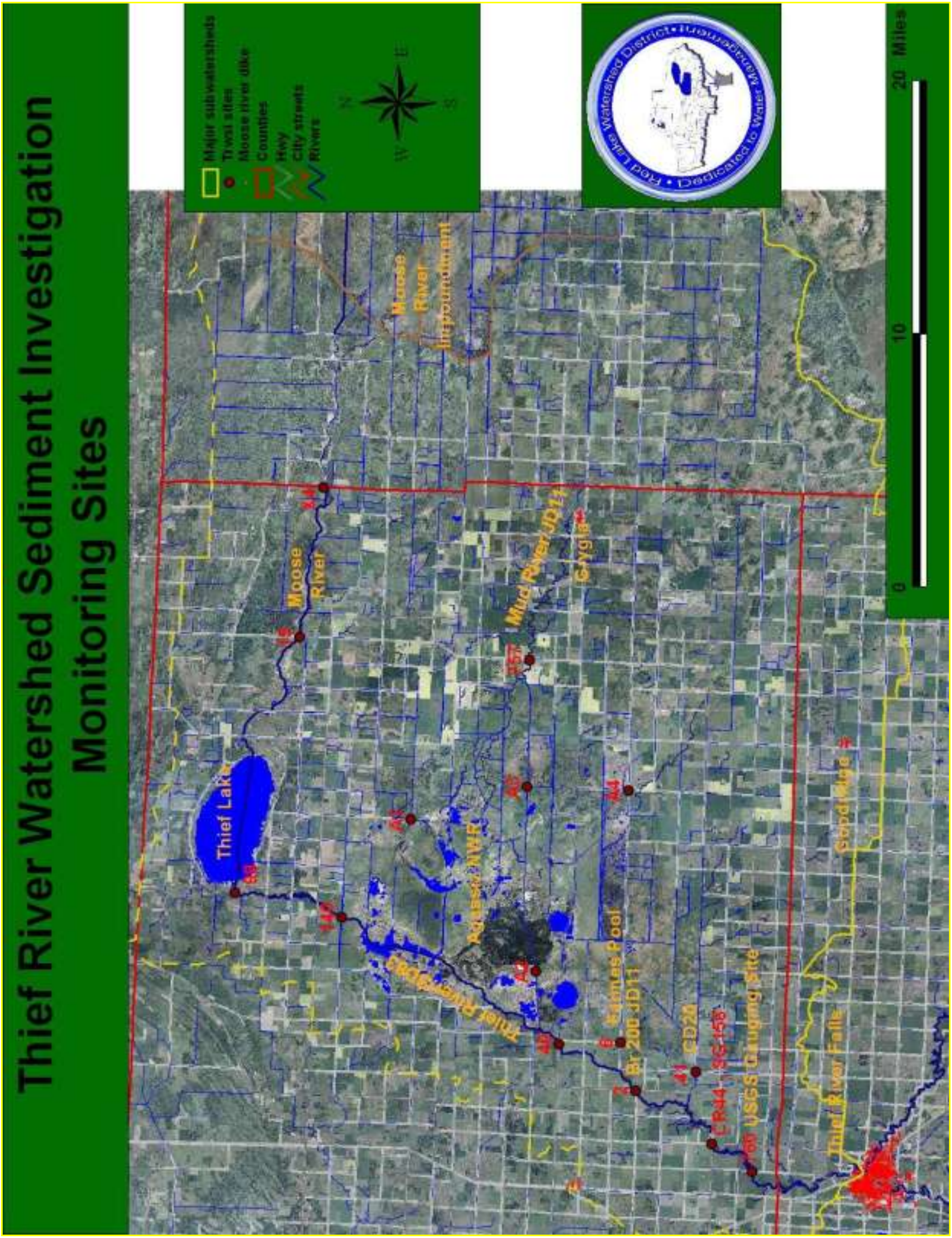

Thief River Watershed Sediment Investigation
Monitoring Sites
Major subwatersheds
Moose river dike
Counties
Hwy
City streets
Rivers
Moose River Impoundment
Moose River
Mud River/JD11
Thief Lake
Agassiz NWR
USGS Gauging Site
Thief River Falls
0
10
20 Miles

Table 2. Example water quality cross-section survey data sheet

					Station No. ______________				
CROSS-SECTION SURVEY INFORMATION									
Method	EWI	EDI	Other______________			No. of Verticals ______________			
Measurement Location:		______________ft		Upstream		Downstream		of Monitor	
Stream Mixing:		Excellent		Good		Fair		Poor	
Comments: ______________									

Station	Time	Ft from Left Bank	Depth to bottom at meas. Location	Measurement Depth	Temp (Deg C)	pH	SC (ug/cm)	DO (mg/L)	Turbidity (FNU)
Gage ht =									
At Monitor									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
At Monitor									
Gage ht =									

CROSS-SECTION COMPARISON AT ______________ CFS/STAGE = ______________			
Parameter	**Cross-section median**	**Point value**	**Indicated coefficient**
Water Temp	#NUM!	#DIV/0!	#NUM!
pH	#NUM!	#DIV/0!	#NUM!
SC	#NUM!	#DIV/0!	#NUM!
Do	#NUM!	#DIV/0!	#NUM!
Turbidity	#NUM!	#DIV/0!	#NUM!
Other______________			

Sampling Frequency

The minimum sampling frequency over the 3-4 year duration of this project will be a monthly sampling schedule. It will be sufficient to provide the amount of data needed to accomplish the goals of the project. Since calculation of loads is a project goal, it will be necessary to conduct additional monitoring during or after storm events when flow is increased on the rivers and ditches.

Water Quality Parameters

The samples collected by the RLWD and Agassiz NWR will be analyzed for total phosphorus, total suspended solids, e-coli, ammonia nitrogen. Field measurements will be collected during site vists with a Eureka Manta sonde for dissolved oxygen (mg/L), % dissolved oxygen saturation, pH, temperature, specific conductivity, and turbidity. A HACH 2100P will also used to collect a turbidity measurement since it has been the “standard” measurement of turbidity within the Red River Basin and RLWD for quite some time. A transparency reading will also be collected using a transparency tube. The RLWD has 60 cm, 100 cm, and 122 cm tubes to collect a measureable transparency value from all but the clearest of waters.

The continuous water quality monitoring sites will provide a continuous (every 30 minutes or hourly – not decided yet) record of dissolved oxygen (optical), turbidity (optical), pH, specific conductivity, depth, and temperature at each monitor location. Data is stored internally on the monitors and will be downloaded on a regular basis during calibration.

Data Requirements

There will need to be enough water quality data collected during the study to reliably assess and model water quality at each site. Spot measurement data requirements are based upon MPCA guidelines for water quality assessment and the data requirements for the FLUX water quality modeling software.

The MPCA’s minimum data requirement for assessment for conventional water quality parameters is 20 measurements.

The data goals of the continuous monitoring will be a little more complicated. The first and foremost goal of this type of monitoring is to collect a complete and accurate set of data. A complete record of stage data is important for determining the average daily flow for FLUX modeling. Also, a reliable, accurate set of data from all monitors will be needed to determine how flow and pollutants move through the watershed during a storm event.

In order to create reliable rating curves for expressing the relationship between stage and flow, there will need to be three key characteristics to the flow measurement data set at each site:

1. Sufficient number of readings
2. Sufficient accuracy of each reading
3. The measurements must cover a wide range of flows.

Monitoring Data Evaluation Procedures

Quality assurance/quality control data will be used to determine the quality of the sampling and field measurement data collected for the study. Relative percent difference values will be collected for duplicate samples.

Continuous monitoring site data will be evaluated and adjusted using, to the extent feasible, the methods described in the *USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitoring: Station Operation, Record Computation, and Data Reporting.* A data sheet will be filled out at each continuous monitoring station maintenance/calibration site visit. Filling out a data sheet similar to the one on page 3-4 of the USGS Guidelines will allow for fouling corrections, drift corrections, and cross-section corrections to the data set. The *Continuous Water-Quality Sampling Programs: Operating Procedures* manual from the British Columbia Ministry of Environment will also be consulted to make sure that installation and data handling of continuous water quality monitors yields a reliable and accurate data set.

Modeling

The Energy and Environmental Research Center (EERC) has completed a Soil and Water Assessment Tool (SWAT) hydrologic model for all watersheds within the Red River Basin. They have the capability and expertise needed to add a water quality component to this model. Part of this project will involve a contract with the EERC to conduct this modeling. The EERC will follow the work plan and methods described in the *Proposal for SWAT modeling, Red River Basin Watersheds*. The EERC will accomplish the tasks described in their proposal along with any specific tasks specified in this contract. The major tasks within the workplan are:

- Model Development, Calibration, and Validation
- Water Quality Assessment
- Identification of Target Areas and BMP Strategies for Model Evaluation
- Evaluation of Hypothetical BMP Implementation
- Compilation of Results

The model will be calibrated and validated by the EERC using water quality data collected within the watershed. The calibrated SWAT models will be used to conduct long-term historical simulations to assess the location and rates of major sediment and nutrient loading within the Clearwater River Watershed. FLUX modeling software will be used to generate long-term constituent loadings using the sampling data provided by the RLWD. This data will be used to create an accurate SWAT water quality model.

Sources of water quality problems will be identified in the watershed. The general processes that are contributing the most to water quality problems will need to be identified (land use, stream bank erosion, natural conditions). For planning and decision making purposes, one of the more important parts of this study will be the creation of maps showing hydrologic units and their relative effects on water quality. These maps will allow for targeting implementation efforts in the hydrologic units that are contributing the most to the problem. The EERC will create maps like this for each parameter (number of maps needed will depend on scale).

The EERC will use the model to determine the effect of buffer strip and BMP implementation. The EERC will work with the RLWD, MPCA, and other agencies (SWCDs) to target BMP implementation scenarios that may achieve a desired improvement in water quality. Input will be received from local agencies on which BMPs are realistic to implement and where they may be implemented. Although the ultimate goal would be to discover a strategy that would meet water quality goals, the ability to attain ideal water quality conditions may be limited by characteristics of the watershed and the feasible extent of water quality improvement projects. Each set of strategies will be described in the modeling report.

The EERC will produce a report that documents model development, calibration, validations, and simulation results. The report will include graphical displays of model simulation results, including tables, maps, and charts. It will define current conditions within the watershed and describe the results of the BMP implementation scenarios. The report will be made available in an electronic format for distribution on the MPCA and RLWD websites.

WATERSHED ASSESSMENT

Physical Description of Project Area

The Moose River, Thief River and Mud River are the primary waterways in this subwatershed. Portions of all of these rivers have been channelized. Dams at impoundment outlets and other impassable areas (e.g., culverts) fragment these stream systems. A network of drainage systems and a few natural waterways are tributaries to these waterways. The hydrology of these waterways has also been modified due to land use changes (flashy flows extended periods of low flow). All these changes have greatly reduced the potential of these waterways to support quality fish populations. The Thief River does provide some quality habitat for some species.

The Thief River subwatershed consists of an approximately 1,068 square mile area. The watershed outlets into the Red Lake River in Thief River Falls. The watershed is located mostly within the Lake Agassiz ecoregion with the extreme northeastern and southeastern areas fringing on the Northern Minnesota Peatlands ecoregion. Soil textures range from fine-loamy in the west to coarse-loamy in the east, with a strip of sandy soils along the northern boundary of the watershed. The area consists of a mix of agricultural lands, forest lands and wetlands, with very little grasslands, lakes or developed urban land.

For this study, a record will be kept of activities within the watershed that may influence water quality and explain some of the data collected for the study. For example, Agassiz NWR plans to install 2 new outlet structures in 2007 and repair JD 11 downstream of their outlet in 2008.

Land Use, Land Cover, Sources of Pollution, and Resource Uses

The Thief River watershed includes the Moose River, Mud River and Thief River minor subwatersheds. Public lands in the eastern and western portion are dominant natural resource features in this subwatershed. The central portion of this subwatershed is primarily private lands used for agriculture. All these lands provide a large area of diverse habitats. Public lands include state wildlife management areas and acres of state forest lands. Prominent public land resource features include: Thief Lake WMA (7,000- acre basin, +WMA), Moose River Impoundment, the Randen Ridge area, Agassiz NWR and Elm Lake WMA.

Quality habitats in this subwatershed primarily include forestlands, brushlands and wetlands (Figure 29). Type 6 and 7 wetlands are particularly abundant. Grasslands are of relatively less importance compared to some other planning basins. These habitats provide seasonal and permanent homes to a variety of species including game species such as white-tailed deer, moose, bear, waterfowl and sharp-tail grouse. Some areas provide important winter habitat for deer and migratory and breeding habitat for waterfowl and other birds (e.g., Thief Lake WMA, Agassiz NWR). One of Minnesota's two elk herds is also found in this subwatershed. Prime sharp-tail habitat is located near Grygla extending about 6 miles to the east and 10 to 15 miles west of Beltrami/Marshall county line. CRP lands, common throughout the central portion of the subwatershed, provide some quality habitats and also provide a habitat connection between public lands to the east and west. These lands are of particular importance because they contain a mix of relatively undisturbed areas of grassland, brushland and wetland. East and west of this area the habitat becomes more wooded or wet and less desirable for sharp-tail.

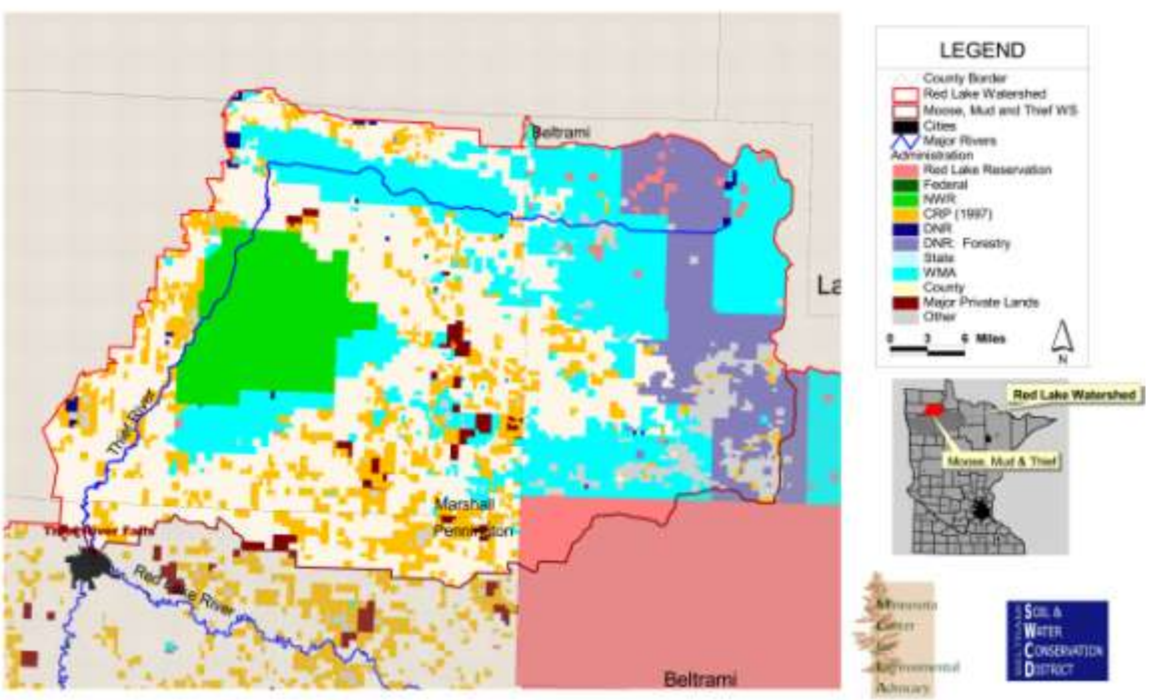


Figure 2. Thief River Subwatershed Existing Resources- Stewardship

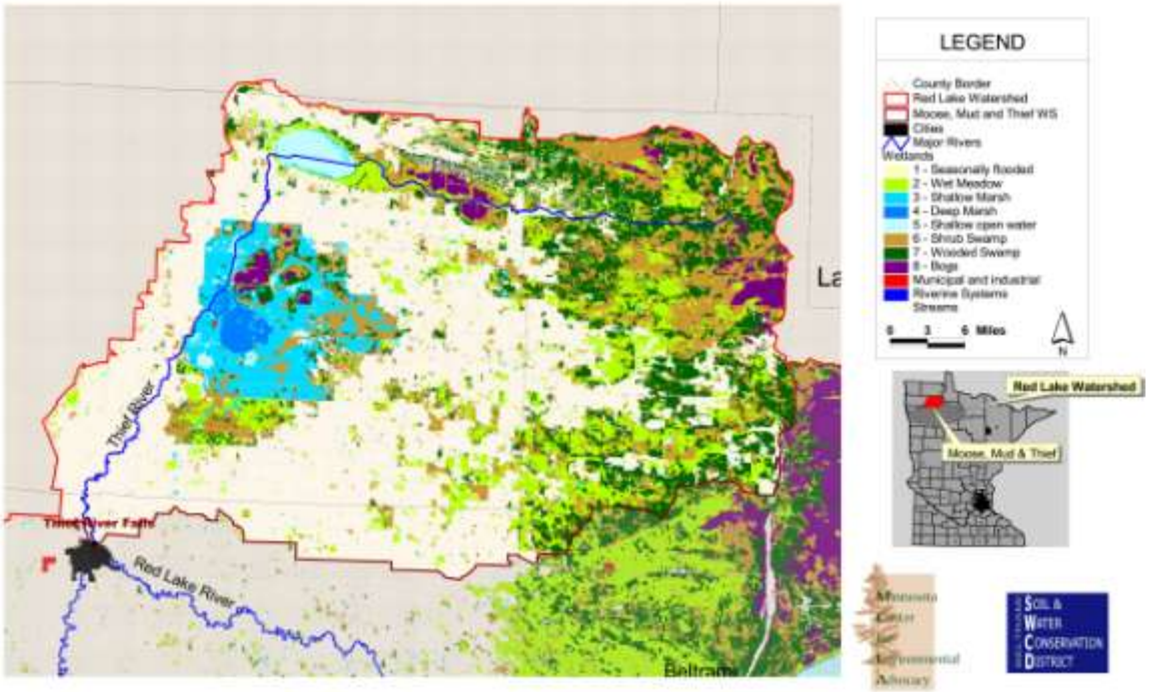


Figure 3. Thief River Subwatershed Existing Resources – Wetlands

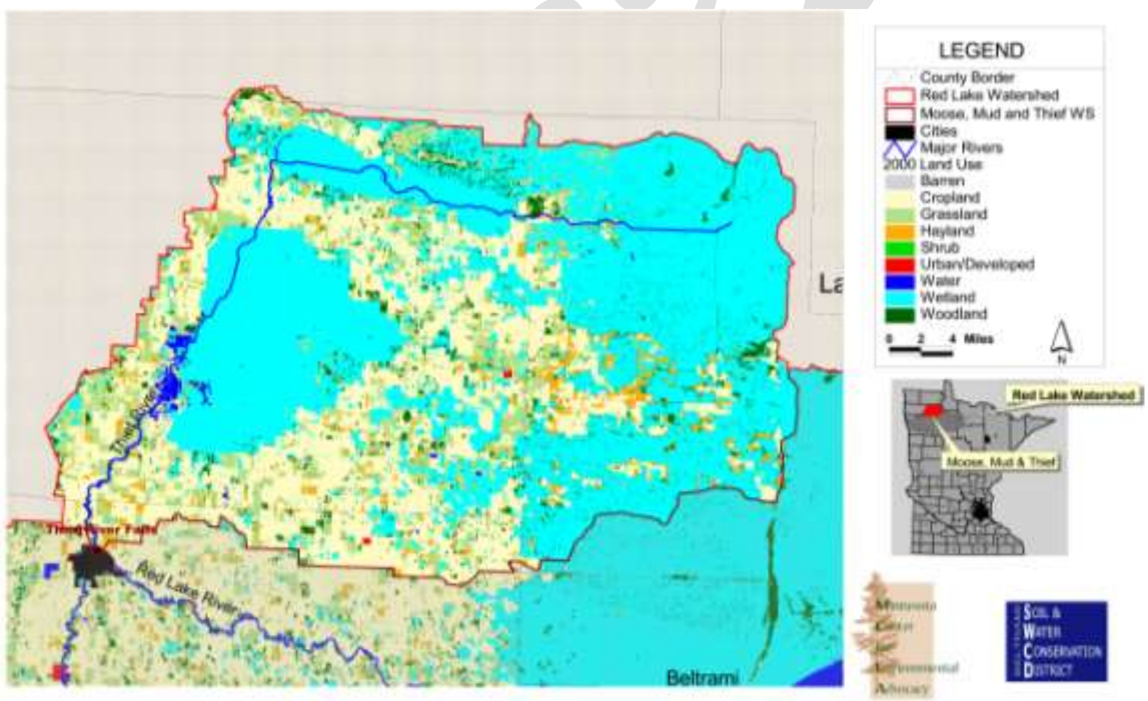


Figure 4. Thief River Subwatershed Existing Resources- 2000 Land Use Land Cover

Table 3. Thief River Watershed Characteristics

CHARACTERISTIC	AREA
Basin Area (sq mi.)	1,068
Basin Area (acres)	683,408
Wetland Area NWI (acres)	349,665
MINNESOTA WETLAND TYPE	
1	3,450
2	79,077
3	37,816
4	5,218
5	9,563
6	106,567
7	93,398
8	14,574
Lakes/Rivers (acres)	10,133
ECOREGIONS OF RLWD (ACRES)	
Lake Agassiz, Aspen Parklands	513,680
Minnesota & NE Iowa Morainal	-
N. Minnesota & Ontario Peatlands	169,728
N. Minnesota Drift & Lake Plains	-
Red River Valley	-
LAND USE (ACRES)	
Cultivated Land	294,904
Forest Land	185,103
Grass/Brushland	60,241
Mines	185
Water	11,515
Developed Land	813
Wetlands	130,599
Other	50

(Sources: EIS, Soil Survey, GIS information, reports, studies)

Hydrologic Characterization

The Thief River subwatershed is also comprised of two smaller subwatersheds which outlet into the Thief River. They are the Moose River and Mud River/Agassiz subwatersheds. The Thief River subwatershed is the northernmost reach of the RLWD. All of the drainage from within the smaller subwatersheds flows into the Thief River and eventually outlets into the Red Lake River at Thief River Falls.

There are seven named lakes in the Thief River subwatershed. Major lakes for limited-use recreation include Thief Lake and Mud Lake/Agassiz. All lakes within this watershed typically support only waterfowl as they are too shallow to support a recreational fishery. Shoreline is typically undeveloped on the lakes.

Wetland areas are scattered throughout the area. These wetland areas are somewhat denser in the eastern portion of the subwatershed, especially east of the Beltrami county line. Many of the wetlands in the western portion of this watershed have been altered by farm drainage for agricultural production. Remaining wetlands in the eastern portion have been estimated to be 2-43 percent of pre-settlement extent.

Drainage systems in this subwatershed are a complex network of natural streams and legal ditch systems developed for agriculture. Generally, the ditch systems are under the administration of the county in which they reside or of the watershed district. Notable existing water management projects within this watershed include Thief Lake, Agassiz NWR, Elm Lake, Lost River Pool and the Moose River Impoundment, which collectively can store up to 138,000 acre feet of water.

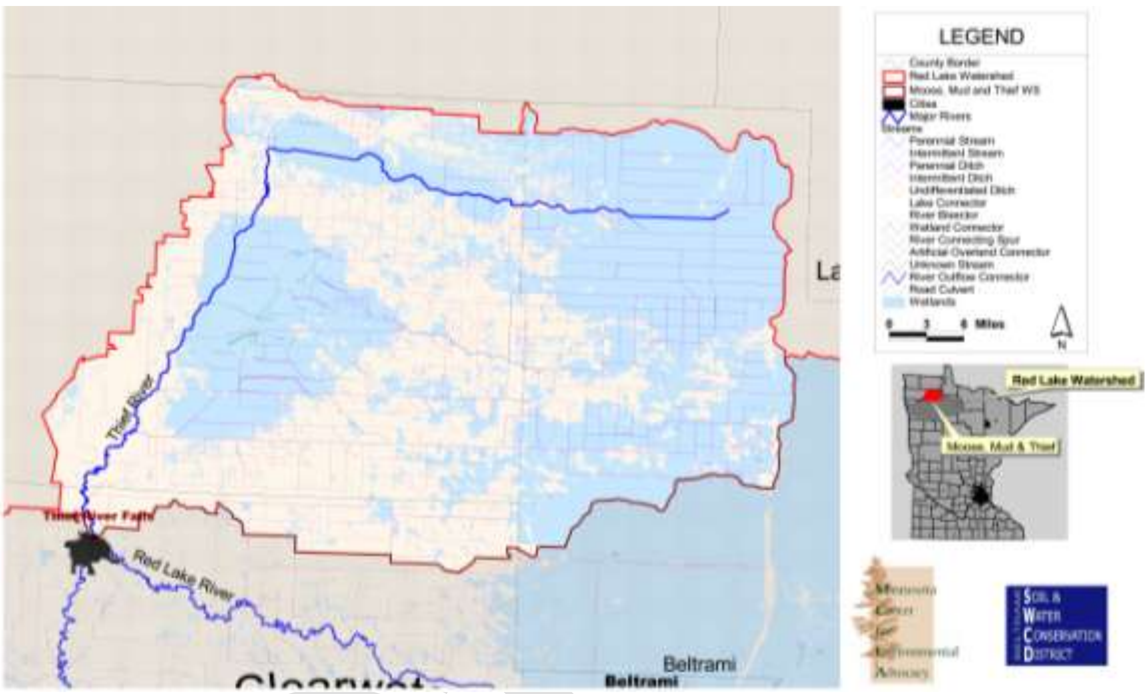


Figure 5. Thief River Subwatershed Existing Resources –Watercourses

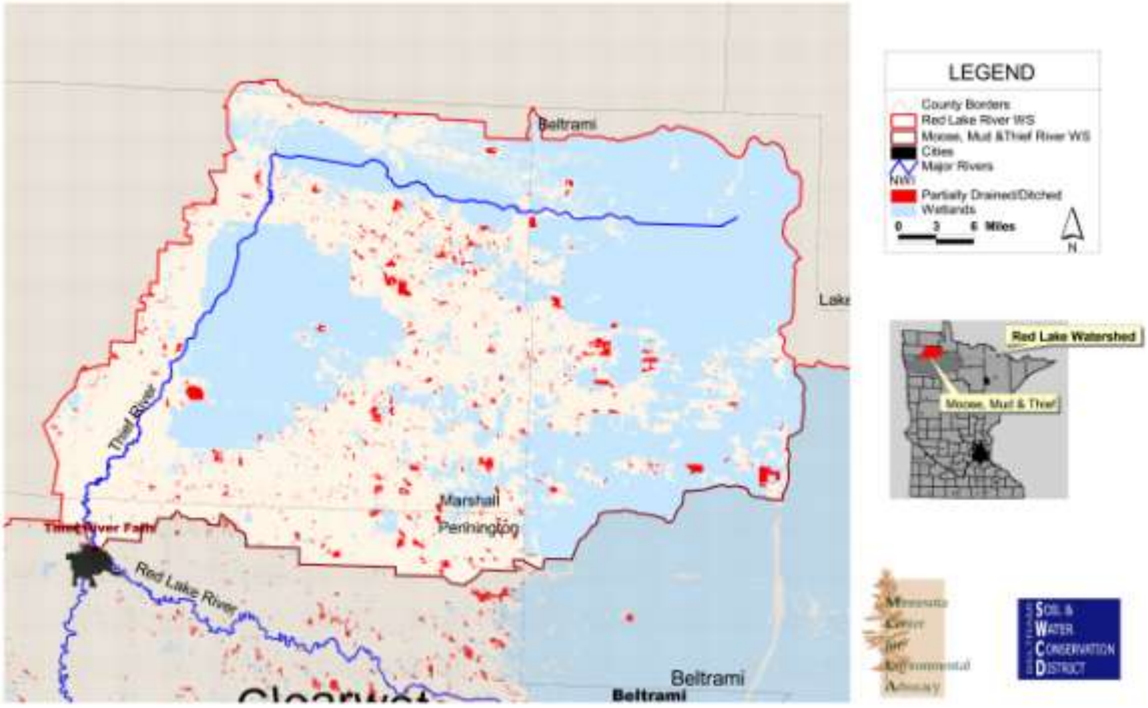


Figure 6. Thief River Subwatershed Restorable Resources – Drained Wetlands

Watershed Characteristics Influencing Water Quality

The Thief River was identified as an important resource within the region that needs to be recognized and protected. Recreational activities including hunting, fishing, tubing, swimming etc. were all identified as being popular activities.

A consideration of the project will be a comprehensive inventory of the watershed characteristics that are influencing water quality. This will involve windshield surveys of the watershed combined with photo monitoring. Also, there should be a prioritized inventory of erosion problems within the watershed. To aid in planning successful erosion control projects, a channel stability assessment should also be performed on the Thief River and its channelized reaches. Examples of some known problems within the watershed that were identified during the RLWD 10-Year plan development process are:

- Flashiness of flows
- Unstable stream banks and excessive erosion
    - Moose River in Sections 1-6 of Northwood Township and Sections 1-12 of Whiteford Township (between MC 54 and bridge on Moose River Road)
    - south of the outlet of the Moose River impoundment (Sprucegrove Township)
    - Continual sloughing on ditch 20 and erosion on laterals
- Channelization of rivers
- Impoundments
- Lack of buffers

- Large deltas are forming on the east end of Thief Lake and in Agassiz NWR.
- There is a need for increased agricultural BMP implementation.
- Other recommended strategies include improved ditches with side inlets, buffer and grassed waterways, residue management, tree plantings, reduce farming into road ditches

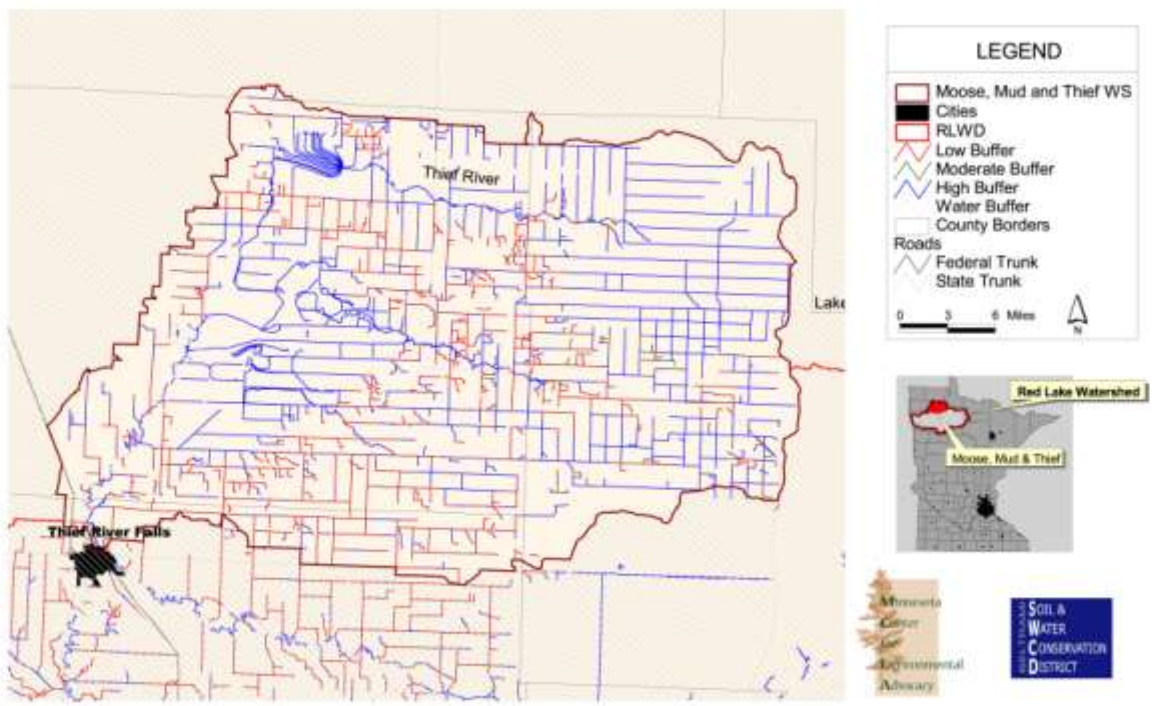


Figure 7. Thief River Subwatershed Restorable Resources – Buffered Watercourses.

Estimation of Water and Pollutant Loads

The estimation of loads will be conducted using FLUX modeling. The FLUX results will be used to calibrate the SWAT model. The SWAT model will then be used to determine the sources of these loads and supply recommendations for reducing them.

Priority Management Areas

Priority management will be identified using the SWAT water quality modeling results. The identification of these areas will also be based upon existing local comprehensive water plans and the RLWD 10-Year Plan.

QUALITY ASSURANCE PROJECT PLAN (QAPP)

A Quality Assusrance Project Plan has been created for the project. It was created as a separate document and inserted as Appendix 1.

WORKPLAN BUDGETS

Original grant application budgets:

Project Expenditure Budget from Grant Application Complete the following table by listing the objectives that will comprise your project and estimated cost of each objective.			
Objectives	**Funding Types**		**Total**
	Grant and Local Cash	**In-kind**	
1. Equipment – Purchase of 5 logging sondes, 3 level loggers, & construction materials; 3 level loggers, profiling sondes, & logging rain gauge are already available from the RLWD	$39,600		$39,600
2. Equipment Calibration & Maintenance	$7,100		$7,100
3. Water quality monitoring (Marshall Co. & RLWD)	$27,050	$25,150	$52,200
4. Flow monitoring (RLWD) – rating curve development	$9,900		$9,900
5. Data entry & reduction (all)	$10,350	$750	$11,100
6. Develop sediment budget – FLUX model (RLWD)	$4,900		$4,900
7. Water quality modeling – SWAT model (EERC)	$45,000		$45,000
8. Assess results (All)	$1,500	$2,500	$4,000
9. Make recommendations ALL	$1,500	$2,500	$4,000
10. Write and review report (All)	$6,500	$2,500	$9,000
11. Publish report (RLWD)	$3,000		$3,000
12. Develop impaired waters study work plans (All)	$2,000	$1,200	$3,200
Total of Program Objectives	**$158,400**	**$34,600**	**$193,000**

Project Revenue Budget: Complete the following sections for all the sources of grant, match money, and in-kind contributions for your project. The match requirement must be no less than the amount of the grant.

	Project Costs		
Project Sponsors (Attach additional sheets if necessary)	Cash Contribution To Project	In-kind Contribution To Project	Total Project Support
A. Project Sponsor Contribution	$63,400		$63,400
B. Local Contributing Sponsors:			
1. Red River Watershed Management Board		$10,000	$10,000
2.Marshall County Water and Land Office		$17,700	$17,700
3.Pennington County		$1,800	$1,800
4.			
B. Subtotal:		**$29,500**	**$92,900**
C. State and/or Federal Contributing Sponsors:			
5.US FWS		$1,800	$1,800
6.MN DNR		$1,800	$1,800
7. MPCA			
8.BWSR			
State and/or Federal Contributing Sponsors Subtotal ** (not including funds being applied for in this application) **C. Subtotal**		**$3,600**	**$3,600**
TOTAL: All project sponsors (A+B+C)	**$63,400**	**$33,100**	**$96,500**
Grant amount requested (cannot exceed $300,000).	**$96,500**		
GRAND TOTALS	Total Cash **$159,900**	Total In-kind **$33,100**	Total Project Cost **$193,000**

Thief River Watershed Sediment Investigation					II.A.	II.B.	II.C.	II.E.
Red Lake watershed District								
ITEMIZED PROJECT BUDGET AND EXPENDITURES						**Cash**	**In-Kind**	**Budget**
Program Element	**Cost Category**	**Unit Cost**	**Rate**	**Quantity**	**Grant**	**Match**	**Match**	**Total**
OBJECTIVE 1 - Development of Project Workplan, Project Administration, and Public Education								
Red Lake watershed District	Water Quality Coordinator	50.00	/hr.	80.00	$ -	$ -	$ 4,000.00	$ 4,000.00
ELEMENT 1 - TOTAL					**$ -**	**$ -**	**$ 4,000.00**	**$ 4,000.00**
OBJECTIVE 2 - EQUIPMENT								
Logging multiprobes with Turbidity and Optical Dissolved Oxygen					$ -	$ -	$ -	$ -
	Eureka Manta	6162.00	each	5.00	$ -	$ 30,810.00	$ -	$ 30,810.00
	Shipping and Accessories	200.00	total		$ -	$ -	$ -	$ -
Water Level Loggers					$ -	$ -	$ -	$ -
	Onset HOBOs	495.00	each	5.00	$ -	$ 2,475.00	$ -	$ 2,475.00
	Shipping	100.00	total		$ -	$ 100.00	$ -	$ 100.00
Steel Measuring Tape		100.00	each		$ -	$ 100.00	$ -	$ 100.00
C Cell Batteries		13.00	/12	70.00	$ -	$ 910.00	$ -	$ 910.00
"Stilling" Well Materials - PVC Pipe and Hardware		400.00	total		$ -	$ 400.00	$ -	$ 400.00
Ring Stand and Clamp for calibrations		75.00	total		$ -	$ 75.00	$ -	$ 75.00
Size 7 Chest Waders		70.00	total		$ -	$ 70.00	$ -	$ 70.00
Barometer for Accurate Calibrations	Angler's Edge	100.00	each		$ -	$ 100.00	$ -	$ 100.00
Unanticipated Expenses/Maintenance		1943.10	total		$ -	$ 1,986.00	$ -	$ 1,986.00
Sales Tax		2416.90	total		$ -	$ 2,574.00	$ -	$ 2,574.00
ELEMENT 2 - TOTAL					**$ -**	**$ 39,600.00**	**$ -**	**$ 39,600.00**
OBJECTIVE 3 - DEPLOYED MONITORING EQUIPMENT CALIBRATION AND MAINTENANCE								
Red Lake watershed District	Water Quality Coordinator	50.00	/hr.	135.00	$ 6,750.00	$ -	$ -	$ 6,750.00
pH Calibration Standards		33.40	/4L	25.00	$ -	$ 835.00		$ 835.00
Conductivity Calibration Standards		65.00	/10L	8.00	$ -	$ 520.00		$ 520.00
Turbidity		149.00	/10L	8.00	$ -	$ 1,192.00		$ 1,192.00
Sales Tax Allowance					$ -	$ 203.00	$ -	$ 203.00
Student Worker		10.00	/hr.	180.00	$ 900.00	$ -	$ 900.00	$ 1,800.00
ELEMENT 3 - TOTAL					**$ 7,650.00**	**$ 2,750.00**	**$ 900.00**	**$ 11,300.00**
OBJECTIVE 4 - WATER QUALITY MONITORING								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	250.00	$ 12,500.00	$ -	$ -	$ 12,500.00
Marshall County	Water Planner	35.00	/hr.	202.00	$ 3,000.00	$ -	$ 3,000.00	$ 6,000.00
Marshall County Water Planning Office	Mileage and Supplies				$ 535.00		$ 535.00	$ 1,070.00
Marshall-Beltrami County SWCD	Staff	35.00	/hr.	200.00	$ 3,500.00	$ -	$ 3,500.00	$ 7,000.00
Student Worker		10.00	/hr.	200.00	$ 1,000.00	$ -	$ 1,000.00	$ 2,000.00
Sample Analysis	RMB Environmental Laboratories, Inc	53.00	/set	300.00	$ 9,540.00	$ 9,540.00	$ -	$ 19,080.00
Shipping	Speedee Delivery	7.00	/cooler	50.00	$ 175.00	$ 175.00	$ -	$ 350.00
ELEMENT 4 - TOTAL					**$ 30,250.00**	**$ 9,715.00**	**$ 8,035.00**	**$ 48,000.00**
OBJECTIVE 5 - FLOW MONITORING								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	150.00	$ 3,750.00	$ -	$ 3,750.00	$ 7,500.00
Red Lake Watershed District	Engineering Technician	50.00	/hr.	34.00	$ 850.00	$ -	$ 850.00	$ 1,700.00
ELEMENT 5 TOTAL					**$ 4,600.00**	**$ -**	**$ 4,600.00**	**$ 9,200.00**
OBJECTIVE 6 - DATA ENTRY AND REDUCTION								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	187.00	$ 4,675.00	$ -	$ 4,675.00	$ 9,350.00
Marshall County	Water Planner	35.00	/hr.	50.00	$ 875.00	$ -	$ 875.00	$ 1,750.00
ELEMENT 6 - TOTAL					**$ 5,550.00**	**$ -**	**$ 5,550.00**	**$ 11,100.00**
OBJECTIVE 7 - DEVELOP SEDIMENT BUDGET								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	98.00	$ 2,450.00	$ -	$ 2,450.00	$ 4,900.00
ELEMENT 7 - TOTAL					**$ 2,450.00**	**$ -**	**$ 2,450.00**	**$ 4,900.00**
OBJECTIVE 8 - WATER QUALITY MODELING								
Energy and Environmental Research Center					$ 35,165.00	$ 9,835.00	$ -	$ 45,000.00
ELEMENT 8 - TOTAL					**$ 35,165.00**	**$ 9,835.00**	**$ -**	**$ 45,000.00**
OBJECTIVE 9 - ASSESS RESULTS								

THIEF RIVER WATERSHED SEDIMENT INVESTIGATION RED LAKE WATERSHED DISTRICT ITEMIZED PROJECT BUDGET AND EXPENDITURES					II.A.	II.B.	II.C.	II.E.
Program Element	**Cost Category**	**Unit Cost**	**Rate**	**Quantity**	**Grant**	**Cash Match**	**In-Kind Match**	**Budget Total**
OBJECTIVE 10 - MAKE RECOMMENDATIONS								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	38.00	$ 950.00	$ -	$ 950.00	$ 1,900.00
Marshall County	Water Planner	35.00	/hr.	40.00	$ 700.00	$ -	$ 700.00	$ 1,400.00
Pennington County	Water Planner	35.00	/hr.	20.00	$ -	$ -	$ 700.00	$ 700.00
Beltrami County SWCD	Staff	35.00	/hr.	20.00	$ -	$ -	$ 700.00	$ 700.00
ELEMENT 10 - TOTAL					**$ 1,650.00**	**$ -**	**$ 3,050.00**	**$ 4,700.00**
OBJECTIVE 11 - WRITE AND REVIEW REPORT								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	159.00	$ 3,975.00	$ -	$ 3,975.00	$ 7,950.00
Marshall County	Water Planner	35.00	/hr.	20.00	$ 350.00	$ -	$ 350.00	$ 700.00
Beltrami County SWCD	Staff	35.00	/hr.	10.00	$ -	$ -	$ 350.00	$ 350.00
ELEMENT 11 - TOTAL					**$ 4,325.00**	**$ -**	**$ 4,675.00**	**$ 9,000.00**
OBJECTIVE 12 - PUBLISH REPORT								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	16.00	$ 800.00	$ -	$ -	$ 800.00
Printing Expenses		0.15	/page	10000	$ -	$ 1,500.00	$ -	$ 1,500.00
ELEMENT 12 - TOTAL					**$ 800.00**	**$ 1,500.00**	**$ -**	**$ 2,300.00**
OBJECTIVE 13 - DEVELOP IMPAIRED WATERS STUDY WORK PLAN								
Red Lake Watershed District	Water Quality Coordinator	50.00	/hr.	64.00	$ 2,410.00	$ -	$ 790.00	$ 3,200.00
ELEMENT 13 - TOTAL					**$ 2,410.00**	**$ -**	**$ 790.00**	**$ 3,200.00**
	TOTAL				**$ 96,500.00**	**$ 63,400.00**	**$ 37,100.00**	**$ 197,000.00**

SUMMARIZED BUDGET FOR THE THIEF RIVER WATERSHED SEDIMENT INVESTIGATION				
OBJECTIVE 1 - TOTAL (Workplan, Admin, Public Ed.)	0.00	0.00	4,000.00	**4,000.00**
OBJECTIVE 2 - TOTAL (Equipment)	0.00	39,600.00	0.00	**39,600.00**
OBJECTIVE 3 - TOTAL (Calibration and Maintenance)	7,650.00	2,750.00	900.00	**11,300.00**
OBJECTIVE 4 - TOTAL (Water Quality Monitoring)	30,250.00	9,715.00	8,035.00	**48,000.00**
OBJECTIVE 5 - TOTAL (Flow Monitoring)	4,600.00	0.00	4,600.00	**9,200.00**
OBJECTIVE 6 - TOTAL (Data Entry and Reduction)	5,550.00	0.00	5,550.00	**11,100.00**
OBJECTIVE 7 - TOTAL (Develop Sediment Budget)	2,450.00	0.00	2,450.00	**4,900.00**
OBJECTIVE 8 - TOTAL (Water Quality Modeling)	35,165.00	9,835.00	0.00	**45,000.00**
OBJECTIVE 9 - TOTAL (Assess Results)	1,650.00	0.00	3,050.00	**4,700.00**
OBJECTIVE 10 - TOTAL (Make Recommendations)	1,650.00	0.00	3,050.00	**4,700.00**
OBJECTIVE 11 - TOTAL (Write and Review Report)	4,325.00	0.00	4,675.00	**9,000.00**
OBJECTIVE 12 - TOTAL (Publish Report)	800.00	1,500.00	0.00	**2,300.00**
OBJECTIVE 13 - TOTAL (TMDL Study Workplan)	2,410.00	0.00	790.00	**3,200.00**
G R A N D T O T A L	**96,500.00**	**63,400.00**	**37,100.00**	**197,000.00**

RLWD billable rates are calculated by multiplying the staff person's hourly wage by 2.5. This accounts for the salary and overhead. The actual billable rate for an hour of the RLWD Water Quality Coordinator's time is currently $41.13. The $50/hour figure is used to allow budgeting to even numbers. The actual hourly billable rate for RLWD Water Quality Coordinator time will likely be under the $50/hour rate throughout the project. The Marshall County Water Planner uses $35 as a billable rate when assisting with other agencies' projects. This rate doesn't include mileage or calibration standards, which will be accounted separately. An erosion/channel stability assessment should be a consideration for this project. This type of assessment will be added in the latter stages of the project if there appears to be enough money left in the monitoring budget and suitable methods can be found.

REFERENCES

British Columbia Ministry of Environment. *Continuous Water-Quality Sampling Programs: Operating Procedures*. Watershed and Aquifer Science, Science and Information Branch. 2006. http://ilmbwww.gov.bc.ca/risc/index.htm

Courneya, Jim. Minnesota Pollution Control Agency. Personal communication.

Deutshman, Mark D. Houston Engineering, Inc. Personal communication. July 27, 2007.

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Hanson, Corey. *Red River Watershed Water Quality Reporting Handbook – Protocols for Project Planning, Data Management, and Data Analysis, First Edition.* Red Lake Watershed District. Thief River Falls. December 2005.

HDR Engineering. *Red Lake Watershed District 10-Year Comprehensive Plan.* May 2006.

Houston Engineering, Inc, Pennington County Soil and Water Conservation District. *Total Suspended Sediment Loadings Red Lake, Thief, Mud and Moose Rivers.* June 6, 2003.

Johnson, Brent. *Hydrogen Sulfide Problems in Thief River Falls: Causes, Effects, and Possible Solutions.* Fall Semester 1998.

United States Department of Agriculture Natural resources Conservation Service. *Erosion Sedimentation Sediment yield Report: Thief and Red Lake Rivers Basin, Minnesota.* April 2006.

Wagner, Richard J., Robert Boulger, Jr., Carolyn J. Oblinger, and Brett A. Smith. *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting*. United States Geological Survey. Reston, Virginia.. 2006

United States Geologic Surveyhttp://water.usgs.gov/nasqan/data/dataintro.html

Appendix 1

Quality Assurance Project Plan for the Thief River Watershed Sediment Investigation

Thief River Watershed
Sediment Investigation CWP Project
Quality Assurance Project Plan

Prepared for:

Red Lake Watershed District
1000 Pennington Ave. S.
Thief River Falls, MN 56701

Prepared by:

Roger Fisher
MPCA Water Quality QA/QC Coordinator
Performance Management & Quality Unit
Environmental Analysis & Outcomes Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155-4194

Revisions by: Corey Hanson, Red Lake Watershed District Water Quality Coordinator

A1. APPROVAL SIGNATURE PAGE

By their signatures below the undersigned attest that they are familiar with the requirements of this document and agree to fulfill their responsibilities as specified herein.

______________________________	______________
Corey Hanson, WQC, Red Lake Watershed District	Date
______________________________	______________
Jim Courneya, Project Manager, MPCA	Date
______________________________	______________
Roger Fisher, WQ QA/QC Coordinator, MPCA	Date

A2. TABLE OF CONTENTS

TABLES

STANDARD OPERATING PROCEDURES (SOPs)

Table 1. List of Acronyms and Abbreviations

APG : Analytical Products Group, Inc., Belpre, OH
C : Centigrade
cm : Centimeter
CWP : Clean Water Partnership
DQO : Data Quality Objective
° : Degree
DI : Deionized
DO : Dissolved Oxygen
EPA : Environmental Protection Agency
ERA : Environmental Resource Associates, Arvada, CO
FD : Field Duplicate
H_2SO_4 : Sulfuric Acid
LIMS : Laboratory Information Management System
L : Liter
μg : Microgram
μ : Micron
mg : Milligram
MDH : Minnesota Department of Health
MNDNR : Minnesota Department of Natural Resources
MPCA : Minnesota Pollution Control Agency
$Na_2S_2O_3$: Sodium Thiosulfate
NIST : National Institute of Standards and Technology
NTU : Nephelos Turbidity Unit
NWR : National Wildlife Refuge
PM : Project Manager
QA : Quality Assurance
QAC : Quality Assurance Coordinator
QAM : Quality Assurance Manual
QAPP : Quality Assurance Project Plan
QC : Quality Control
RLWD : Red Lake Watershed District
RPD : Relative Percent Difference
RSD : Relative Standard Deviation
SB : Sampler Blank
SM : *Standard Methods* (*for the Examination of Water and Wastewater*, 20th Ed.)
SOP : Standard Operating Procedure
STORET : STOrage and RETrieval (federal database)
TMDL : Total Maximum Daily Load
TP : Total Phosphorus
TRWSI : Thief River Watershed Sediment Investigation
TSS : Total Suspended Solids
TB : Trip Blank
WQ : Water Quality
WQC : Water Quality Coordinator

DOCUMENT CONTROL

This document has been prepared according to the United States Environmental Protection Agency publication, *EPA Requirements for Quality Assurance Project Plans*, dated March 2001 (QA/R5). This QAPP will be reviewed annually and updated as needed. Updated versions of this QAPP will bear a new (x + 1) revision number. Corey Hanson will assume responsibility for archiving outdated versions of this QAPP which will be kept at project headquarters. Archived versions of this QAPP will be retained for a minimum of ten years from the date of archival.

GROUP A. PROJECT MANAGEMENT

A3. DISTRIBUTION LIST

Each person listed on the Approval Signature Page and each person listed in Table 2 will receive a copy of the final approved version of this Quality Assurance Project Plan. A copy will also be made available to other persons taking part in the project and to other interested parties. A comprehensive list of project staff representing all project partners may be found in the project Work Plan.

Table 2. QAPP Distribution List

Name	Title/Affiliation	Address	Phone/e-mail
Corey Hanson	Water Quality Coordinator, Red Lake Watershed District	1000 Pennington Ave. S., Thief River Falls, MN 56701	218.681.5800; coreyh@wiktel.com
Jim Courneya	Project Manager, MPCA, Regional Environmental Management Div.	714 Lake Ave., Suite 220, Detroit Lakes, MN 56501	
Myron Jesme	Administrator, Red Lake Watershed District	1000 Pennington Ave S, Thief River Falls, MN 56701	218-681-5800, jesme@wiktel.com
Jan Kaspari	Marshall County Water Planner	Marshall County Water and Land Office 208 East Colvin Ave, Suite 3 Warren, MN 56762	218-745-4217 Jan.kaspari@co.marshall.mn.us
Pete Fastner	MPCA Regional Environmental Management	MPCA St. Paul, MN 55155-4194	218-282-6245 Peter.fastner@pca.state.mn.us
Roger Fisher	WQ QA/QC Coordinator, MPCA, Environmental Outcomes Division	520 Lafayette Road North, St. Paul, MN 55155-4194	651.296.7387 roger.fisher@pca.state.mn.us

Project partners include the Red Lake Watershed District, the U.S. Fish and Wildlife Service, the Minnesota Department of Natural Resources, Marshall County Water Planners, Pennington County Water Planners, the Board of Soil and Water Resources, and the Minnesota Pollution Control Agency. All partners will share responsibility for project management.

A4. PROJECT/TASK ORGANIZATION

Table 3. Project Personnel

Name/Title	Project Responsibility
Corey Hanson, WQC	Project planning and coordination, sampling, field instrument deployment and maintenance, report writing, data analysis
Jim Courneya, MPCA PM	Technical assistance, data review
Jan Kaspari	Water quality monitoring, data entry, assessing results
Roger Fisher, WQ QA/QC Coordinator	QA/QC support

A more detailed list of project personnel and their specific project responsibilities may be found on page 14 of the project Work Plan.

The MPCA QA/QC Coordinator (QAC) is independent from project staff including those who generate data. The extent of the QAC role is to assist in the writing of this QAPP and to be available to address project QA/QC problems and concerns. The QAC is not accountable to anyone directly or indirectly associated with this project.

Corey Hanson is responsible for maintaining the latest officially approved version of this QAPP.

A5. PROBLEM DEFINITION/BACKGROUND

A5.1 The Thief River

The Thief River flows to the Red Lake River and is the drinking water source for Thief River Falls, East Grand Forks, and Grand Forks, ND. Red Lake Watershed District (RLWD) monitoring determined that the Moose River, the Thief River from Thief Lake to Agassiz Pool, and the Thief River from Agassiz Pool to the confluence with the Red Lake River are impaired for turbidity, dissolved oxygen, and ammonia.

The Thief River Watershed Sediment Investigation (TRWSI) Project is intended to diagnose the impact of hydrologic modifications and anthropogenic and natural factors influencing Thief River Watershed water quality.

This project is the result of twenty years of quarterly monitoring by the RLWD, three years of monthly monitoring by the Marshall County Water Plan, and additional RLWD investigative monitoring.

A6. PROJECT/TASK DESCRIPTION

A6.1 Resource Goals

This project is intended to identify the sources of the impairments, improve wildlife impoundments management, and protect drinking water sources.

A6.2 Water Quality Characterization Goals

Eleven sites throughout the watershed and four sites in the Agassiz NWR will be monitored to verify the turbidity, dissolved oxygen, and ammonia impairments. The resulting data will be used for model development, pollutant load estimation, and the evaluation of pollutant reduction strategies.

In addition, *in situ* continuous monitoring data will be gathered at five of these sites and used to characterize sediment movement throughout the watershed. The continuous monitoring parameters are turbidity, dissolved oxygen, pH, temperature and water level.

Table 4. Thief River Watershed Sediment Investigation CWP Project Milestone Schedule (2007 – 2009)

Tasks	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec – Feb
Personnel Training	●	●								
Collect Water Samples for Laboratory Analysis	●	●	●	●	●	●	●	●		
Conduct Ambient Water Quality Analysis	●	●	●	●	●	●	●	●		
Lab Analysis	●	●	●	●	●	●	●	●		
Data Review, Analysis, and Interpretation		●	●	●	●	●	●	●	●	●

A7. QUALITY OBJECTIVES AND CRITERIA

Water quality goals are to reduce watershed turbidities so that at least 90% of Turbidity measurements are less than 25 NTU, the state 303(d) impairment listing threshold and increase Dissolved Oxygen levels so that at least 90% of the measurements are greater than the state impairment listing standard of 5 mg/L.

A7.1 Water Quality Sampling and Analysis

Water samples taken at the eleven watershed sites and four Agassiz NWR sites will be analyzed for E. coli, ammonia nitrogen, total phosphorus, ortho phosphorus, and total suspended solids. Field measurements of turbidity, dissolved oxygen, temperature, pH, specific conductivity, and stage are recorded during site visits

Table 5. Laboratory and Field Measurement Parameter Objectives

Parameter	Precision (% RPD)	Range	Reporting Limits	Units	Holding Times
E. coli Bacteria	30%	1 – 50,000	1	cfu	<30 H*
Ammonia Nitrogen	30%	0.01 - 1.5	0.01	mg/L	28 D
Total Phosphorus	30%	0.005 – 3	0.03	mg/L	28 D
Total Suspended Solids	30%	1 - >1,000	1.0	mg/L	7 D
Dissolved Oxygen†	[0.1 mg/L]	0 - 50	---	mg/L	---
pH†	[0.3 Units]	2 - 12	---	Standard Units	---
Specific Conductivity	30%	0 - 100,000	4	µS/cm	
Optical Dissolved Oxygen	[0.1 mg/L]	0 - 25	.01	mg/L	
Turbidity	30%	0 - 1000		NTRU	
Turbidity	30%	0 - 3000	.1	FNU	---

†Field measurement; *8 hours if used for enforcement purposes.

Virtually all environmental data are only approximations of the true values of the parameters measured. These estimates are affected by the variability of the medium being sampled and by random and systematic errors introduced during the sampling and analytical procedures.

Data Quality Objectives (DQOs) are qualitative or quantitative statements of:

- Precision (a measure of random error)
- Bias (a measure of systematic error)
- Accuracy
- Representativeness
- Completeness,
- Comparability, and
- Sensitivity

The DQOs must be defined in the context of project requirements and objectives not the test method capabilities.

Precision – This quality element measures how much two or more data values are in agreement with each other. Precision is discussed in the introductory chapter of *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998. Field sampling precision is determined by using field split samples and/or field duplicate samples. Laboratory analytical precision is determined by comparing the results of split samples, duplicate samples, and duplicate spike samples.

Sampling and/or analytical precision may be determined from split or duplicate samples by calculating the Relative Percent Difference (RPD) as follows:

$$\mathbf{RPD = (A - B) \div ((A + B) / 2) \times 100}$$

where A is the larger of the two duplicate sample values and B is the smaller value.

Where three or more replicate samples or measurements have been taken, calculate the Relative Standard Deviation (RSD) instead of the RPD as follows:

$$\mathbf{RSD = (s/\chi) \times 100}$$

Where **s** is the standard deviation of the replicate values and χ is the mean of the replicate values.

Bias – This expresses the degree to which a measured value agrees with or differs from an accepted reference (standard) value due to systematic errors. Field bias should be assessed by use of field blanks and trip blanks. Adherence to proper sample handling, preservation, and holding time protocols will help minimize field bias.

Both sampler blanks and field blanks are collected by the RLWD in proportion to the number of samples collected using each sampling method (Van Dorn sampler and dip sampling, respectively). Trip blanks are taken only for VOC sampling which is not a parameter to be measured by this project. Thus bias due to field activities will not be determined. However, laboratory bias will be determined as part of its internal quality control. Bias effects that fall outside the laboratory's acceptance limits will be flagged.

Accuracy – This expresses the degree to which an observed (measured) value agrees with an accepted reference standard (certified sample value) or differs from it due to systematic errors.

Completeness – Expressed as the number of valid (usable) data points made to the total number of measurements expected according to the original sampling plan. Percent completeness is determined separately for each parameter and is calculated as follows:

% Completeness = (no. of usable data points ÷ no. of planned data points) x 100

High or low water levels may reduce the number of samples that can be taken. This may be compensated for by scheduling additional sampling events or sampling as near to the original sampling site as possible. Any such variances to the established sampling protocol will be thoroughly documented. Resulting data will also be qualified to reflect this. The completeness of the continuous monitoring dataset will depend upon the amount of time that the equipment is out of the water.

Representativeness – This expresses the degree to which data accurately and precisely represents parameter variations at a sampling point, or of a process or environmental condition. Representativeness of field data are dependent upon proper sampling program design and is maximized by following the sampling plan, using proper sampling protocols, and observing sample holding times.

Data will also be compared to historical project data and to current and historical data generated by other organizations

Comparability – This represents the level of confidence with which the project data set can be compared to other data. Indicate the steps to be taken to ensure the comparability of field measurements and laboratory analyses. Comparability is dependent upon establishing similar QA objectives for the sets being compared and is achieved by using similar sampling and analytical methods.

Sensitivity – For laboratory analyses this represents the lowest level of analyte that can be reliably detected by the laboratory analytical method. For field measurements this represents the lowest level of analyte the field analytical method or meter can reliably detect.

A8. SPECIAL TRAINING/CERTIFICATION

Training of TRWSI Project staff is done through assistance from knowledgeable staff, project partners, and the MPCA Project Manager. Corey Hanson is responsible for field sampling training and monitoring oversight.

Corey Hanson is also responsible for ensuring key project staff have or receive adequate training to effectively and correctly perform their project duties. Key staff include samplers, sample handlers, data reviewers, and data assessors. He is also responsible for documenting such training and maintaining the training records.

A9. DOCUMENTATION AND RECORDS

All versions of the QAPP are retained in the Thief River Watershed District Office. RLWD staff retain sampling sheets for five years. Data are entered into STORET by MPCA staff.
http://www.pca.state.mn.us/publications/wq-s5-04.xls
Sampling sheets are completed on-site at the time of sampling. A chain of custody form is filled out for each set of samples (each cooler). Data is entered into an Excel spreadsheet that is in the format of the most current template provided by the MPCA for submitting data for STORET entry.

Sampling collection records, field notebooks, and all records of field activity are retained by RLWD staff for five years following completion of the project.

GROUP B. DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN

TRSWI Project staff in consultation with project partners developed the sampling plan.

Water chemistry, temperature, and transparency data are collected and used to monitor project effectiveness. Water samples taken during the project are considered a snapshot of current water quality conditions. Long-term monitoring programs need to be established to truly measure water quality improvements.

B2. SAMPLING METHODS

All field work for this project, including collection of water samples and delivery of water samples within the required time frame to RMB Laboratories, Inc. (RMB), are conducted by TRSWI Project staff. A certified laboratory conducts all water sample analyses. Shipping is overnight from Thief River Falls to Detroit Lakes via Speedee Delivery. This QAPP supports the laboratory's QAM and SOPs and is specific for this TRSWI Project.

The RLWD uses the same set of Standard Operating Procedures for water sampling for every project because these methods are the best practical methods for sampling within the Red River Basin. They have been developed with the cooperation of the Red River Basin Monitoring Advisory Committee, so they are accepted and used throughout the Red River Basin. All samples are collected using approved methods and sampling devices. Samples are transferred from sample collection devices to pre-cleaned polyethylene or glass bottles. Bacteriological samples are collected in sterile glass, polypropylene, or polycarbonate vessels. TRSWI Project staff are responsible for collection and transport of the samples to RMB. RMB provides the pre-cleaned bottles and the sterile bacteriological bottles.

Stream Sampling

Stream sampling is performed from open water season March – October of each year. TRSWI Project staff will collect field data on Turbidity, Dissolved Oxygen, pH, Temperature, and Stream Stage with monitoring equipment. Samples for laboratory analysis are collected by RLWD staff and are analyzed by RMB Labs. Samples are analyzed include total phosphorus, orthophosphorus, total suspended solids, ammonia nitrogen, E. coli, and turbidity.

Grab Samples

Water quality samples are collected using clean polyethylene bottles of appropriate size to provide the laboratory with sufficient sample to perform the requested analyses and reanalysis, if necessary. All samples are preserved as required, labeled with a unique identifier, and placed in a cooler on ice. Sample information is logged on field data sheets.

Grab sampling is conducted using the container type and size appropriate for each particular analysis. In-stream samples are collected at mid-depth near or at the thalweg to obtain a well mixed sample. The method used for any particular sampling event depended on several factors including flow rate, stream depth and width, and accessibility. For information on the grab sampling method see Appendix 1A.

Regardless of collection method, the grab sample is stored and transported in a clean, labeled container. The clean container supplied by the analyzing laboratory is not rinsed before the sample is collected.

Variations of the grab sampling method are described below and may be used as needed.

Wading and Hand Collection

If the stream is safe to wade, the sample collector wades to the center of the stream with a sample bottle. The sample collector faces upstream taking care not to disturb any stream bottom debris or sediment which may contaminate the sample. The sample bottle is inverted and dipped below the surface, then turned upright to collect the sample while holding the bottle about one foot below the water surface. When considering wading, the general rule is that if stream depth (in feet) multiplied by its velocity (feet/second) is greater than the sampler's height (in feet), then the sampler MUST NOT WADE.

Bridge Sampling with a Van Dorn Sampling Device

Samples collected for this study will be collected using a sampling device lowered from the bridge. The device that will be used by all monitoring staff will be the Van Dorn sampling device. A sample is collected with this horizontal sampler by lowering it to a depth that is approximately 60% of the stream depth below the surface (a little deeper than mid-depth). The sampler is rinsed with distilled water at the beginning of the sampling run and after every set of samples to avoid biasing samples at one site with contaminants from another. Prior to collecting a sample, the Van Dorn sampler is triple rinsed with sample water to make sure that the samples are representative of the water being sampled. More details on this technique are included in the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed.*

B3. SAMPLE HANDLING AND CUSTODY

Corey Hanson is the field sample custodian and keeps records of all samples taken by field personnel. Sample bottles are labeled with bottle number, site identification, and date. They are sealed tightly and packed in a cooler on ice at the sampling location. The field record includes project name, sampler's signature, unique station identification number, sample number, parameters for laboratory analysis, matrix, number and size of containers, and date and time. All laboratory samples are delivered to RMB within 24 hours of collection. Sufficient ice packs and/or ice is placed in coolers to ensure sample temperatures remained cooled at a temperature of 4°C ± 2°C. Temperature blanks are placed in each cooler so the lab can test the temperature of liquids stored in the cooler upon arrival at the laboratory.

Information on field conditions, such as the weather, deviations from written procedures, operating condition of the equipment, and other unusual occurrences are also recorded for each sampling event.

Samples will be collected in three sample bottles. The bottles used for the study are provided by RMB Environmental Laboratories. These bottles are a bacteria bottle (about 120 ml), phosphorus/nutrient sampling bottle (1 pint/750 ml), and a larger bottle for total suspended solids analysis (approx. 1000 ml). The pint bottle (middle bottle in photo) is used for phosphorus analysis and needs to be preserved with 2 ml of sulfuric acid. Vials of acid preservative are provided by RMB Labs.

Table 6. RMB Laboratories Inc., Analytical Methods, Sample Containers, and Preservatives

Parameter	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
Coliform Bacteria	>100 mL	Plastic	$Na_2S_2O_3$, Cool to 4°C	24 H**	SM 9222 B
Ammonia Nitrogen	Pint bottle	Plastic	H_2SO_4, Cool to 4°C	28 D	SM 4500-NH_3 F
Total Suspended Solids	100 mL	Plastic	Cool to 4°C	7 D	SM 2540 D
Total Phosphorus	Pint bottle	Plastic	H_2SO_4, Cool to 4°C	28 D	SM 4500-P E
Turbidity	100 mL	Plastic	Cool to 4°C	2 D	2130 B

*8 Hrs if used for enforcement purposes.

Laboratory Sample Handling

The laboratory provides sample containers. Container cleanliness is verified by QA/QC procedures as specified in the laboratory's QAM and SOPs. The laboratory verified sample bottle cleanliness by running a specified number of bottle blanks on each shipment received and on each batch of sample bottles following laboratory cleaning and sterilization. A preservative is added to specific bottles, as required, or accompanies the bottles in a separate container. Preservatives used and their volumes and concentrations are specified in the laboratory QAM.

Temperature blanks are included in the coolers provided by the laboratory to verify whether the appropriate sample temperature of 4°C ± 2°C has been maintained.

Upon arrival at the laboratory, the condition of the samples is determined. The samples are checked for leaks and appropriate preservation and the temperature taken. The information is recorded on the sample identification sheet. The sample identification sheet information is then compared to the information on the sample bottles and any discrepancies are noted. The samples are then logged into the Laboratory Information Management System (LIMS). They are assigned two identification numbers, a work order number and a unique laboratory number. The samples were then stored in the appropriate area as determined by required storage temperature, matrix, and analyses required. The laboratory sample storage areas are monitored daily.

Samples are tracked using LIMS. Any problems encountered are reported to the client. An analytical report is printed out. The samples are held until their holding time has expired or until 30 days after completion of the analysis. Samples are then disposed of in an environmentally acceptable manner. Samples are returned to the client if requested. Water samples that are environmentally safe are disposed into the local sanitation system. Samples that contain hazardous waste may be returned to the client for proper disposal.

Analytical Standard Operating Procedures (SOPs) are part of the laboratory QAM.

Field Information Sheets

Field data sheets are the primary method for documenting most stream monitoring field activities. These sheets served as an initial record of any field measurements and weather conditions at the time of sampling. Jessica Poegel, MPCA Monitoring Coordinator, created the template for the field data sheets used by RLWD, Marshall County Water Plan, River Watch, and the MCPA, beginning in 2007. The sheets used for this study (and all RLWD monitoring from now on) are a modified version of Jessica's template. The RLWD uses one sheet for each monitoring site. This helps keep data sheets more organized and also allows the monitoring staff to look back at previous records for the site if necessary.

Field Notes

Field notes are used to document important information during sampling events. They are entered into a bound notebook with waterproof pages. Entries are made using pens with indelible ink. The field notebook becomes part of the project data and is retained with the analytical data hard copies and other project documents.

Sample Labeling

Each sample container has a label attached that is filled out in its entirety. The laboratory does not, as per laboratory policy, accept sample containers without labels or labels that are missing information. The sample label includes the water body code or name, the site number, the date, and time of sample collection.

Sample Shipping

All samples are packed in an ice-filled cooler for transport to the laboratory. Samples are generally transported within 24 hours of collection. They are shipped within a cooler packed with ice/ice packs in the manner described in the Laboratory Sample Handling section of this QAPP. RMB Environmental Laboratories provides shipping labels. Empty preservaive vials are placed in a plastic bag and returned to the lab within the cooler. Coolers are securely taped shut with packing tape and weighed prior to shipping. Samples may be shipped Monday through Thursday. Unless told otherwise, it is courteous to call RMB Environmental laboratories on

Thursdays if sampling fecal coliform or E. coli bacteria because they have to make sure there will be someone at the lab on Saturday to complete the analysis. Speedee Delivery is open for walk-in shipments at around 4:30 pm. Samples should be brought to Speedee Delivery no later than 6:30. Samples will arrive in at the lab in Detroit Lakes the next morning.

B4. ANALYTICAL METHODS

Analytical protocols are found in the RMB Laboratories, Inc. QA/QC Manual and SOPs. Analytical accuracy is routinely checked by the laboratory's analysis of standard certified reference analytes.
Laboratory analytical methods are listed in Table 6.

All raw data generated in the laboratory are recorded in bound notebooks, on project specific raw data sheets, RMB custom logbooks, or as an instrument printout. This data includes sample numbers, calibration data, calculations, results, analyst notes and observations, quality control data, date of analysis, and initials of the analyst. Completed notebooks are returned to the Quality Assurance Unit where they are archived. Chromatograms, graphs, and strip charts are kept with the laboratory raw data. All items are labeled, dated and signed by the analyst. When completed, the data are integrated into a final report.

For out-of-control situations, a corrective action plan is in place. The initial action is to repeat the analyses of the samples bracketed by the unacceptable quality control sample. Replication of unacceptable results are investigated as a matrix effect by reviewing blank spikes or laboratory knowns. If the quality control samples are still unacceptable, the entire process is repeated. This includes sample preparation or extraction. If re-analysis is not possible due to the sample being past holding times or sample quantity is insufficient, documentation of the situation will be added to the raw data. In these cases, the client is notified and the report flagged.

B5. QUALITY CONTROL

Where applicable, internal reference standards will be analyzed and recorded with each sample run. External reference standards and standard reference material obtained from ERA, APG, or another approved provider will also be used. All stock standard solutions will be properly labeled, stored, and expiration dates visibly recorded on the label. The measured data for the certified standards must fall within the specified range as given by the provider or corrective action will be taken.

The Red River Basin Monitoring Network (coordinated by monitoring staff from the Detroit Lakes MPCA office) conducts blind sample tests on RMB Environmental Laboratories on a regular (yearly) basis.

The Minnesota Department of Health (MDH) certifies RMB Laboratories, Inc. As such the laboratory is subject to audit by MDH and MPCA.

One field QC grab sample duplicate for laboratory analysis is collected at the sampling site for every ten like samples taken. The grab sample collection protocol is described in Appendix A1 and in the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*. The field duplicate for laboratory analysis is collected to determine sampling and laboratory analytical precision. Blank samples are collected for 10% of hand-dipped grab samples (field blanks) and 10% of all Van Dorn sampler collected samples (sampler blanks). QA/QC results for all RLWD monitoring will be used to test the accuracy and bias of RLWD monitoring procedures.

If QC samples revealed a sampling or analytical problem, field and laboratory personnel attempt to identify the cause.

Upon working out a plausible solution, personnel take necessary steps to ensure that similar problems do not arise during future sampling events. If possible the sampling event is repeated. As per laboratory protocol, suspect data are flagged or qualified depending upon the nature and extent of the problem.

RMB implements specific QA/QC methods and procedures for dealing with out-of-control situations. These are documented in RMB's QAM and SOPs, copies of which are maintained on file at MPCA and available for consultation and review upon request.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

The pH, specific conductance, dissolved oxygen, and turbidity probes of the field-deployed continuous monitoring sondes calibration are checked according to manufacturer recommendations. Profiling sonde dissolved oxygen calibration will be checked daily and pH and specific conductance checked monthly. All hand-held instruments, when used, are inspected and tested each sampling day prior to their use in the field. Steps are taken to fix any instrument problems noted during testing. If any problems cannot be resolved the instrument is taken out of service and a substitute instrument is used. pH buffer solutions are replaced with fresh solutions before the buffer solution expiration date. Batteries for all meters are routinely checked and replaced when meters showed power-related problems. Spare batteries for all instruments are taken on all sampling trips. All maintenance procedures are documented in the meter maintenance logs or the field notebook. Deployed Eureka Manta multiprobes use 8 C cell batteries, which last for about one month of water quality logging at a 30-minute interval and 1 minute warm-up time. The portable Eureka Manta sonde is controlled by a Eureka Amphibian hand pad and powered by a battery pack within the hand pad. Since the hand pad is essentially a PDA (iPaq hx2110) within a rugged case, it is always drawing power and should be plugged in to its charging cord nightly.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Thermometers used during this project, if any, are checked for accuracy with a NIST-certified thermometer. The field thermometer must read within ±0.1°C of the NIST-certified thermometer to be used. Thermometer accuracy is confirmed at the beginning of each sampling season. Dissolved oxygen probes on portable field instruments are calibrated each day. Specific conductivity, pH, and turbidity probes on portable field measurements are calibrated at a minimum frequency of once every month. HACH 2100P portable turbidimeter calibration checks with Gelex Secondary Turbidity Standards (0-10, 0-100, and 0-1000 vials) are performed daily prior to being used in the field. Portable turbidimeters should not be allowed to have an error greater than 5% with any of the checks. Instrument calibration is checked periodically throughout the sampling day and recalibrated if necessary.

All instrument calibration checks and procedures are documented on the instrument maintenance log or in the field notebook. An instrument calibration logbook is kept in the laboratory at the RLWD office. It includes calibration log worksheets for the Eureka Manta portable sonde, HACH 2100P portable turbidimeter, and continuous monitoring equipment. The worksheet on the following page is used for keeping track of all continuous monitoring equipment maintenance and calibration done by the RLWD. It is used to test the validity of continuous monitoring equipment – how well it matches up to portable equipment.

Table 7. Continuous Monitoring Equipment Maintenance/Calibration Log

CONTINUOUS MONITORING MAINTENANCE/CALIBRATION LOG AND DATA VALIDATION

						Pre Cleaning Data				Pre-Cleaning Data Grade	Post Cleaning/Pre-Calibration Data		Post-Cleaning Data Grade	Re-Deployment/Post Calibration Data				Post-Cal. Data Grade
						In-Situ		Bucket of Stream Water			Bucket of Stream Water			In-Situ		Bucket of Stream Water		
Deployed Sonde ID/ Site Name	Portable Sonde ID	Site Name	Parameter	Date	Staff	Deployed	Portable	Deployed	Portable		Deployed	Portable		Deployed	Portable	Deployed	Portable	

Table 8. Continuous monitoring data grades from the British Columbia Ministry of Environment's *Continuous Water-Quality Sampling Programs: Operating Procedures*

Parameter	Data Grade Criteria				
	Excellent	Very Good	Good	Fair	Poor
Temperature	≤ ± 0.2 °C	> ± 0.2 to 0.4 °C	> ± 0.4 to 0.6 °C	> ± 0.6 to 0.8 °C	> ± 0.8 °C
Specific conductance (≤ 100 µS/cm)	≤ ± 3µS/cm	> ± 3 to 6 µS/cm	> ± 6 to 9 µS/cm	> ± 9 to 12 µS/cm	> ± 12 µS/cm
Specific conductance (> 100 µS/cm)	≤ ± 3% of reading	> ± 3 to 6% of reading	> ± 6 to 9 % of reading	> ± 9 to 12 % of reading	> ± 12 % of reading
pH	≤ ± 0.2 pH units	> ± 0.2 to 0.4 pH units	> ± 0.4 to 0.6 pH units	> ± 0.6 to 0.8 pH units	> ± 0.8 pH units
Turbidity (≤ 40 NTU)	≤ ± 2 NTU	> ± 2 to 4 NTU	> ± 4 to 6 NTU	> ± 6 to 8 NTU	> ± 8 NTU
Turbidity (> 40 NTU)	≤ ± 5 % of reading	> ± 5 to 10% of reading	> ± 10 to 15% of reading	> ± 15 to 20% of reading	> ± 20% of reading
Dissolved oxygen (≤ 4 mg/l)	≤ ± 0.2 mg/L	> ± 0.2 to 0.4 mg/L	> ± 0.4 to 0.6 mg/L	> ± 0.6 to 0.8 mg/L	> ± 0.8 mg/L
Dissolved oxygen (> 4 mg/l)*	≤ ± 5 % of reading	> ± 5 to 10% of reading	> ± 10 to 15% of reading	> ± 15 to 20% of reading	> ± 20% of reading

* The sensors may be less accurate for values > 20 mg/l.

B8. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables used during this project include all or some of the following: paper supplies, turibidty standard solution (7.6 NTU), deionized water, batteries (72 C cells should be on-hand for rounds of deployed Manta Maintenance), probe filling solutions, probe membranes, Kimwipes, pH buffer solutions, and specific conductance standard solution. Supplies and consumables are purchased only from reputable and reliable suppliers and inspected for usability upon receipt and are checked regularly for continued usability.

B9. DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

RLWD Project staff review historical water quality data collected by previous assessment projects and used the data for comparative purposes with the data from this project. Modeling is also used in this project to determine nutrient transport and sediment loading.

B10. DATA MANAGEMENT

The field sampler is responsible for completing the field data sheets. This information is entered into a spreadsheet or database and archived. Laboratory results are entered into a computer database and/or spreadsheet which is maintained by the WQC who also assists with data maintenance, reduction, and transmittal. The Project Manager also reviews all data prior to its approved entry into STORET.

Quality assurance data sheet checks include scanning for apparent entry errors, measurement errors, and omissions. Suspect data are flagged and/or excluded from use. Project staff will review 10% of new data entries by checking entered values against field data sheets and lab reports. All data will be checked to make sure all values are within range. This is accomplished by double-checking the highest and lowest values (outliers) for each parameter and any other values that may be questionable. The RLWD's water quality Micosoft Access database has quality controls built in that do not allow the entry of values that are out-of-range. Data may be presented in table, graph, and chart format. Unusual data are rechecked to verify its accuracy. Site establishment forms for STORET submittal are completed in May of each year for new monitoring sites. MPCA data entry personnel then enter the data into STORET.

Data collected is analyzed on an annual basis with in-depth analysis and modeling being conducted at least once during the project. TSI and concentration averages are determined. Flow/discharge curves are created for each tributary. Flow and nutrient loading are determined in streams using the FLUX modeling program. FLUX modeling requires that collection of daily average flow data coupled with periodic sampling. Load modeling accuracy can be improved by increased monitoring frequency during high flows. Project staff will team with project partners to conduct SWAT modeling based on the monitoring results in an effort to identify the major sources of sediment loading. Modeling is completed by RLWD staff with assistance from the MPCA and other project partners. All data are collected and analyzed in accordance with this QAPP. RLWD staff provide the data and modeling results to project partners and makes it available to the public on the RLWD website and in STORET.

GROUP C: ASSESSMENT AND OVERSIGHT

C1. ASSESSMENT AND RESPONSE ACTIONS

Corey Hanson as WQC is responsible for all field activities, reviewing the data, reporting to the group on findings, and forwarding all data to the appropriate state regulatory agency for inspection and input into STORET. He oversees and assesses all field sampling and data collection. The MPCA Project Manager and QA staff are also authorized to oversee field activities during this project. The MPCA Project Manager and WQ QA/QC Coordinator are also authorized to follow up on sampling activities during the project.

C2. REPORTS TO MANAGEMENT

A draft report of the TRWSI Project findings will be prepared for the MPCA and shared with all involved watershed districts, local resource managers, and other involved parties.

The WQC submits semi-annual reports to the Project Manager with the monitoring section updated semi-annually, as needed. Problems that arise during the project are corrected and reported to all parties involved in the project.

RLWD staff are responsible for the reporting, tracking, and overall management of the TRWSI Project. The RLWD bookkeeper tracks expenditures for all RLWD projects by project and work type. This is explained in the Report – Report Writing section of the project workplan. A form will be provided to project partners for recording expenditures so they may be submitted to the RLWD. 50% of the Marshall County expenditures will be counted as in-kind contributions and the rest will be reimbursed by the RLWD from CWP grant money (up to the amount budgeted).

All data are recorded and tracked through use of the Microsoft Excel database management system. The data compiled during this project is incorporated into spreadsheets and sent to the MPCA for perpetual storage in STORET, the EPA environmental database.

GROUP D: DATA VALIDATION AND USABILITY

D1. DATA REVIEW, VERIFICATION, AND VALIDATION

All raw data are transcribed to the data transmittal form and stored in a binder-type notebook. Where applicable, the data is organized electronically and filed in the MPCA STORET database. A report on statistical analyses on replicate samples collected within the Thief River Watershed will be generated so that the degree of certainty can be estimated.

All data are reviewed by the project monitoring coordinator and signed by the analyst. Copies of the data transmittal form and all pertinent records of calibration, standardization, and maintenance will be archived.

All laboratory analytical results are cross-checked against the field notebook and sample tags to ensure that the raw, computer-generated summary of the laboratory analyses are assigned to the correct sampling stations. All analytical results are compared to the field sheets to ensure that the data are complete. After electronic data entry, each row in a field data sheet is marked with the initials of the person entering the data and the date it was entered. This ensures that all data will be entered and that there is more accountability in the data entry process.

Field data and field QC sample sets are reviewed by Corey Hanson to determine if the data meets the DQO and QAPP objectives. In addition, Jim Courneya, MPCA Project Manager, assists in the data review. Data is examined and outliers identified through statistical analysis. Decisions to reject or qualify data are made by Corey Hanson and Jim Courneya.

D2. VERIFICATION AND VALIDATION METHODS

Project staff follow the EPA *Guidance on Environmental Verification and Validation* (EPA QA/G-8) whereby the data is reviewed and accepted or qualified by project and/or MPCA staff.

D3. RECONCILIATION WITH USER REQUIREMENTS

Within 48 hours of receipt of results of each sampling event, calculations and determinations of precision, completeness, and accuracy are made and corrective action implemented, if needed. If data quality does not meet project specifications, the deficient data is flagged or discarded and the cause of failure evaluated. Any limitations on data use is detailed in the project reports and other documentation.

Project data is compared to historic data and is also used as complimentary data for other monitoring efforts within the basin.

For the data to be considered valid, data collection procedures, the handling of samples, and data analysis must be monitored for compliance with all the requirements described in this QAPP. Data is flagged and qualified if there is evidence of habitual violations of the procedures described in this QAPP. Any limitations placed on the data are reported to the data end user in narrative form.

Appendix 1A

Hand-Collected (Grab) Sampling

Standard Methods for Collection

Water is collected at the sampling point using one of the following methods depending upon physical accessibility:

- Sample bottle dip while wading
- Sample bottle dip through hole cut in ice

Follow bottle rinse and preservation methods as directed by the analyzing laboratory. Bottles shall **not** be rinsed before sample collection. Sample bottles are pre-cleaned and disposable. Do not use bottles that may have been contaminated (caps have fallen off).

Samples are collected at a point that best represents the water quality of the total flow at the cross section. Grab samples collected using the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* are collected in the thalweg of the stream (representative of the most flow) at a depth down from the surface that is approximately 6/10 of the total depth of the stream (mid depth, target depth has the average flow velocity at that point in the cross-section). Avoid sampling points that are poorly mixed or affected by local temporary conditions such as ponding across part of the stream width, obviously disproportionate sediment load, or backwater conditions. If a site is poorly mixed across the stream, integrated sample across the stream width should be used, or, more practically, another site should be chosen that is well mixed across the stream width.

Collect the sample at a middle (approximately 6/10 of the total depth down from the surface) depth in the water column without disturbing stream bed sediments or collecting floating materials from the surface. When grab sampling, the bottle should be lowered mouth down to the middle depth below the water surface then turned upward to collect the sample. Opening the bottle, upside down, under the surface of the water can help avoid contamination/bias from debris floating on the water surface. Always stand downstream of the sampling point to avoid contaminating the sample. During ice conditions, keep ice and snow out of the sampling hole cut in the ice. Be mindful that, during low flow conditions, disturbed sediment can actually float in an upstream direction. Avoid contaminating samples with this disturbed sediment.

SAFETY FIRST!

If wading, as a general rule, if stream depth (in feet) multiplied by its velocity (feet/second) is greater than your height (in feet), and then DO NOT WADE!

(Stream Depth) [ft.] x Stream Velocity [ft./sec.] > your height [ft.] = Do Not Wade!

Appendix 1B

QA Field Sampling Procedures

Sampler Blanks

A sampler blank (also commonly referred to as a rinsate blank or an equipment blank) is a sample of distilled water that is rinsed through the sampling device and collected for analysis. The RLWD collects one set of sampler blanks for every set of samples collected with a Van Dorn sampling device (also done for other devices, but the Van Dorn is the only type being used for this study). It is basically a simulated sample collected with the sampling device using a frsh bottle of distilled water instead of river water. These samples can be used to determine whether or not the sampler is being properly cleaned in between samples. The first step in collecting a sampler blank is to decontaminate the sampling device in the same manner that is used to collect your regular samples. For example, if you clean the sampling device with detergent and rinse with DI water, then conduct this same procedure before you collect the blank. **Because the sampling device is rinsed 3 times with sample water before collecting your sample, then conduct this rinse with DI water instead of sample water before collecting the sampler blank** – this will prevent any residual sample water from being detected in your results. Try to eliminate as much of the rinse water from the sampling device as possible before you collect the blank.

To collect the blank, fill the sampling device with distilled water and transfer the water to the appropriate collection bottles. Handle the device as close to your normal sampling procedure as possible: agitate the sampling device in the same manner, try to leave the water in the sampling device for the same amount of time, and collect the same volume of water.

Trip Blanks

Trip Blanks are sample bottles of deionized water that are filled before going out into the field and are carried along the entire sampling trip in the cooler. They are typically obtained ahead of time from the laboratory and are preserved in the same manner as the regular sample. Trip blanks are generally only used when collecting samples for volatile organic compounds.

Field Blanks

Field Blanks are similar to sampler and trip blanks. They are collected for 10% of all sets of samples that are collected using the hand-dipping grab sample method. They are collected by filling sample bottles with fresh distilled water at the sampling site. Contamination sources for this sampling method may include the atmosphere (rain, blowing dirt), the sampling personnel themselves, and the sample bottles.

Field Duplicates

A field duplicate is a second sample taken right after an initial sample in the exact same location. Field duplicates assess the sampler's precision, laboratory precision, and possible temporal variability. The duplicate sample should be collected in the exact same manner as the first sample, including the normal sampling equipment cleaning procedures.

Lab Sheets

A column labeled "QA Type" has been added to the lab sheets. If you are collecting a QA sample, fill in the type of QA sample in this column. Leave the column blank if it is a normal sample. The abbreviations for the QA samples are as follows:

SB = sampler blank FD = field duplicate TB = trip blank FB = Field Blank

The sampler blanks and field duplicate samples will have the exact same station, date, time, depth, and substation as the samples with which they are associated. The only thing distinguishing the samples apart will be the specified sample type in the "QA Type" column. So please remember to fill in this column with the QA sample type (SB or FD). Since the trip blanks are associated with an entire sampling trip, these samples will not have a station or time associated with them. Fill in the date of the trip and the QA sample type (TB).

Data is examined to determine if the results are acceptable.

Appendix 1C

Coliform Bacteria Sampling

Sample Collection, Preservation, and Storage

Because sterile conditions must be maintained during collection, preservation, storage, and analysis of indicator bacteria samples, specific procedures have been developed that must be strictly followed. These procedures vary with types of sampling equipment and source of sample (surface water, ground water, treated water, or waste water).

Surface-Water Sample Collection

The areal and temporal distribution of indicator bacteria in surface water can be as variable as the distribution of suspended sediment because bacteria commonly are associated with solid particles. To obtain representative data, use the same methods for collecting surface-water samples for bacteria analysis as for suspended sediment.

Quality Control

Depending on the data-quality requirements, quality-control (QC) samples (blanks and replicates) can comprise from 5 to 30 percent or more of the total number of samples collected over a given period of time. E. coli QC samples will be collected at a rate of 10% for this study, the same rate as all the other samples.

Collect and analyze field blanks to document that sampling equipment has not been contaminated.

Blank bacteria samples are collected in the same manner as other blank samples. If there is contamination from equipment, bottles, or sampling methods, it will show up in the laboratory results. A laboratory result higher than the minimum reporting limit should trigger a review of sampling protocols and field notes to determine the cause of the sample contamination and prevent future reoccurrences.

Hand-Dip Method

Open a sterile, narrow-mouth borosilicate glass or plastic bottle; grasp the bottle near the base, with hand and arm on downstream side of bottle.

Without rinsing, plunge the bottle opening downward, below the water surface. Allow the bottle to fill with the opening pointed slightly upward into the current.

Remove the bottle with the opening pointed upward from the water and tightly cap it, allowing about 2.5 - 5 cm. of headspace. This procedure minimizes collection of surface film and avoids contact with the streambed.

Sample Preservation and Storage

After collection, immediately chill samples in an ice chest or refrigerator at 4°C ± 2°C. Do not freeze samples. Begin analysis as quickly as possible preferably within 1 hour but not more than 8 hours[†] after sample collection to minimize changes in the concentration of indicator bacteria.

Preserving Sample Cleanliness

Keep the rope, used to lower the sampler, coiled inside of a bucket or case. While pulling the sampler up, constantly recoil the rope into the bucket/case. This keeps the rope from being contaminated by substances from the bridge deck.

When lowering and raising the sampler do not let the rope rub against the side of the bridge. Such rubbing knocks material from the bridge into the sampler, and can contaminate the sample.

Safety When Sampling From a Bridge

If you are in traffic wear a traffic safety vest. Carry a white bucket to increase your visibility. If visibility is low, set a blinking warning light next to you while you are collecting the sample. It is advisable to have a warning beacon on the top of the vehicle. Orange traffic cones can add another level of safety when working on highway bridges or other busy roads.

If you are on a Warner truss or similar bridge and it is a sunny day, also use a warning light. Place the light in one of the shadows. The shadows of the truss work on the bridge deck will cause optical confusion for approaching drivers and will hide your presence.

[†]MPCA Environmental Analysis & Outcomes Division policy is as follows:

The maximum 8-hour holding time must be strictly observed if the sampling is being done in conjunction with a possible enforcement action. A chain-of-custody form must also be used. If the sampling is not for possible enforcement purposes, the maximum holding time is 24-hours and a chain-of-custody form need not be used.

Appendix 1D

pH Measurement

Note: The methods written below are not instrument or monitoring program specific. Please consult the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* and your instrument's manual for more information. Project specific notes are inserted below, where necessary.

pH Meter Calibration

Calibrate and check the operation of a pH instrument system at the field site. Two pH buffers are needed to properly calibrate the pH instrument system (pH 7 buffer and either the pH 4 or 10 buffer, depending on the anticipated sample pH). A third buffer can be used to check instrument system performance over a larger range. The pH of the buffer solution is temperature dependent: pH 10 buffers change more per unit change in temperature than do pH 4 buffers. The temperature of buffer solutions must be known, and temperature-correction factors must be applied before calibration adjustments are made. Calibration and operating procedures differ with instrument systems--check the manufacturer's instructions.

Meters with microprocessors have reliable autocalibration functions and will automatically compensate for buffer temperatures and indicate Nernst slope. For such meters, follow the manufacturer's calibration instructions precisely--do not take shortcuts.
Check the records of electrode performance before each calibration and field trip. Electrode response is optimum between approximately 98 percent and 99.5 percent. A slope of 94 percent indicates possible electrode deterioration. **At 90 percent slope, the electrode cannot be used.**

Calibrate or check the temperature sensor at least three times per year, and tag the sensor with the date of last calibration. Do not use the automatic temperature compensating function of a pH meter if it has not been calibrated within the past 4 months.

Record calibration in the instrument log book at the time of instrument calibration.

pH Measurement

The pH of a water sample can change significantly within hours or even minutes after sample collection as a result of degassing (such as loss of carbon dioxide, hydrogen sulfide, and ammonia); mineral precipitation (such as formation of calcium carbonate); temperature change; and other chemical, physical, and biological reactions. The electrometric method of pH measurement described below applies to filtered or unfiltered surface water and ground water, from fresh to saline.

The pH of a water sample must be measured immediately in the field. Do not rely on laboratory-measured pH in lieu of field-measured pH. **Measurement of pH for the Thief River Watershed Sediment Investigation study will be made in-situ with the pH probe on a portable multiparameter sonde.**

Field conditions, including rain, wind, cold, dust, and direct sunlight can cause measurement problems. To the extent possible, shield the instrument and measurement process from the effects of harsh weather.

In dry, windy climates, a static charge can build up on the face of a pH meter and cause erratic readings on the display.
Polish the face of the display with a soft, absorbent tissue treated with several drops of antistatic solution (such as plastic polish) to minimize this interference.

Technical Note: Temperature has two effects on pH measurement of a sample: it can affect electrode potential (Nernstian slope effect), and it can change hydrogen-ion activity (chemical effect). The electrode-potential problem can be solved by using an automatic or manual temperature compensator. The change in hydrogen-ion activity resulting from temperature changes in the sample can be minimized if the electrodes, buffers, and container are allowed to equilibrate to the same temperature.

Surface Water

It is generally preferable to measure pH *in situ* rather than on a sample taken from a splitter or compositing device. If stream conditions are such that water would pass the in situ pH sensor at a very high rate of flow, however, streaming-potential effects could affect the accuracy of the measurement. For such conditions, it is preferable to withdraw a discrete sample directly from the stream or compositing device and use the subsample measurement procedures described below. When sampling from a boat, the pH instrument system should be set up on board the boat so that pH is measured at the time of sample collection.

***In Situ* Measurement**

Follow the steps listed below for *in situ* pH measurement:

- Calibrate a pH system on site after equilibrating the buffers with the stream temperature, if necessary. Check the electrode performance and the calibration date of the thermometer being used.
- Flowing, shallow stream - Wade to the location(s) where pH is to be measured.
- Stream too deep to wade - Lower a weighted pH sensor with a calibrated temperature sensor from a bridge, cableway, or boat. Don't attach the weight to sensor or sensor cables.
- Immerse the pH electrode and temperature sensor in the water to the correct depth and hold them there for at least 60 seconds to equilibrate them to water temperature.
- Measure the temperature.
- If the pH instrument system contains an automatic temperature compensator (ATC), use the ATC to measure water temperature.
- If the instrument system does not contain an ATC, use a separate calibrated thermometer, adjust the meter to the sample temperature (if necessary), and remove the thermometer.
- Record the pH and temperature values without removing the sensor from the water.
- Values generally stabilize quickly within ±0.05 to 0.1 standard pH unit, depending on the instrument system.

Appendix 1E

The Field Notebook

This section summarizes information, guidelines, and minimum requirements that apply generally to field measurements for all studies of water quality and the collection of basic data. Other terms commonly used for field measurements are field parameters and field analyses. Before proceeding with field work, check each field-measurement section for recommended methods and equipment, detailed descriptions of measurement and quality-control procedures, and guidelines for troubleshooting and data reporting.

Field Measurements—determinations of physical or chemical properties that are measured on-site as close as possible in time and space to the media being sampled.

Records, Field Instruments, and Quality Assurance

Field-measurement data and other field information must be recorded, either on paper or electronically, while in the field. *Reported* field measurements are defined as those data that are entered into STORET. The conventions used for reporting field measurement data are described at the end of each field measurement section.

Record field-measurement data, methods and equipment selected, and calibration information on field forms and in instrument log books.

Field forms include national or study-customized field forms and analytical services request forms; other forms and records (for example, chain-of-custody records) may be required for the study.

Instrument log books for each field instrument are required to document calibrations and maintenance.

Electronic records are maintained for each uniquely identified sampling location.

Field personnel must be familiar with the instructions provided by equipment manufacturers. This manual provides only generic guidelines for equipment use and maintenance or focuses on a particular instrument or instruments that currently are in common use. There is a large variety of available field instruments and field instruments are being continuously updated or replaced using newer technology. Field personnel are encouraged to contact equipment manufacturers for answers to technical questions.

Data Quality Objective (DQO) – Representativeness:

Field measurements should represent, as closely as possible, the natural condition of the surface water or ground water system at the time of sampling.

Field teams must determine if the instruments and method to be used will produce data of the type and quality required to fulfill study needs. Experience and knowledge of field conditions often are indispensable for determining the most accurate field-measurement value. To ensure the quality of the data collected:

- Calibration is required at the field site for most instruments. Make field measurements only with calibrated instruments.

- Each field instrument must have a permanent log book for recording calibrations and repairs. Review the log book before leaving for the field.
- Test each instrument (meters and sensors) before leaving for the field. Practice your measurement technique if the instrument or measurement is new to you.
- Have back-up instruments readily available and in good working condition.
- If a probe is not working properly, discard the data and repair the probe as soon as possible.

Data Quality Objective (DQO): Precision

Determined by taking duplicate samples. The closer the two values the better the precision. Usually expressed as Relative Percent Difference (RPD). Duplicate samples can measure:

- Laboratory analytical proficiency
- Sampling proficiency
- Analyte variability occurring at the sampling point

Data Quality Objective (DQO): Accuracy

The closer the sample value is to the true sample value, the better the accuracy. What is the *true* value of the sample?

Quality-assurance protocols are mandatory for every data-collection effort and include practicing good field procedures and implementing quality-control checks. Make field measurements in a manner that minimizes artifacts that can bias the result. Check field-measurement variability (precision) and bias (accuracy plus variability).

Requirement: Use reference samples to document your ability to make an accurate field measurement. Field teams also are encouraged to verify accuracy of their measurements at least quarterly against reference samples.

For measurements such as alkalinity made on sub-samples, check precision in the field every tenth sample by repeating the measurement three times using separate sample aliquots from the same sample volume.

Standard procedure: Before making field measurements, allow sensor to equilibrate to the temperature of the water being monitored. Before recording field measurements, allow the measurement readings to stabilize. The natural variability inherent in surface water or ground water at the time of sampling generally falls within these stability criteria and reflects the accuracy that should be attainable with a calibrated instrument.

For surface water: Allow at least 60 seconds (or follow the manufacturer's guidelines) for sensors to equilibrate with sample water. Take instrument readings until the stabilization criteria are met. Record the median of the final three or more readings as the value to be reported for that measurement point.

For sites at which variability exceeds the criteria: Allow the instrument a longer equilibration time and record more measurements. To determine the value to be reported for that measurement point or well, either use the median of the final five or more measurements recorded, or apply knowledge of the site and professional judgment to select the most representative of the final readings.

Table 1. Stabilization Criteria for Recording Field Measurements

±, plus or minus value shown; °C, degrees Celsius; ≤, less than or equal to value shown; μS/cm, microsiemens per centimeter at 25°C; >, greater than value shown; unit, standard pH unit; mg/L, milligram per liter]

Standard direct field measurement	Stabilization criteria for measurements (variability should be within the value shown)
Temperature:	± 0.2°C
Conductivity: when ≤ 100 μS/cm; when > 100 μS/cm	± 5 percent; ± 3 percent
pH: meter displays to 0.01	± 0.1 unit
Dissolved Oxygen: Amperometric method	± 0.3 mg/L
Turbidity: Turbidimetric method	± 10 %

Surface Water

Field measurements must accurately represent the body of surface water or that part of the water body being studied. Field teams need to select a method to locate the point(s) of measurement and the method(s) to be used to make the field measurements
.

Normally, the point(s) at which field measurements are made correspond to the location(s) at which samples are collected. Standard procedures for locating points of sample collection for surface-water sampling are detailed in Chapter A4 of the USGS National Field Manual and within the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*.

Properties such as temperature, dissolved-oxygen concentration, and Eh must be measured directly in the water body (*in situ*). Properties such as pH, conductivity, and turbidity are best measured in situ, but also may be measured in a sub-sample of a composited sample. Because determinations of alkalinity or acid-neutralizing capacity (alkalinity/ANC) cannot be made *in situ*, a discrete sample must be collected or sub-sampled from a composite.

The method selected to locate the point(s) of measurement usually differs for still water and flowing water. If the water system is well-mixed and its chemistry is relatively uniform, a single sample could be sufficient to represent the water body. Often, however, multiple points of measurement are needed to determine a representative set of field-measurement values.

Still Water

Still-water conditions are found in storage pools, lakes, and reservoirs. They also occur in rivers during times of no flow caused by low water levels or backwater conditions. Field measurements usually are made *in situ* at multiple locations and depths. Alternatively, pH, conductivity, and turbidity can be measured in a discrete sample or sub-sample. Measurement of alkalinity/ ANC must be in a discrete sample. The location, number, and distribution of measurement points are selected according to study objectives.

Locating Point(s) of Measurement

Flowing Water

Flowing water conditions are found in perennial (water always present) and ephemeral (water intermittently present) streams. The location and the number of field measurements depend on study objectives. Different study objectives could dictate different methods for locating the measurement point(s). For example, field measurements designed to correlate water chemistry with benthic invertebrates may require measurements on one or more grab samples that represent populated sections of the stream channel. Generally, a single set of field measurement data is used to represent an entire stream cross section at a sampling site and can be useful when calculating chemical loads.

To locate measurement points:

USGS EWI (Equal Width Increment) and EDI (Equal Depth Increment) methods are beyond the scope of our surface water sampling programs.

Most sampling is single-point grab sampling.

Knowledge and experience must often be applied to sampling site selection in that a single sample will represent the entire stream width.

The sampling site must be well-mixed.

Backwaters, pools, and eddies must be avoided.

As a rule, if stream flow feet per second • stream depth (in feet) > sampler's height (in feet), Do Not Wade!

In Situ and Sub-Sample Measurement Procedures

In situ Measurement

In-situ measurement, made by immersing a field measurement sensor directly into the water may be used to determine parameter variability at a single stream point. *In situ* measurement can be repeated at a variety of points if stream discharge is highly variable and a single measurement point may not be as representative as the average of multiple measurement point values.

Measurements made directly in the surface water body (*in situ*) are preferable to avoid changes that result from removing a water sample from its source. *In situ* measurement is necessary to avoid changes in chemical properties of anoxic (devoid of oxygen) water.

In situ measurement is mandatory for determination of:

- Temperature,
- Dissolved Oxygen, and
- Eh (Oxidation-Reduction Potential)

In situ measurement also can be used for pH, Conductivity, and Turbidity, but not for Alkalinity.

Sub-Sample Measurement

Depth- and width-integrated sampling methods can be used to collect and composite samples that can be sub-sampled for some field measurements. Again, these sampling methods are generally beyond the scope of our ambient surface water quality sampling programs. However, the same field measurements can be performed on discrete samples collected with a thief, a bailer, or a grab sampler. Sub-samples or discrete samples that have been withdrawn from a sample-compositing device or point sampler can yield good data for conductivity, pH, turbidity, and alkalinity as long as correct procedures are followed and the water is not anoxic (devoid of oxygen).

Sub-samples are necessary for Alkalinity determinations.

Before using a sample-compositing/splitting device, pre-clean and field-rinse the device in accordance with approved procedures.

When compositing and splitting a sample, follow manufacturer's instructions for the device being used.

Again, do not measure temperature, dissolved oxygen, or Eh on sub-samples.

Appendix 1F

Sampling from a Bridge

Sample Bottles

Follow sample bottle rinse and preservation methods as directed by the analyzing laboratory. Typically, laboratories (including the Minnesota Department of Health) recommend that their bottles *not* be rinsed before sample collection in that they are typically pre-cleaned and each lot of sample bottles is quality-tested for cleanliness in accordance with each laboratory's Quality Assurance Manual (QAM) and Standard Operating Procedures (SOPs).

Repeat-Use Sampling Equipment

Repeat-use sampling equipment such as a bucket and rope that contact sample water should be rinsed thoroughly with sample water three times before water is collected for transfer to sample containers.

Selecting a Stream Sampling Point

It is important to select a stream sampling point beneath the bridge that is representative of the entire stream. Select a point beneath the bridge where the water is well mixed. Typically, this point will be at or near the stream center where the rate of flow is at or near its maximum. Avoid points where the stream is swirling (eddies) or has pooled. Also avoid points near the stream banks in that this water may be atypically high in sediment.

Sampling

After you've selected your sampling point, carefully lower the bucket to the stream surface. Due to stream flow velocity and the plastic bucket's buoyancy it may not be possible to obtain a sub-surface sample. Tip the bucket until it has filled with stream water, raise it to the bridge, and empty the contents back into the stream. Repeat this procedure twice more, i.e., triple rinse the bucket. Lower the bucket again and draw a bucket of stream water for transfer to sample containers for analysis.

Maintaining Sample Cleanliness

When lowering and raising the sample bucket do not let it or the rope rub against the side of the bridge, the railing, or the abutments at the ends of the bride. Such rubbing may loosen material from the bridge, railing, or abutment that may contaminate the sample.

Ensure that the rope is affixed securely to the plastic bucket handle. When not in use, keep the rope coiled inside of a bucket.

Quality Assurance Samples and Procedures

Each type of quality assurance sample should comprise at least 10% of all samples taken. This is to say that if you are taking both Sampler Blanks and Field Duplicates, one of each should be taken for every nine analytical samples taken. If you typically take fewer than nine analytical samples during one field trip, it is recommended that you develop in advance of your first field trip a sampling schedule for the entire season and designate every tenth sample on the schedule to be a Field Duplicate and/or a Sampler Blank. This is particularly helpful if multiple field personnel will be doing this work throughout the course of the season.

The Sampler Blank

A sampler blank (also commonly referred to as a *rinsate blank* or an *equipment blank*) is a sample of distilled or de-ionized water that is use to rinse the sampling device and collected for analysis to determine if the sampling device is adequately cleaned before taking a sample for analysis.

When collecting a Sampler Blank, decontaminate the sampling device in exactly the same way you do before you collect a routine sample for analysis. For example, if you triple-rinse a bucket with stream water before taking a sample for analysis, do the same before collecting a Sampler Blank. Empty as much of the triple-rinse water from the bucket as possible before collecting the Sampler Blank.

To collect the Sampler Blank, pour sufficient de-ionized water into the bucket to make contact with its entire inner surface when swirling. Pour a portion of the de-ionized water into a sample bottle and enter the station number, date, time, and 'SB' on the bottle label. Place the sample in the cooler with ice.

Field Blanks

Field Blanks are similar to sampler and trip blanks. They are collected for 10% of all sets of samples that are collected using the hand-dipping grab sample method. They are collected by filling sample bottles with fresh distilled water at the sampling site. Contamination sources for this sampling method may include the atmosphere (rain, blowing dirt), the sampling personnel themselves, and the sample bottles.

The Field Duplicate

A field duplicate is a second sample taken immediately after an analytical sample and from exactly the same sampling spot in the stream. A field duplicate assesses the sampler's sampling precision, the laboratory's analytical precision, and can provide information about the stream's temporal variability. The duplicate sample should be collected in exactly the same manner as its corresponding analytical sample including use of the normal sampling equipment cleaning procedures. Pour a portion of the Field Duplicate water into a sample bottle and enter the same station number, date, and time on the bottle label as its corresponding analytical sample. Also label the bottle 'FD.' Place the sample in the cooler with ice.

The Trip Blank

The Trip Blank is a sample bottle of de-ionized water that is carried in the cooler with ice unopened during the entire sampling trip. It is typically obtained in advance from the analytical laboratory and contains the same preservative(s), if any, as the regular sample. A Trip Blank is typically only used when collecting samples for Volatile Organic Compound (VOC) analysis.

The Lab Sheet

The Lab Sheet has a column labeled *QA Type*. When collecting a QA sample, enter the QA sample type in this column. Leave the column blank if it is a routine analytical sample. The abbreviations to use for the QA sample types are as follows:

SB : Sampler Blank FD : Field Duplicate TB : Trip Blank FB: Field Blank

The Sampler Blank and the Field Duplicate will have the same station, date, time, depth, and substation as the analytical sample with which each is associated. The only difference between the analytical sample and its associated QA Sample is that the QA Sample will be designated as SB, FD, or TB in the *QA Type* column. The Trip Blank, if used, represents the entire sampling trip thus will not have a station or time associated with it. For a Trip Blank enter only the date and the QA sample type (TB) in the *QA Type* column.

Safety When Sampling from a Bridge

If possible park your vehicle on the up-traffic side of the bridge from which you will be sampling, or right at the sampling site. This way your vehicle will be seen by approaching drivers who are traveling in the lane next and will be alerted to your presence well before they reach the bridge.

After parking, turn on you vehicle's flashing hazard lights and rooftop warning beacon to alert approaching traffic to drive cautiously. Place orange traffic cones on the up-traffic side of your vehicle and where you are working on the bridge.

If available, wear a traffic safety vest for greater visibility. If a traffic safety vest isn't available, dress in bright clothing to enhance your visibility. Also use a brightly colored bucket if possible for greater visibility. If available, set a blinking warning light next to you while you are collecting the sample.

If you are on a Warner truss or similar bridge and it is a sunny day, also use a warning light, if available. Place the light in one of the bridge shadows. The shadows cast by the truss work on the bridge deck may cause optical confusion for approaching drivers and may hide your presence.

Appendix 2

Abstract and summary of the *Erosion, Sedimentation, Sediment Yield Report, Thief and Red Lake Rivers Basin, Minnesota* report produced by the Natural Resources Conservation Service

Abstract

This document describes the development of a sediment budget for the Thief and Red Lake Rivers Basin. The study includes a drainage area of 970,900 acres located upstream of the Thief River Fall Reservoir (reservoir) in the city of Thief River Falls in northwestern Minnesota. It does not include the drainage area upstream of the outlet of Lower Red Lake. The sediment budget contains all the soil erosion and sediment deposition processes that occur within the basin. About 9.500 tons of sediment are yielded annually to the pools of the public wildlife areas within the basin, of which about 98 percent is deposited in them. The reservoir receives about 19,800 tons of sediment annually, of which about 27 percent (5,330 tons) is deposited in it. The rest remains in suspension and is yielded downstream of the reservoir. The sediment budget was used to analyze various future options to predict the changes in the erosion-sedimentation processes in the basin.

Natural Resources Conservation Service Study of Erosion and Sedimentation in the Thief and Red Lake River Watersheds

From the Minnesota Pollution Control Agency Website:

http://www.pca.state.mn.us/water/basins/redriver/studies.html#nrcs-study

The Natural Resources Conservation Service (NRCS) in cooperation with the Marshall-Beltrami and Pennington SWCDs and other local, state, and federal agencies issued a report on this study in April 1996, entitled: Report on Erosion, Sedimentation, and Sediment Yield for the Thief and Red Lake Rivers Basin - Natural Resources Conservation Service. The study addressed the watershed of the Thief River Falls Reservoir, a drainage area of 970,900 acres. Findings of the study include:

- Public wildlife areas in the watershed receive about 9,500 tons of sediment annually, 98% of which is deposited in them;
- The reservoir receives 19,800 tons of sediment annually, 27% of which is deposited in it;
- Sheet and rill erosion amounts to about 4% of total gross erosion in the watershed;
- Wind erosion amounts to about 94% of total gross erosion in the watershed;
- Gully erosion and ditchbank erosion each amount to less than 1% of total gross erosion in the watershed;
- 65% of streambanks of the Thief River are eroding, and about 60% of this erosion is severe;
- About 2% of the sediment from erosion is yielded to ditches and streams; and
- Of the 53,900 tons of sediment yielded to streams, 58% is from streambank erosion, 22% is from sheet and rill erosion, 14% is from wind erosion, 5% is from ditchbank erosion, and 1% is from gully erosion.

For more information on this report, contact the NRCS, the Marshall-Beltrami SWCD, or the Pennington SWCD.

Appendix 3

Summary of:

Hydrogen Sulfide Problems in Thief River Falls: Causes, Effects, and Possible Solutions

CE678 Water Quality
Graduate Student Project

Brent Johnson
Fall Semester 1998
Dr. Wei Lin, Professor

Introduction

The city of Thief River Falls is located at the confluence of the Thief and Red Lake Rivers. Hydrogen sulfide gas (H_2S) is transported to Thief River Falls by these rivers, under certain winter conditions. The primary concern is the objectionable odor given off as the river water is discharged through the gates and powerhouse of the municipal dam. The strong odor envelops the center of the city, and irritates passersby, nearby residents, and people in the adjacent medical center, water treatment plant, and power plant. Additional concerns have been raised over the possible health effects of exposure to H_2S, and to the additional costs required to treat the water for the public water supply.

Hydrogen Sulfide Generation

Hydrogen sulfide is produced by the reduction of sulfur compounds by bacteria. These bacteria are called "sulfate-reducing bacteria." This group of anaerobic bacteria obtain energy for growth by oxidation of organic substances.

Hydrogen Sulfide Toxicity

Hydrogen sulfide is a toxic substance. It is a colorless, poisonous gas with the characteristic smell of rotten eggs. Hydrogen sulfide gas is heavier than air, but does mix with air. Exposure to high levels of hydrogen sulfide in the air can quickly cause death. Concentrations exceeding 2000 ppm H_2S in the air can be fatal to humans within minutes, and longer exposures at concentrations as low as 200 ppm have also caused death. Hydrogen sulfide is one of the "three invisible killers" in sewers. These include: explosive gases, lack of oxygen, and H_2S gas. Hydrogen sulfide gas at low levels is irritating to the eyes, nose, and throat. Higher concentrations of 1000 ppm cause immediate unconsciousness, respiratory paralysis, and death – unless artificial respiration is immediate.

OSHA reports that levels of 300 ppm H_2S cause the olfactory nerve to lose sensitivity, so that with exposure to high levels of H_2S the victim's personal warning system – his sense of smell – is diminished or deleted. High concentrations of hydrogen sulfide do not proportionally increase the odor, and the sense of smell can be rapidly fatigued by exposure to hydrogen sulfide, so odor is not always an adequate warning of the danger present.

The OSHA permissible exposure limit for hydrogen sulfide is set at 10 ppm. At low concentrations, less than 10 ppm, hydrogen sulfide irritates the eyes, mucous membranes, and respiratory system. At higher levels of 10 to 50 ppm people also experience headaches and dizziness. Exposure to levels between 50 and 200 ppm can cause severe irritation of the eyes and respiratory tract, as well as breathing difficulties and sudden loss of consciousness. At still higher levels, H_2S exposure can cause severe loss of motor functions, coma, respiratory paralysis, and death.

- Hydrogen sulfide is removed from water by volatilization

- H_2S usually dissipates in the atmosphere, but can build up to dangerous levels in closed spaces
- H_2S is also toxic and irritating to animals and fish.
- The Department of Energy quotes the detection threshold for H_2S at <1 ppm.

Hydrogen Sulfide Measurements near Thief River Falls

On March 19 and 26, 1996 water samples were collected at eight locations upstream of Thief River Falls. These samples were analyzed for dissolved H_2S. As expected, the highest concentrations were found downstream of the shallow reservoirs that were being drained. Significant levels of hydrogen sulfide were unexpectedly found in the Red Lake River above the mouth of the Thief River, even though samplers did not notice a H_2S smell on the Red Lake River. Mixing provides significant dilution to the H_2S contributed by the Thief River, although clearly not enough to remove the odor problem. The H_2S contribution from the Thief River approximately doubles the ambient Red Lake River H_2S concentration.

Hydrogen Sulfide Control Technologies

1. Prevention
2. Confinement and collection
3. Combustion and oxidation
4. Electric field oxidation
5. Chemical oxidation
6. Scrubbers and bio-filters
7. Mask odor
8. Adjustment of pH

Applicable Hydrogen Sulfide Control Technologies in Thief River Falls

1. Location
    a. Remove H_2S in a remote area.
2. Prevention
    a. Don’t release anoxic water from reservoirs while the Thief River is ice-covered.
    b. Preventing formation of H_2S in shallow wetlands difficult and impractical.
3. Aeration of reservoir discharge
4. Volatilization
    a. Outside of town
    b. Weirs, baffles, hydraulic jumps
    c. Reservoirs areas are located on state and federal wildlife management lands so there are few people living nearby to be bothered by the odor.
    d. Open up ice cover on the Thief River upstream of Thief River Falls.
        i. Aeration
        ii. Increasing river flow
            1. Not likely to be practical

5. Avoiding volatilization within Thief River Falls
    a. Reduce turbulence in flow – not practical
6. Cover
    a. River is ice-free below the dam
        i. Covering for confinement, collection, and treatment is not practical
    b. Ventilation and collection system added to the powerhouse and tailrace.
        i. Volatilized H_2S could be scrubbed, filtered, or oxidized
7. Oxidation
    a. Addition of chemical oxidants – may be reasonable
8. pH adjustment
    a. Adjust to a level of about 9
    b. May be difficult
9. Masking

Conclusions

Hydrogen sulfide gas is generated by anaerobic bacteria. Dissolved H_2S gas is released from shallow reservoirs in late winter and early spring along with water being drained from the reservoirs. This water flows in the ice-covered Thief River to Thief River Falls. The ice cover prevents the volatilization and release of the dissolved H_2S, and also prevents natural aeration of the river. The Thief River outlets to the Red Lake River in Thief River Falls. The combined flow from both rivers is discharged through the turbines and spillways of the municipal dam. The dam is located near the center of Thief River Falls. Hydrogen sulfide gas is volatilized by turbulence as water passes over the dam. The obnoxious hydrogen sulfide odor, within the center of Thief River Falls, results in a significant nuisance and numerous associated complaints.

Hydrogen sulfide control is a common need in municipal, industrial, and agricultural facilities. Numerous technologies have been developed and implemented to control hydrogen sulfide. Many of these technologies could be applied toward solving the odor problem in Thief river Falls. Revising reservoir management to discontinue all over-winter pool drawdowns, would address the core problem. Building additional reservoirs to offset the loss of over-winter pool drawdowns for spring flood control would likely cost $5 Million to $7 Million. Choosing the correct control technology, or combination of multiple technologies, will require additional study and/or field tests. Controlling Hydrogen Sulfide odors is certainly within our grasp.

Appendix 4

Summary of:

Total Suspended Sediment Loadings
Red Lake, Thief, Mud, and Moose Rivers

By:

Pennington County Soil and Water Conservation District

June 6, 2003

Introduction

As part of the Total Suspended sediment study of the Red Lake, Thief, Mud, and Moose Rivers, Houston Engineering, Inc. (Houston) was requested to proved engineering services to estimate the flow and to compute the suspended sediment load to each sampling site during the monitoring period, and to briefly describe the methods, assumptions and results of the hydrology and load computations.

Houston performed this work in three phases. Phase 1 analyzed the Thief River Falls Reservoir sites consisting of two inflow-sampling sites (Thief River and Red Lake River) and one outflow-sampling site (Thief River Falls Reservoir Dam). Phase 2 analyzed the Thief Lake sites consisting of none inflow-sampling site (Moose River Crossing) and one outflow-sampling site (Thief Lake Dam). Phase 3 analyzed the Agassiz National Wildlife Refuge sites consisting of two inflow-sampling sites (Thief River at Thief Bay Bridge and Mud River at Highway 89) and one outflow-sampling site (Judicial Ditch 11 at Mud Lake outlet).

Discussion

The results are tabulated by sampling year. Sampling periods were generally the open water season, and except for the Thief River Falls reservoir, load estimates do not include the full calendar years.

The TSS loadings appear to be similar to those computed by the USGS in the Red River Valley (USGS Water Resources Investigations Report 85-4312) and by the Red lake Watershed District (Thief River Falls Reservoir Study, March 1992).

The large reservoirs at Thief Lake and Agassiz National Wildlife Refuge are discharging a significant amount of sediment, although the Agassiz Pools appear to be retaining about 2/3 of the sediment inflow. The load estimates and average TSS concentration data for Thief Lake indicate that more sediment is flowing out of Thief Lake than is flowing in. This seems contrary to “common sense” and may be a result of assumptions made to compute discharge.

Appendix 6

Red River Basin Water Quality Team
Thief River Watershed Meeting
June 27, 2005
Issues Summary

Red River Basin Water Quality Team
Thief River Watershed Meeting
June 27, 2005
Issues Summary

The Thief River is the northernmost tributary to the Red Lake River, and flows through wildlife management areas, row crop agricultural lands and meets the Red Lake River, where it is both a recreational destination and the city of Thief River Falls' drinking water source.

The river has been managed for nearly 100 years, when the state of Minnesota first encouraged farmers to drain wetlands for farming. The public lands are important parts of the nation's waterfowl management system. However, farming remains the dominant economic land use. Release of water from the public wildlife areas often carries a load of organic sediment which has downstream impacts; timing on releases from the upper reservoirs is important to farmers. Public land managers and farmers often have different perspectives on how best to manage the reservoir and ditches. This has, at times, resulted in controversy.

Due to topography, soils and climate, the Thief River has a tendency to flood in the spring or early summer, while it runs at low flows in other season. These conditions encourage erosion of sediment overland and in the stream channel. Heavy sediment loads create taste and odor problems for drinking water operations, resulting in additional (and theoretically preventable) costs and the creation of carcinogenic byproducts. Water quality has been monitored by Red Lake Watershed District for 20 years; the district has worked proactively with stakeholders on identifying issues and strategies to resolve issues. The Marshall SWCD, the Pennington SWCD, and the Grygla River Watch also conduct water quality monitoring in the Thief River watershed. Although many interpretations/assumptions can be made with existing monitoring data, more intensive (continuous) monitoring is needed to reliably assess the timing and causes of problems on the Thief River. At this time, there is a need for resources to implement these strategies.

What are the issues identified in planning?

1. Streambank failure/ ditchbank slumping in the watershed
2. Sediment in ditches/streams
3. Water quality impairments
4. Flooding – upstream? downstream?
5. Drinking water at Thief River
6. Sediment in Thief River Reservoir

Information sources, planning efforts and initiatives in the watershed
**** denotes item was used in preparation of this report***

1. *NRCS Sediment Budget Study
2. *Hydrogen Sulfide in the Thief River Reservoir
3. *Marshall – Pennington – Polk county water plans
4. *Red Lake Watershed District Comprehensive Planning
5. *City of Thief River Falls Source Water Assessment
6. *Agassiz Wildlife Refuge Comprehensive Conservation Plan and annual Water Management Plan
7. Flood Damage Reduction Work Group Planning
8. *MPCA Basin Planning
9. DNR Planning - ?
10. Red Lake Band of Chippewa Planning - ?

Background Information:
The Thief River rises at the outlet of Thief Lake. Like the Red Lakes, Thief Lake is a remnant of Glacial Lake Agassiz, although at 7,000 acres it is much smaller than Red Lake. The topography of the Thief River watershed is flat, as a result of the impacts of the glacial lake. Thief Lake is shallow, with a mean depth of approximately three feet. Thief Lake lies entirely within the Thief Lake Wildlife Management Area (WMA), and is managed for wildlife by the Minnesota Department of Natural Resources.

The Thief Lake subwatershed is 1,068 square mile in area. The watershed is located mostly within the Lake Agassiz ecoregion with the extreme northeastern and southeastern areas fringing on the Northern Minnesota Peatlands ecoregion. Two smaller sub-watersheds drain into the Thief River: the Moose River and Mud River/Agassiz sub-watersheds. The Thief Lake sub-watershed is the northernmost reach of the Red Lake River watershed.

The Thief River flows into and out from the Agassiz National Wildlife Refuge (NWR) downstream of Thief Lake. The Agassiz NWR is managed by the US Fish and Wildlife Service for wildlife production – primarily waterfowl. The Agassiz Refuge includes a large complex of shallow wetlands that are diked and controlled for wetland management Thief Lake WMA and Agassiz NWR also have relatively good water quality, but as shallow wetlands they at times have much different water quality than Red Lake.

Wetlands are often characterized by low dissolved oxygen, when the rate of oxygen use exceeds the rate of re-aeration. Over winter the rate of oxygenation is diminished due to the ice cover which acts as a barrier to aeration, and due to reduced plant growth resulting from reduced light and lower temperatures. Low dissolved oxygen levels result in anaerobic decomposition of the organic materials and nutrients contained within wetlands.

The Thief River drains Thief Lake, a large marsh managed by the Minnesota DNR and located 4 miles north of the Refuge. This lake, in turn, is fed by the Moose River. The Mud River Judicial Ditch 11 system drains from the east into the Refuge. The channel capacity of Thief River is approximately 1,500 cubic feet per second (cfs), while that of Ditch 11 is about 900 cfs at the Mud River diversion. Despite the smaller size of its drainage area and channel, Mud River usually contributes more water to Agassiz NWR than the Thief River does due to the storage effect of Thief Lake and its controlled outlet. The Refuge's many pools furnish water storage capacity. In April and May of 1996, two flood events occurred back to back. The first was caused by snowmelt and the second by rainfall. The Refuge stored a total of 102,071 acre-feet during these two events.

Drainage systems in this sub-watershed are a complex network of natural streams and legal ditch systems developed for agriculture. Generally, the ditch systems are under the administration of either the County or the Watershed District. Notable existing storage projects within this watershed include Thief Lake, Agassiz National Wildlife Refuge, Elm Lake, Lost River Pool, and the Moose River Impoundment which collectively can store up to 138,000 acre feet of water.

Land Use and Pollution Issues

Land use is a mix of agricultural lands, forest lands, and wetlands, with very little grasslands, lakes or developed urban land. Noted problems along the Thief River are high turbidity and TSS levels.

Public land ownership is predominant in the northern and eastern reaches of the watershed; and the urban area is growing north from Red Lake Falls; the Red Lake Indian Reservation is located in this area.

Agricultural row crops is the dominant land use. Marshall County is near the maximum allowable limit for crop lands in Conservation Reserve Program (25 percent) of crops.

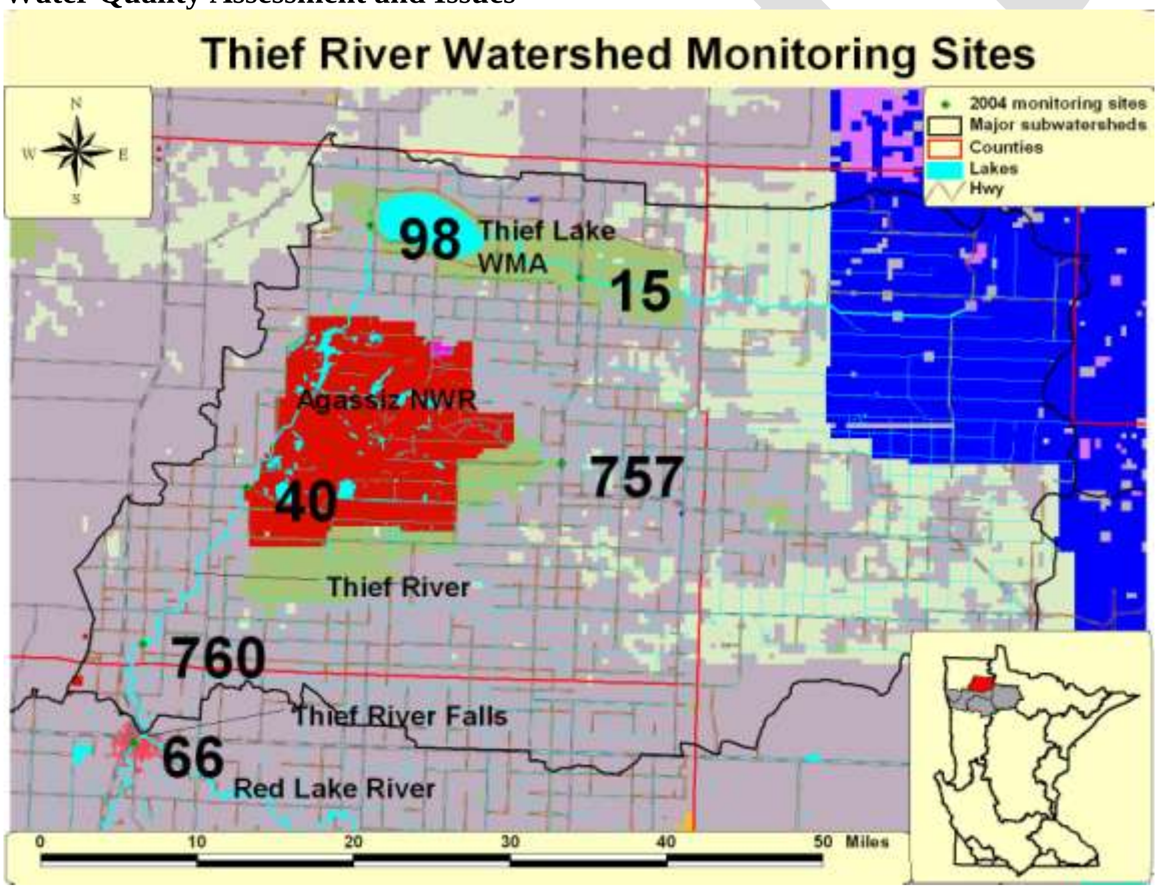
Thief Lake is a waterfowl management area and receives extremely large spring and fall migration of ducks and geese. No human fecal coliform bacteria sources are known. Turbidity in the lake may be due to algal blooms and dissolved organic material. Decomposition of plant material likely results in low oxygen levels which hurts aquatic life, and may limit the water quality of the water body. Ammonia may be due to duck and geese use.

The Thief River joins the Red Lake River in Thief River Falls. The Red Lake River has been dammed below the confluence; this reservoir is the drinking water source for the city of Thief River Falls. Data shows that water quality on the Red Lake River is quite good upstream of Thief River Falls and that water quality on the Thief River is comparatively much worse. Throughout most of the open water season – particularly in the summer months – water quality on the Thief River generally meets state and federal water quality standards.

The Minnesota Department of Health Source Water Assessment team identified the western portion of the Red Lake and the Thief River Watersheds as the inner-emergency response area for the city drinking water supply. This geographic area is defined by the amount of time the city needs to be notified, shut off the surface water intake and provide a "buffer" to accommodate unanticipated delays in notification and shut down.

The part of the Thief River watershed lying west of Highways 219 and 89 (south to north) is defined as the outer source water management area, which is designated to protect users from long-term effects related to low levels (chronic) of chemical contamination or the periodic presence of contaminants at low levels.

Water Quality Assessment and Issues



Methods from the MPCA *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305 (b) Report and 303 (d) List* were used to assess data from rivers and streams within the RLWD. This was done in preparation for the Best Professional Judgment meeting for the MPCA's 2005 assessment process. The MPCA has set state standards for several water quality parameters, including minimum dissolved oxygen levels (5 mg/L), maximum turbidity levels (25 NTU), an acceptable pH range (6.5 - 8.5/9), maximum fecal coliform levels (200 col/100ml), and maximum un-ionized ammonia levels (.04 mg/L). Other water quality parameters such as total phosphorus, nitrates and nitrites, and total suspended solids are compared to standards (minimally impacted stream values) that are different in each ecoregion.

Water quality monitoring has been conducted by the Red Lake Watershed District at five sites associated with streams within the sub-watershed since 1980 for dissolved oxygen, pH, temperature, turbidity, transparency, and conductivity. Laboratory analysis is performed on stream samples for fecal coliform, total suspended solids, total dissolved solids, chemical oxygen demand, total phosphorus, orthophosphorous, nitrates and nitrites, ammonia, total Kjeldahl nitrogen, alkalinity, dissolved oxygen, pH, temperature, turbidity, transparency, and conductivity. Major locations for sampling include the Hillyer Bridge and two sites on the Moose and Mud Rivers.

MPCA assesses whether the state's waters "attain" uses designated in water quality standards biennially, most recently in March 2005. At that meeting, the following assessments were made for the Thief River Watershed:

Thief River, from Agassiz Pool to Red Lake R (MPCA Reach Number 09020304-501):
Partially supports aquatic life due to low oxygen; does not support aquatic life due to turbidity; and the best professional judgment team recommended additional bacteria monitoring June & August

Thief River, from Thief Lake to Agassiz Pool (MPCA Reach Number 09020304-504):
Supports aquatic life; seasonal problems with ammonia

Moose River, from its Headwaters to Thief Lake (MPCA Reach Number 09020304-505)
Partially supports aquatic life due to low oxygen; exceeds desired values for total suspended sediment (this is not a water quality standard violation).

Mud River, from its Headwaters to Agassiz Pool (MPCA Reach Number 09020304-507)
Fully supports aquatic life.

Red Lake River, from its confluence with the Thief River to Thief River Falls dam(MPCA Reach Number 09020303-509)
Partially supports recreational use due to fecal coliform bacteria; may not support drinking water use, but has not been assessed for drinking water.

Sampling on Thief River, Hillyer Bridge on March 6, 2003
Seasonal conditions reduce oxygen in the water, creating anoxic conditions under the ice in the winter, which result in hydrogen sulfide problems in the reservoir. Other seasonal issues are heavy loads of sediment and organic material. High total dissolved solids concentrations and high conductivity

readings have been found during spring runoff.
The reservoir is the drinking water source for the city of Thief River Falls. The heavy loads of sediment and organic material require treatment with chlorine to assure satisfactory taste and odor for municipal drinking water. Chlorine disinfection of drinking water is costly and creates carcinogenic byproducts; local resource managers suggest measure to reduce loading from the upper watershed.

The *Hydrogen Sulfide Problems In Thief River Falls: Causes, Effects, and Possible Solutions* study by Brent Johnson states that the H_2S problem can be alleviated through revised reservoir management and/or volatilization with weirs upstream of town where the odor won't be a nuisance.

High total suspended solids and total phosphorus concentrations have been associated with discharges from Agassiz National Wildlife Refuge, or eroding ditches that drain to the river above and below Agassiz NWR.

The USDA Natural Resources Conservation Service *Erosion Sedimentation Sediment Yield Report: Thief and Red Lake Rivers Basin, Minnesota* states that "the major source of sediment yielded to streams and ditches is from streambank and ditchbank erosion (63 percent)." The study recommends the implementation of filter strips, field windbreaks, strip cropping and crop residue management. It also estimated that streambank stabilization and in-stream structural measures (cross-vane weirs) on the Thief and Red Lake Rivers could reduce sediment yields at Thief River Falls by up to 58 percent.

Recommendations from Plans
Red Lake Watershed District 10-Year Comprehensive Plan:
The planning team reviewed natural resource and flood damage reduction issues for each sub-watershed. In the Thief River subwatershed, the following natural resource issues were ranked "high":

1. River and ditch bank failures
2. Ditch 20 sloughing and erosion on laterals
3. Active erosion Section 1 Northwood Twp; MC TH 54 and bridge on Moose River
4. Ditch erosion
5. Overall sloughing and sedimentation
6. SD 83 sedimentation, bank erosion
7. CD18/30 bank sloughing
8. Sedimentation deltas Thief Lake, Agassiz, Elm Lake
9. Channel and streambank erosion

The following flood damage reduction issues were rated "high" for the Thief River watershed (the issues are ranked by priority):

1. Farmstead flooding
2. Farmstead ringdikes
3. Goodridge flooding
4. Ag land flooding
5. Overland flooding
6. Ditch 20 system problems (maintenance)

7. Ditch 20 to 200
8. Better maintenance on public systems; extensive ditch systems draining non-productive lands
9. Beaver problems
10. Thief River flows into Agassiz
11. Extended periods of high flow in Thief River (SD # 83); extended periods of low flow in TR; flashiness in flow from Agassiz to NWR

Agassiz National Wildlife Refuge Comprehensive Conservation Plan, Chapter 2 (excerpts):

Suggestions received by certain individuals during scoping that Agassiz NWR should be managed primarily as a flood control facility for the benefit of surrounding and downstream landowners contradicts the founding purpose of the Refuge and the spirit and mission of the National Wildlife Refuge System. For the interests of wildlife to be relegated to a secondary purpose of a national wildlife refuge or merely an incidental benefit of its presence would require Congressional or Presidential action…

Some people said that farmers on the west side of Agassiz NWR could benefit from small changes in water management. In the opinion of some people, a diversion ditch or a better (or repaired) outlet for the Refuge could prove to be a positive move. Analysis by flood control engineers has shown there would be little impact on downstream flooding from a diversion ditch or improved outlet. Some people said that Agassiz NWR staff should continue to participate in a comprehensive watershed management plan that brings together many diverse and sometimes conflicting parties and interests.

The major threat of flooding at Agassiz is the result of spring runoff of snowmelt following wet winters. Flood peaks are affected by the amount of moisture in the soil at freeze-up, amount of accumulated moisture at the start of the spring melt, and weather conditions during the spring melt. Spring and summer thunderstorms that drop more than 5 inches of rainfall on a single day occur occasionally and can cause severe flooding.

Flooding is one of the key issues affecting the Refuge – both its habitat and its facilities – as well as the neighboring region. Not only does flooding affect the Refuge and surrounding private lands, roads, and infrastructure directly, but it also has a big impact on relations between the Refuge and property-owners and officials in the surrounding community. Floods occur most often during March, April and May, when spring rains may combine with snowmelt to exceed channel capacity. The largest flood discharge ever recorded at the Thief River Falls gauge 15 miles downstream of the Refuge was 5,610 cfs in May 1950. During that flood an estimated 108,000 acre-feet of water was stored in the Refuge's various pools. During the 1997 flood event, inflows to the Refuge averaged 5,985 cfs for six consecutive days (April 15 to April 21, 1997). The average outflow at the Refuge was 808 cfs during the same time period, resulting in over

10,350 acre-feet of water put into storage on the Refuge per day, making a dramatic difference in reducing the level of flooding in downstream communities.

Agassiz NWR includes 26 impoundments (known variously as lakes, ponds, pools, or moist soil units) and three natural lakes. Whiskey Lake and Kuriko Lake are located in the Wilderness Area and Webster Lake is located in the northeast area of the Refuge. The artificial impoundments vary widely in size, ranging from 30 acres to the approximately 9,000 acres that comprise the Agassiz Pool. Water is contained within the impoundments by an extensive network of dikes, and water levels can be raised or lowered in any given impoundment by adjusting water control structures at pool outlets. Agassiz's impoundments with their marshes, mudflats, and open water are the dominant geographic features of the Refuge. They are also the focus of the Refuge's aquatic habitat management efforts on behalf of migratory birds.

The federal Conservation Reserve Program (CRP), administered by the USDA Farm Services Agency, pays farmers to keep marginal croplands out of production. Often these are sites with poor natural drainage that were wetlands prior to conversion to agriculture fields. Such areas are plentiful in flat northwestern Minnesota and readily lend themselves to being restored into wetlands, simply by plugging drainage ditches. For a number of years, Agassiz NWR staff have been engaged with numerous wetland restoration projects within the RMD. The year 2000 was an exceptionally active year in this regard. The Mississippi Headwaters/Tallgrass Prairie Ecosystem and Regional Office Refuges and Private Lands Offices had recognized the need to make CRP signups with wetland restorations a priority in Marshall County and other areas within 20 miles of Agassiz NWR. In a monumental undertaking that came to be known as "The Agassiz Adventure," 20 Service employees – including biological and engineering technicians, heavy equipment operators, biologists, Refuge operation specialists, and maintenance mechanics from 10 field stations – working over a period of 472 days, contacted 186 landowners, checked 1,031 wetlands, and restored 832 wetlands. This resulted in a total of 2,722 wetland acres restored. The following year, 45 Service employees assisted with the effort, surveying 924 basins on 548 properties and contributing to the restoration of 4,200 acres of wetlands. Little upland habitat restoration is requested off-Refuge, since these private farmlands are generally being used for agricultural production.

Agassiz NWR's water management program is very complex and involves 26 impoundments. Pools are frozen for about 5 months of the year, November to April. During periods of "ice-out," May to October, water management not only must balance competing considerations of wildlife and habitats on the Refuge itself, but it must deal with the requests of off-Refuge neighbors upstream and downstream as well as other township, county, state, watershed, and flood control agencies.

Regulating water levels – whether at maximum pool levels or in drawdown (emptying pools almost entirely of water) – is a vital management tool for waterfowl, shorebirds, and wading birds. Over the years, water management has been further complicated by increased land clearing, drainage and stream channelization on private lands upstream of the Refuge, which increase flood flows and sediment transport onto the Refuge. In addition, over the last 10 years the area has experienced an extremely wet cycle causing repeated severe flooding, which results in rapid pool level increase, or “bounce,” of two to three feet. Bounces during the breeding season negatively affect nesting efforts of many species. For instance, the June 11, 2002, event essentially wiped out a production year for many species. Managers must be cognizant of conditions throughout the watershed, exercise good judgment, and at times be willing to deviate temporarily from Refuge objectives when downstream cities and towns are experiencing extreme flooding events.

Agassiz NWR’s Marsh and Water Management Plan (1987) guides management of the Refuge’s marshes, open water, water levels and discharges. The plan states that production and maintenance of waterfowl are the primary objectives at Agassiz NWR, and that to fully achieve these objectives, a diversity of habitats must be provided to meet the life history requirements of waterfowl for nesting, brood rearing, and migration. The presence or absence of water, its depth, and the seasonal timing of water depth fluctuations are all manipulated to produce various stages of marsh habitats on which different water-dependent birds rely.

An annual marsh and water management plan is written every winter. This plan summarizes operations during the previous year, describes major water management problems, and documents construction and rehabilitation projects. It also identifies proposed pool elevations for the upcoming years along with stated objectives for each management unit. Agassiz Pool, by far the largest on the Refuge, serves as an example. Its spillway elevation is 1,141 ft. above mean sea level (MSL), its drawdown elevation is 1,136, it was last drawn down in 2000, and the next planned drawdown is in 2010. Objectives in 2001 were to maintain and reestablish hardstem bulrush and limit the increase of cattails by flooding out new plants

Refuge management is continually adjusting scheduled water manipulation in response to the vagaries of the weather or maintenance of water control structures. For instance, in 2002, spring runoff was insufficient to recharge eight pools that were in drawdown in 2001. Therefore, it was decided to keep the same pools in drawdown and continue to hold water in the six pools originally scheduled for a 2002 drawdown. Continual maintenance and repair of aging water control facilities such as gates, pilings, gauges, dikes, bridges, riprap, and channels are necessary to keep facilities and controls operable, and thus to meet water and marsh habitat management objectives.

In the early 1980s, five impoundments were developed in the Golden Valley and Goose Pen farm fields as moist soil units, which are valuable habitat for both waterfowl and shorebirds. Difficulties with managing water in these units led to their neglect from the late 1980s to the late 1990s, but in 1998 staff began a concerted new effort to manage them with frequent drawdowns timed to coincide with shorebird migration. All water control structures were replaced in 1999 and 2000 and burning and discing can be used when the units are dry enough to run a tractor across them. Annual outflows have a wide range of fluctuation at Agassiz NWR, depending on precipitation. Outflow can range from virtually zero discharge from the Refuge into the Thief River during dry years to over 300,000 acre-feet in wet years with one or more large storms. The largest annual outflow, since record keeping began in 1965, was 414,147 acre-feet in 1999.

There have been persistent flooding problems within the watershed, both upstream and downstream of the Refuge, and on the Refuge itself. Possible solutions have been investigated and explored for a number of years. One possibility, developed under the state-mandated flood reduction mitigation process, is construction of a diversion ditch leading from the southern boundary of the Refuge to the Thief River, along with upstream and off-channel storage. In conjunction with the diversion ditch located off Refuge, several water control structures would be enlarged or new ones installed on the Refuge from Agassiz to Headquarters pools, Headquarters to South pools, and South to Farmes pools. During flood events water from Refuge pools could theoretically be discharged faster after the flood peak, to the benefit of the Refuge and its marsh habitats and agricultural areas immediately downstream of the Refuge. It would also allow more flexibility in managing water on the southern half of the Refuge. At present, this proposal has not advanced beyond the concept stage, and it is not being considered in this CCP.

<u>Ideas for dealing with Thief River water quality problems*</u>

1. Conduct water quality studies (with a focus on turbidity) for three locations on the Thief River: Thief Lake to North side of Agassiz NWR, Agassiz NWR (all inlets and outlets will need to be continuously monitored) and Agassiz NWR to Thief River Falls.
    a. Turbidity levels vary greatly, both temporally and spatially within the watershed. Continuous monitoring is essential to understanding the movement of turbid water through the Thief River watershed and where high turbidity levels originate. This type of monitoring will show things that even daily spot monitoring can miss. TMDL or 319 Grant funding would be necessary to conduct this type of study.
2. Install a series of cross vane weirs in the Thief River near Agassiz NWR in order to stabilize the channel grade (reduce channel erosion) and aerate water in the winter. This action is recommended by the NRCS *Erosion Sedimentation Sediment Yield Report for the Thief and Red Lake Rivers Basin* and the *Hydrogen Sulfide Problems in Thief River Falls: Causes, Effects, and Possible Solutions* study by Brent Johnson. This project would be eligible for EPA 319 grant funding (administered by the MPCA) and the match to the grant money can be cost-shared among the Red Lake Watershed District, US Fish and Wildlife Service, Soil and Water Conservation Districts, and the City of Thief River Falls. Potential complicating factors: grade, flow volume (or lack thereof), State Ditch 83 conflicts, snowmobiling safety.
3. Install erosion control measures along other ditches, streams, and rivers. The NRCS erosion study recommends streambank stabilization along 33 miles of the Thief and Red Lake Rivers for a 58 percent reduction in sediment yields. The cost of this was estimated at $8.7 million in 1996. So, the cost to do all that is recommended will be too high, we could chip away at this goal a little at a time. This can be done using methods of bank stabilization that do not impede flow.

4. Conduct a survey of erosion sites using GPS equipment and erosion site evaluation forms so they may be mapped and prioritized.
5. Possible Goal: Reduce turbidity levels on the Thief River at TRF by 20 percent
6. ”Accelerate the application of conservation tillage, crop residue use, field shelterbelt, and filter strips on two-thirds of the cropland (150,000 acres)” - NRCS *Erosion Sedimentation Sediment Yield Report for the Thief and Red Lake Rivers Basin.*

*These ideas are based upon study findings and brainstorming – they are not currently part of any official plans or goals.

Agassiz NWR Management Recommendations:
Goal: Restore and enhance a natural landscape within the Refuge and its seven-county Management District to emulate naturally functioning watersheds and habitats within the tallgrass prairie, prairie pothole, aspen parkland, and northern coniferous forest, including habitat corridors for wildlife.

Open Water / Mudflat Conversion:
Beginning in 2005, experiment with decreasing open water / mudflat habitat by 400 acres in Webster, Kelly and Upper Mud River Pools by converting portions to sedge habitats and restoring streams to a more natural watercourse for species such as LeConte’s Sparrow, Sedge Wren, Nelson’s Sharp-tailed Sparrow and the Yellow Rail.

Rationale:
Open water and mudflat habitats are much more abundant on the Refuge than sedge meadow, hence the intent to augment sedge acreage. Sedge meadows constituted more than three-quarters of Minnesota’s original wetlands and were indispensable habitat for plants like lilies, irises and native orchids. Moreover, LeConte’s Sparrow, Sedge Wren and Nelson’s Sharp-tailed Sparrow are all Regional Conservation Priority species and the Yellow Rail is both a Regional Conservation Priority species as well as a species of State Special Concern.

Strategies:
1. Place Webster Creek, Kelly, and Upper Mud River Pools in drawdown to create
2. conditions appropriate for sedge growth.
3. Monitor extent of sedge habitat annually by visual inspection, aerial overflights and GPS mapping. Use digitized geo-referenced aerial photography and GIS spatial analyses to track long-term trends.
4. Monitor for invasion by reed canary grass and Phragmities.
5. Stay abreast of research developments, experimental efforts, and pilot projects elsewhere in the state with regard to restoration of sedge meadow habitat.

6. Evaluate results after 5 years for success. If successful, explore removing water control structures and portions of dikes where feasible. If sedge establishment fails, management should return the pools to deep marsh habitat.

Goal: Manage water impoundments as a complex of basins to provide wetland diversity for maximum benefits to migrating and breeding birds. Management will be within the capabilities of the wetland system as a whole and individual impoundments will be drawn down on a 3- to 10-year rotation.

Rationale:
Water level manipulation allows managers to simulate different stages of the natural flood/drought cycle at the same time in different impoundments. This increases the diversity of habitat types and food resources in the wetland complex that is available to migrating and nesting birds. The emphasis is on semi-permanent wetlands as these wetlands can be the most productive type for marsh nesting birds. The larger impoundments on Agassiz NWR provide a wide diversity of habitats within each impoundment. Management can increase this diversity by varying the water regime in nearby impoundments. The outcome will be interspersion of cover and openings for dabbling duck and marsh bird pair and brood habitat, open bays and medium density cover for diving duck broods, and post breeding/molting habitat.

Strategies:
1. Agassiz Pool (9,350 surface acres) will be in drawdown once every 10 years. The emphasis is on maintaining the hardstem bulrush plant community which is the most desirable for the nesting colony of Franklin's Gulls.
2. The six small Golden Valley and Goose Pen impoundments (normal summer pool 25 to 52 surface acres in size; total 218 acres) will be in a drawdown cycle of 3 years with burning and mechanical treatments of mowing and discing.
3. Sixteen other impoundments totaling 16,276 acres will be staggered in a drawdown cycle of 4 to 6 years. The emphasis is on maintaining openings in cattail areas. Burning will be prescribed to occur during the drawdown phase. If the natural watercourse trial objective is not successful in establishing sedge meadow habitat in the 3 impoundments, they will be added to this strategy (total 1,300 acres).
4. Provide stable water levels from May 1 to July 15 in a variety of cover types for
5. Over-water nesting birds and to prevent flooding of upland nests.
6. Lower water levels 6 to 12 inches in some impoundments during the fall to provide shallow foraging sites for migrating waterfowl.
7. Maintain sufficient depth of water during the winter for minnow survival to maintain food resource for piscivorous (fish-eating) birds and for muskrat survival to increase openings in cattail.

Agassiz National Wildlife Refuge Operating Needs (Highest Priority):

<u>Ditch 11 Dike Rehabilitation (East & West of Agassiz Pool).</u>

Water management is the most important tool used to control wetland vegetation, providing critical habitat for birds and mammals at Agassiz NWR. In 1909, the Judicial Ditch No. 11 Drainage System was excavated, disrupting the natural flowage pattern of 609 square miles of the Thief River Subwatershed. Even today, this 455-mile ditch system is the largest single human-made impact on habitats within the Refuge. Waters entering the 1,500-acre Refuge from this system directly affect every wetland acre and the associated infrastructure. During a spring flood in 1996, waters from this system contributed over 12,000 acre feet of water daily for 9 consecutive days.

In 1937, the establishment of the Agassiz NWR voided the easements for all roads, except County Road 7, and ditches and placed the responsibility for management and maintenance of these facilities on the Service. Ditch 11, both the ditch and associated dikes formed from the original spoil banks, affect wetland management in two basic ways.

The ditch facilitates water flow into, within and out of the Refuge, all of which can contribute to the success and failure of management goals. The dikes form the foundational infrastructure for pool definition and wetland characteristics. Despite the historical or any futuristic effects the ditch system has had or could have on Refuge habitats, current management of the Refuge is based on it continuing to function.

Human failure to complement natural hydrologic water physics has resulted in continuous maintenance of ditches and dikes, especially those associated with Ditch 11 within the Refuge boundary. Although there are signs where natural hydrologic forces are trying to reclaim landscapes along a majority of Ditch 11, the area that appears to be closest to catastrophic failure due to slumping of dike slopes is downstream (west) from the main Agassiz Pool control structure. This 2.5-mile segment affects dikes associated with two pools (Parker and Madsen) totaling 5.0 miles of dike. Test borings indicate that the foundation of the dikes shows signs of deep pivoting, which could result in total loss of the dikes. This would be devastating to the habitats of both pools. The rehabilitation of the dikes is needed to preserve traditional wildlife goals of the Refuge. Without needed repairs both the capability of manipulating pool elevation and ability to isolate the pools from major floods will be lost. The cost of thousands of acres of destroyed prime wetlands habitat is incalculable.

Efforts to find cost effective solutions yet keep existing dikes within the current footprint began in 1999. In 2001, nearly $400,000 was spent to repair seven of 14 major slumps. Some of the slumps cost nearly $400/foot when pilings were installed based on soil compaction tests. The June 2002 flood event caused further extensive damage to both dikes. The estimated cost to repair the 5 miles of dikes west of Agassiz Pool using the piling method is $10,000,000. Currently we plan to complete soil compaction surveys of the entire dike and based on results seek a more cost effective solution – such as moving the dikes and ditch, lowering the dikes, etc.

2004 Red Lake Watershed District Investigative Sampling:
Effect of Water from Agassiz Pool on Water Quality in the Thief River:
In the spring of 2004, the RLWD received advance notice that Agassiz National Wildlife Refuge would be releasing water into the Thief River from its main pool. Although it is not the only major source of pollution on the Thief River, spring and fall releases of water from Agassiz NWR have been associated with poor water quality – in the form of high total phosphorus, total suspended solids, and turbidity levels. Water in the Thief River is visibly thick with organic matter and there are numerous chunks of cattails floating down the river when the refuge is releasing water at a high rate of flow. To examine and document how water quality is affected by these discharges, samples were collected on April 5th, 12th, 14th, and 15th, and 19th of 2004. Samples were collected upstream of the refuge at Marshal County Road #6 and downstream of the refuge at Marshall County Road #7. Agassiz NWR began discharging at a rate of 100 cubic feet per second (cfs) and increased the discharge daily until a level of 500 cfs was reached and sustained. Samples were analyzed for total phosphorus (TP), orthophosphorus (OP), total suspended solids (TSS), and total dissolved solids (TDS). Field measurements of dissolved oxygen, pH, conductivity, temperature, turbidity, and transparency were also collected.

The April 5th sample was collected as a regularly scheduled sample for the RLWD long-term monitoring program and was collected prior to the release of water from Agassiz Pool. The results of this sample were not bad, especially considering the fact that the samples were collected during the spring runoff season.

The April 12th – 19th samples were collected while Agassiz was discharging. The average TSS and turbidity levels at CR #7 were more than twice as high as those at CR #6. When we sampled the 500 cfs flow, the refuge had been discharging at this rate for several days.

The TSS levels were similar on this day, which implies that once a moderate, steady flow is reached, the increased sediment loads from Agassiz begin to diminish. They are still high, but not a lot higher than what is already in the river. TDS levels, as expected, remained at a normal level and were not affected by the discharge from Agassiz NWR. Total Phosphorus increased downstream of Agassiz NWR vs. upstream but orthophosphorus was very low and did not change from upstream to downstream. This implies that the increase in phosphorus levels comes from an increase in organic phosphorus found in particulate organic matter and suspended sediment. The high amount of suspended, decaying plant matter was very noticeable.

The Mud River flows into Agassiz NWR and its contribution was overlooked during this sampling. Any increases in TSS or TP may be partially caused by the Mud River. However, normally, when the Mud River comes into Agassiz NWR, the flow dissipates because the channel going through Agassiz NWR is no longer functional. When this happens, sediment and nutrients are deposited on the east side of the pool.

This investigative sampling focused on Agassiz NWR, but Agassiz is not the only source of pollution along the Thief River. Although water quality decreases in the Thief River from upstream of Agassiz NWR to downstream of Agassiz NWR, the water quality in the river also decreases from Agassiz downstream to the Hillyer Bridge monitoring site north of Thief River Falls. The majority of sediment in the river comes from channel erosion. Large spikes in flow facilitate this erosion.

There were several questions raised by this investigative monitoring that may require more intensive monitoring and research to answer. What is the impact of the Mud River upon water quality in and leaving Agassiz Pool? Could the relatively high level of flow into Agassiz during the 2004 discharge increase the amount of bottom material that was suspended and carried downstream from the refuge? Can the Agassiz operating plan be altered to attempt to achieve as steady and as moderate an outflow as possible? Can the operating plan be altered with measures to keep the Thief River below bank-full stage if possible? Is there a way that water can be released from Agassiz without severely impacting water quality? Do TSS, turbidity, and TP concentrations begin to decrease as a particular level of flow is maintained for a while (April 19th), or does the pool simply begin run out of loose sediment to flush out of the outlet (or both)? Does the amount of time since gates were adjusted (flow increased) have an effect on water quality results?

Appendix 7

Summary of December 2005 Impoundment Meeting

MARSHALL COUNTY WATER RESOURSE ADVISORY COMMITTEE
December 15, 2005
Thief River Water Quality Issue – the Basin Perspective
Meeting Notes

Meeting Purpose:
The purpose of this Task Force Meeting is to develop an inventory of water impoundments in the Thief River Watershed, in order to help resource managers understand water management as an aspect of water quality of the Thief River.

Presentations and Background Material
Agassiz National Wildlife Refuge, MN DNR and Red Lake Watershed District summarized information about impoundments managed or built by the respective agencies; a summary of those forms is attached. Each agency presented information about operations of the impoundments. Questions and discussions about the presentations are below. The presentations are available on-line at the Red Lake WD website, under presentations.

Red Lake WD Presentation
- For the Lost River Channel for the impoundment, has water ever gone over the emergency spillway. Do you have problems getting the water into that or why aren't you getting volumes into that?
- What is the input from Ditch 200?
- How much is considered runoff and how much is considered storage? Does water move slower over water than land? How does pool storage differ than ag land storage? When does it become runoff? Discussion on crest.
- What progress has been made on building impoundments?

Agassiz National Wildlife Refuge Presentation - FWS
- How has the amount of water changed going into the impoundments?
- Has the precipitation changed over the years?
- Is there more water coming into Moose Impoundment and therefore washing out.
- How is storage planned for? There is decreasing storage area due to sediment build up. What do we do about life expectancy of the pools?
- Destabilization – has it been contributing to the backside water held?
- By losing open water, are we losing flood control? (wildlife standpoint want open waters for cattails)
- Is there more transpiration at Red Lake than water release (what is the water budget?
- Address hydrogen sulfide. P. 51 of the Agassiz plan states that the Agassiz NWR communicates with downstream entities; TRF city has worked with Agassiz NWR; hard to manage for extra heavy snowfall in winter; considering aeration system in Ditch 11
- How can communities communicate on the release of waters?
- How can you predict events like in 1997?

- Are spoil banks at Ditch 11 a source of sediment? backside of ditch is wet? Engineers say it is because of the changing water levels in the ditch. As water table rises (fluctuates – it's the up and down that is the problem?), the bank destabilizes
- Unstable banks contributing sediment to ditches is a problem for many FWS refuges; managing sediment is their biggest issue.
- Red Lake – head Rapid River used to be wide open water, 30-40 acres;
- settlers left in 1937 – same as Agassiz – it's all cattails – Red Lake is a desert for wildlife.
- Hybrid cattail is harder to manage
- Gary: we are considering reaeration on ditch 11. ND is concerned about hydrogen sulfide (Nate Dalager? North Dakota?)

<u>Thief Lake Wildlife Management Presentation- DNR</u>

Thief Lake is a natural lake basin; dredged between 1914 and 1916 (spoil banks are still evident); it's 7100 acres in size; 15th largest lake (in the state?); inlet is Moose River; outlet is Thief River. Dam installed in 1931; lake did not fill till 1937; it's a very large wetland restoration – max. depth is 4 feet;

Operations coordinated with Agassiz NWR, also with Red Lake WD and the Moose River impoundment.

Operating objectives:

- Maintain streamflow
- Released ramped for wildlife needs
- Some runoff exceeds downstream channel capacity

June 2002 was the biggest event

There are several other smaller impoundments – six to 10 acres in size; five moist soil units with water control that are 8 – 19 acres in size

Monitoring: wildlife surveys – aerial in the fall; spring breeding pairs production; invertebrate sampling; anthropod (?); smaller lake surveys; 10 year basis – vegetative, water quality and invertebrate sampling; lake level and discharge

Sediment photo showing moose river deposit into Thief lake – presented for Eckvoll (which was supposed to be dry but within two years it was wet); Farmes; Lost River; Moose River; East park (aka Nelson slough)

- What is cumulative storage?
- What is the purpose: wildlife or storage?
- How did the elevation of the spillway increase?
- Was the elevation of the lake raised?
- What was the concern for safety aspect of the dam?
- Summer elevation of Farmes Pool?

Concerns:

- Sources of sediments
- Where flooding occurs
- Coordination of operations
- Primary outlets out of impoundments need maintenance
- Water quality monitoring
- Ditch maintenance

Afternoon Small Group Discussions Reports:
What are the three most issues heard today and what are we going to do about it?
Can you have wildlife and flood control and be successful?

Group 1:

- Coordinate between impoundments for releases
- Look at downstream levels
- Uncontrolled runoff – this is the problem that downstream is being flooded when upstream is being released.
- Understanding the dynamics of sediment movement from ditches to impoundment
- Need continuous monitoring (Corey has an idea of how to do this – measure the turbidity plume into the reservoir?)
- Need a sediment budget for each impoundment – timing of each
- Flow monitoring and sediment monitoring would be necessary – start at Thief Lake.

Group 2:

- Sediment loads – Solution: prevent amount of land coming into refuge pools and settling
- Source of sediment is not just from impoundments: solution – buffer strips are just voluntary now
- Long term plan (need for one?)
- Ditch – scheduled maintenance and design (contribute to sediment loading?)
- Land uses – land coming out of CRP
- One impact the others even though different goals
- Conflict in management

Group 3:

- Want to see cooperation among agencies
- Manage to the benefit of landowners
- We have more storage than place in northern MN (?)
- Does water management create the sediment problem? Are the artificial ditch banks on the Thief River a sediment source?
- What is the rate of flow that produces sedimentation?

Next Steps:

1. Summarize meeting and discussion
2. Map impoundments and problem areas
3. Develop sediment budgets

Appendix 8

Memorandum Agreement from the Marshall County Water and Land Office

MEMORANDUM OF AGREEMENT

Purpose:
This Memorandum of Agreement between the Marshall County Water and Land Office (Water Plan Coordinator), the Minnesota Pollution Control Agency and the Red Lake Watershed District is to provide staff time and expenses as a partner in the Clean Water Partnership Resource Investigation Grant for the Thief River Watershed.

Grant Project: **Thief River Watershed Sediment Investigation**

Total Project Costs: $193,000

Partners:
Funded by: Minnesota Pollution Control Agency, Red Lake Watershed District

In-Kind Contributions: Marshall County Water Plan, U.S. Fish and Wildlife Service, Pennington County SWCD Water Plan, MN Department of Natural Resources

Agreement Period: February 12, 2007 through February 12, 2010

Marshall County Water Plan Project Annual Budget (3-Year Project)			
	Grant	In-Kind	Total
Water Quality Monitoring and Assessment	$5900	$5900	$11,800

Sites monitored: Seven (7) sites in the Thief River Watershed in Marshall County: Moose River (Sites X4, X5), Thief River (Sites T1, T2), Mud River (Site D6), SD 83 (Site SG140), and JD11 (Site 6)

Responsibilities:
Marshall County Water and Land Office will allocate approximately 198 hours per year to the project. Technical assistance of approximately 28 hours per year may be contracted to Marshall-Beltrami SWCD for assistance with stream monitoring. Marshall County Water and Land Office will provide a 50% in-kind match to grant dollars received for the 3-year project. Reports and invoices for staff time, lab fees, supplies and other fees will be submitted and payments received through the grant administrator, Red Lake Watershed District.

APPROVED: MARSHALL COUNTY BOARD OF COMMISSIONERS

Sharon Bring 8-21-07

CHAIRPERSON, DATE

Appendix 9

Field Data Sheets

RED LAKE WATERSHED DISTRICT STREAM FIELD SHEET

Individual Observers-First and Last Names : ______Corey Hanson______

Sonde S/N: Eureka Manta___________

Handpad S/N: Eureka Amphibian

Turbidimeter S/N: HACH 2100P_________

FIELD INFO.	A	B	C	D	E	F	G	H	I	J
SITE ID										
DATE										
TIME (military)										
Sample #										
STAGE: Surface*										
Stream Water Depth*										
Sample Depth Goal*: 50% of water depth										
Actual Sample Depth*										
GAGE TYPE*										
Appearance: 1A-clear; 1B-tea-colored; 2-cloudy; 3-muddy; 4-green; 5-muddy & green										
Appearance:										
Recreation Suitability: 1-Beautiful; 2-Excellent body contact; 3-Body contact impaired; 4-no swim/boating OK; 5-recreation nearly impossible										
Recreation Suitability:										
StreamCondition* H-N-L or NoFlow										
Rain Event (Y/N)*										
T-Tube Reading 60 cm : First / Final AVG *(Circle which tube used if it is greater than 60cm)	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120	__/__ 100/120
Water Temp °C										
Conductivity (uS/cm)										
DO (% Saturation)										
DO (mg/l)										
pH										
Turbidity (NTUs) Hach 2100P *										
Turbidity (FNUs) Eureka Manta Sonde *										
SAMPLE DEVICE* (Van Dorn / or see instructions)										
SAMPLE TYPE* (Grab)										
QA* (Field Dup)										

* See back of sheet for additional instructions/information

Observer(s):____ **Date:** ____________________

FIELD NOTES: station name/location, vegetation status (leaf out, cropping, harvest), land use, erosion, wildlife, general phenology, wind, cloud cover, recent precipitation, ice condition, picture #, foam, any floating or suspended matter in sample or stream, etc.
Also record here if NO FLOW.

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	

* **See back of sheet for additional instructions/information**

ADDITIONAL INSTRUCTIONS

PROJECT NAME
Write down project this data is being collected for: for river watch enter: **REDRWTCH** (Other examples: Red River Conditon, FDR , etc…)

SAMPLE TYPE	ABBREVIATION	DEFINITION
Grab	G	Sampling vessel or bottle filled at one point in water column and cross section of a waterbody
Composite-F	CF	Flow-weighted with auto-sampler
Composite-M	CM	Samples from multiple locations on a waterbody, combined w/churn splitter (describe in comments)
Composite-O	CO	Composite – Other (describe in comments)

FIELD CODE OR STREAM NAME
If this is an unestablished site and you want the site established and data entered in STORET, please supply GPS coordinates and station description/location. Note these in the field observation section.

QA
FD = Field Duplicate, SB = Sampler Blank, TB = Trip Blank, BB = Bottle Blank, RB = Reagent Blank

STAGE (feet):
Stage is a measurement of the elevation or level of the water surface. It is determined by reading a staff gage, recording gage, wire-weight gage, or by subtracting a tape down measurement to water level from a fixed measuring point elevation or reference point (RP). The gage type abbreviation below should be entered into the front of the field sheet under Gage Type. Note in "field observations", any unusual conditions that affect the measurement (debris around the staff, wind catching the tape, standing waves, etc.) **Depth to Bottom:** is the measurement from the RP to the stream bottom. **Stream Water Depth:** depth to Bottom minus Stage. **Sample Depth Goal:** half or 50% of the stream water depth. **Actual Sample Depth:** is the depth at which the sample was actually collected.

GAGE TYPE	ABBREVIATION	DEFINITION
USGS Staff or Wire Weight	U-R	USGS outside reference gage, such as staff or wire-weight, at an active gage
Tape-down from RP Tape-down from known Elevation	TD	Measured distance to water level from established reference point (RP) on bridge or other structure. Tape-down to water level subtracted from established measuring point elevation (describe in comments)
Other Staff or Wire Weight	R	Outside reference gage, such as staff or wire-weight, that is maintained by a non-USGS agency (describe in comments)

STREAM CONDITION
This refers to the relative amount of water flowing in the stream channel.
L = Low: Water covers 1/3 or less of the distance from the stream bottom to the top of the bank.
N = Normal: Water covers 1/3 to 2/3 of the distance from the stream bottom to the top of the bank.
H = High: Water covers 2/3 or more of the distance from the stream bottom to the top of the bank.
NF or No Flow Water is not flowing. May be dry or water present in pool. Water quality readings may or may not be taken.

RAIN EVENT (Y/N)
Put a "Y" in the "Rain event" column if you are sampling in response to a significant rainfall event (over 1" in previous 24 hour period; an "N" if you are taking your weekly or monthly stream measurements.

SAMPLING TURBIDITY
When sampling turbidity use your YSI sonde, otherwise you can use the HACH 2100P Turbidimeter to measure turbidity (**ONLY USE ONE**).

SAMPLING DEVICE

ABBREVIATION	STORET CONFIG ID	NAME
VD		Van Dorn Type Sampler – Bottle type sampler with trip for closing ends.
None		Sample collected directly into sample bottle (hand dip)
SIM	SIMPLE	Simple Open Plastic Bucket
ROD	ROD	Telescoping Rod with Bottle
ICE1	ICE 1	Ice Conditions Water Sampler (straight rod with bottle attached to lower through ice)
DI		Depth Integrating (USGS type)
WB	WEIGHTED	Weighted Bucket with Cover (aka triple sampler, "labline")
AS		Automatic Sampler
Other		Another type of sampler (describe in notes)

* **See back of sheet for additional instructions/information**