REDWOOD – COTTONWOOD RIVERS CONTROL AREA

Middle Minnesota Major Watershed;
First Order Streams of Redwood and Brown County

Diagnostic Study and Implementation Plan

JUNE 2011

Submitted by the RCRCA

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This implementation plan was written by the Redwood-Cottonwood Rivers Control Area (RCRCA), with the assistance of the Advisory Committee, Technical Committee, and guidance from the Minnesota Pollution Control Agency.

Table of Contents

RCRCA Board of Directors i
Project Staff Directory ii
Executive Summary iii

Chapter 1. Introduction and Project Background 1
Introduction 1
History of Area Watersheds 2
Project History (Middle Minnesota Watershed Activities) 3
Middle Minnesota Major Watershed: First Order Streams of Redwood and Brown County 8
Why the Project is Taking Place 8
Who is Involved in Carrying out the Project 9
Project Staff Directory 11
Final Project Budget 12
Project Milestones 13
Chapter 2. Methods 14
WATER QUALITY MONITORING 14
Monitoring Season 16
Monitoring Season Description 16
2009 16
2010 16
Water Quality Monitoring Equipment 17
Field Equipment 18
Sampling Methodology 18
QUALITY ASSURANCE – QAPP REVIEW 19
Quality Assurance 19
DATA MANAEMENT, STATISTICS, AND MONITORING TECHNIQUES 20
Flow Conversion and Data Management 20
Discharge Ratings 20
Water Sample Analysis 20
Loading Rates, FLUX Calculations, and Flow Weighted Mean Concentrations 21
Runoff and Normalized Yield 22
Ecoregion Assessment/Water Quality Standards 23
WATERSHED ASSESSMENT and MODELING 26
Geographic Information Systems (GIS) 26
Load Duration Curves (LDCs) 26
Sediment and Nutrient Modeling 28
Tailored Integrated Stream Watershed Assessment (TISWA) 29
Soil and Water Assessment Tool (SWAT) 30
Fishery Surveys 30
Description of Sampling Sites 31
MMCC 31
MMWC 31
MMNE 32
MMSC 32
COD13 33
COD10 33
Chapter 3. Description of Project Area 34
General Summary 34

Middle Minnesota Major Watershed: First Order Streams of Redwood and Brown County 34
Crow Creek *35*
Wabasha Creek *36*
North Eden Creek *36*
Spring Creek *36*
Brown County Ditch #13 .... *36*
John's Creek/Brown County Ditch #10 .... *37*
Topography 37
Hydrogeology 40
Land Use 42
Soils 45
Feedlots 49
Crop Residue Survey Results 50
Fertilizer/Pesticide Use 50
Corn *51*
Soybeans *51*
Drainage 51
Precipitation 53
Runoff 55
Wetlands 55
Lakes 58
Protected Waters and Shoreland Classifications *58*
Community Water Supplies 59
Population 60
Landfills/Dumps 61
Permitted Withdrawal Permits 61
Hazardous Waste Sites 61
Official Historical Sites 61
Unique Features and Scenic Areas 62
Stream Classifications 64
Wildlife Management Areas 65
Scientific and Natural Areas 65
Chapter 4. Results and Discussion 66
Sampling Results 66
Fishery Surveys 72
Hindeman (Spring) Creek (trout stream portion) *72*
John's Creek (trout stream portion) *73*
Tailored Integrated Stream Watershed Assessment (TISWA) 73
Results of TISWA Survey 74
RUSLE Results 76
FLUX Results 77
Assessment of Water Quality 77
Crow Creek (MMCC1) 78
Wabasha Creek (MMWC) 79
North Eden Creek (MMNE) 80
Spring Creek (MMSC) 80
County Ditch #13 (COD13) 81
County Ditch #10 (COD10) 82
Summary of Pollutant Loads 82
Chapter 5. Conclusions and Goals 83
Goals 84

Crow Creek *87*
Wabasha Creek *87*
North Eden Creek *88*
Spring (Hinderman) Creek *88*
Brown County Ditch #13 .... *89*
Brown County Ditch #10 (John's Creek) *89*
Chapter 6. Implementation Plan 91
Introduction 91
Goals and Objectives 92
BEST MANAGEMENT PRACTICE (BMP) ALTERNATIVES and ANALYSIS 93
Nonpoint Source Management Measures, Alternatives, and Analysis 93
Livestock Waste Management/Manure Management *93*
-Feedlot fixes *94*
-Feedlot inspections *94*
-Level III land application inspections *94*
-Development of manure management plans (MMP) *94*
Pasture Management *95*
Structural Practices *96*
-Terraces *96*
-Water and sediment control basin *97*
-Streambank and shoreland protection/restoration *97*
-Diversion *98*
-Grade control structure *98*
-Rock inlets *98*
Vegetative Practices *98*
-Wetland restoration *98*
-Filter strips, grass buffers, and riparian buffer strips *99*
-Grassed waterway *99*
-Nutrient management *99*
-Residue management *100*
-Contour farming *100*
-Urban practices *100*
Point Source Management Measures, Alternatives, and Analysis 101
Subsurface Sewage Treatment Systems (Septic Systems) *101*
Municipal Sewage Control *102*
MS4 Communities – Stormwater *102*
National Pollutant Discharge Elimination System (NPDES) Livestock Facilities *102*
BMP Selection and Justification 102
Priority Management Areas 104
Adaptive Management Process – Implementation, Monitoring, and Evaluation 106
Evaluation *107*
Water Quality Monitoring *107*
Program Evaluation *107*
Roles and Responsibilities of Project Partners 108
Redwood-Cottonwood Rivers Control Area (RCRCA) *108*
Soil & Water Conservation Districts (SWCD) and County Environmental Services (CES) *108*
Farm Service Agency (FSA) *109*
Board of Water and Soil Resources (BWSR) *109*
AREA II Minnesota River Basin Project, Inc. (AREA II) *109*
Natural Resources Conservation Service (NRCS) *109*
Department of Natural Resources (DNR) *109*

Southwest Research and Outreach Center (SW-ROC)/University of Minnesota Extension *109*
Minnesota Pollution Control Agency *110*
Minnesota Department of Agriculture (MDA) *110*
Counties (Brown, Redwood) *110*
BMP Operation and Maintenance Plan 110
Information and Outreach Program 110
Media *111*
Materials *111*
Publications *111*
Legal Authorities and Permits Required for Completion of Project 112
Identification and Summary of Implementation Objectives and Action Items 113
Milestone Schedule 120
Implementation Plan Budget 121
References 124

Appendices:
Appendix A – Excerpt from the Middle Minnesota River in Redwood and Brown Counties CWP Diagnostic Project QAPP 127
Appendix B – Excerpt from MPCA – Guidance Manual for Assessing the Quality of Minnesota Surface Waters 151
Appendix C – Initial Site Survey 159
Appendix D – Monitoring Data 166
Appendix E – TISWA Material 238
Appendix F – Fishery Surveys 242

Figures:

Figure 2-1: Crow Creek Flow Duration Curve Daily Mean (2009 – 2010) 27
Figure 3-1: Cross Section of the Minnesota River Valley 39
Figure 3-2: Glacial River Warren and Major Moraines @11,000 y.a. 40
Figure 3-3: Average Annual Precipitation 53
Figure 3-4: 2009 and 2010 Growing Season Precipitation 54
Figure 4-1: Turbidity Mean vs. Median 72

Tables:

Table 1-1: Project Revenue Summary 11
Table 1-2: Final Project Budget 12
Table 1-3: Milestone Schedule 13
Table 2-1: Monitor Parameter Summary 15
Table 2-2: Water Quality Reporting Units and Analytical Methods 17
Table 2-3: Water Quality Sample Requirements and Analytical Methods 21
Table 2-4: Interquartile Range of Concentrations for Reference Streams in Minnesota by Ecoregion. Distribution of Annual Data from 1970-1992 24
Table 3-1: Watershed Area by County 35
Table 3-2: Subwatershed Area by County 37
Table 3-3: Land Use in the Project Area 44
Table 3-4: Erodible Soils by Subwatershed 48
Table 3-5: Livestock Animal Units (AU) 50
Table 3-6: Crop Residue Survey 50
Table 3-7: Precipitation Totals from April to September, 2009 54
Table 3-8: Precipitation Totals from April to September, 2010 55
Table 3-9: Wetland Acreage 56
Table 3-10: Drained Wetland Acreage Determined by Soil Characteristics 57
Table 3-11: Major Lake/Wetlands 58
Table 3-12: Population Calculations 60
Table 3-13: Landfills/Solid Waste Centers 61
Table 3-14: Species of Concern in the Middle Minnesota Project Area 63
Table 3-15: MPCA Stream Classifications 64
Table 3-16: Wildlife Management Areas 65
Table 4-1: MMCC1 Summary of Monitoring Data (2009-2010) 66
Table 4-2: MMWC Summary of Monitoring Data (2009-2010) 67
Table 4-3: MMNE Summary of Monitoring Data (2009-2010) 68
Table 4-4: MMSC Summary of Monitoring Data (2009-2010) 69
Table 4-5: COD13 Summary of Monitoring Data (2009-2010) 70
Table 4-6: COD10 Summary of Monitoring Data (2009-2010) 71
Table 4-7: RUSLE Results 77
Table 4-8: Watershed Loadings Average Yield 77
Table 4-9: Watershed Loadings 77
Table 5-1: Water Quality of Minimally Impacted Streams in the Western Corn-belt Plains 85
Table 5-2: Study Findings Compared to Ecoregion Values (75th percentile) 86
Table 5-3: Flow Weighted Mean Concentrations 90
Table 5-4: Reductions to Meet Goals 90

Maps:

Map 1-1: Middle Minnesota – Monitored Watersheds in Redwood and Brown Counties 5
Map 1-2: Middle Minnesota Major Watershed 6
Map 1-3: Middle Minnesota Watershed Monitored Watersheds 7
Map 2-1: Minnesota’s Seven Ecoregions. Mapped by USEPA. 24
Map 3-1: Study Area Map 35
Map 3-2: Elevation Map 38
Map 3-3: Geologic Sediment Associations Map 39
Map 3-4: Groundwater Contamination Susceptibility in Minnesota 41
Map 3-5: Presettlement Landuse 42
Map 3-6: Landuse in the Middle Minnesota Project Area 43
Map 3-7: Minnesota Soil Suborders 46
Map 3-8: Erodible Soils 48
Map 3-9: Livestock Facilities in the Middle Minnesota Project 49
Map 3-10: National Wetland Inventory – Wetlands 56
Map 3-11: Areas with Soil Type Characteristics of Drained Wetlands 57
Map 3-12: Community Water Sources 60
Map 4-1: TISWA Survey Results 75
Map 4-2: TISWA Survey Results – Normalized 76

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June, 2011

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Executive Summary

The Minnesota River currently does not meet federal water quality standards and is a major source of pollution to the Mississippi River, Lake Pepin, and ultimately, the Gulf of Mexico where hypoxia of coastal waters continues to be an issue. The first order streams in this project area need to be protected and enhanced to ensure their water quality standards are aiding in TMDL goals and accomplishments in the Minnesota basin. The overriding goal of the state of Minnesota is to restore the Minnesota River to a resource that is fishable and swimmable. Recommendations for reduction in the Minnesota River watershed, based on modeling scenarios put forth in the preparation of the Minnesota River Turbidity TMDL, are for fifty percent turbidity (mostly sediment) and phosphorus.

The purpose of this study was to document factors affecting sediment and nutrient transport in the smaller first order tributaries to the Minnesota River in Brown and Redwood counties, and determine reductions necessary to meet water quality goals. The study has defined the standards and reasoning used to determine the reductions needed and the characteristics of the pollutants and their transportation methods within the watershed. Priority management areas were selected based on contributions of pollutants relative to each of the separate reaches in the study.

The project area consists of 159,935 acres of Middle Minnesota Watershed between the outlets of the Redwood River and the Cottonwood River draining portions of Brown and Redwood counties in south-central Minnesota. This area consists of first order streams: Crow Creek, Wabasha Creek, North Eden Creek, Spring Creek, Brown CD #13 and Brown CD #10. These streams generally orient from southwest to northeast as they drop into the Minnesota River valley to meet the Minnesota River. This area has been included by designation as a part of the Middle MN River Basin but for the most part been overlooked by major watershed initiatives. The Brown-Nicollet-Cottonwood Board had contributed to work in the area by providing low interest loans for the area for non-compliant SSTS systems and had been meeting with some landowners to implement continuous CRP buffers along ditches and tributaries. This project expanded those efforts in conjunction with establishing six long term monitoring sites that enabled the project to develop an implementation plan prioritizing each of the watersheds and devising best management practices geared to maintian or improve water quality and keep these first order streams off of the 303d list.

There are three general topographic features of the six streams involved in the project: the plains, the Minnesota River bluffs/transition, and the Minnesota River floodplain. A majority of the watersheds are nearly level to flat with poorly drained soils formed from glacial till. About eighty-seven percent of the watershed area formed in glacial till, seven percent by alluvium and colluvium processes, .28 percent due to outwash, and .5 percent is down to bedrock. A further four and a half percent of the project area is considered the Minnesota River terrace. As each stream nears the Minnesota River it transitions through the steep bluffs of the south side of the Minnesota River then drops onto the Minnesota River Valley floor and levels out in the Minnesota River floodplain until it reaches the Minnesota River.

Most of the wetlands in the project area have long since been drained with high efficiency by modern tile and ditch drainage. The predominant land-use in the project area is agricultural production, with a majority of that land in row-crop planted cropland. Just over 5,000 acres of wetlands of types 1-4 exist in the project area and there are about 1,500 acres of state wildlife management areas and county parks affording access to the Minnesota River for fishing and canoeing. Recreational opportunities in the surrounding area are limited by degraded

water quality, channel obstructions, limited access, and a general lack of awareness by watershed residents. Potentially, the project area can be a major recreational resource.

The primary research tool was a water quality monitoring program used to gather data at the six sites of the project area. Fishery surveys underscoring fish species population and diversity within each subshed, the TISWA assessment, the RUSLE modeling, GIS data relating physical attributes of the watershed including landscape slope, soil types, and hydrolaugic properties, and field observatons supplemented monitoring data for this project.

This study had the benefit of having a large variety of flow conditions and extreme variability over the two year period. Study findings suggest that runoff during high flow conditions, periodically during the growing season (April-June), result in high sediment and nutrient loads, and that during the remainder of the duration these loads are substantially reduced. Further, sampling data collected during the course of the study indicate that each separate sub-shed shows variability in water quality and in their contribution to the condition of the river. Some carry very high sediment and phosphorus loads, others exhibit high nitrate nitrogen concentrations, and others carry very low pollutant loads. A correlation in streams with more land area in the upper, flatter portion of the study area and higher nitrate nitrogen loads exists in the study area. There also seems to be a positive correlation between systems that are heavily ditched and pollutant loads. *E. coli* bacteria are a concern in all waters of the study area, underscoring the need to doubly ensure the implementation of manure and nutrient management practices, replace non-compliant septic systems, and maintain NPDES permits on point source discharges. The goal for these tributaries is to reduce the pollutant load to be in compliance with state standards according to Minnesota Rules Chapter 7050.

In all likelihood, the waters investigated in this diagnostic study area will be listed on the federal 303(d) list in accordance to the Clean Water Act. These stretches would also be subject to a TMDL investigation study in the next few years. One goal of this project was to set the groundwork and perhaps expedite the process of TMDLs for the separate reaches involved. This study should serve to complement the information needed in the coming statewide intensive watershed monitoring strategy for the Middle Minnesota River Basin.

Based on watershed assessments, the goal to obtain water quality compliance with state standards can be accomplished through a combination of best management practices and stream restoration measures applied within priority management areas. The connection between water quality and the hydrologic system is readily apparent in area watersheds, and measures to reduce runoff will play a central role in improving water quality in the small streams of this diagnostic study area. Slowing down the rate of runoff will not only improve water quality, but it will also provide more stable flow to enhance fishery resources, and make the river more useable for water-based recreational activities such as canoeing. Practices that reduce polluted runoff, for example, conservation tillage, storm drain holding ponds, restored wetlands, buffer strips, etc., provide an equally valuable stream flow control function so that multiple benefits are obtained from these practices. Appropriate best management practices focused on selected watershed areas can provide the means for achieving water quality goals.

Water quality goals based on analytical and statistical standards dictate a 75 – 85 percent reduction for the phosphorus/TSS complex, a 25 – 55 percent reduction in nitrates, and a 50 – 75 percent reduction in *E. coli* bacteria levels. These reductions will be accomplished through Best Management Practices (BMP) within priority management areas. Project evaluation will be accomplished through effectiveness monitoring, citizen monitoring, BMP tracking, and continued work from other agencies through crop surveys, fisheries surveys, and watershed inventories.

The estimated cost to carry out the ten-year implementation plan is slightly under $2 million. About 25% of these funds would be used for permanent vegetative easements, wetland restorations, and septic replacement grants. These funds will be derived from existing federal and state land retirement programs. Clean Water Partnership low interest loans will be used to upgrade septic systems, increase residue plan acreage, and reduce livestock impacts on water quality. State and federal cost-share will be sought to cover costs of other BMPs and activities listed in the plan. Additional staff positions may be added if grants are successful.

Middle Minnesota Major Watershed
First Order Streams of Redwood and Brown County

CHAPTER 1: INTRODUCTION AND PROJECT BACKGROUND

Introduction

Little is known about the six small agricultural watersheds of the project area. The purpose of the resource investigation phase of this project has been to document factors that may be affecting the six streams of the study and to determine if reductions are indeed needed on these watercourses to preserve or meet water quality goals. The Minnesota River currently does not meet federal water quality standards and is a major source of pollution to the Mississippi River, Lake Pepin, and ultimately, the Gulf of Mexico where hypoxia of coastal waters continues to be an issue. The first order streams in this project area need to be protected and enhanced to ensure their water quality standards are aiding in TMDL goals and accomplishments in the Minnesota basin. The overriding goal of the state of Minnesota is to restore the Minnesota River to a resource that is fishable and swimmable. Recommendations for reduction in the Minnesota River watershed, based on modeling scenarios put forth in the preparation of the Minnesota River Turbidity TMDL, are for fifty percent turbidity (mostly sediment) and phosphorus. With the TMDL plan approved on the lower Minnesota River for phosphorus reduction, it is important to continue the implementation of best management practices that will reduce the total phosphorus contribution from the project area and work to de-list the lower Minnesota River Dissolved Oxygen TMDL impairment. Recreational opportunities in other area watersheds are limited by degraded water quality, channel obstructions, limited access, and a general lack of awareness by watershed residents. Potentially, the project area can be a recreational resource.

This report is the product of scientific diagnostic methods in an attempt to understand the watershed areas and determine the most effective and economic activities to enhance water quality. Ultimately an implementation plan will be set into motion to outline activities needed in priority areas of these watersheds to help reach not only the water quality levels needed for the individual reaches to meet their goals but also the overall objectives of the Minnesota River on the whole. Six main goals in achieving these objected are listed below:

- Determine whether the six streams in the study area fall under a restoration or protection criteria through the completion of a thorough diagnostic study.
- Identify pathways of pollutant delivery.
- Identify sources of pollutants contributing to water quality reductions.
- Define sediment/nutrient loads and concentrations in the six tributaries of the study.
- Identify BMP solutions to facilitate any load/concentration reductions that may be needed within the framework of an implementation plan.
- Develop and implement public awareness from farm and non-farm prospectives.

Major funding sources for this project included the Minnesota Pollution Control Agency, the Redwood-Cottonwood Rivers Control Area, and the Minnesota Department of Natural Resources.

History of Area Watersheds

There are few accounts of water quality and land use in pre-settlement and settlement times in what would become Brown and Redwood Counties. Accounts of early explorers remark of transparent streams abundant with fish. Accounts from nearby streams echo these accounts and paint a picture of an environment that may have been different from today.

According to survey notes in the late 1850s and early 1860s, many lakes and sloughs populated southwestern Minnesota and the landscape was dominated with tall grasses. Trees, mostly cottonwood and willow, were found along the Minnesota River and its bluffs as well as the lower reaches of tributaries to the Minnesota. Pockets of trees also existed where they were protected from fire.

There is little knowledge of specific interactions between man and land prior to European settlement. Some interaction between the Dakota people and fur trappers, as well as stories and drawings passed down from indigenous people as well as the first settlers in the area paint a picture of subsistence as their lives were shaped by the land. The first American settlers became more and more numerous in the area in the early 1800s and the tribes of the Dakota were forced to relinquish their land. By 1860 most native peoples were restricted to an area along the Minnesota River valley. In 1862, this system of life proved to fail as the Dakota were starving and the agencies were not delivering on the food and goods promised by the federal government. Infuriated by the broken promises of the Anglo-American system of government, the Dakota sought answers and were turned away by the agencies. In one instance it was reported that a government agent told the hungry to go eat grass. He was found dead, his mouth stuffed with grass. Settlers and outposts were attacked by Dakota warriors in what became the U.S. - Dakota war of 1862. Many innocent people died all around because of the incidents of 1862, much of these events happened in the very area of this study. As a result the Dakota were largely expelled from Minnesota and scattered as a people. By the time settlers started to return to the area, they found that the land was void of people.

At first, pioneer agriculture was undertaken using small tracts of land to sustain themselves and to provide enough to trade for supplies. More efficient tools and mechanization allowed for more land to be put into production and many sloughs and wetlands were drained for production land. Drainage projects were accomplished by hand, at first, and by machine later. Eventually, extremely efficient systems of drainage and premium areas of agricultural production are what we have today. One farmer in Redwood County could sustain six people in 1880. That figure is estimated to be close to 1 and 200 today. This does not come without a tradeoff. Silt and bacteria have been cited in fish surveys as the main contributing factor in fish population deterrents. Settlement, drainage, and agricultural development have allowed water to move from the land quicker and have resulted in increased flooding. Spring floods are common to the landscape and frequently cause damage and delay of planting in the area.

Recent work through organizations such as the Brown-Nicollet-Cottonwood Water Quality Board (BNC), the Redwood-Cottonwood Rivers Control Area (RCRCA), the Lower Sioux Community/Environmental Office, county Soil and Water Conservation Districts (SWCDs), the Minnesota Department of Natural Resources (DNR) and the Natural Resources Conservation Service (NRCS) have helped to improve water quality and land management in southwestern Minnesota and it appears that we have turned a corner in the effort to bring waters back from just a drainage system to a system that can sustain both agriculture and a prairie ecosystem .

Project History

Middle Minnesota Basin[1]

The Middle Minnesota Basin covers 1,350 square miles in parts of eight counties in south central Minnesota--Redwood, Brown, Cottonwood, Blue Earth, and Le Sueur on the south and east side of the Minnesota River, and Renville, Nicollet, and Sibley on the north side. The basin ranks sixth in area of the twelve watersheds supplying the Minnesota River.

Map 1-1 gives the location of the Middle Minnesota Major Watershed and the project area in context to the state and map 1-2 shows the Middle MN in more detail. Map1-3 shows the watersheds monitored in this report. Except for the Little Cottonwood River, the streams comprising the Middle Minnesota Basin are first- or second-order streams. That makes this basin somewhat unique; the rest of the twelve basins all have identifying dendritic rivers. The Middle also differs from all the other basins in that there is no single reach on the main river where the effects of the basin drainage can be monitored. This is because the mouths of four entire basins (Cottonwood, Blue Earth, Watonwan, and Le Sueur) enter the Minnesota at points in the area of the Middle Minnesota. Due to the large number of small streams feeding the Minnesota River, this can pose difficulty in establishing water resource monitoring and implementation plans for the Middle Minnesota Major Watershed. There are three major streams in the Middle Minnesota Major Watershed which are already under assessment by separate Clean Water Partnerships--the Little Cottonwood River Project (see *Little Cottonwood River Restoration Project*, 2000 for more information on that particular watershed), the Seven-mile Creek Watershed Project (see *Seven-mile Creek Watershed Project* 2001), and the Lake Crystal-Minneopa Creek Project.

The Major Middle MN streams on the south and east sides of the Minnesota are: Wabasha Creek, Hindeman (also known as Spring) Creek, the Little Cottonwood River, Minneopa Creek, and Shanhaska Creek. Major streams on the north side of the Minnesota include: Birch Coulee, Ft. Ridgely Creek, Eight Mile Creek, St. George Creek, Nicollet Creek (also known as the Swan Lake Outlet), North Ridge Outlet, Hiniker Creek, Seven Mile Creek, and Robart's (also known as Robert's or Roger's) Creek. The Middle Minnesota Basin includes several small pothole lakes, and two major lakes--Crystal Lake in Blue Earth County and Swan Lake in Nicollet County.

During the Minnesota River Assessment Project (MRAP) study, major tributaries and the main stem of the Minnesota River were monitored for flow and water quality parameters. Springs and general biological integrity were also evaluated to determine the relative impairment of the riverine environment. The results of the study suggested that not only do flows increase from west to east, but also that loads of sediment and nutrients increase in a downstream progression. The implication is that every small tributary likely contributes to the overall pollutant load. None of the Middle Minnesota streams were directly monitored during the MRAP study. Follow-up monitoring on the streams in the Middle Minnesota Basin is needed to more clearly define their potential impacts on the Minnesota River. Some of the streams have been

[1] Portions extracted from "Seven-mile Creek Watershed Project – A Resource Investigation within the Middle Minnesota Major Watershed" Diagnostic Study Report, BNC Water Quality Board, October 2001

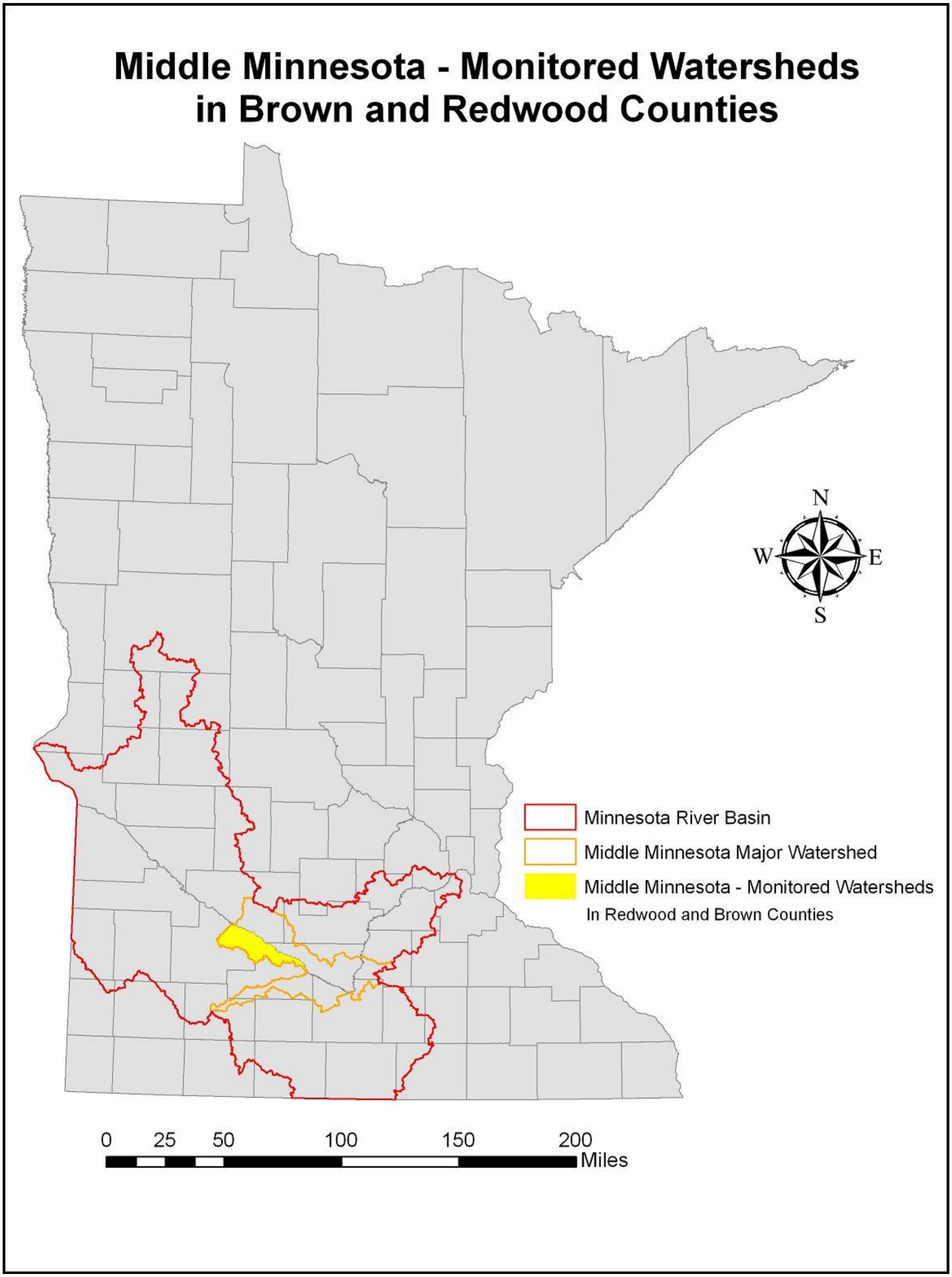
monitored since 1989 as part of groundwater studies, or county water planning initiatives, and localized resource investigation projects. The following Middle MN streams were monitored in 1996 and 1997 in the Middle/Lower Assessment Project (MLAP), a resource investigation project cosponsored by the MPCA:

- Camp Pope in Redwood County
- Hindeman (also known as Spring) Creek in Redwood and Brown Counties
- Shanhaska Creek in Le Sueur County
- Fort Ridgely Creek in Renville and Nicollet Counties
- Eight Mile Creek in Sibley and Nicollet Counties
- St George Creek in Nicollet County
- Nicollet Creek (also known as Swan Lake Outlet) in Nicollet County
- Seven Mile Creek in Nicollet County
- Robart's (also known as Roberts and Rogers) Creek in Nicollet County

The streams were sampled under two schemes; the channel/bed status was evaluated using Tailored Integrated Stream/Watershed Assessment (TISWA), and potential wetland restoration site exploration was begun. The MLAP project also began other watershed assessment activities and established communications with watershed landowners.

Monitoring has also taken place at the following Middle Minnesota locations:

- Birch Coulee Creek in Renville County
- City of Fairfax inputs from storm and sanitary sewers to Fort Ridgely Creek
- Hiniker Creek in Nicollet County
- Fritche Creek in Nicollet County
- Little Rock Creek in Renville and Nicollet Counties
- Morgan Creek in Brown and Blue Earth Counties
- Thompson Ravine, Rasmussen Creek (and Tributaries), and Glenwood Creek in the City of Mankato and Blue Earth County


Middle Minnesota - Monitored Watersheds
in Brown and Redwood Counties
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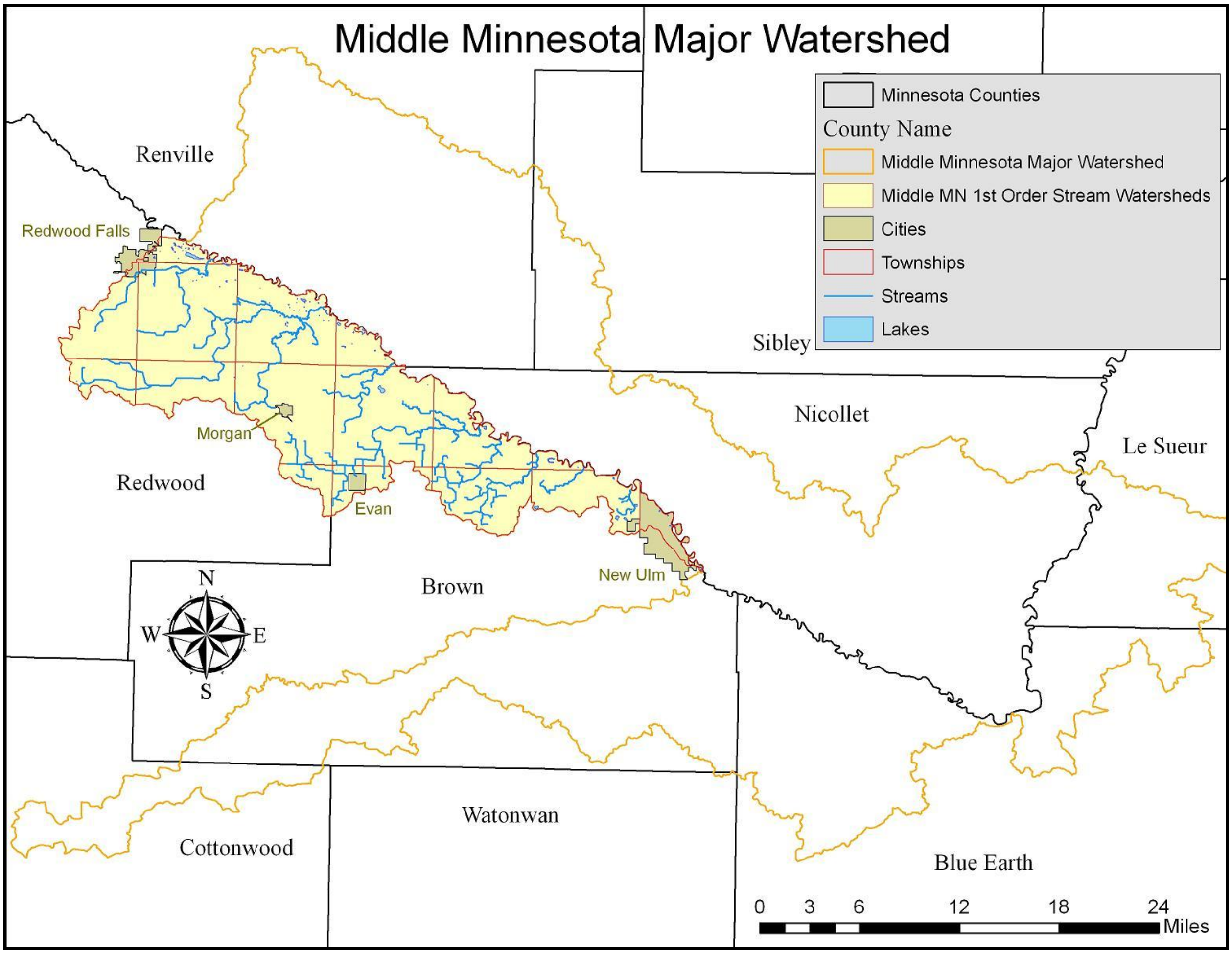
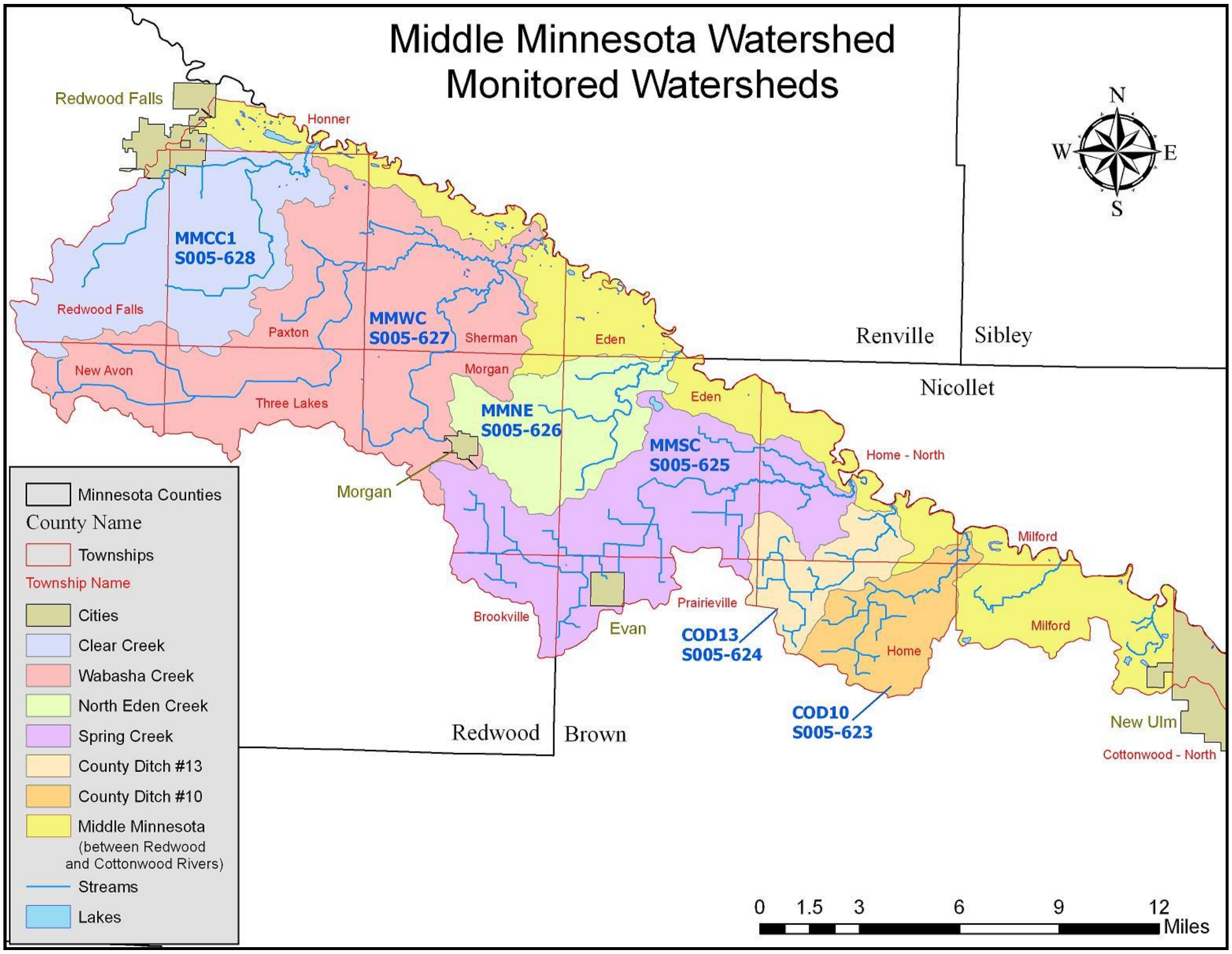
S
Minnesota River Basin
Middle Minnesota Major Watershed
Middle Minnesota - Monitored Watersheds
In Redwood and Brown Counties
0
25
50
100
150
200
Miles

Map 1-1


Middle Minnesota Major Watershed
Minnesota Counties
County Name
Middle Minnesota Major Watershed
Middle MN 1st Order Stream Watersheds
Cities
Townships
Streams
Lakes
Renville
Redwood Falls
Sibley
Nicollet
Le Sueur
Morgan
Redwood
Evan
New Ulm
Brown
N
W
E
S
Watonwan
Cottonwood
Blue Earth
0 3 6 12 18 24
Miles

Map 1-2



Map 1-3

The Minnesota River does not meet state and federal water quality standards and is a major source of pollution to the Mississippi River. It had been a high priority of the State of Minnesota to restore the Minnesota River to fishable and swimmable conditions within ten years, from 1992-2002. The Minnesota River Assessment Project MRAP recommendations translate this general goal into specific pollutant reduction targets and suggest changes required to achieve the targets.

Recommendations included:

- Forty percent reduction in total suspended solids
- Maintenance of nitrate concentrations at less than ten parts per million
- Development of a phosphorus standard for the basin
- The implementation of sediment-reduction and cropland soil loss programs
- Removal of bacteria and other pathogens, which make the river unsafe for human contact

Land and water management has strongly influenced current water quality and habitat conditions of the Minnesota River. The nature and character of drainage facility development has produced channel instability and overall ecological imbalance. The current array of ditches, urban channeling, storm sewer systems, open-tile intakes, side inlets and subsurface tile lines has transferred flooding problems downstream to other land operators, created highway maintenance problems, and major ditch clean-out expenses. Drainage augmentations have also influenced water quality in the tributaries and the Minnesota River itself. Drainage from unsewered communities, septic systems directly connected to underground tiles and/or ditches, animal manure from feedlots and winter field applications have increased levels of bacteria and other pathogens. Nitrates and phosphorus are other contaminants of concern from the above situations; contribution of these nutrients is also occurring through untimely and/or heavy applications of chemical fertilizers. Another concern is that of high sediment loads resulting from erosion due to overland runoff, bank erosion and rapid drainage resulting from ditching and tiling. Urban situations also lead to water quality impairment of the streams and the river. These include sediment, nutrients, and other contaminants from storm runoff, periodic inundation of sewage treatment ponds located in the river flood plain, and pollution resulting from over application of fertilizers within tributary communities. Working with counties, communities, agriculture, industry, institutions and citizens to increase awareness and concern about the above contaminant contribution situations is the highest priority of the Middle Minnesota Basin Project.

Middle Minnesota Major Watershed: First Order Streams of Redwood and Brown County

The project area consists of 159,935 acres or about 18.5% of Middle Minnesota Watershed. The area is between the outlets of the Redwood River and the Cottonwood River draining portions of Brown and Redwood counties in south-central Minnesota. This area consists of first order streams: Crow Creek, Wabasha Creek, North Eden Creek, Spring Creek, Brown CD #13 and Brown CD #10. These streams generally orient from southwest to northeast as they drop into the Minnesota River valley to meet the Minnesota River.

There are three general topographic features of the six streams involved in the project: the plains, the Minnesota River bluffs/transition, and the Minnesota River floodplain. A majority of the watersheds are nearly level to flat with poorly drained soils formed from glacial till. About eighty-seven percent of the watershed area formed in glacial till, seven percent alluvium and colluvium processes, .28 percent due to outwash, and .5 percent is down to bedrock. A further four and a half percent of the project area is considered the Minnesota River terrace. As each stream nears the Minnesota River it transitions through the steep bluffs of the south side of the Minnesota River then drops onto the Minnesota River Valley floor and levels out in the Minnesota River floodplain until it reaches the Minnesota River.

Why the Project is Taking Place

The Minnesota River currently does not meet federal water quality standards and is a major source of pollution to the Mississippi River, Lake Pepin, and ultimately, the Gulf of Mexico where hypoxia of coastal waters continues to be an issue. The first order streams in this project area need to be protected and enhanced to ensure their water quality standards are aiding in TMDL goals and accomplishments in the Minnesota basin. The overriding goal of the state of Minnesota is to restore the Minnesota River to a resource that is fishable and swimmable. Recommendations for reduction in the Minnesota River watershed, based on modeling scenarios put forth in the preparation of the Minnesota River Turbidity TMDL, are for fifty percent turbidity (mostly sediment) and phosphorus.

The project area lies between two major watershed confluences, the Redwood and Cottonwood Rivers. This area has been included by designation as a part of the Middle MN River Basin but for the most part has been overlooked by major watershed initiatives. The Brown-Nicollet-Cottonwood Water Quality Board has contributed to work in the area recently by providing low interest loans for the area for non-compliant SSTS systems and has been meeting with some landowners to implement continuous CRP buffers along ditches and tributaries. This project will expand those efforts in conjunction with establishing six long-term monitoring sites that will enable the project to develop an implementation plan that will prioritize each of the watersheds and implement best management practices geared to maintian or improve water quality and keep these first order streams from being placed on the 303d list. In the event the data does support listing the watersheds the implementation plan will be constructed according to current TMDL implementation plan guidance and the data will be readily available to be used for the development of a TMDL if it is warranted. Currently none of the streams are listed individually. Data provided with a successful Phase I will help support future watershed management decision making. Proper management of these reaches to reduce sedimentation and loss of nutrients will provide economic benefits to both the watershed and to downstream areas. The cost of not managing land use practices within the watershed will continue to rise as well as the cost to maintain productivity for generations to come.

Who is Involved in Carrying out the Project

The project sponsor is the Redwood-Cottonwood Rivers Control Area (RCRCA). RCRCA, established in 1983, is a Joint Powers Organization of eight counties and their Soil and Water Conservation Districts. (For additional information, go to www.rcrca.com). Member counties and Soil and Water Conservation Districts include Brown, Cottonwood, Lincoln, Lyon, Murray, Pipestone, Redwood, and Yellow Medicine. Douglas Goodrich, Executive Director of RCRCA, is the project administrator. Counties involved in the project area would be Brown and Redwood counties through their environmental offices and SWCDs. These groups will work together with RCRCA to share already collected data along with being the technical advisory team that will produce the Phase I Diagnostic Study along with an Implementation Plan. A more complete list of responsibilities and timelines are listed in the milestone section (Section 5). Other entities involved in the project in a advisory and stakeholder capacity are the Lower Sioux Community/Environmental Office, Brown Nicollet Cottonwood Water Quality Board, the National Resources Conservation Service, city utilities staff, and the Minnesota Pollution Control Agency.

Redwood and Brown Counties are members of the RCRCA JPO and Brown County is a member of BNC. A new member will be the Lower Sioux Community and their environmental office. Both RCRCA and BNC have been working on Phase I and II CWPs on the Redwood, Cottonwood, Little Cottonwood and Seven Mile Creek watersheds. This will add to the area effectively assessed on the Minnesota River Basin. The current track record for successful implementaiton of RCRCA will enhance the success of this new resource investigation grant. Hydrologic and water quality monitoring wil be a cooperative effort through RCRCA staff, DNR waters, MPCA, and county personnel. RCRCA staff will be in charge of field work involving sampling and stage checking as well as outreach, data evaluation, grant facilitation, report writing, and a summation of the diagnostic study ultimately leading to the creation of priority regions in the study area. MPCA will supply staff for initial site investigation and placement of agency supplied stage monitoring hardware which RCRCA will supplement as needed. DNR-waters are contracted to make stream measurements in the streams of this project and complete the data collection. County environmental offices and SWCD staff will support the sponsor in analysis and selection of priority management areas and best management practices

RCRCA has a proven history backed with an extensive database, a long-term monitoring program, and an organizational structure that remains supportive and flexible to ensure that projects such as the Redwood River Clean Water Project and the Cottonwood River Restoration Project are successful. This success can be viewed in the 2001 Final Report, "Evolution of Watershed Restoration", which can also be found at our website. The project area lies between two major watershed confluences, the Redwood and Cottonwood Rivers. This area has been included by designation as a part of the Middle MN River Basin but for the most part been overlooked by major watershed initiatives.

Table 1-1: PROJECT STAFF DIRECTORY

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TABLE 1-2: Final Project Budget

Objectives	Cumulative Cash Expended	Cumulative Match In-kind Expended	Cumulative Total Expended
Objective 1): Work Plan/Monitoring Plan Development			$0.00
Task A- Investigate and Write Preliminary Plans; Prepare and Adopt Final Plans	$5,234.34		$5,234.34
Total Element 1	$5,234.34	$0.00	$5,234.34
Objective 2): Water Quality Monitoring and Data Analysis - Sampling and Field Monitoring, Rating Curve Development, Data Interpretation, and Loading Estimates for Incorporation of Final Report Components			$0.00
Task A- Watershed Tech. - Annually Re-establish Sites and Collect Water Quality Samples; Perform Analysis Needed to Complete Diagnostic Report	$12,650.00		$12,650.00
Task B- Water Monitoring Analysis for E. coli, TSS, TSVS, Turbidity, Total Phosphorus, Ortho-phosphorus, TKN, Ammonia, andNitrate-Nitrite as N	$25,145.70		$25,145.70
Brown-Nicollet Cottonwood SWAG Analysis in the Project Area		$7,427.28	$7,427.28
MnDNR - Site Flow Measurement		$28,000.00	$28,000.00
Task C- Misc. Monitoring Supplies/Equipment, Vehicle Expenses	$2,068.45	$3,500.00	$5,568.45
Total Element 2	$39,864.15	$38,927.28	$78,791.43
Objective 3): Watershed Prioritization and Implementation Plan Development - Surveying, Compiling GIS/Survey/WQ Data, Modeling, Technical Advisory Meetings, and BMP Analysis for the Implementation Prioritization of the Project Area; Implementation Plan Development			$0.00
Executive Director	$19,101.81		$19,101.81
Watershed Tech.	$12,592.28		$12,592.28
Watershed Engineer	$3,337.28		$3,337.28
County SWCD's		$6,903.50	$6,903.50
MNDNR		$14,598.09	$14,598.09
Total Element 3	$35,031.37	$21,501.59	$56,532.96
Objective 4): Outreach, Information, and Awareness Efforts - Providing Material for Support, Newsletters, Media, and Public Informational Meetings			$0.00
Task A- Water Quality Tech. Asst.			$0.00
Total Element 4	$0.00	$0.00	$0.00
Objective 5): Grant Administration and Facilitation			$0.00
JPO Appropriations		$68,978.07	$68,978.07
Executive Director	$4,230.00	$3,870.00	$8,100.00
Support Staff	$18,662.49		$18,662.49
Office Supplies	$1,800.00		$1,800.00
Misc. Services/expenses	$8,271.34		$8,271.34
Total Element 5	$32,963.83	$72,848.07	$105,811.90
Objective 6): Implementation Efforts			$0.00
Task A- Implementation incentives and cost-share for sediment reduction	$77,573.00		$77,573.00
Landowner Match/Program Match		$57,391.00	$57,391.00
Total Element 6	$77,573.00	$57,391.00	$134,964.00
ITEMIZED PROGRAM ELEMENT BUDGET			
Total Element 1 – Work Plan/Monitoring Plan Development	**$5,234.34**	**$0.00**	**$5,234.34**
Total Element 2 – Water Quality Monitoring and Data Analysis	**$39,864.15**	**$38,927.28**	**$78,791.43**
Total Element 3 - Watershed Prioritization and Imp. Plan Dev.	**$35,031.37**	**$21,501.59**	**$56,532.96**
Total Element 4 – Outreach, Information, and Awareness Efforts	**$0.00**	**$0.00**	**$0.00**
Total Element 5 – Grant Administration and Facilitation	**$32,963.83**	**$72,848.07**	**$105,811.90**
Total Element 6 – Implementation Efforts	**$77,573.00**	**$57,391.00**	**$134,964.00**
Project Grand Total	**$190,666.69**	**$190,667.94**	**$381,334.63**

Project Milestones

Table 1-3: Milestone Schedule

Program Element	Timeline	Responsibility
Work Plan Development		
investigate and write preliminary work plan	03/09 - 04/09	RCRCA
prepare and adopt final work plan	04/09 - 06/09	RCRCA
Water Quality Monitoring and Data Analysis		
sampling and field readings	04/09 - 10/10	RCRCA, MnDNR
rating curve development	04/09 - 03/11	RCRCA, MPCA
laboratory analysis	04/09 - 11/10	RCRCA
data interpretation	10/09 - 03/11	RCRCA, MPCA
loading estimates	10/09 - 03/11	RCRCA
final report	01/11 - 06/11	RCRCA
Watershed Prioritization and Implementation Plan Development		
stream bank surveys	04/09 - 11/10	RCRCA
GIS	04/09 - 11/10	RCRCA
modeling (FLUX, LDC, SWAT)	10/09 - 03/11	RCRCA
selection of priority areas	10/10 - 03/11	RCRCA, SWCDs, NRCS, MPCA, Counties
BMP analysis	03/11 - 04/11	RCRCA, SWCDs, NRCS, MPCA, Counties
final plan	01/11 - 06/11	RCRCA
Information and Awareness Efforts		
brochures	01/10 - 03/11	RCRCA
newsletters	01/10 - 03/11	RCRCA
public meetings	01/10 - 03/11	RCRCA
Administration		
reporting	06/09 - 06/11	RCRCA
project coordination/facilitation	06/09 - 06/11	RCRCA

CHAPTER 2: METHODS

WATER QUALITY MONITORING

The purpose of this project was to assess the first order tributaries to the Minnesota River between the watersheds of the Redwood and Cottonwood Rivers in Redwood and Brown counties to determine the actions, if any, needed to sustain or improve these waters at/to the levels necessary to meet both state and local goals. Goals relating to nitrate-nitrogen, *E. coli* bacteria, phosphorus, and sediment calculations were produced in this process in both pollution concentration and loading to the streams. Goals for the specific stream reaches ultimately translate into the implementation plan for the study area. Water quality monitoring sites were established at six primary sampling site locations. Site selection for these sites was determined and selected in November, 2008. The selection process was based on the following:

- *Spatial Proximity to Capture the Entire Watershed*
- *Proximity to Road or Culvert*
- *Previous Water Quality Study Location*
- *Rating Curve Development Feasibility*

Data gleaned from these sites will act as a TMDL and aid in the determination of where these streams are in terms of water quality and what actions need to be taken to restore or protect the respective streams with the ultimate goal of creating an implementation plan to make better use of BMP funds.

Four primary stations were established and are located: 1) on Crow Creek before it enters the Minnesota River valley near Redwood Falls; 2) near the mouth of Wabasha Creek south of Franklin; 3) near the mouth of North Eden Creek on Brown County Road 10; and 4) near the mouth of Hinderman (Spring) Creek on Brown County Road 10. These stations were equipped with stage measuring equipment that was maintained by RCRCA staff. The DNR-waters group had been contracted to provide services to take flow discharge measurements at these sites so that pollutant loadings could be calculated. The sites were named MMCC1, MMWC, MMNE, and MMSC respectively. These sites were monitored according to the sampling regime outlined in ***Table 2-1*** below.

Two secondary sites are located: 1) Brown County Ditch #13 at Brown County Road 10; and 2) Brown county Ditch #10 at Brown County Highway 29. The sites were named COD13 and COD10 respectively. These sites were monitored with the same sampling regime outlined in ***Table 2-1*** below but did not have flow measurements taken because of site limitations. Tape-down measurements were taken to relate concentration values from sampling and discharge calculations.

The plan was to collect water samples approximately 25 times from April (or ice out) to October during the sampling season of 2009 and 2010. There were a few limitations on the two secondary sites due to late summer dry conditions (more so in 2009) and samples were not taken at times of extreme low flow. ***All loading rates and calculations are based on the "growing season of April 1 to September 30 time period (roughly 180 days).*** Samples were analyzed for turbidity, TSS, TSVS, TP, OP, NO2_NO3, TKN, and NH3. Also, *E. coli* samples were taken at a rate of five/month over two years between April and October at each of the six site in the project area. Again, RCRCA staff was charged with collection of the samples in the sampling regime. Samples were analyzed by MVTL Laboratories, Inc., (MVTL) New Ulm for the parameters listed in above.

Table 2-1: Monitor Parameter Summary

SELCTED PARAMETERS FOR LABORATORY ANALYSIS AND FREQUENCY OF SAMPLING						
STORET CODE **S005-###**	1)**628**	2)**627**	3)**626**	4)**625**	5)**624**	6)**623**
TOTAL SUSPENDED SOLIDS	T/S	T/S	T/S	T/S	T/S	T/S
TOTAL SUSPENDED VOLATILE SOLIDS	T/S	T/S	T/S	T/S	T/S	T/S
TURBIDITY	T/S	T/S	T/S	T/S	T/S	T/S
TOTAL PHOSPHORUS	T/S	T/S	T/S	T/S	T/S	T/S
ORTHO-PHOSPHORUS	T/S	T/S	T/S	T/S	T/S	T/S
NITRATE-NITROGEN	T/S	T/S	T/S	T/S	T/S	T/S
AMMONIA NITROGEN	T/S	T/S	T/S	T/S	T/S	T/S
TOTAL KJELDAHL NITROGEN	T/S	T/S	T/S	T/S	T/S	T/S
E. coli BACTERIA	5M-2	5M-2	5M-2	5M-2	5M-2	5M-2
SELCTED PARAMETERS FOR FIELD ANALYSIS AND FREQUENCY OF SAMPLING						
pH	T/S	T/S	T/S	T/S	T/S	T/S
TEMPERATURE	T/S	T/S	T/S	T/S	T/S	T/S
DISSOLVED OXYGEN	T/S	T/S	T/S	T/S	T/S	T/S
TRANSPARENCY (T-TUBE)	T/S	T/S	T/S	T/S	T/S	T/S
WATER LEVEL RECORDS for WATERSHED MONITORING SITES 625-628 is 24 HOUR, SEVEN DAY per WEEK STAGE RECORDING DURING ICE FREE MONTHS						

Key: T = twice monthly, S = storm event, 5M-2 = Five times monthly over two years

Water samples were sampled and analyzed according to methods adopted by the USGS, MPCA, and US Environmental Protection Agency protocol. Collection of all grab samples followed protocols established by the Environmental Protection Agency[2]. Samples were field-tested using portable meters for pH, temperature, dissolved oxygen and transparency. Field meters were calibrated before each day of use. Collection and field measurement protocol are outlined in the excerpt of the project QAPP in Appendix A. Water samples were collected over a range of river discharge conditions to characterize the change in water quality as the creeks responded to both dry and wet conditions.

Base flow sampling was conducted at least once monthly (twice monthly in non–storm event periods) from April to October to determine parameter levels during baseline conditions. In addition, sampling was to be conducted for a minimum of two storm events to assess parameter levels during peak flow conditions to determine the impact of surface runoff in contributing to contaminant levels. In 2009, this proved to be problematic at a few of the sites due to dry

[2] U.S. Environmental Protection Agency, Handbook for Sample Preservation of water and Wastewater. 1982.

conditions and a lack of pronounced "storm spikes". In 2010, two storm events were sampled. Sampling for water quality parameters and flows under climatic conditions included:

- *Early Spring (first storm after snow melt)*
- *Emergent Crop Period Storm*
- *Post ET (fall) Low Flow (late fall)*

Monitoring Season

In general, all six sites were sampled from late March through early October. In 2009, a total of 20 grab samples were taken. In 2010 a total of 23 grab samples were taken at most sites. The partial monitoring season is beneficial in two different ways. First, monitoring costs, time and equipment maintenance are reduced. Second, the vast majority of the flow in the Minnesota River Basin typically occurs between mid-March through mid-July. Most of the loads of the commonly monitored pollutants (sediment, phosphorus, nitrogen and fecal coliform bacteria) also pass through during this period. A disadvantage of partial year monitoring involves the potential for missing a portion of the annual load of the common pollutants. In the smaller streams of this project, this is a lesser problem since they tend to be intermittent (dry up in the fall). Another potential complication relates to delays associated with getting station equipment established during high water or snow levels in the spring.

Monitoring Season Description

2009

Water quality sampling began early in early April and quickly subsided due to lack of significant rainfall. Although low flows were common until mid-June, sampling continued to characterize baseflow (groundwater) dominated conditions. A minor rain event occurred June 8. Thereafter, precipitation patterns for the watershed became dryer than normal. A total of 20 samples were taken with 25% taken in the month of June. At least two samples were taken every month from April through October. By early July the watershed and surrounding counties experienced below average rainfall, hence monitoring intensity decreased. By mid September, low to zero flow conditions were present on some tributaries. There was another minor storm event in early October and this was sampled due to the lack of other events during the season. . Due to the flashy nature of the drainage system, it is recommended that auto-samplers be installed to refine pollutograph and loading estimates.

2010

Water quality sampling began mid March and quickly subsided due to lack of significant rainfall. Although low flows were common until mid-June, sampling continued to characterize baseflow (groundwater) dominated conditions. A major rain event occurred June 11. Thereafter, precipitation patterns for the watershed began to normalize with more frequent and heavier rainfall frequencies. A total of 23 samples were taken with seven taken in the month of June and five taken in September. At least one sample was taken every month from March through September. Late September brought an extremely large precipitation event, which was sampled to close out the season. Due to the flashy nature of the drainage system, it is recommended that auto-samplers be installed to refine pollutograph and loading estimates.

Water samples were sampled and analyzed according to methods adopted by the USGS, MPCA, and US Environmental Protection Agency protocol. Collection of all grab samples followed protocols established by the Environmental Protection Agency[1].

Samples were field-tested using portable meters for pH, temperature, dissolved oxygen and transparency. Field meters were calibrated before each day of use. Samples were analyzed by MVTL Laboratories, Inc., (MVTL) New Ulm for the following parameters: turbidity, total suspended solids, total suspended volatile solids, total phosphorus, ortho-phosphorus, nitrate-nitrogen, total kjeldahl nitrogen, ammonia nitrogen, as well as *Escherichia Coli* bacteria. Reporting units and methods are shown in Table 2-2.

Table 2-2. Water Quality Reporting Units and Analytical Methods

Parameter	Reporting Unit	Analytical Method
E. coli Bacteria	Coliforming Units/100 mL	SM** 9223 B (Colilert)
Total Phosphorus	mg/L	EPA 365.1
Ortho – phosphorus	mg/L	EPA 365.1
Ammonia Nitrogen	mg/L	EPA 350.1 Rev 2.0
Total Kjeldahl Nitrogen	mg/L	SM 4500–N_{org} B / NH_3 E
Nitrate + Nitrite	mg/L	EPA 353.2
Total Suspended Solids	mg/L	USGS I–3765–85
Total Suspended Volatile Solids	mg/L	EPA 160.4
Turbidity	Nephlometric Turbidity Units (NTU)	EPA 180.1 B
Dissolved Oxygen	mg/L	
pH	units	
Transparency (tube)	cm	
Water Temperature	°C	
Discharge	ft^3/sec	velocimeter

*8 hrs if used for enforcement purposes; ***Standard Methods for the Examination of Water and Wastewater*.

Water Quality Monitoring Equipment

Instrumentation used at four primary monitoring sites provided a 24 hour a day account of the stage height (water elevation related to a fixed height) on these reaches. The equipment at these four sites were provided by the MPCA and complemented by the equipment that RCRCA had on hand. Included at each of these sites were a solar panel kit, a rechargeable power source, a voltage regulator, a data logger, a temperature meter with housing, and an ultrasonic stage transducer. The operation was powered by the rechargeable battery which kept its charge through solar power. A power regulator was used to avoid overcharging and destruction of the data logger. The data logger is the heart of the operation which has been programmed to communicate instructions to the peripheral instruments while logging/calculating instrument output and storing them with time and date stamps at a 15 minute interval. The continued stage monitoring was conducted by an ultrasonic sonar pulse transducer instrument which is suspended perpendicularly over the surface of the stream. The instrument cycles between a “send” and “receive” mode, allowing the instrument to measure how much time it takes for the pulse to “bounce” back from the water surface and returns a value to be translated into stage height every 60 seconds.

There were no continuous stage conditions monitoring equipment or data collection equipment at the two secondary sites. Manual stage measurements and sampling methods were used at these sites.

Field Equipment

Instruments used to determine field parameters include a TSI 85 D.O./Temp probe, standard MPCA 60 cm transparency tube, and Oakley model TestrII pH meter. Both the dissolved oxygen and pH meter were calibrated before each use. Field analysis methods can be found in the excerpts of the project Quality Assurance Project Plan (QAPP) found in Appendix A, pages 17 – 20.

Sampling Methodology

Grab sampling and automatic samplers are two methods of storm event sampling utilized in the Minnesota River Basin. Automatic sampler collection is typically supplemented by grab samples during non-event (baseflow) periods. The objective of the automatic sampler methodology is to completely characterize the entire stormflow volume with sampling or equal-flow increment (EFI) sampling. With EFI sampling, composite samples are collected throughout the event with discrete sub-samples representing equal volumes of flow. For example, 200 ml of river water may be collected for every 1,000 cfs of flow resulting in one composite sample that represents several days (or hours on smaller streams) of flow. In theory, EFI composite sampling gives greater data resolution as all flow conditions are represented in one sample. However, auto-samplers have inherent problems associated with their use. They are very high maintenance. A major maintenance issue associated with auto sampler use relates to controlling sample intake tube location to collect samples from the most representative portion of the stream and premature battery failures. Also of potential concern are issues associated with maintaining adequate velocities in the sample tube, potential contamination sources in the sampler/tubing and maintaining a relatively clean intake orifice. At RCRCA, such problems have been realized at other small stream sites using automatic sampling equipment. Samplers used in the past proved to be a significant challenge during times of rapidly changing flow. There are also problems associated with collecting samples without automatic equipment. Small stream systems can be very flashy in nature, and the risk of missing the peak or a major portion of the hydrograph is great, especially when the peak occurs at night. Larger river systems have storm hydrographs that can last for weeks. During these periods, it can be difficult to accurately assess the timing and number of grab samples necessary to accurately characterize the flow. In addition there are complexities associated with sampling methods, equipment and the most appropriate location to collect the grab storm sample. Given the proximity of the sites to the office and the hydrology of these smaller streams, samples taken at all sites were accomplished using the grab sampling methods. These sampling methods are spelled out in the excerpts of the QAPP for the project found in Appendix A, sections “B1” and ”B2” (page 7), and pages 17-20.

QUALITY ASSURANCE – QAPP REVIEW

Quality Assurance

It is the responsibility of RCRCA to ensure that all data presented in the final report of this project be quality data. Methods to arrive at this level of quality need to be planned accordingly. The quality assurance plan for this diagnostic study can be viewed in the Quality Assurance Project Plan (QAPP) associated with this project ("Phase I QAPP - The Middle Minnesota River in Redwood and Brown Counties CWP Diagnostic Project"). Excerpts of the plan relating to data quality and handling can be found in Appendix A.

DATA MANAGEMENT, STATISTICS, and MONITORING TECHNIQUES

Flow Conversion and Data Management

Average 15-minute stage readings from the four primary sites were extracted from the data loggers on site periodically through the year using a storage module. Downloaded data was then viewed, checked, and summarized into a continuous file at the end of the year using Campbell Scientifics' 'PC208' analysis program. Collected data was then converted into a format which could be checked and edited in a spreadsheet program. This data was sent to the Minnesota Pollution Control Agency-Mankato watershed modeling unit along with known physical attributes, field flow measurements (performed by the Minnesota Department of Natural Resources Waters Division), and other known data (see parameters below) to derive a usable rating curve for each of the four primary sites.

HYDSTRA Dataset Parameters:

- Gage locations, site characteristics, reader, type, and drainage area
- Benchmark information
- Flow measurements
- Stage gage readings and electronic readings
- Rating curves, rating tables
- Computed stream flows
- Hourly headwater and tailwater readings
- Flow statistics
- Electronic documents including: photos, maps, schematics, etc.

Discharge Ratings

Stream flow at the four primary sites (MMCC, MMWC, MMNE, and MMSC) was determined by developing a stream-discharge relationship. MN DNR waters division staff, MPCA hydrologists and RCRCA staff determined the rating curves for all the sites during monitoring years 2009 and 2010. A total of seven discharge readings per site were used for 2009 to develop a rating curve for each primary station. High flow readings to refine the rating curve occurred in 2010. Development and use of stage-discharge relationships required measurement of stage, datum, channel dimensions, water velocity and discharge as specified in the MPCA quality control manual and USGS protocol.

Water Sample Analysis

All parameters were analyzed by the state certified MVTL Laboratories, Inc., (MVTL) in New Ulm, MN. Transportation of samples from field to lab was done by project staff. Samples were transported in ice filled coolers, and analyzed within 12-24 hours of sample collection. Since the lab and watershed is within close proximity, many of the samples were analyzed within 12 hours. Chain of Custody protocol, sample labeling protocol, and sample temperature requirements were observed at all times. The MVTL lab is a certified state lab. Therefore the lab is open to audit by the MPCA, and Minnesota Department of Health. **Minnesota State lab number is 027-015-125 and EPA lab code is MN00008.**

A list of parameters and their respective maximum holding times to be analyzed by Redwood–Cottonwood Rivers Control Area (RCRCA) sampling are listed in Table 2-3. Water quality data collected during 2009 and 2010 was analyzed by RCRCA and reviewed by MPCA staff.

Table 2-3. Water Quality Sample Requirements and Analytical Methods

Analyte	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
E. coli Bacteria	100 mL	Sterile Plastic	Cool to 4°C	24 H*	SM** 9223 B (Colilert)
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.1
Ortho – phosphorus	500 mL	Plastic	Cool to 4°C	2 D	EPA 365.1
Ammonia Nitrogen	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 350.1 Rev 2.0
Total Kjeldahl Nitrogen	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	SM 4500–N_{org} B / NH_3 E
Nitrate + Nitrite	250 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 353.2
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I–3765–85
Total Suspended Volatile Solids	500 mL	Plastic	Cool to 4°C	7 D	EPA 160.4
Turbidity	250 mL	Plastic	Cool to 4°C	2 D	EPA 180.1 B

*8 hrs if used for enforcement purposes; ***Standard Methods for the Examination of Water and Wastewater*.

Loading Rates, FLUX Calculations, and Flow Weighted Mean Concentrations

Stream loading is a measure of mass passing by a specific location over a unit of time. Loading estimates for the project are provided in Chapter 4.

Individual water samples, particularly those with no associated flows, gives only a snap shot in time of water quality conditions. Large variations in climatic conditions, and therefore flows can influence the chemical and physical make up of riverine systems on a daily or even hourly basis. To obtain a better representation of water quality during a particular season, flow weighted mean concentrations (FWMC) and mass and loading rates (e.g. tons of sediment per day) are often used to help accurately portray water quality. A statistical computer model, FLUX32 for Windows (version Dec, 2010) was used to determine FWMC's and loading rates for the four sites with calculated discharge. FLUX is an interactive program developed by the U.S. Army Corp of Engineers that allows the user to estimate loadings from grab sample concentration data and continuous flow records.[3] It is designed for use in estimating loadings of

[3] Department of the Army, U.S. Army Corp of Engineers, Empirical Methods for Predicting Eutrophication in Impoundments, Report 4, Phase3, Application Manual, 1987.

nutrients or other water quality components passing a tributary sampling station over a given period of time. The estimates are based on flow-weighted average concentrations multiplied by the mean flow over the monitoring period. Data requirements include:

- Grab sample water chemistry results, typically measured at a weekly to monthly frequency for the growing season
- Water sample results from several storm events
- Corresponding flow measurements (instantaneous or daily-mean values)
- Complete flow record for the period of interest

Using six calculation techniques for statistical significance, FLUX maps the flow/concentration relationship developed from the sample record onto the entire flow record to calculate total mass discharge and associated error statistics. An option to stratify the statistics into groups based upon flow, date, and or season is also possible. In many cases stratification allows one to decrease the coefficient of variance and thereby increase the accuracy and precision of FWMC and loading rates. The program allows the user to fine tune the outputs to best describe the dataset for use in graphical depictions. FLUX also provides information, which can be used to improve the efficiencies of future monitoring programs.[4]

Runoff and Normalized Yield

As defined above, a "load" is an estimate of the total amount of material or mass coming out of a specific watershed or passing a specific point. A better way of assessing loads and comparing watersheds of different sizes is to determine the "yield" or the mass per unit area (such as lbs. /acre) coming out of the individual watershed. This normalizes the mass on an area basis and allows for a more relative comparison between all the watersheds. Yield is calculated by dividing the total mass or load associated with the time frame of interest by the area (acres) in the respective watershed. When comparing the six streams in the study area with each other and other watersheds, yields are further reduced by dividing them by the number of inches of runoff for the respective watershed, producing a "normalized yield". When yields are normalized, it is important to remember the spatial differences in precipitation and runoff. Runoff is that part of precipitation that appears in rivers and streams, including base flow, storm flow, flow from ground water, flow from point sources, and so on. Simply put, it is all the flow passing a particular location along the river. By evaluating runoff, comparisons can be made of the relative amount of water coming out of the individual watersheds. To calculate growing season runoff, we add up the total flow or amount of water that came past the station during the monitored period. This value is converted to acre-inches of water, and then divided by the total number of contributing acres, thus converting to inches of runoff.[5]

Example:

[4] FLUX Stream Load Computations Version 4.5 Environmental Laboratory USAE Waterways Experiment Station Vicksburg MS, 1995.

[5] "Seven-mile Creek Watershed Project – A Resource Investigation within the Middle Minnesota Major Watershed" Diagnostic Study Report, BNC Water Quality Board, October 2001

*Take for example year 2010 flow data for site MMCC1. It was found that a total of 8,711 cubic feet of water entered the MN River from Crow Creek Watershed for the 224 days of the monitoring season for 2010. The first step to determine runoff from a watershed is to convert cubic feet per second (cfs) to acre-feet. This translates into a conversion factor which is the following: 8,711*60*60*24/43,560=17,278 acre-feet. This is basically the amount of area in acres that would be covered by water at a depth of one foot. The next step is to convert acre-feet to runoff: 17,278 acre-feet/23,390.25acres in watershed*12=8.86 inches of runoff. In the truest sense this does not represent the actual amount of water that ran off the surface of the land. Research shows that for this area around 1/6 of the runoff goes to surface water runoff. So if there is six inches of runoff, about 1 inch is in the form of actual runoff and the remaining five inches is in the form of shallow subsurface tile flow tributaries and groundwater near the stream.*

The scenario is equivalent to redistributing all the flow out equally over the watershed, then measuring the depth in inches. Typically, the more precipitation that occurs in the basin, the more runoff there will be. However, the timing and intensity of the precipitation, antecedent soil moisture conditions, soil types, land slopes as well as several other factors can dramatically influence the final runoff number.

By evaluating runoff as well as the mass or load simultaneously, we can better determine if a particular watershed had higher or lower loads because of climatic conditions and soil properties when compared to other watersheds or whether it was actually related to land use characteristics. In general, runoff tends to be high in the middle Minnesota River Basin due to the clay soils and curve numbers. However, the high amount of private sub-surface tile drainage tends to decrease the long-term effect of these high curve numbers.

Ecoregion Assessment/Water Quality Standards

Ecoregions are based on similarities of land use, soils, land surface form, and potential natural vegetation. Water Quality information from minimally impacted streams by the MPCA within these regions is used to assess the degree of impairment on a water resource.

Map 2-1 -Minnesota's Seven Ecoregions. Mapped by USEPA.

Table 2-4 - Interquartile Range of Concentrations for Reference Streams in Minnesota by Ecoregion.[1] Distributions of annual data from 1970-1992 (McCollor and Heiskary, 1993; note 1 mg/L = 1 ppm = 1,000 ppb)

	Total Phosphorus (mg/L)			Total Suspended Solids (mg/L)			Turbidity (NTU)		
Region/ Percentile	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**
NLF	0.02	0.04	0.05	1.8	3.3	6.0	1.7	2.5	4.3
NMW	0.04	0.06	0.09	4.8	8.6	16.0	4.1	6.0	10.0
NCHF	0.06	0.09	0.15	4.8	8.8	16.0	3.0	5.1	8.5
NGP	0.09	0.16	0.25	11.0	34.0	63.0	5.6	15.0	23.5
RRV	0.11	0.19	0.30	11.0	28.0	59.0	6.0	12.0	23.0
WCBP	0.16	0.24	0.33	10.0	27.0	61.0	5.2	12.0	22.0

[1]Interquartile range is determined by sorting measures from lowest to highest and represents those measures between the 25th and 75th percentile.

Historically, MPCA Ecoregion values from minimally impacted streams were used to further refine the categories.[6] In Minnesota there are 7 defined ecoregions. The study area falls within part of the Western Corn Belt Plains ecoregion. Summer mean values from 1970-1992 were used to help determine the categories. The U.S. Environmental Protection Agency has divided the continental United States into ecoregions based on soils, geomorphology, land use, and potential natural vegetation. For Minnesota, this results in seven fairly distinct ecoregions (map 2-1). For example, the Northern Lakes and Forests ecoregion (NLF) is predominantly forested with numerous lakes and covers the northeastern part of MN. The Western Corn Belt Plains ecoregion, located in the southern third of MN, has rolling terrain and is extensively cultivated with row crops. Land use, topography, and water quality characteristics of the ecoregions were reviewed to assess the non-point source pollution problems across the state. This review can be found in a 1993 MPCA report by McCollor and Heiskary. The ecoregion framework provided a good basis for evaluating differences and similarities in Minnesota's streams. Reference streams, thought to be representative and reflect expected water quality for a region, were sampled by the MPCA to characterize stream conditions for each ecoregion. The reference streams were one yardstick by which to measure other streams. Table 2-4 lists the typical total phosphorus, total suspended solids, and turbidity for reference streams in six ecoregions[7].

A more commonly used method of assessing water bodies in the advent of TMDLs is set standards for water quality assessment. Water quality standards are one of the fundamental tools that help protect Minnesota's surface waters from pollution. Water quality standards consist of three elements (USEPA 1994, Minn. R. chs. 7050 and 7052):

1. Classifying waters with designated beneficial uses
2. Narrative requirements and numeric concentration standards to protect those uses
3. Nondegradation (antidegradation) policies to maintain and protect existing uses and high quality waters

Water quality standards are the fundamental benchmarks used to assess the quality of all surface waters. In Minn. R ch. 7050, statewide water quality standards are listed in Minn. R. ch. 7050.0220 to 7050.0227. The term "water quality standards" is commonly used in both a broad and narrow sense. Broadly speaking, water quality standards include all the legal requirements in water quality rules described above and include the general standards found in 7050.0210, minimum wastewater treatment requirements, and effluent limits for point source dischargers. In the more narrow sense, pollutant-specific numeric and narrative criteria when associated with a beneficial use classification are referred to as "standards"; both numeric and narrative criteria define acceptable conditions for the protection of the uses we make of waters of the state. For a more complete discussion of water quality standards see this web site: http://www.pca.state.mn.us/water/standards/index.html.[8]

Pollutants or water quality characteristics assessed and associated with data collected through this project include dissolved oxygen, pH, temperature, *Escherichia coli* bacteria, nitrates, and turbidity. Appendix B contains excerpts from the MPCA document **"**Guidance

[6] Water Quality Division, Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoreregions. February 1993.
[7] MPCA, 1998 Report on the Water Quality of MN Streams, Environmental Outcomes Division, 1998.
[8] MPCA, Guidance Manual for Assessing the Quality of Minnesota Surface Waters, October 2009

Manual for Assessing the Quality of Minnesota Surface Waters", published in October 2009, describing these elements.

WATERSHED ASSESSMENT and MODELING

Geographic Information Systems (GIS)

Watershed assessment through GIS land use layers, tillage surveys, stream bank surveys, feedlots, drainage patterns, etc. exist for the project area. Maps can be created and analyzed to facilitate the selection of priority management areas outlined in watershed maps. Spatial relationships will be obtained using ArcMap and ArcGIS analysis. Most layers used for this analysis including surface hydrology, land use, nonpoint pollution source potential, soils, feedlots, and field gradients were readily available, but a few layers had to be tailored to the study with newer available data. Analysis of this land use information was used to establish potential priority areas in the implementation plan and as input data in the watershed modeling. GIS maps created by the project can be seen throughout this report and are useful tools to display data spatially from a variety of sources at once. This data can show the potential "hot spots" in the project area that may need attention by local planners as well the processes and dynamics that shape the physical, biological and chemical environment of watersheds.

The linkage between GIS, the internet, and environmental databases is especially helpful in planning studies where information exchange and feedback on a timely basis is very crucial and more so when there are several different agencies and stakeholders involved. GIS has been used for a wide array of studies, ranging from diagnostic studies to implementation assessments using hydrodynamic and spatially explicit hydrologic/water quality modeling. As an example, alternatives for restoring a waterbody or a watershed can be studied by creating digital maps that show existing conditions and comparing them to maps that represent the alternative scenarios. GIS has been proven to provide a platform for collaboration among researchers, watershed stakeholders, and policy makers, significantly improving consensus building and offering the opportunity for collaborative work on interdisciplinary environmental policy questions.

One thing that had to be considered with the use of any data set for assessment and planning is that even though a data set that has employed the most rigorous of quality control procedures, some data can be deemed quickly outdated one example being the feedlot coverage data, which dates from 2003. The septic system (SSTS) data is from 2006.

Load Duration Curves (LDCs)

According to recent studies (MRAP, Minnesota River DO, Minnesota River Turbidity and the like), there is a strong positive correlation between streamflow and suspended sediments, nutrients (phosphorus, nitrate-nitrogen), and *E. coli*/Fecal Coliform bacteria and an indication that sediments carried in the Minnesota River and tributaries such as Crow Creek and Wabasha Creek originate from gullies, banks, and cropland, the primary land use in southwestern Minnesota. There had been a limited number of analytical samples taken in any of the streams within the scope of this project. As a result of the limited testing results, none of the tributaries in the area appeared on the 2008 303d list as there was insufficient data to effectively determine impairments. However, reaches between tributaries on the Minnesota River itself may have listings.

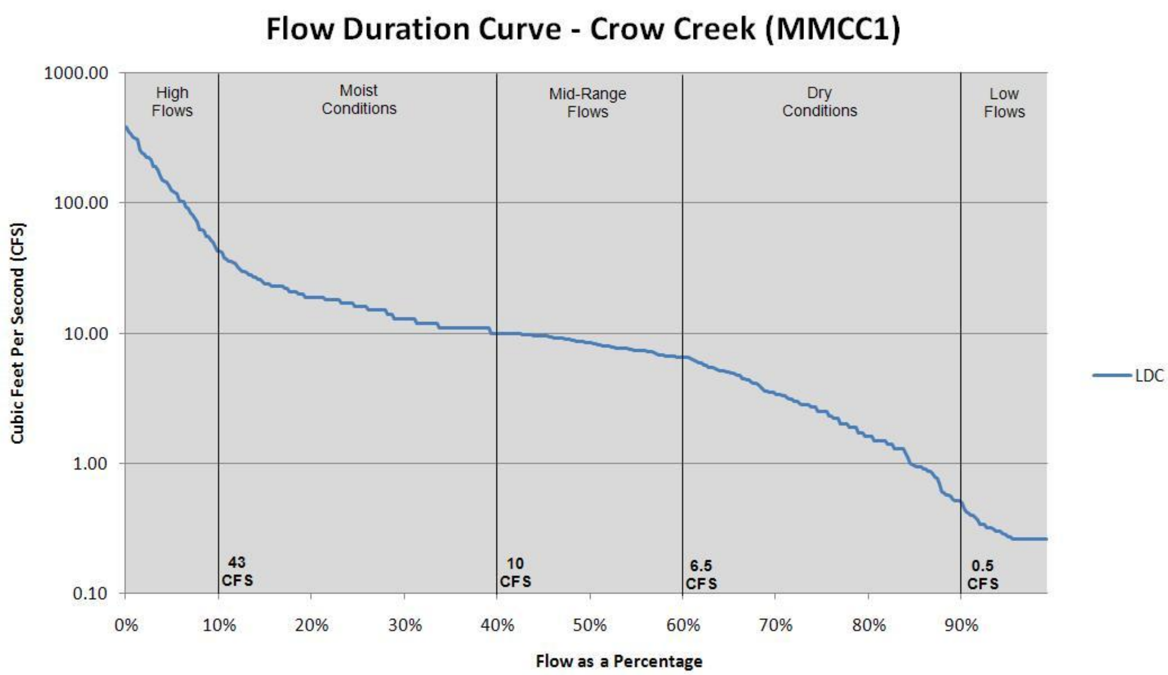
Information gathered as part of this diagnostic study may result in listing the six reaches on the next round of 303(d) listings in 2012. Measurements and data gleaned from the sampling sites give us the tools to compare the health of different streams spatially, but there is a method to approximate water quality over the entirety of flow conditions on a reach and at what percentage of time the stream meets standards.

For TMDLs and diagnostic studies to be more beneficial in the assessment and implementation process, they should reflect adequate water quality across flow conditions rather than at a single flow event such as average daily flow. Many states have begun to use load duration curves as a more robust method for setting TMDL targets. It is also a useful tool for better characterizing the pollutant problems over the entire flow regime.

A duration curve is a graph representing the percentage of time during which the value of a given parameter (e.g. flow, load) is equaled or exceeded. Such a graph can be easily generated using a spreadsheet computer program. Using available daily streamflow data, a flow duration curve is developed for the site in question. Data for the curve is generated by: 1) ranking the daily flow data from highest to lowest; 2) calculating percent of days these flows were exceeded (= rank ÷ number of data points).[9]

For this diagnostic study, the daily flow values were sorted by flow volume, from highest to lowest to develop a flow duration curve. Figure 2-1 displays the flow duration curve for Crow Creek, based on flow monitoring data obtained from the 2009 and 2010 sampling seasons. The chart depicts the percentage of time any particular flow is exceeded. For example, during the flow record 43 CFS was exceeded by 10 percent of daily flow values, and thus represents "high flow" conditions. A value of 0.5 CFS was exceeded by 90 percent of flow values and represents "low flow" conditions.

Figure 2-1: Crow Creek Flow Duration Curve Daily Mean (2009-2010)



[9] Nevada Division of Environmental Protection "Load Duration Curve Methodology for Assessment and TMDL Development", April 2003

Sediment and Nutrient Modeling

Soil erosion is frequently associated with sediment and phosphorus transport to surface water bodies. Identifying the extent and location of area with high erosion within a watershed will help managers pinpoint areas where best management practices should be implemented such as filter strips or conservation tillage. The soil erosion potential model was calculated using the Revised Universal Soil Loss Equation (RUSLE) for sheet and rill erosion predications. Corn and soybean rotation found in medium residue was assumed to be the cropping factor for all fields.

The RUSLE equation is: A= R Factor * K Factor * LS Factor * C Factor * P Factor

Methodology

Land use in the watershed was clipped by each monitored watershed. The number of acres of each type of land use was calculated and processed to develop a C factor for the RUSLE equation. Soils within each watershed were identified and assigned a K and LS factor based on NRCS ratings for each soil type. Each watershed was then processed using the RUSLE equation to determine soil loss for each watershed. P factor or conservation factor was given a value of 1. It was assumed special conservation practices such as conservation tillage, strip cropping or other practices were not present. Although there are many areas where conservation is incorporate on cultivated land, P factor was not considered in this analysis since detailed locations at the time were not readily available.

R Factor (Rainfall and Runoff)

- Incorporates the rainfall frequencies of geographic areas. RUSLE contains expanded and more precise information for locations across the United States. R factor has the ability to calculate the effect that ponded or puddled water has on raindrop erosion
- Values used for analysis
    - 115 Brown County
    - 110 Redwood County

K Factor (Soil Erodiblity)

- More significant erodibility data from around the world such as the soil type, the diameter of soil particles, and the presence of rock fragments. Adjusted to account for soils in South-Central Minnesota.

- K values assigned by specified soil unit and adjusted for RUSLE zone 100B/C
    - .17 adjusted to .15 .28 adjusted to .26
    - .32 adjusted to .30 .20 adjusted to .17
    - .37 adjusted to .35 .24 adjusted to .22
    - .43 adjusted to .40

LS Factor (Slope Length and Steepness)

- Known value found in the Soil Survey
- Possesses the ability to predict soil loss on complex slopes
- Can apply different functions based on the relative amounts of rill and interrill erosion.

C Factor (Cover and Management)

- .16 cultivated land 0.0 shallow or seasonal wetlands (types 1, 2, 3)=.003
- .02 grassland/CRP .45 gravel pits and open mines
- .003 forested .15 farmsteads and other rural developments
- .26 Urban and industrial 0.0 lakes and deeper water wetlands

P Factor (Support Practice)

- Assumed no special practices on any cultivated land (constant of 1.0)

Tailored Integrated Stream Watershed Assessment (TISWA)

The Tailored Integrated Stream Watershed Assessment (TISWA) is a screening tool that combines varying degrees of existing estimated and observed data. The purpose is to rank sub-watersheds of a watershed in order to determine areas which have higher pollution potential. Using this study, there can be a focus on a particular area of a watershed with a scientific basis for choosing these locations, or target areas, for best management practice implementation. In conjunction with other factors such as highly erodible soils, water quality sampling results, and loading estimates, areas associated with poorer water quality can be addressed first in the most economical and environmentally beneficial way.

In the summer of 2011 a TISWA survey was conducted in the project area. Staff from the Redwood-Cottonwood Rivers Control Area conducted the survey. Before the actual field survey was conducted, relevant information was gathered from maps and GIS systems to determine survey locations and background information of the area. A map is included in chapter 4 that shows the results of the TISWA survey. The map indicates the location of each TISWA point and impairment rating for that location. Three to four locations were identified in each of the 6 sub-watersheds. The survey points were conducted on tributaries and the main stem of the streams in the study area. TISWA Survey locations were located where a tributary or the main-stem of the streams traversed a public roadway. Again, the conditions of the site only reflect the vicinity within viewing distance of the observer. Conditions of sampling point using the below criteria are subjective. Impairment ratings were determined from the total range of scores within each category. An example of a field worksheet used for scoring can be found in the Appendices. Using the TISWA survey questions, the study addressed four categories:

- Land-use/Landscape. Depending on the percentages of land use/land cover at the site location, the potential for contaminants to be carried to specified creeks can be determined.
- Pollutant Sources. This section relates to the number and condition of feedlots, point source facilities and septic systems.
- Riparian Zone and Channel Morphology. This section attempts to document the general condition of the riparian zone.
- Biotic and Abiotic Indicators. This section estimates the overall biological and biochemical condition of the subwatershed.

Soil and Water Assessment Tool (SWAT)

The Soil and Water Assessment Tool (SWAT) was employed in the project area in an effort to determine the effects of land-use management and describe watersheds that have yet to be assessed. The model used known values including weather, runoff, storage, crop, groundwater flow, soil type, and nutrient loads within the modeling. Knowing the sediment, water, and nutrient movement in the watershed helps in estimating priority areas within the watersheds as well as aid in building an implementation plan in the future.

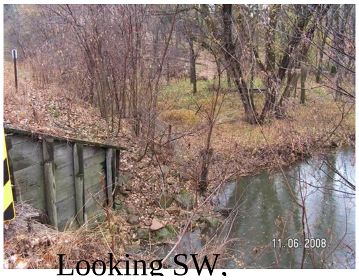
Fishery Surveys

Reviewing fish surveys that had been undertaken in the project area will give us an idea of the progression of management strategies of fish species in the surface waters over time. The Minnesota Department of Natural Resources (DNR) performed surveys, sampling, and population assessments on Hindeman and Johns Creeks over the past 40 years. These two streams are designated trout streams and had been stocked in the past and managed from the DNR fisheries office in Hutchinson.

Typically, there are different types of electro-fishing equipment used in assessments, depending on stream width and depth at each particular site. In deeper, wider sections of large rivers, a boat-mounted generator-powered “boom” shocker is used. In shallow, narrow upstream sites or small streams like these, a battery-powered backpack shocker, carried by one person, is sufficient.

Description of Sampling Sites –

- **MMCC:**
  - Primary Site on Crow Creek near Redwood Falls, MN. Location: Lat. 44.535636 Long. -95.047577, in Paxton Township Section 03 T. 112N, R. 35W, Redwood County, at bridge on Noble Avenue, 3 miles east of Redwood Falls.


Looking SW,


Looking W,


Looking NW,


Looking NE,


Looking E,


Looking SE,

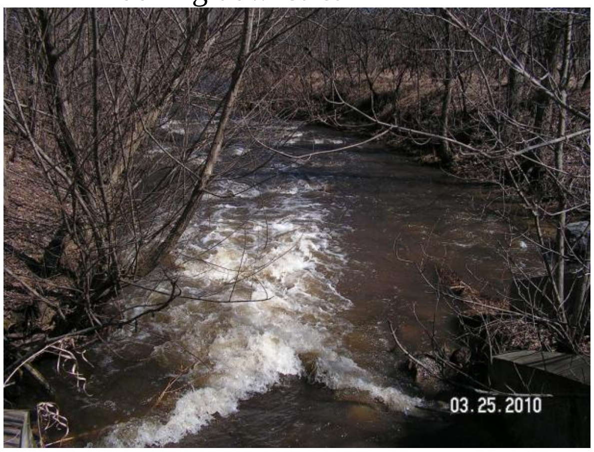
- **MMWC:**
  - Primary site on Wabasha Creek near Franklin, MN. Location: Lat. 44.505894, Long. -94.885831, in Sherman Township, Section 13, T. 112N, R. 34W, Redwood County, at bridge on county road 11, 2 miles south of Franklin.

Looking downstream

Looking upstream

- **MMNE:**
  - Primary site on North Eden Creek near Morgan, MN. Location: Lat. 44.456438, Long. -94.799014, in Eden Township, Section 34N, T. 112N, R. 33W, Brown County, at culverts on county road 10, 8 miles northeast of Morgan.

Looking downstream



Looking upstream

- **MMSC:**
  - Primary site on Spring (Hinderman) Creek near Essig, MN. Location: Lat. 44.398466, Long. -94.688001, in Home 'N' Township, Section 21, T. 111N, R. 32W, Brown County, at culverts on county road 10, 8 miles northwest of Essig.

Looking US

Looking DS

Looking DS

- **COD13:**
  - Primary site on Brown County Ditch 13 near Essig, MN. Location: Lat. 44.376635, Long. -94.673041, in Home 'N' Township, Section 34, T. 111N, R. 32W, Brown County, at culverts on county road 10, 6 miles northwest of Essig

Looking upstream

Looking downstream

- **COD10:**
  - Primary site on Brown County Ditch 10 near Essig, MN. Location: Lat. 44.363277, Long. -94.633318, in Home Township, Section 01, T. 110N, R. 32W, Brown County, at culverts on county road 29, 3.5 miles north by northwest of Essig

Looking upstream

Looking South, US

Looking downstream

Looking NE, DS

Middle Minnesota Major Watershed
First Order Streams of Redwood and Brown County

CHAPTER 3: DESCRIPTION OF PROJECT AREA

General Summary

Most of the watersheds in the project area are level to gently rolling agricultural lands. Soils in the area are mostly heavy, poorly to moderately-well drained silty clays and clay loams. The watershed is almost entirely privately owned apart from a few public accesses and state wildlife management areas in the lower reaches of the tributaries and the Minnesota River bottom lands. The predominant land-use in the project area is for agricultural production, with a majority of that land in row-crop planted cropland. Just over 6,000 acres of wetlands of types 1-4 exist in the project area and there are about 1,500 acres of state wildlife management areas and county parks affording access to the Minnesota River for fishing and canoeing. Recreational opportunities in the surrounding area are limited by degraded water quality, channel obstructions, limited access, and a general lack of awareness by watershed residents. Potentially, the project area can be a major recreational resource.

The courses of the streams in this study are similar in that they are heavily "ditched" and extended from their natural state for the most part. While all six stream courses do fall roughly 210 feet from headwaters to the Minnesota River, the majority of the stream course is determined by the floodplain and wetlands. Most of the fall for the streams of the project area comes in the final couple of miles from the mouth as the stream transitions into the Minnesota River flats. Much of the floodplain along the individual streams is pastured or simply put under row-crops and the remainder is tree-lined steep banks in the lower regions of the streams as they drop into the Minnesota River valley.

Middle Minnesota Major Watershed: First Order Streams of Redwood and Brown County

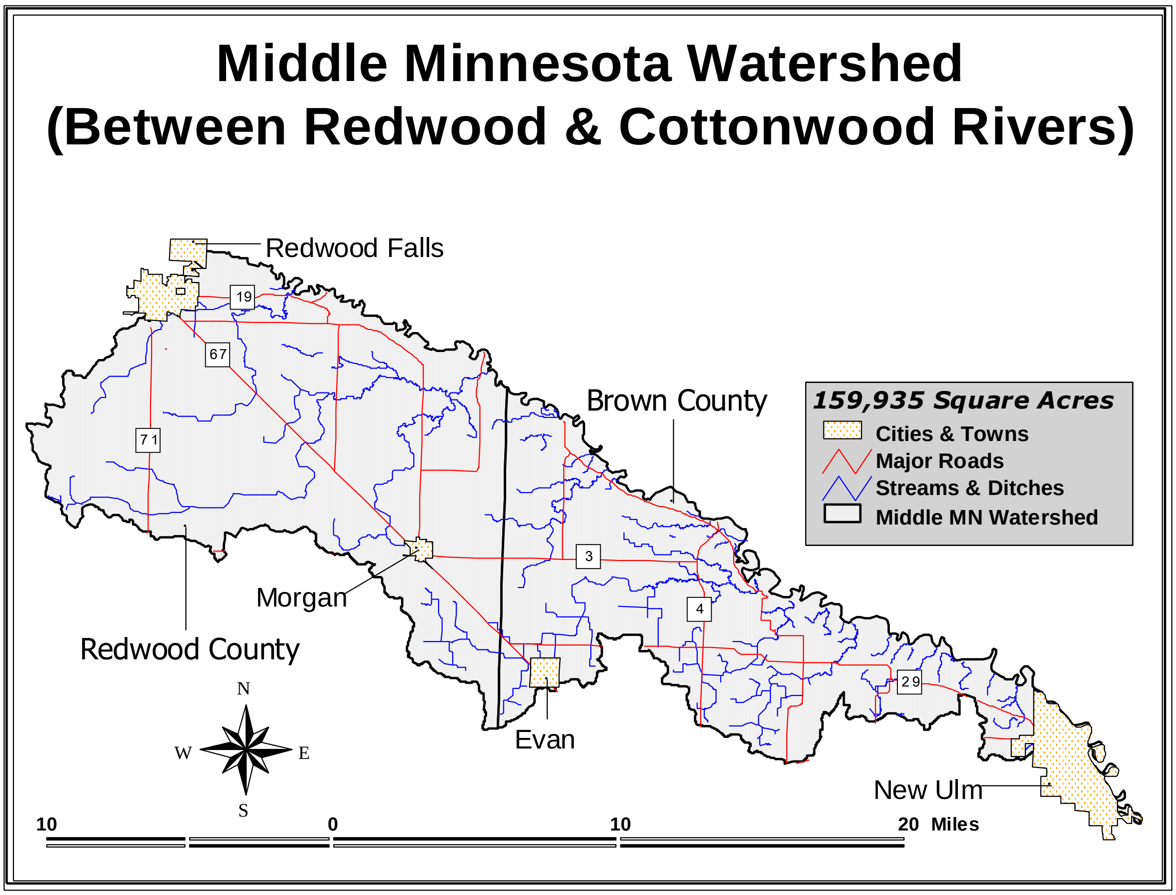
The Middle Minnesota Basin covers 1,347 square miles in parts of 8 counties in South Central Minnesota. The basin ranks sixth in area of the twelve major watersheds supplying the Minnesota River. The Middle MN River Watershed defines a large irregular-shaped area that drains into the MN River through a number of relatively small streams, seeps and small springs. The Middle MN minor watersheds differ from most of the other watersheds of the MN River basin in that they are defined more by the main stem of the Minnesota than by any particular tributary. That makes this basin somewhat unique; the rest of the 11 basins all have identifying central rivers. This unique feature of the watershed can pose difficulty in making water quality assessments and implementation since there are a large number of first and second order streams.

The project area consists of 159,935 acres or about 18.5% of Middle Minnesota Watershed. The area is between the outlets of the Redwood River and the Cottonwood River draining portions of Brown and Redwood counties in south-central Minnesota. The area described here is portrayed in the map (Map 3-1) and Table 3-1 below. This area consists of first order streams: Crow Creek, Wabasha Creek, North Eden Creek, Spring Creek, Brown CD #13, and Brown CD #10. These streams generally orient from southwest to northeast as they drop into the Minnesota River valley to meet the Minnesota River. Smaller streams in the project area, which are essentially confined to direct draws and seeps that contribute directly to the Minnesota River proper, are included in the area description figure but were not assessed in the diagnostic study. Areas of these smaller streams are summarized in Table 3-2 below.

Table 3-1: Watershed Area by County

COUNTY	ACRES of the PROJECT WATERS WITHIN the COUNTY	% of WATERSHED in the COUNTY	% of the COUNTY in the WATERSHED PROJECT AREA
BROWN	69,320	43%	17.5%
REDWOOD	90,615	57%	15.9%
Total	159,935	100%	

Map 3-1: Study Area Map



<u>*Crow Creek*</u>

Crow Creek's headwaters begin about 5 miles southwest of Redwood Falls in Redwood Falls Township Section 27. The reach is more or less a drainage ditch (Co. Ditch 52) as it heads northeast toward the city of Redwood Falls. The system cuts through Redwood Falls city limits taking on stormwater effluent and heads straight east to where Co. Ditch 22 meets it in Section 4 of Paxton Township just west of the Noble Avenue Bridge. From this point on it takes on more of a natural stream characteristic as it turns north to drop into the Minnesota River valley, crossing under U.S. Highway 71/MN Highway 19 to where it meets the Minnesota River within the Tiger Lake WMA.

Wabasha Creek

Wabasha Creek's headwaters are greatly extended by Redwood County Ditch 64 which served to drain the Three Lakes lake beds of Three Lakes Township (Sections 3-4, 7-10). As it stands today, Co. Ditch 64 starts out in New Avon Township Section 4 and heads roughly due east cutting through old lake beds and sloughs until it reaches Three Lakes Township Section 1 and heads north, crossing State Highway 67 just west of Gilfillan. The system meets up with Co. Ditch 106 and takes on more of a riverine characteristic just before it crosses Redwood County Road 13 about 2 miles south of the Lower Sioux Indian Reservation (Mdewankanton Tribal Community). Wabasha Creek then picks up a large unnamed tributary from the south including Co. Ditch 109 in Section 22 of Sherman Township. County Ditch 109 is the receiving water for the wastewater effluent from the city of Morgan. Wabasha Creek meets the Minnesota River just east of the Cedar Mountain Scientific and Natural Area (SNA) near the County Road 11 crossing.

North Eden Creek

North Eden Creek is a small system where the headwaters of the main reach start out as JD 17 in Morgan Township Section 12 in Redwood County. The ditch crosses into Brown county at Eden Township Section 7 and picks up JD 18 1½ miles later, where it takes on a more stream-like nature shortly after. The small stream then picks up a north branch as it falls into the Minnesota River bottom, crossing under Brown County Road #10 into 'North' Eden Township Section 34, where it meets the Minnesota River.

Spring Creek

Spring Creek is the 2nd largest system of the area of study. Like all of the streams in the study, the reach has been augmented through drainage ditches. The main reach starts out in Redwood County just south of the city of Morgan as JD 29 draining old sloughs and shallow lake with multiple laterals. JD 29 crosses the Redwood-Brown county line just west of the villiage of Evan where it crosses MN 68 and heads northeast in a winding but angular fashion (due to road right of ways and property lines) between low spots and old sloughs. As the reach crosses Brown County Road 8, it starts to take on more of a river system characteristic in Eden Township Section 23 where it turns into what is deemed a fishable trout stream for about 3½ miles as it drops into the Minnesota River valley at its confluence in "North" Home Township Section 21 north of Brown County Road #10.

Brown County Ditch 13

The smallest reach, draining only a little over 11 square miles, Brown County Ditch #13 starts out only about 10 river miles from where it enters the Minnesota River and retains a perennial stream designation throughout the system. The stream drops steeply and winds northeastward as it crosses under Brown County Road #10 and meets the Minnesota River in "North" Home Township Section 27.

John's Creek/Brown County Ditch 10

John's Creek system drains only a little over 13 square miles of land. The system starts out as Brown County Ditch #10 and retains a perennial stream designation throughout the system. The stream drops steeply and winds northeastward as it crosses under Brown County Road #29 and meets the Minnesota River in Milford Township (111N) Section 31 just west of Horseshoe Lake. It is this section of the stream that is considered a trout stream by DNR fisheries.

Table 3-2: Subwatershed Area by County

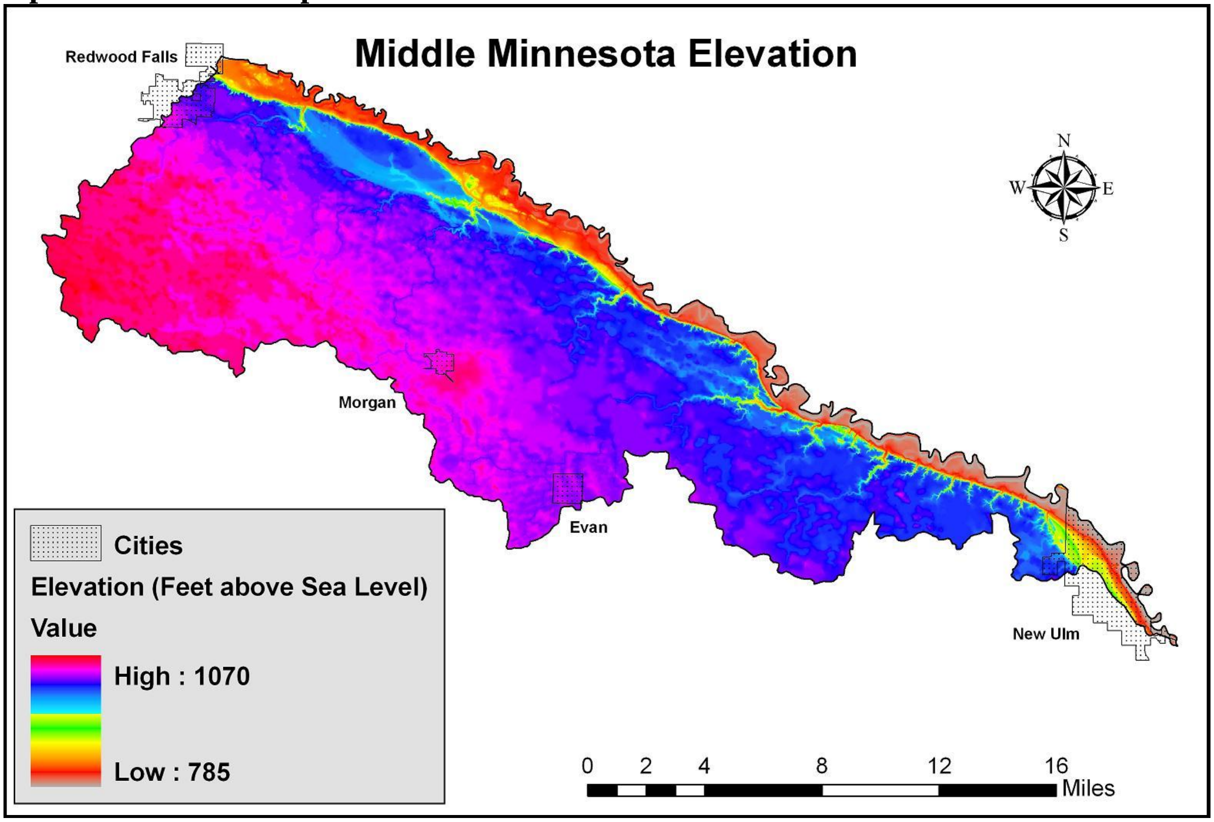
WATERSHED	ACRES of WATERSHED	ACRES of the PROJECT WATERS WITHIN BROWN COUNTY	ACRES of the PROJECT WATERS WITHIN REDWOOD COUNTY	% of WATERSHED in BROWN COUNTY	% of COUNTY AREA	% of WATERSHED in REDWOOD COUNTY	% of COUNTY AREA
CROW CREEK	23,390.25	-	23,390.25	-	-	100.00%	4.11%
WABASHA CREEK	44,484.09	-	44,484.09	-	-	100.00%	7.82%
NORTH EDEN CREEK	12,718.94	6,360.21	6,358.73	50.01%	1.61%	49.99%	1.12%
SPRING CREEK	28,759.52	21,312.78	7,446.74	74.11%	5.39%	25.89%	1.31%
BROWN CD #13	7,256.99	7,256.99	-	100.00%	1.83%	-	-
JOHN's CREEK (CD10)	8,514.11	8,514.11	-	100.00%	2.15%	-	-
MINNESOTA RIVER ADJACENT DRAWS	34,811.63	25,876.03	8,935.60	74.33%	6.54%	25.67%	1.57%
Total	159,935.53	69,320.12	90,615.41		17.52%		15.92%

Topography

The project area consists of 159,935 acres (249.9 sq. miles) or about 18.5% of Middle Minnesota Watershed consisting of six main subsheds and many smaller draws, intermittent streams, and seeps that empty directly into the Minnesota River itself or the valley floodplain. The area is between the outlets of the Redwood River and the Cottonwood River draining portions of Brown and Redwood counties in south-central Minnesota. The six main streams generally orient from southwest to northeast as they drop into the Minnesota River valley to meet the Minnesota River at lengths ranging from around 8.5 miles in the case of North Eden Creek, Brown CD #13, and Brown CD #10 to nearly 23 miles in the case of Wabasha Creek.

Elevation within the project area ranges from roughly 1,050 feet to about 795 feet of elevation at the Minnesota River in Brown County near New Ulm. While all six stream courses do fall roughly 210 feet from headwaters to the Minnesota River, the majority of the stream course is determined by the floodplain and wetlands. Most of the fall for the streams of the project area comes in the last couple of miles from the mouth as the stream transitions into the Minnesota River flats. The average gradient of the studied streams range from nearly twenty-three feet per mile for smaller streams to roughly 10 feet per mile at Wabasha Creek. Map 3-2 illustrates the topography of the study area, and shows the varying elevation over the watersheds.

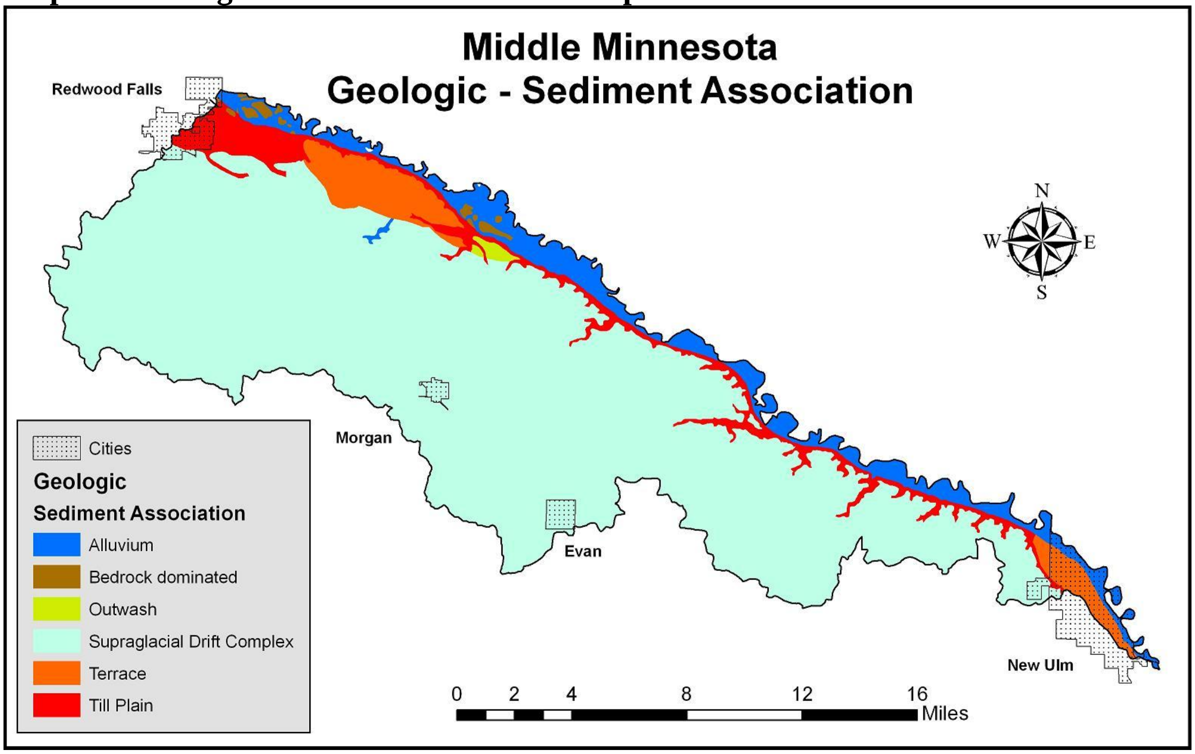
Map 3-2: Elevation Map



A majority of the watersheds are nearly level to flat with poorly drained soils formed from glacial till. About eighty-seven percent of the watershed area formed in glacial till, seven percent by alluvium and colluvium processes, .28 percent due to outwash, and .5 percent is down to bedrock. A further four and a half percent of the project area is considered the Minnesota River terrace. Most of the surface features found in the project area are a product of events happening during and after the last ice age 12,000 to 16,000 years ago.

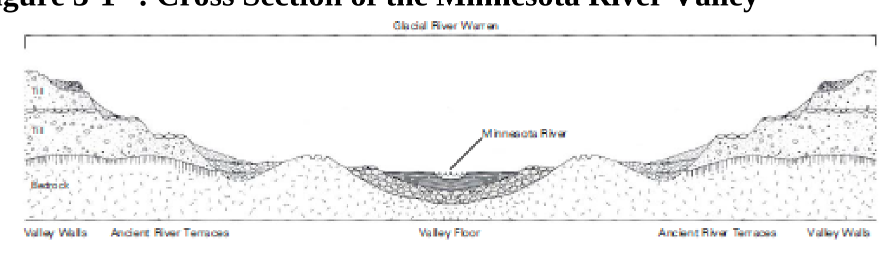
Three distinct topographic features represent the project area: the glacial moraine/till plains, transition zone, and lower river terrace/alluvium. The till plains, in the project area, is a flat area of land northeast of the Coteau des Prairies. The Coteau des Prairies is a wedge shaped plateau made up of several hundred feet of glacial deposits overlying Cretaceous age bedrock. The resultant action of the glacial roughing against the northeast edge of this formation created a layer of ground moraine that occupies about three quarters of the project area. Soils of the watershed formed mostly in glacial till based on shale and sands, or in material sorted out of the glacial till by the action of water. The landscape undulates gently with low wetland zones connected by shallow overland drainage and old ox-bow lakes as well as sand and gravel deposits near rivers. The transition area is the area between the upland till and the lower river floodplain or the remnant river terraces above the current Minnesota River. The topography of the region is generally steep and forms bluffs containing ravines and gullies, some of which are deep-cutting. The soils of the area are generally sands and gravels deposited in glacial till with exposed kaolinitic clays in the ravines which formed later.

Map 3-3: Geologic Sediment Associations Map



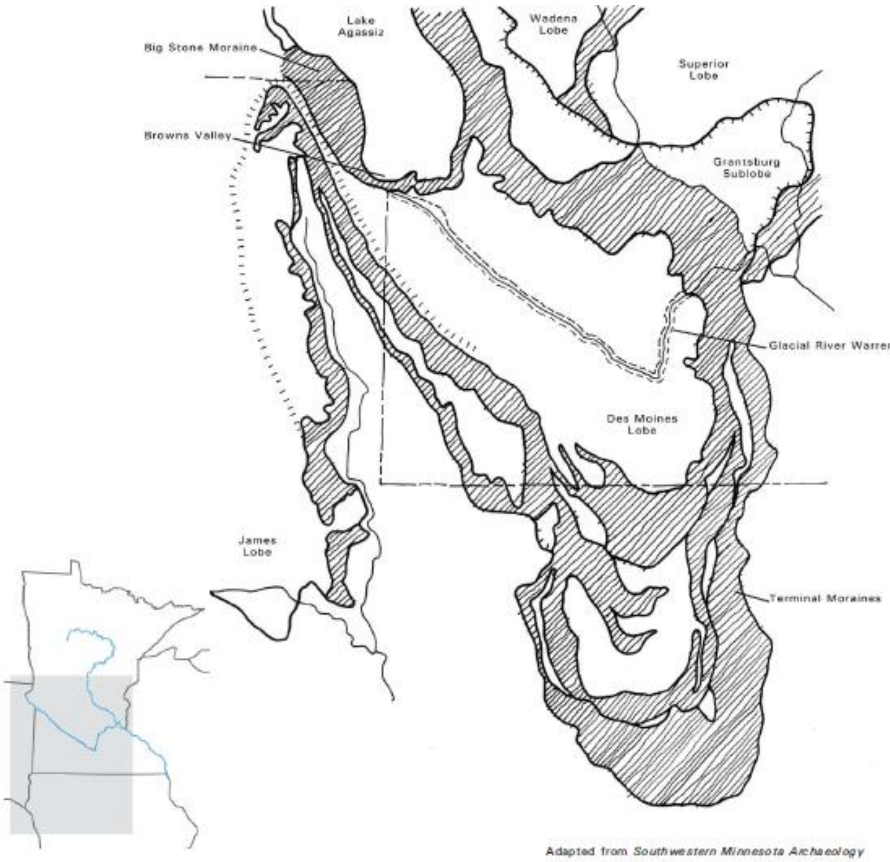
The last features are post-glacial in nature and were formed as the valley of the River Warren was formed between 11,700 and 9,400 years ago. A substantial amount of flow from a growing glacial Lake Agassiz (due to glacial melt water) poured through southwestern Minnesota following the breaching of a moraine built by ice damming which formed a natural dam near present day Browns Valley (Figure 3-2). The relatively quick rush of water carved the large valley in which the Minnesota River currently flows. At Redwood Falls, the valley is 2 miles across and the valley walls are around 150 feet from the valley floor. Some ancient river terrace formations still exist above the current Minnesota River valley, but for the most part surface formations in the valley are products of post-glacial fluvial processes. In a few spots along the Minnesota River valley, post glacial processes have exposed some of the bedrock under the project area. There are a few spots where hard rock outcrops of granitic and gneiss formations are readily exposed to the surface. These exposures are some of the oldest known rocks in North America. See Figure 3-1.

Figure 3-1[10]: Cross Section of the Minnesota River Valley



[10] Taken from: http://ccl.design.umn.edu/publications/mnriv07/MNRIV07_minnesota%20river%20valley.pdf

Figure 3-2[11]: Glacial River Warren and Major Moraines @11,000 y.a.



Hydrogeology

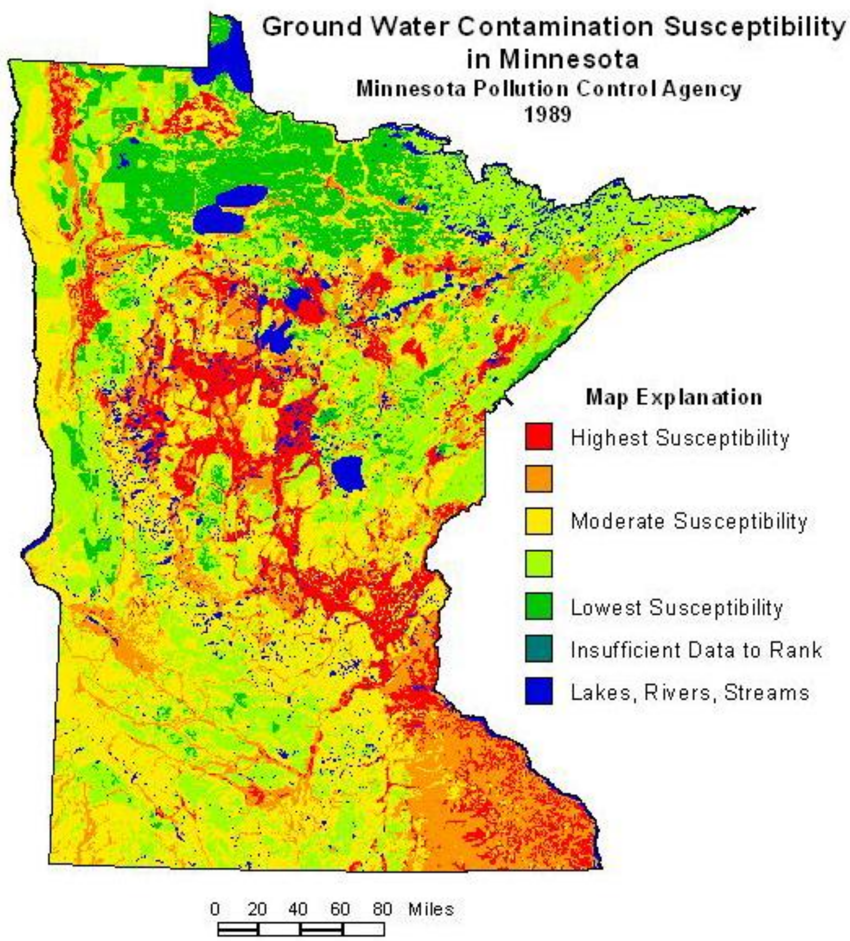
Ground water flow is generally northeastward, perpendicular to water table contours. This flow begins in Cambrian formations and is diverted locally by Precambrian crystalline rock intrusions that form nearly impermeable barriers to water movement. There is downward recharge from precipitation to ground water as it enters the watershed. The regional ground water flow is northeastward from the topographic high of the Coteau that moves towards the Minnesota River. Pleistocene glacial deposits cover almost the entire project area, and contain most of the widely used aquifers. These glacial deposits are composed mostly of till, which is an unsorted and unstratified mixture of clay, silt, sand and gravel. Sand and gravel beds are the easiest to find, and are most commonly used for water source within the watershed. In most cases, water can be drawn directly from this glacial outwash. Because these aquifers are so close to the surface, contamination is more likely to occur than in aquifers that are buried deeper in the ground. Roughly ten percent of the Pleistocene layer of sediment within the watershed is glacial outwash and alluvium along the Minnesota River that consists of sand, gravel, and other material that has been transported and deposited by streams. Approximately eighty-seven percent of the sediment is classified as ground moraine, which is composed of mostly glacial till. In this area, the till can be too thin to support a reliable source of groundwater but may be the only source

[11] Taken From: http://ccl.design.umn.edu/publications/mnriv07/MNRIV07_minnesota%20river%20valley.pdf

available. In some areas of the project area, a layer of shale and interspersed sandstone exists in the area due to coastal flat and shallow sea deposits during the Cretaceous period. The Cretaceous deposits lay directly below the glacial deposits where they exist in the project area. This type of deposit is composed of mostly shale, but they do contain some poorly consolidated sandstone aquifers. The aquifers are thin layers of sandstone concentrated near the base of the Cretaceous deposits and generally move in the direction of shallow aquifers. Where the Cretaceous formations are absent, the glacial till or alluvial sand lies directly over bedrock. Bedrock formations in the area range from Precambrian Gneiss in the northwest to late-Precambrian quartzite outcrops near New Ulm. Most bedrock in the area is granitic (Morton Gneiss) in nature and provides little value for water sources, unless fractured.

Ground water throughout much of southwestern Minnesota has a very high mineral content. Iron and manganese concentrations regularly exceed recommended standards. In addition, much of the ground water has high concentrations of sulfate and dissolved solids. Consequently, municipalities are required to treat water supplies to meet Minnesota Department of Health (MDH) drinking water quality standards.

Map 3-4[12]: Groundwater Contamination Susceptibility in Minnesota



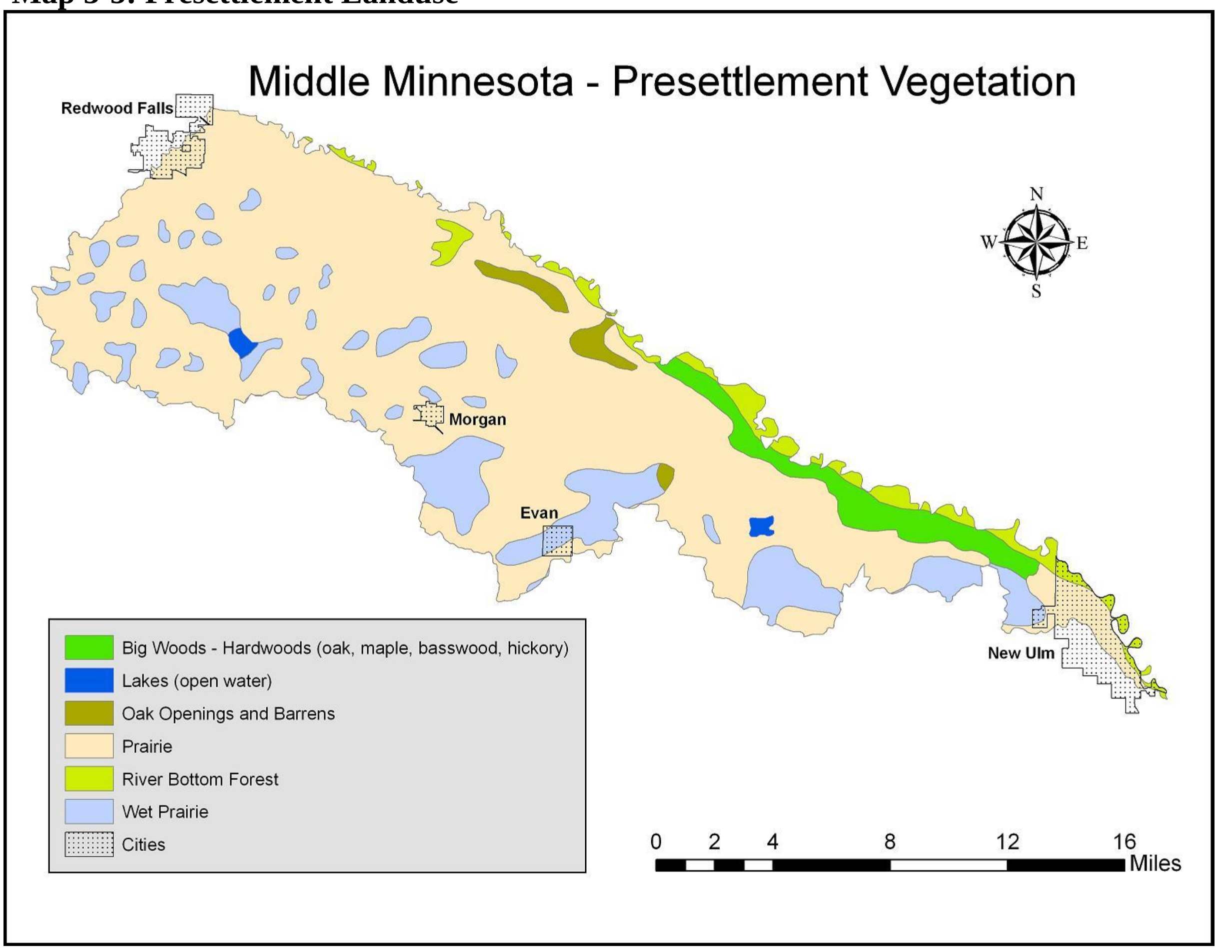
[12] Taken from: http://www.dnr.state.mn.us/waters/groundwater_section/mapping/gwcontam_susceptibility.html

Though the majority of the project area's water table has a low to moderate susceptibility to surface water pollution contact, ground water pollution in the project area likely results from excessive use of fertilizers, recharge water that has passed through livestock feedlots, and poorly constructed or maintained drinking water wells and septic systems. Map 3-4 shows groundwater contamination potential on the state level.

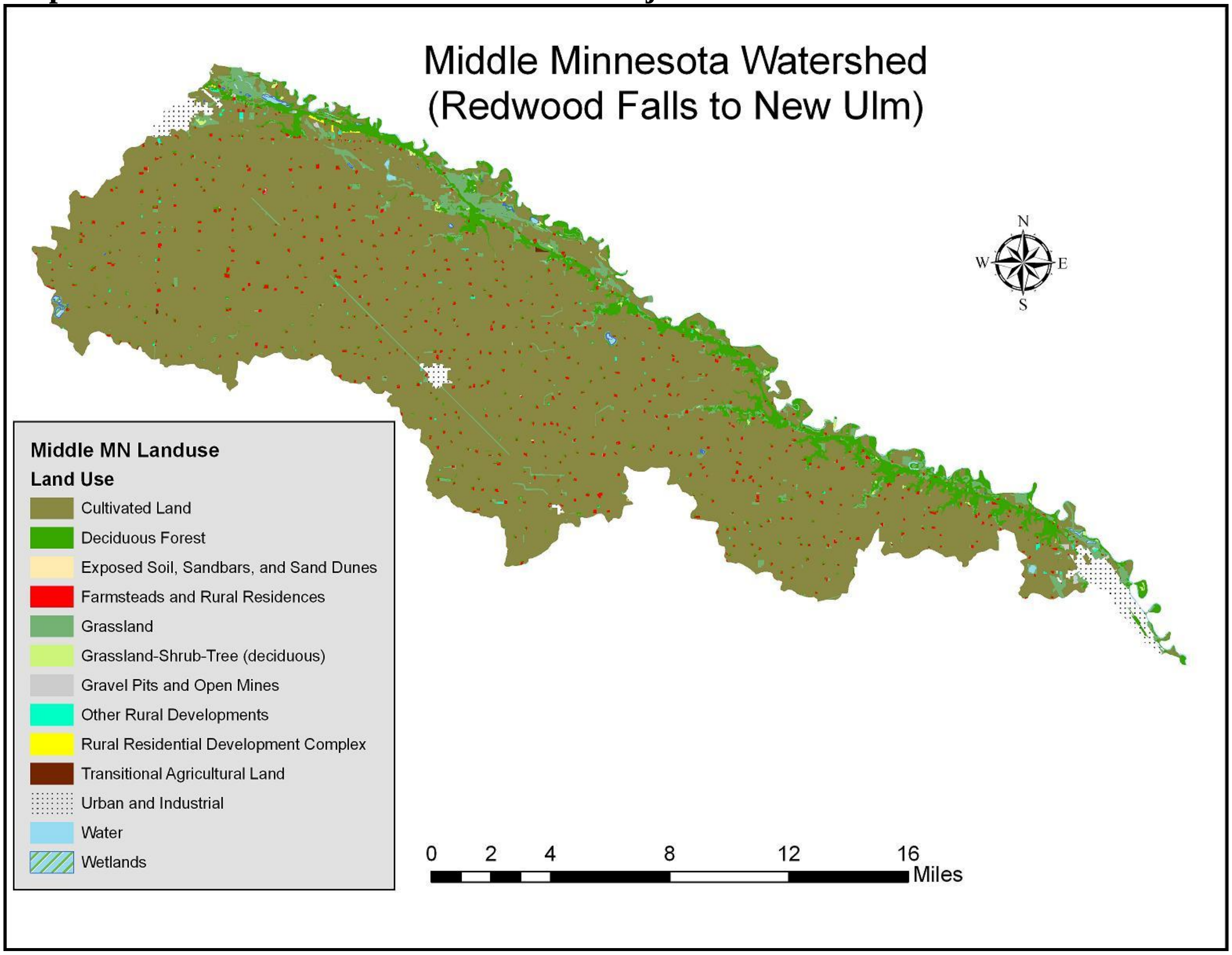
Land Use

Since the 1850s the watershed has been transformed from open prairie, pothole wetlands, and small areas of hardwood forests and oak openings to an intensively developed agricultural area (See Map 3-5). Whereas the market for the products of the early farmers was limited to areas only about 30 miles away, much of the current agricultural production is marketed around the U.S and overseas. Roads on virtually every section line provide transportation routes. Southwestern Minnesota is predominantly an agricultural region. Approximately 85 percent, or 135,419 acres in the project area, are under cultivation. Within the six monitored subwatersheds, the cultivated land percentage is over 90 percent. About 80 percent of the cropland is planted to row crops (corn and soybeans) with some pasture and occasional feedlots, and small forested areas. Municipalities within the watershed include the cities of Morgan, Evan, the Lower Sioux Nation, and portions of New Ulm and Redwood Falls.

Map 3-5: Presettlement Landuse



Map 3-6: Landuse in the Middle Minnesota Project Area



The past couple of decades had shown a decrease in cropland acreage, largely attributable to highly erodible and other marginal land being enrolled in the Conservation Reserve Program (CRP). Although this program has taken many of the erodible watershed acres out of production for a short time, some of these acres have recently come out of the program. With ever evolving farm program guidelines, fewer acres are now being enrolled. However, the acres that are being accepted into programs are located mostly in highly sensitive areas. Instead of placing whole fields into a program, only the parcels of land that specifically meet guidelines should be accepted, with the theory being that the placement of the most economical environmental benefit in the smallest geographic area for the greatest return**.** One exception to this trend of fewer acres being enrolled in farm programs may have been participation in the Conservation Reserve Enhancement Program (CREP). This program combined features of CRP and Reinvest in Minnesota (RIM) to offer very attractive payments for permanent or long term land easements in the Minnesota River basin. Most land along the Minnesota River and its tributaries was automatically eligible for the program. The program was so successful that it was expanded to include other parts of Minnesota in 2005. Table 3-3 shows current land use by subwatershed. Map 3-6 represents current land use within the study area.

Table 3-3: Land Use in the Project Area

Land Use

Watershed		C	DF / G / GST	F / RR / OR	Exp / GP	Wet / W	UI / T / O	Total Acres
Crow Creek (mmcc1)								
	Acres	21,314.85	883.05	431.98	3.19	10.18	747.01	23,390.25
	Percent	91.13%	3.78%	1.85%	0.01%	0.04%	3.19%	100.00%
Wabasha Creek (mmwc)								
	Acres	40,992.35	2,448.08	661.51	15.13	143.60	223.42	44,484.09
	Percent	92.15%	5.50%	1.49%	0.03%	0.32%	0.50%	100.00%
North Eden Creek (mmne)								
	Acres	11,823.10	598.96	198.46	0.00	0.00	98.41	12,718.93
	Percent	92.96%	4.71%	1.56%	0.00%	0.00%	0.77%	100.00%
Spring Creek (mmsc)								
	Acres	26,785.63	1,415.92	470.54	0.17	46.88	40.40	28,759.52
	Percent	93.14%	4.92%	1.64%	0.00%	0.16%	0.14%	100.00%
County Ditch 13 (cod13)								
	Acres	6,569.25	531.48	149.79	0.00	6.47	0.00	7,256.99
	Percent	90.52%	7.32%	2.06%	0.00%	0.09%	0.00%	100.00%
County Ditch 10 (cod10)								
	Acres	7,761.55	628.23	124.26	0.08	0.00	0.00	8,514.12
	Percent	91.16%	7.38%	1.46%	0.00%	0.00%	0.00%	100.00%
Total Monitored								
	Acres	115,246.73	6,505.72	2,036.53	18.58	207.13	1,109.23	125,123.92
	Percent	92.11%	5.20%	1.63%	0.01%	0.17%	0.89%	100.00%
All Middle MN (Redwood to New Ulm)								
	Acres	135,419.59	17,790.38	2,617.05	133.19	1,141.60	2,833.74	159,935.55
	Percent	84.67%	11.12%	1.64%	0.08%	0.71%	1.77%	100.00%

Key

C = Cultivated Land

DF, G, GST = Deciduous Forest / Grassland / Grassland-shrub-tree

F, RR, OR = Farmsteads and Rural Residences / Rural Residential Development / Other Rural Dev

Exp, GP = Exposed Soil; Sandbars and Sand Dunes / Gravel Pits and Open Mines

Wet, W = Wetlands / Water

UI, T, O = Urban and Industrial / Transitional Agricultural Land / Other

Soils[13]

Soil is the basic resource upon which all terrestrial life depends. Our fields and forests and the quality of our lakes and streams is dependent upon the quality of the soil. Many of the environmental decisions about using a resource in Minnesota are based on the mechanics of soil and the ability of the soil to support a particular resource use. The productive agriculture of southwest Minnesota, including that of this study area, is a direct result of the fertile soils and favorable climate of the area. Soils are classified and sorted into different major orders, sub-orders, grouping, etc. depending on five major environmental factors:

1. Parent Material
2. Climate in which the Material is Found
3. Relief of Landscape
4. Types of Organism's the Material can Potentially Support
5. Timing of Element Interaction

The major soil orders are defined largely on the basis of having certain kinds of diagnostic horizons or diagnostic materials. The locations of the soil orders depend mainly on climate and organisms they are able to support. In the case of this study area, the parent material of all but rock outcrops and certain fluvial processes was derived from glacial till. The climate of the area was considered to be a moist prairie climate capable of growing thick prairie grasses owing to high organic content. In summary, most soils in the area are considered in the order of Mollisols with a smaller area of Entisols in the Minnesota River valley and along its valley walls. A description of both orders, taken from the University of Minnesota publication "Soils and Landscapes of Minnesota", follow:

> ***Mollisols***--*This order covers a considerable land area of Minnesota and is the basis for the state's productive agricultural base. The formative syllable,* 'oll'*, is derived from the Latin word* 'mollis' *or soft. Its most distinguishing feature is a thick, dark-colored surface layer that is high in nutrients. It occurs throughout the former prairie areas of Minnesota. The Latin term for soft in its name is descriptive in that most of these soils usually have a rather loose, low density surface. Three suborders of mollisols occur in Minnesota: Aquolls, Udolls, and Ustolls.*
>
> ***Entisols***--*Soils of this order occur throughout Minnesota. The formative element here is* 'ent' *which refers to recent soil. Soils developed in recent river bottom alluvium and sandy soils where the parent materials consist of weather-resistant quartz are typical of this soil order. Because of insufficient time or material resistant to weathering, soil properties change very little with depth. The major suborders of entisols that occur in Minnesota are Aquents, Orthents, and Psamments.*

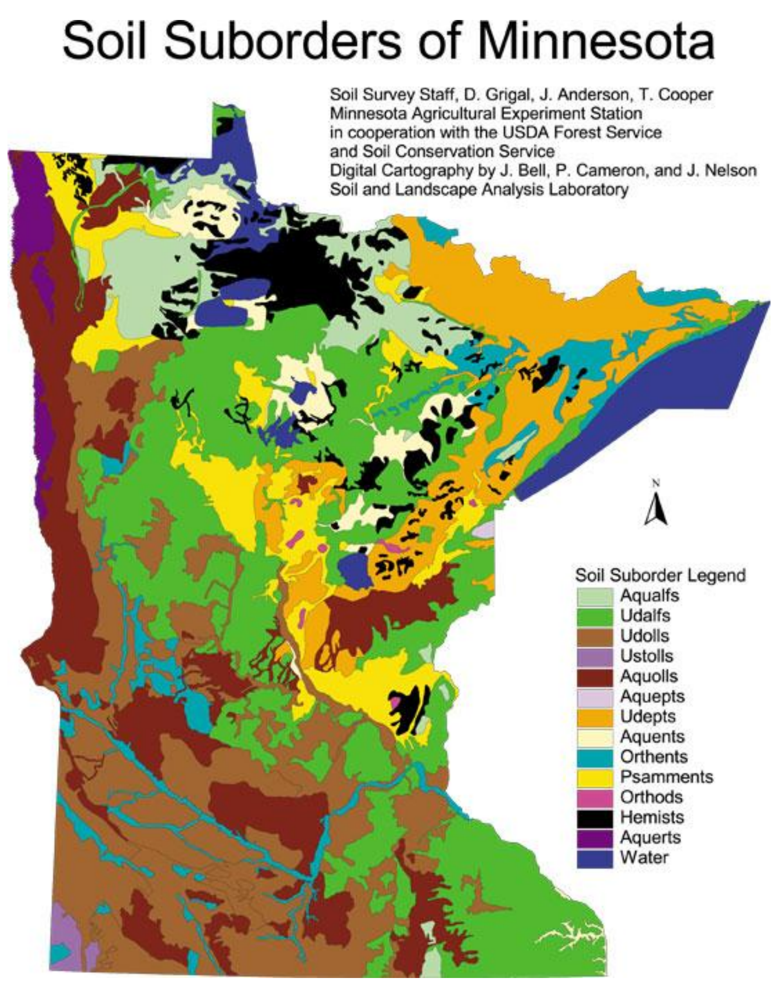
Suborders within a soil order are separated on the basis of important soil properties that influence soil development and plant growth. The most important property is how wet the soil is throughout the year. The study area is generally has a thicker, high organic, humid soil. Again, a smaller area of hard rock, steep slopes, and fluvial soils can be found near the Minnesota River valley. In summary, most soils in the area are considered in the sub-order of Udolls with a

[13] Portions taken from "Soils and Landscapes of Minnesota" Anderson, Bell, Cooper, & Grigal, U of M, 2001

smaller area of Orthents in the Minnesota River valley and along its valley walls. A description of both sub-orders, taken from the University of Minnesota publication "Soils and Landscapes of Minnesota", follow:

> ***Udolls--****are moist prairie soils. The Latin root '*udus' *refers to humid. These are soils of humid climates. These soils cover much of the western one-half and southern one-third of the state, and are very productive agricultural soils. The dominant crops on these soils are corn and soybeans.*
>
> ***Orthents--****are shallow or poorly developed soils. '*Orthos' *means true in Greek. These are the true or common entisols. These soils primarily occur in two areas. In northeastern Minnesota, they occupy tops of ridges where outcrops of rock are common. The trees that are present are usually pine. These soils and associated vegetation are picturesque reminders of wilderness. Orthents are also scattered in other areas of the state, especially the west-central and southwest, where glacial deposits have steep slopes and the material is not easily weathered.*

Map 3-7[14]: Minnesota Soil Suborders



[14] Taken from University of Minnesota publication "Soils and Landscapes of Minnesota"

More precise soil taxonomy further divides soils into great-groups, then sub-groups, then families depending on characteristics including interaction amongst groups, distinct physical and chemical properties influencing plant growth, land management decisions, and engineering purposes. The lowest level of distinction recognized is the soil series. Soils comprising an individual series are nearly homogeneous and their range of properties is limited. Soil series are separated on the basis of observable and mappable properties such as color, structure, texture, and horizon arrangement. A soil series is named for the location where the soil was first identified. The series is the level that is generally used to name mapping units of detailed soil surveys completed at scales between 1:24,000 and 1:15,840. Such soil surveys have been done for most counties in Minnesota including Brown and Redwood County. Within these surveys soil associations have been compiled. The soil association is a descriptor of an area containing like soil properties named after the one or more series names that make up a majority of the area and include a few minor series.

Main soil associations in the project area include:

- Canisteo/Webster-Normania/Nicollet-Okoboji in the till plains
- Canisteo/Webster-Nicollet-Ves/Clarion in the flat transitional areas
- Terril-Storden-Clarion-Swan Lake- in the steep slopes of transitional areas
- Millington-Dupage/Minneiska-Calco soils along the Minnesota River
- Estherville-Mayer/Dickman-Estherville-Lemond in the glacial outwash terraces
- Wadena Varient-Rock Outcrop-Copaston in the valley rock outcrops

A general description of these soils follows:

- **Canisteo/Webster-Normania/Nicollet-Okoboji**—Poorly drained, moderately permeable soils, and very poorly drained nearly level soils formed in loamy glacial till or silty alluvial moraines in glacial till; on uplands.
- **Canisteo/Webster-Nicollet-Ves/Clarion**—Poorly drained, very poorly drained, and well drained, undulating and nearly level soils formed in shale, calcareous, loamy glacial till.
- **Terril-Storden-Clarion-Swan Lake**—Well drained and moderately well-drained, steep and very steep soils that formed in glacial till and in local alluvium derived from glacial till; on river bluffs and foot slopes.
- **Millington-Dupage/Minneiska-Calco**—Nearly level poorly drained and nearly level moderately drained soil, found along flood plains and natural levees that are adjacent to streams and rivers.
- **Estherville-Mayer/Dickman-Estherville-Lemond**—Well drained and poorly drained, nearly level to moderately steep soils that formed in glacial outwash; on outwash plains, terraces, and moraines
- **Wadena Varient-Rock Outcrop-Copaston**—Rock outcrop and well drained and moderately well drained, nearly level to very steep soils that formed in glacial drift and alluvium; on terraces

All cropland soils, which have demonstrated potential for significant water erosion levels, were included in the GIS analysis. This includes soils with slopes ranked as B2, C, C2, D2, E and F. Soils with slopes ranked as E and above are almost all under permanent vegetative cover, such as grassland or woodland, and contribute little sediment from water erosion except in cases where overgrazing has occurred. The procedure for obtaining the highly erodible soil types is as follows. The GIS soil layers were used. Each subwatershed soil layer was displayed, along with its accompanying soil data. The soil types B2, C, C2, D2, E and F were queried out from each subwatershed soil layer. These soil types were summarized in the GIS to determine the acreage. This was completed for each subwatershed, with percentages calculated by comparing the highly erodible land acreage with the total acreage of the subwatershed. The results can be found in Table 3-4. Map 3-8 represents erodible soil location throughout the watershed.

Map 3-8: Erodible Soils

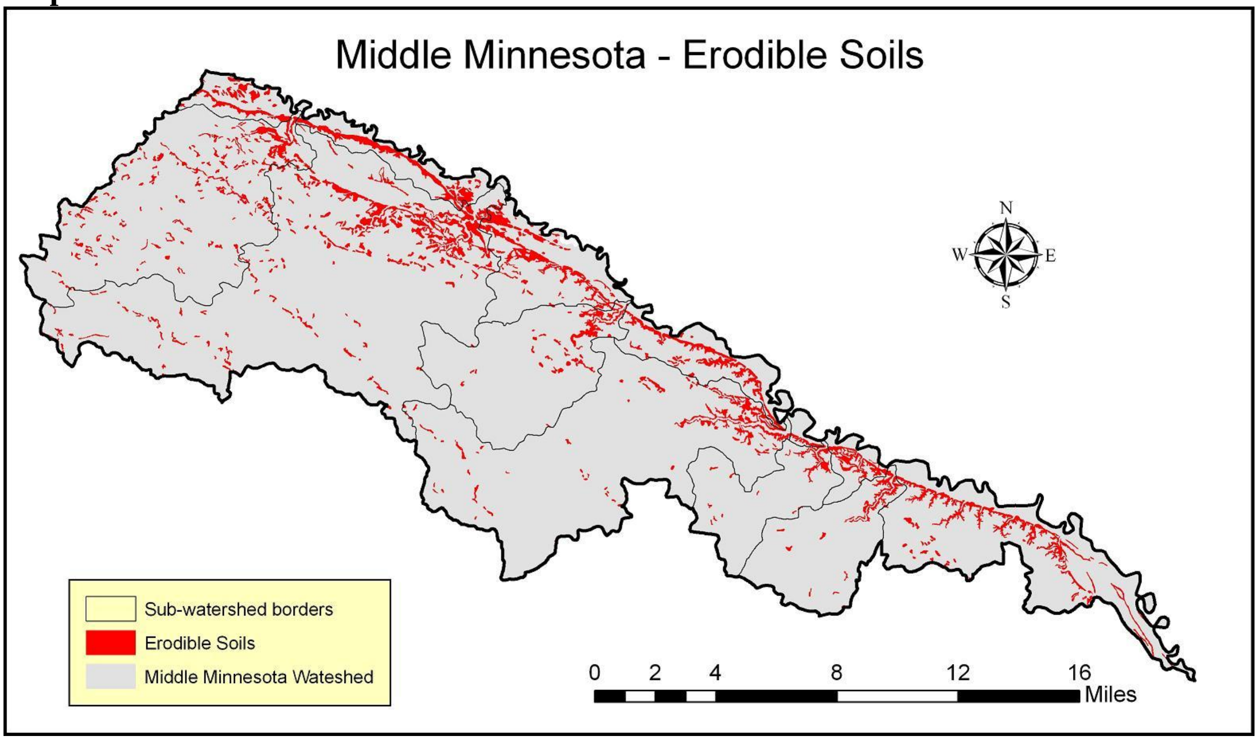


Table 3-4: Erodible Soils by Subwatershed

Subwatershed	Total Acres	Erodible Acres	Percent Erodible
Crow Creek (MMCC1)	23390.25	1603.07	6.85%
Wabasha Creek (MMWC)	44484.09	2994.73	6.73%
North Eden Creek (MMNE)	12718.93	575.38	4.52%
Spring Creek (MMSC)	28759.52	1100.26	3.83%
County Ditch 13 (COD13)	7256.99	265.60	3.66%
County Ditch 10 (COD10)	8514.12	379.63	4.46%
Unmonitored Areas	34811.63	5308.13	15.25%
Total	159935.55	12226.80	7.64%

Feedlots

The area is heavily agriculture and many feedlots exist in the area. Feedlots shown on Map 3-9 were created from the GIS database supplied from Minnesota State University Water Resources Center, Mankato. Table 3-5 shows the distribution of livestock facilities across this section of the Middle Minnesota watershed. The highest numbers of animal units are in Wabasha Creek and Spring Creek, but the highest concentration of animal units per square mile is in Brown County Ditch 13 and Brown County Ditch 10. Animal units (AU) are used in permitting, registration, and the environmental review process because they allow equal standards for all animals based on size and manure production. The total AU at a facility is calculated by multiplying the number of animals by an animal unit factor for the specific type of animal. As an example; a piglet under 55 pounds has an AU factor of 0.05 while a full grown pig over 300 pounds has an AU factor of 0.4 and a mature dairy cow over 1,000 pounds has an AU factor of 1.4 and a calf has an AU factor of 0.2.

Map 3-9: Livestock Facilities in the Middle Minnesota Project

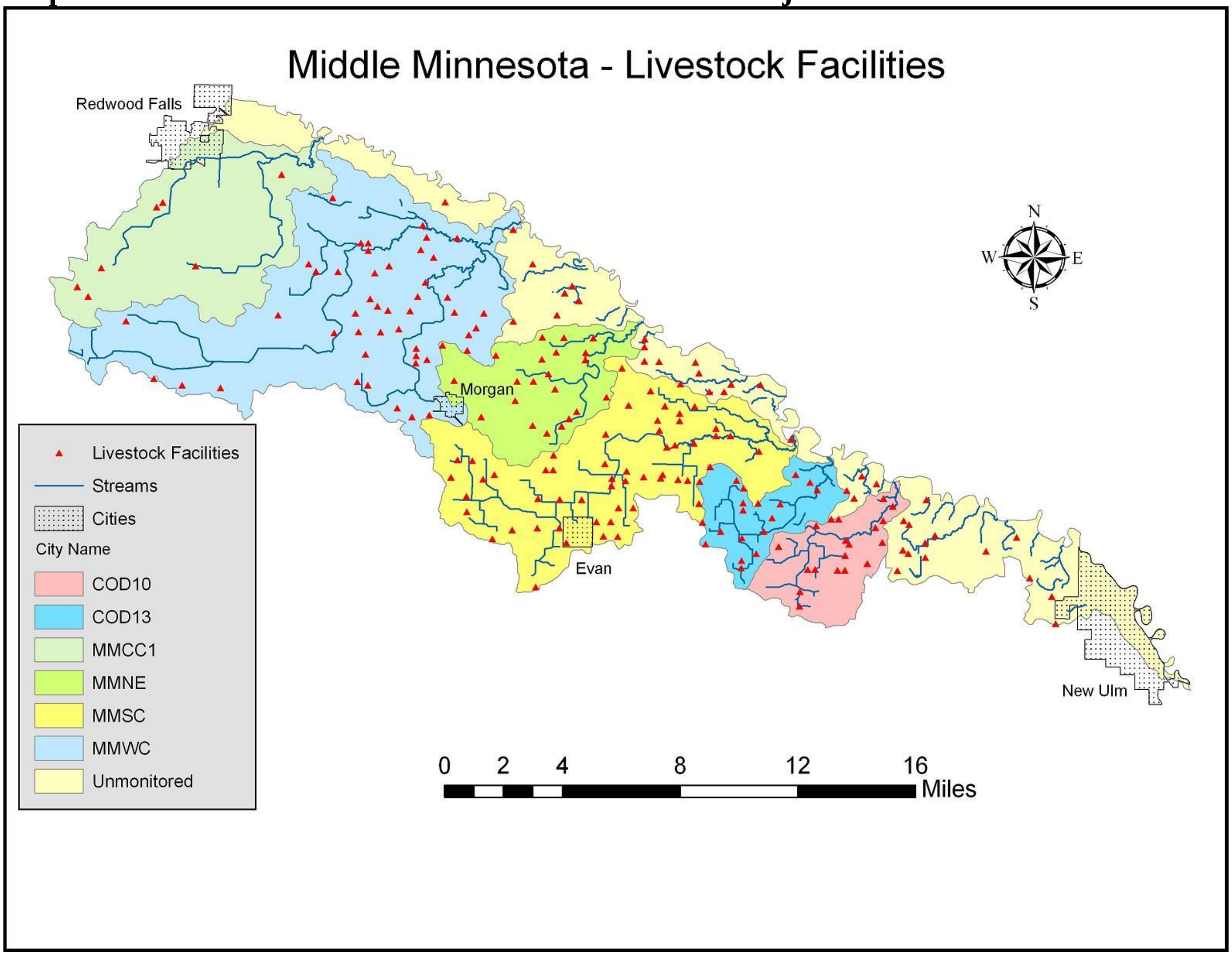


Table 3-5: Livestock Animal Units (AU)

Subwatershed	# lots registered	Total Animal Units (AU)	Acres	Square Miles (mi2)	AU/mi2
Crow Creek (MMCC1)	7	1,400.500	23,390.25	36.55	38.32
Wabasha Creek (MMWC)	47	17,183.770	44,484.09	69.51	247.23
North Eden Creek (MMNE)	24	6,548.539	12,718.94	19.87	329.51
Spring Creek (MMSC)	56	15,043.210	28,759.52	44.94	334.76
County Ditch 13 (COD13)	19	8,037.000	7,256.99	11.34	708.79
County Ditch 10 (COD10)	20	5,445.000	8,514.11	13.30	409.30
Unmonitored Areas	37	5,038.800	34,811.63	54.39	92.64
Total =	210	58,696.819	159,935.53	249.90	234.88

Crop Residue Survey Results

Crop residue management is using last year's crop residue to help stop erosion. Residue on top of the soil surface after planting will intercept raindrops, which prevents runoff. Allowing the water to soak into the residue slows the movement of water. Additionally, organic matter is added to the soil as the crop residue decomposes. Extra organic matter can lead to lower amounts of fertilizer needed on the field. The last tillage transect survey in the study area was completed in 2007. The survey is not an inventory of all field conditions in the watershed, but rather a sampling of field conditions. Results of this survey indicate just under 10% of fields were not tilled, often due to enrollment in a conservation program or use as pasture for livestock. Over 42% of the fields surveyed had conventional (~21%) or reduced (~21%) tillage. The largest category was in conservation tillage, most notably mulch tillage with around 47% of fields observed reporting this conservation tillage. This crop residue survey is done in each county to assess the percentage of agricultural crops planted into residue of less than 15%, 15% to 30% or greater than 30% residue. This information is then used to determine the overall percentage of cropland meeting residue targets in the county. Table 3-6 shows these results.

Table 3-6: Crop Residue Survey

Practice	% of Observations
Mulch Till	46.7%
Reduced Till	21.0%
Conventional Till	21.6%
Tillage N/A	9.6%
Unknown Till	1.2%

Fertilizer/Pesticide Use

Applicators create a unique mixture of fertilizer and/or pesticide that is suited to the specific soil type and crop history of that parcel of land. Therefore, it is impossible to get an absolute number on a given application rate for a specific area in the watershed. However, using current farm statistics, one can make rough approximations of the total amount being used in each county within the watershed. The most up-to-date statistics on fertilizer and pesticide use come from the 2006 Minnesota Agricultural Statistics, issued annually by the U.S. Department of Agriculture. The latest data contained within the book available for interpretation is from 2005.

Corn[15]

According to U.S. Ag Statistics, in Minnesota, ninety-four percent of the corn cropland had nitrogen applied. An average of 81 lbs./acre/application was applied, with an average of 1.7 applications being delivered. Phosphate was applied to eighty-six percent of the land, at a rate of forty-nine lbs./acre/application, and an average application rate of 1.2 times. Herbicides were applied to one-hundred percent of the land surveyed. Insecticides were applied to only twelve percent of the acres. Of the nineteen identified herbicides, Glyphosate iso. salt, Atrazine, and, Acetechlor were the most frequently used, being spread over forty-four, fourty-one, and thirty-threer percent of the land at an average of 0.74, 0.49, and 1.27 lbs. per acre/application, respectively.

Soybeans[16]

Sixteen percent of the soybean crop had nitrogen applied to it, at an average rate of thirteen lbs. per application, with only an average of one application being done. Eighteen percent of the soybean acres had forty lbs. of phosphate applied to it, with an application rate of 1. Insecticides were applied to fifty-six percent of soybean ground in Minnesota; herbicides were applied to over ninety-nine percent. Four herbicide types were found to be spread over the soybean acreage throughout the state. Glyphosate iso. salt (aka Roundup and others), is the most prevalent herbicide applied to soybeans in Minnesota. It is applied to ninety-three percent of the land at a rate of 0.80 lbs. per acre/application with an average application rate of 1.6.

Numbers are available on the amount of cropland, within each county, from the 2007 U.S Ag Census. Using these counts, and the numbers from the preceding paragraphs, a rough estimate of the amount of fertilizer use in the project area can be made. For corn, a rough average of 4,300 tons of nitrogen and 1,680 tons of phosphate are applied. For soybeans, a rough average of 58 tons of nitrogen and 202 tons of phosphate are applied.

Drainage

The small watersheds of the Minnesota River first order tributaries in Brown and Redwood counties have been extensively drained. Nearly all wetlands have been drained by a highly efficient and interconnected artificial drainage system. This drainage system has allowed agriculture, the primary land use, to flourish. Corn and soybeans are the main crops grown in the watershed. Unfortunately, the efficient drainage of land can expedite water movement from the land into open ditches and streams. The streams of the project area are greatly influenced by open ditch and tile systems so are thought to have amplified storm event flows just as other streams in this area of the Minnesota River watershed. The excellent farmland in the area most likely means that agricultural practices will continue in the area, however, some of the marginal

[15] U.S. Department of Agriculture, National Agricultural Statistics Service, Agricultural Chemical Usage 2005 Field Crops Summary, May, 2006

[16] U.S. Department of Agriculture, National Agricultural Statistics Service, Agricultural Chemical Usage 2005 Field Crops Summary, May, 2006

lands in the watershed especially in the Minnesota River bottom land may be allowed to return to a more riparian system. In addition to the natural network of waterways, artificially made drainage systems outlet into the tributaries and streams of the study. This influx of water contributes to the flow of the entire watershed and establishes the importance of determining the location of these manmade systems. Unfortunately, it is very difficult to locate where many of these lines are, especially the private tile lines.

There are two main reasons for drainage in the watershed. First, a proper drainage network will allow timely seedbed preparation, planting, harvesting, and other field operations. Second, efficient draining of an area can help protect field crops from extended periods of flooded soil conditions. Although these are valid reasons for drainage, problems do offset the benefits. Significant problems associated with drainage are the loss of wetland habitat and excessive nutrient and sediment transport. The tiling or draining of wetlands may destroy spawning, feeding and cover habitat, and result in siltation, increased water temperatures, and other influences that will adversely affect fish populations. Wetland drainage began in the early 1900s. This loss of water-orientated critical habitat affects many wildlife species. Wetland drainage eliminates or largely diminishes wetland contributions to recharging ground water aquifers, and reducing downstream flows during and after peak storm events. Wetland drainage may increase the availability of tillable land, thereby providing economic benefits in the short term, but downstream landowners may suffer from more flooding and ground water supplies for irrigation or on-farm domestic use may be affected.

Nutrient loss, such as nitrogen, to surface waters through drainage systems has been documented in numerous studies. According to an Ohio State University study[17], high concentrations of nitrate-N can easily be lost to subsurface drainage from high organic matter soils, even if no nitrogen or very small amounts are applied, especially when dry weather limits crop production. These studies primarily showed that nitrate-N losses depend upon the nitrogen application rate and amount of precipitation. Timing of application, and the type of crop grown, has also been shown to influence nitrate-N loss to drainage systems. Results like these suggest agricultural drainage may contribute to water quality problems downstream, especially from nitrate-N loadings that occur after flood events which occur after extended dry periods. Research has also shown that higher concentrations of nitrate-nitrogen can be found in soil water beneath row crops like corn, than beneath perennial crops like alfalfa. The study area has about 80 percent of the cropland planted to row crops (corn and soybeans). It has been reported that row crop production results in higher nitrate-N runoff losses because of higher flow volumes leaving the field. One solution is that of cropping systems that can maintain profitability while including a perennial crop as a possible method of limiting nitrate-N losses to surface waters.[18]

Recent studies are starting to point to higher kinetic energy as another complication of increasing drainage efficiency in watersheds. The higher energy due to increased water velocities over short periods may be overloading the natural streams capacity to handle the influx of efficient drainage. This forces the system to find a way to expense the extra energy and accommodate the increased volume and velocity during storms and other high water events. This is accomplished by widening and deepening the natural stream course and pushing the bed

[17] Agricultural Drainage, Water Quality Impacts and Subsurface Drainage Studies in the Midwest, Ohio State University, 1998.

[18] Extensive research has been conducted at the Southwest Research and Outreach Center, which is documenting possible nitrate reduction when using third crop plantings and in-tile water retention.

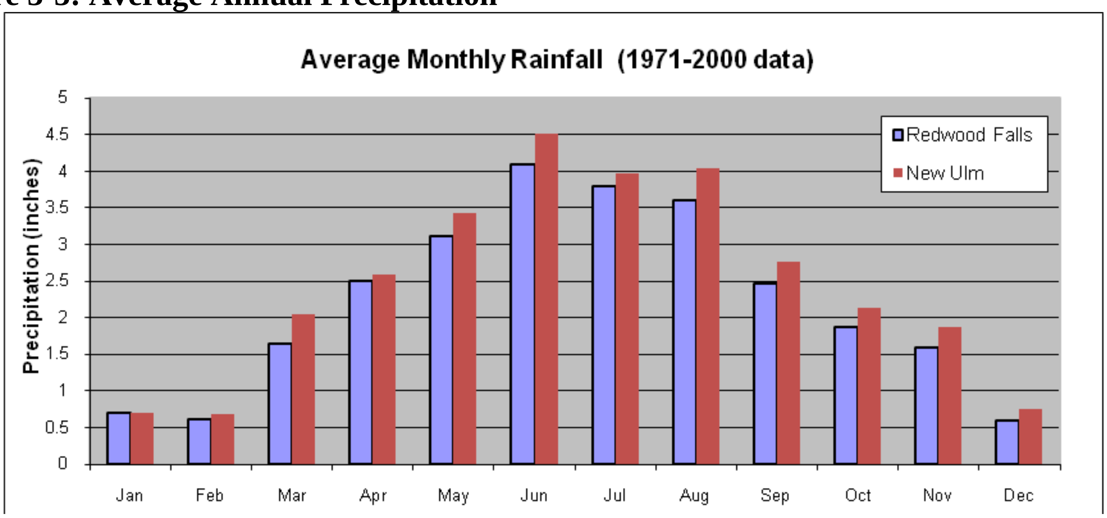
and bank material down the stream as it goes. Some studies and models are suggesting that the portion of the sediment load in some rivers due to stream bank/bed sediment erosion approaches 40% of the total mass at times.[19]

Drainage Systems are subject to provisions of the drainage law (M.S. 103E) which establishes environmental and land use criteria for proposed drainage systems. Prior to establishing a drainage system, the drainage authority must consider: 1) private and public benefits and costs of the proposed drainage project; 2) the present and anticipated agricultural land acreage availability and use in the drainage project or system; 3) the present and anticipated land use within the drainage project or system; 4) flooding characteristics of property in the drainage project or system and downstream for 5, 10, 25, and 50 year flood events; 5) the water to be drained and alternative measures to conserve, allocate, and use the waters including storage and retention of drainage water; 6) the effect on water quality from construction of the proposed drainage project; 7) fish and wildlife resources affected by the proposed drainage project; 8) shallow groundwater availability, distribution, and use in the drainage project or system; and 9) the overall environmental impact of all the above criteria.

Precipitation

Precipitation data were gathered from a network of fourteen stations in both 2009 and 2010. Table 3-7 and Table 3-8 list location used and the corresponding rainfall amounts during the growing season, April through September. According to historical records, mean annual precipitation in the watershed is about 28 inches. Growing season precipitation averages 20.5 inches watershed wide**.** As shown in Table 3-7 and Table 3-8, and in Figure 3-3 and Figure 3-4, precipitation in the watershed varied considerably between 2009 and 2010. Rainfall during the 2009 growing season averaged 14.10 inches, below the historical average. Rainfall during the 2010 growing season, however, was over fourteen inches more, averaging 28.35 inches, well above normal.

Figure 3-3: Average Annual Precipitation



[19] Minnesota River Turbidity Draft TMDL Modeling, Lake Pepin Sediment Source Studies, etc.

Figure 3-4: 2009 and 2010 Growing Season Precipitation

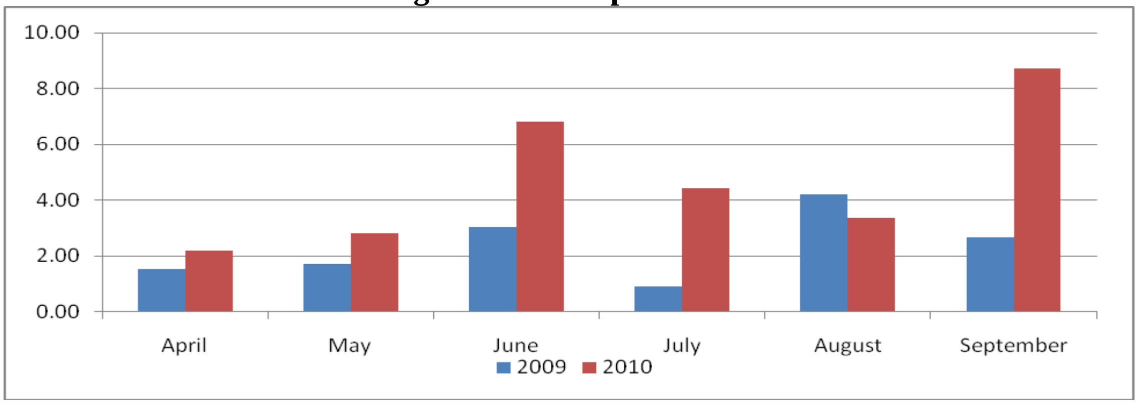


Table 3-7: Precipitation Totals from April to September, 2009

2009

County	TWP	RNG	SEC	APR	MAY	JUN	JUL	AUG	SEPT	Total
Redwood	113	35	33	1.17	1.6	2.82	0.6	4.14	2.73	13.06
Redwood	112	36	22	1.16	1.43	2.76	0.51	4.05	2.89	12.8
Redwood	112	35	22	1.17	1.36	2.74	0.63	4.63	2.29	12.82
Redwood	112	34	28	2.43	1.36	3.01	0.63	4.63	2.29	14.35
Redwood	111	36	9	1.27	1.57	2.87	1.21	4.28	2.96	14.16
Redwood	111	35	10	2.43	1.36	3.01	0.63	4.63	2.29	14.35
Redwood	111	34	15	2.43	1.87	3.01	1.1	2.99	2.04	13.44
Redwood	110	34	1	1.42	2.01	3.8	1.39	4.14	2.31	15.07
Brown	111	33	10	1.13	2.1	3.21	0.65	3.81	2.48	13.38
Brown	111	32	20	1.33	1.9	2.84	1.21	4.2	3.72	15.2
Brown	110	33	5	1.42	2.01	3.8	1.39	4.14	2.31	15.07
Brown	110	32	10	1.33	1.9	2.84	1.21	4.2	3.72	15.2
Brown	110	31	4	1.19	1.88	2.94	0.56	4.64	3.5	14.71
Brown	110	30	18	1.79	1.87	2.92	0.97	4.21	2.06	13.82
AVERAGES				**1.55**	**1.73**	**3.04**	**0.91**	**4.19**	**2.69**	**14.10**

Table 3-8: Precipitation Totals from April to September, 2010

2010										
County	**TWP**	**RNG**	**SEC**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEPT**	**Total**
Redwood	113	35	33	1.88	2.82	8.31	3.52	2.98	8.52	28.03
Redwood	112	36	22	1.81	2.86	8.45	4.14	2.88	8.65	28.79
Redwood	112	35	22	1.92	3.16	5.88	4.73	3.41	9.26	28.36
Redwood	112	34	28	1.92	3.16	5.88	4.73	3.41	9.26	28.36
Redwood	111	36	9	1.4	2.99	8.08	3.8	4.07	8.35	28.69
Redwood	111	35	10	1.92	3.16	5.88	4.73	3.41	9.26	28.36
Redwood	111	34	15	2.48	2.95	7.46	4.91	4.16	8.92	30.88
Redwood	110	34	1	2.76	2.32	6.06	6.29	3.45	8.89	29.77
Brown	111	33	10	2.64	2.73	5.83	4.15	2.99	9.79	28.13
Brown	111	32	20	2.23	2.61	5.73	3.87	2.94	8.81	26.19
Brown	110	33	5	2.76	2.32	6.06	6.29	3.45	8.89	29.77
Brown	110	32	10	2.23	2.61	5.73	3.87	2.94	8.81	26.19
Brown	110	31	4	2.49	2.91	7.79	3.31	3.8	6.94	27.24
Brown	110	30	18	2.5	2.63	8.49	3.52	3.31	7.68	28.13
AVERAGES				**2.21**	**2.80**	**6.83**	**4.42**	**3.37**	**8.72**	**28.35**

Runoff

Average annual runoff in the watershed is approximately three and a half inches. Over eighty-seven percent of the precipitation falling within the watershed is returned to the atmosphere through the processes of evaporation and transpiration. Data collected by the U.S. Geological Survey between 1938 and 1969 indicates that, "most of the annual runoff occurs in spring and early summer when evapotranspiration losses are low and soil conditions, such as frozen or saturated soil, are favorable for runoff."[20]

Wetlands

Just over 6,000 acres of wetlands of types 1-4 remain in the project area. Nearly all wetlands have been drained by a highly efficient and interconnected artificial drainage system. The project is within the "prairie pothole" region of North America, where it is estimated that over eighty percent of the naturally occurring wetlands have been drained or substantially altered. In most cases, drainage in the watershed was instituted to facilitate agricultural production. This has resulted in an extensive network of public and private tile and open ditch systems. Soil data was analyzed to identify soils with characteristics of drained wetlands. In the monitored areas of this study it is estimated that over 19% of all the cultivated land was originally wetlands that have since been drained. Table 3-9 lists the National Wetland Index wetland acreage per subwatershed and Table 3-10 lists the area of drained wetlands, determined

[20] Department of Interior, USGS, Water Resources of the Cottonwood River Watershed, Southwestern Minnesota, Hydrologic Investigations Atlas HA-466, 1973.

by soil type. Map 3-10 shows existing National Wetland Index wetlands and Map 3-11 shows the location of the drained areas listed in Table 3-10.

Table 3-9: Wetland Acreage

WATERSHED	ACRES of WATERSHED	ACRES of WETLANDS	% of WETLAND ACRES in SUBSHEDS
CROW CREEK	23,390.25	127.61	0.55%
WABASHA CREEK	44,484.09	637.54	1.43%
NORTH EDEN CREEK	12,718.94	279.90	2.20%
SPRING CREEK	28,759.52	592.31	2.06%
County Ditch 13 (cod13)	7,256.99	264.75	3.65%
County Ditch 10 (cod10)	8,514.11	441.28	5.18%
MINNESOTA RIVER ADJACENT DRAWS	34,811.63	3,683.65	10.58%
Total	**159,935.53**	**6,027.04**	**3.77%**

Map 3-10: National Wetland Inventory - Wetlands

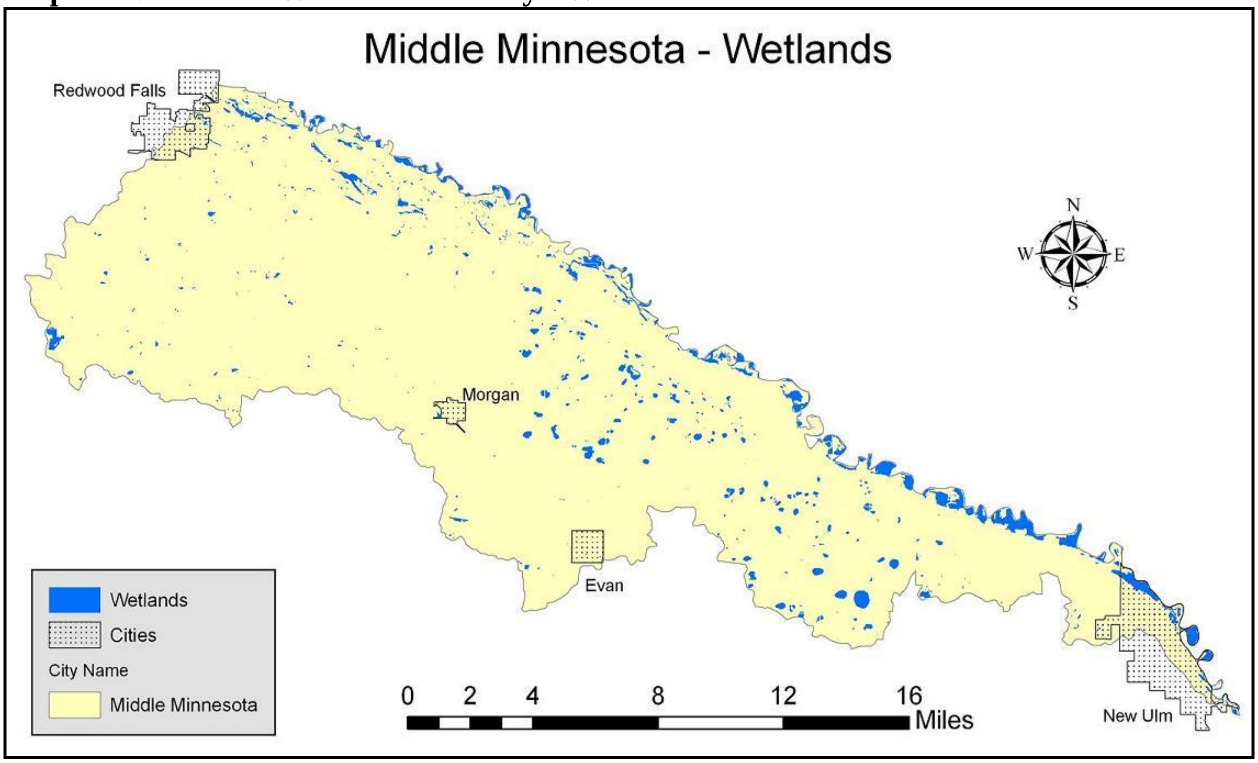
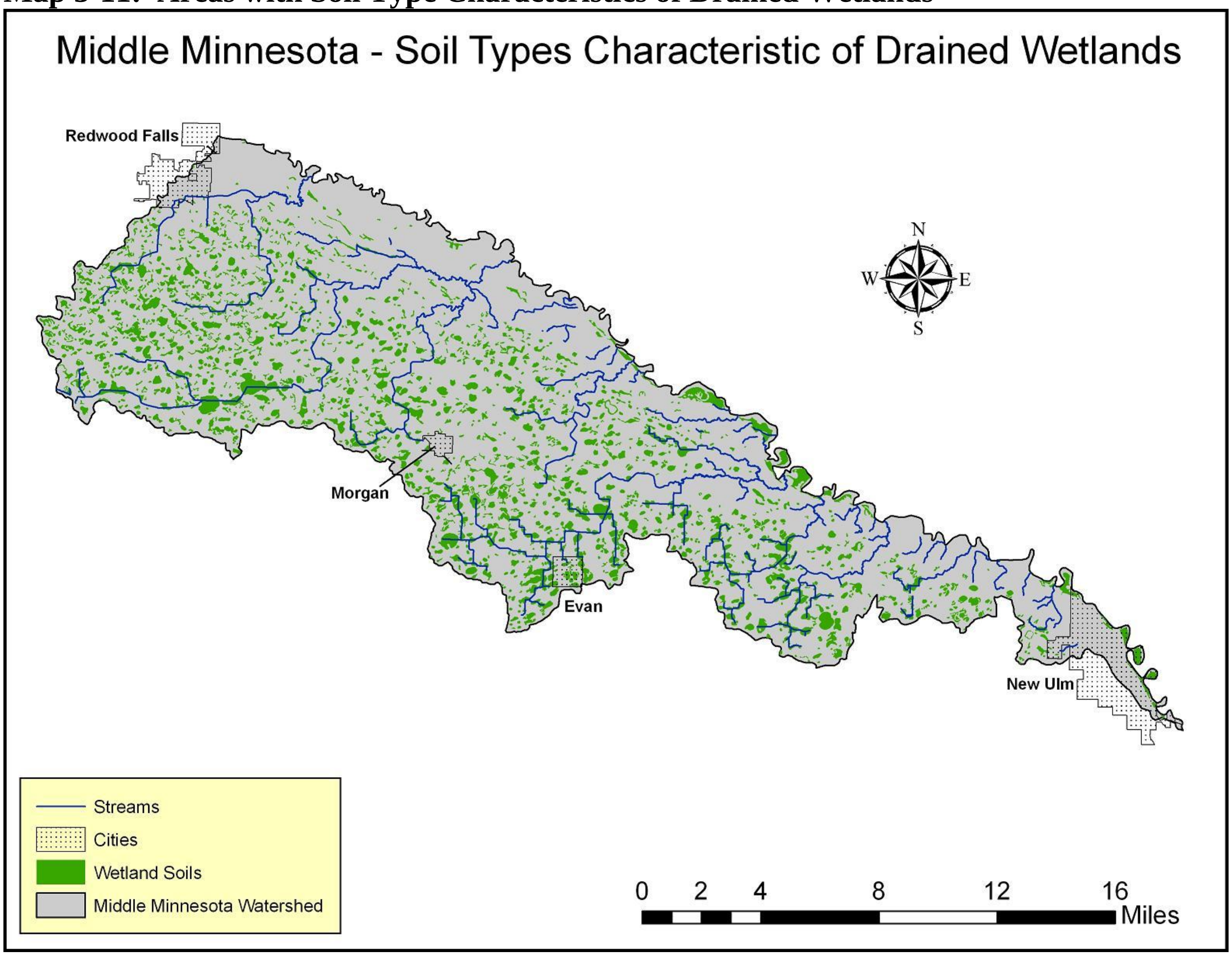


Table 3-10: Drained Wetland Acreage Determined by Soil Characteristics

Subwatershed	Acres	Acres of soils with drained wetland characteristics	% of all acres drained	Cultivated Acres	% of tilled acres drained
Crow Creek (MMCC1)	23,390.25	4,111.17	17.58%	21,314.85	19.29%
Wabasha Creek (MMWC)	44,484.09	7,173.26	16.13%	40,992.35	17.50%
North Eden Creek (MMNE)	12,718.94	1,864.13	14.66%	11,823.10	15.77%
Spring Creek (MMSC)	28,759.52	5,880.86	20.45%	26,785.63	21.96%
Brown County Ditch 13 (COD13)	7,256.99	1,369.19	18.87%	6,569.25	20.84%
Brown County Ditch 10 (COD10)	8,514.11	1,545.65	18.15%	7,761.55	19.91%
Unmonitored Areas	34,811.63	3,010.65	8.65%	20,172.86	14.92%
Totals	159,935.53	24,954.91	15.60%	135,419.59	18.43%

Map 3-11: Areas with Soil Type Characteristics of Drained Wetlands



Lakes

Lakes in the watershed are included on Map 3-10. Table 3-11 provides additional information about size and classification of these lakes. There are few major bodies of open water in the project area. A couple of lakes in the area have been evaluated by the Department of Natural Resources (DNR). They have developed management plans for some of these lakes. The following information summarize these plans.[21]

Table 3-11: Major Lakes/Wetlands

Location	Name	Acres	Shoreland Class	Ecological Class	Management Class	Protection Type
Brown	Somson	20.15	Not in Shoreland Program	-	-	Protected Water
Brown	Lone Tree	58.7	Natural Environment	BLH	RWK	Protected Water
Brown	Horseshoe	25.49	Not in Shoreland Program	-	-	Protected Wetland
Brown	Unnamed	20.06	Not in Shoreland Program	-	-	Protected Wetland
Brown	Unnamed	14.48	Not in Shoreland Program	-	-	Protected Wetland
Redwood	Sulpher	6.98	Not in Shoreland Program	-	-	-
Redwood	Tiger	98.55	Natural Environment	BLH	RWK	Protected Water

There are three levels of classifications for lakes, as determined by the DNR.[22]

Protected Waters and Shoreland Classifications

Shoreland Classification:

- Natural Environment (NE): This classification is intended for those waters needing a significant amount of protection because of their unique natural characteristics or their unsuitability for development and sustained recreational use. They are usually shallower lakes, with marginal soils that can be eroded away quite easily. They are assigned the most restrictive development standards.
- Recreational Environment (RE): This classification is intended for those waters that are larger in size than natural environment lakes, but still need protection. Development can occur on these lakes, but special considerations have to be used to help achieve minimal impact for the lake.
- General Development (GD): This classification is intended for those bodies of water which are at the present highly developed or which, due to their location, may be needed for high density development in the future. The lakes are able to withstand high levels of activity because of the type of soil or other features inherent to the lake. These lakes are assigned the least restrictive development standards.

[21] Lakes information was obtained from the DNR Website, files maintained at the DNR Regional Office in New Ulm, and from discussions with DNR staff.

[22] Department of Natural Resources, DNR Lake Summary Data Base (SWIM), 1987.

<u>Ecological</u>:

- <u>Centrarchid-Walleye (CEW):</u> Medium to large sized, usually consisting of many ecologically different bays or sections, some being natural walleye habitat, or others more suitable for panfish species. This type of water body may also have substantial bullhead and/or carp and/or buffalo populations.
- <u>Rough Fish-Game Fish (RFG):</u> Fertile, hard water lakes in southern and central Minnesota, characterized by relatively large rough fish populations, such as carp, buffalo, sheepshead, bullhead. Many of these lakes may occasionally experience winterkill.
- <u>Game (GAM):</u> These are lakes with very high fertility, usually with an abundance of aquatic vegetation present. Winterkills may occur annually. This type of lake is characterized by substantial populations of muskrats and/or waterfowl.
- <u>Bullhead (BLH):</u> Shallow lakes, in which frequent winterkills promote the dominance of bullheads.

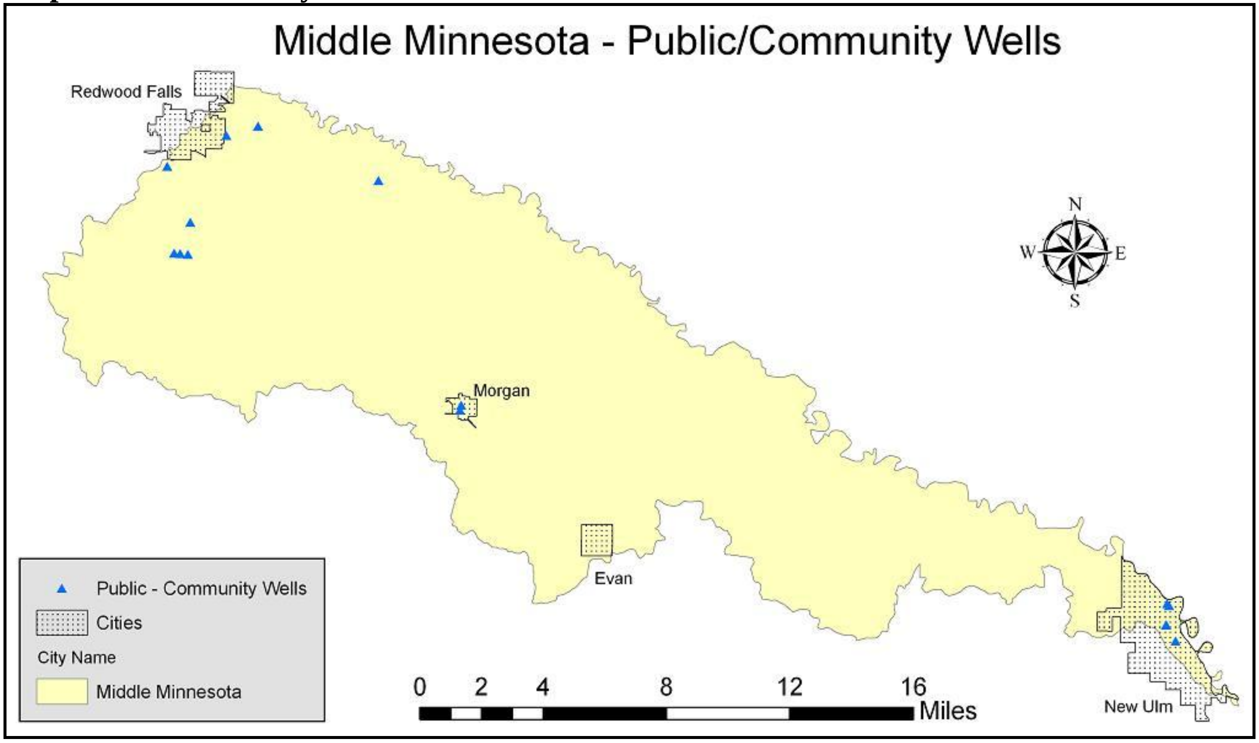
<u>Management</u>:

- <u>Walleye-Centrarchid (WAC):</u> This type of management is designed to furnish a walleye fishery of moderate size, without displacing largemouth or smallmouth bass or panfish populations.
- <u>Centrarchid (CEN):</u> Specified as largemouth or smallmouth bass since physical characteristics of the lakes managed will differ depending on the species. In addition to bass and panfish, considerable attention is usually given to the northern pike.
- <u>Warmwater Gamefish (WWG):</u> This classification is designed to cover those lakes in southern and central Minnesota where non-game fish removal and stocking of rescued fish are common management procedures. They include lakes which occasionally have winter kill where management is aimed at building up a desirable fish population in as short a time as possible.
- <u>Regular Winterkill (RWK):</u> Management of lakes in this classification is usually confined to rescue work and/or walleye fry stocking.
- <u>Game (GAM):</u> Game Lakes are those lakes shallower than six feet, which ordinarily contain water throughout the year. They are ordinarily deeper marshes.

Community Water Supplies

A public water supply well is defined by the Minnesota Department of Health (MDH) as a well supplying water for human use for fifteen or more service connections, or for twenty-five or more people for at least sixty days per year. Refer to Map 3-12 for locations of community water supplies. Within the project area are community water supply wells for the cities of Redwood Falls, New Ulm, Morgan, and the Lower Sioux Indian Community. Water supplies for the community of Evan are private wells.

Map 3-12: Community Water Sources



Population

Table 3-12: Population Calculations

COUNTY	TOWNSHIP/CITY	POPULATION	% of TOWNSHIP/CITY in PROJECT AREA	ADJUSTED POPULATION
REDWOOD	Brookville	224	13%	***28***
REDWOOD	Honner	79	60%	***47***
REDWOOD	Morgan (CITY)	896	100%	***896***
REDWOOD	Morgan (TWP)	257	80%	***206***
REDWOOD	New Avon	191	25%	***48***
REDWOOD	Paxton	555	100%	***555***
REDWOOD	Redwood Falls (CITY)	5254	39%	***2,049***
REDWOOD	Redwood Falls (TWP)	181	40%	***72***
REDWOOD	Sherman	370	100%	***370***
REDWOOD	Three Lakes	194	45%	***87***
BROWN	Eden	254	99%	***251***
BROWN	Evan	86	100%	***86***
BROWN	Home	545	75%	***408***
BROWN	Milford	694	45%	***312***
BROWN	New Ulm	13522	58%	***7,894***
BROWN	Prairieville	255	20%	***51***
Total				***13,360***

The study area lies within the predominately rural southwestern region of the state. This region is experiencing an overall population decline accompanied by an increasingly older average age. Projections made by the Minnesota State Demographic Center, Office of Minnesota Planning, reveal that population trends within the watershed have only Brown County maintaining or increasing population through 2035. Projections for Redwood County show these areas to continue the trend of a declining population. Accurate estimates of population count by watershed are difficult to make due to census data being reported on the basis of political boundaries. Recognizing some inaccuracy as a result of some townships and cities not being wholly within the watershed, the population of the project area is estimated around 13,360. Most (82%) of the population lives in cities or towns in the project area. Population statistics by cities and townships are shown in Table 3-12.

Landfills/Dumps

Table 3-13: Landfills/Solid Waste Centers

Permit #	Name	City
PBR000577	Riverview Sanitation	New Ulm (Milford Township)
PBR000204	Mathiowitz, Dean PBR	Redwood Falls (Paxton Township)
PBR000601	Redwood County Recycling Cntr.	Redwood Falls (Paxton Township)
PBR000576	Southside Auto Salvage	New Ulm

Permitted Withdrawal Permits

There is only one active surface water withdrawal permit in the project area for mining operations near the Minnesota River. The permit has not been used for activities since 2005.

Hazardous Waste Sites

There are no known hazardous waste sites in the project area according to the Minnesota Department of Health. A couple of companies including 3M and Daktronics do handle large quantities of hazardous material and multiple small quantity sites exist. A few former unpermitted dumps could have contained such material at one time including the Morgan City dump, New Ulm city dump, New Ulm demolition dump, and the Minnesota Steel Drum Company in New Ulm.

Official Historical Sites

There are several official historical sites in the project area. In Redwood County, the Gilfillan Estate, the Birch Coulee Schoolhouse, St. Cornelia's Episcopal Church, and the Lower Sioux Agency building, all near the Lower Sioux Community, are on the national historical places registry and are places of significance. Numerous sites in New Ulm and Redwood Falls are of historic interest and there are numerous placards, markers and monuments in the area related to activities of the U.S.-Dakota War in 1862.

Unique Features and Scenic Areas

The Natural Heritage Program, a section of Ecological Services for the Minnesota Department of Natural Resources, gathers statewide data on location and status of natural communities which have been only slightly modified by human activities. This database is the most complete source of data on Minnesota's rare, endangered, or otherwise significant plant and animal species, plant communities, and other natural features. Information contained in the database is used to better understand and protect these rare features. Occurrences of natural communities with their pre settlement features have been greatly reduced and now represent only a small fraction of the Minnesota landscape**.** The database includes fields that explain either the federal or the state status of the species. With federal status, a species can be endangered, threatened, or a candidate for listing. At the state level, the categories are endangered, threatened or of special concern.[23] In the project area and along the Minnesota River, there are a variety of animals and plants listed. Examples of the Dry Prairie, Floodplain Forest, Mesic Prairie, and Wet Prairie natural communities are found in the sub-sheds of this study. Smaller localized examples of Bull Rush Marshes, Native Dry Prairie Rock outcrops/Bedrock outcrops, Burr Oak-Ash Forests, and Sugar Maple-Basswood Forest stands are also found mostly adjacent to the Minnesota River valley. Examples and explanations of the environs can be found at the Minnesota DNR Natural Heritage Program website. In Table 3-14, below is a listing of species of concern in the project area.

The area is also part of the Minnesota River Scenic Byway and Green Corridors Initiative which seek to attract nature enthusiasts, history enthusiasts, and the general public to experience the beauty of the valley and realize the significance and rarity of the area.

[23] Minnesota Department of Natural Resources, Section of Ecological Services, Natural Heritage & Nongame Research Program, August 1998

Table 3-14: Species of Concern in the Middle Minnesota Project Area

NAME	SCIENTFIC NAME	GROUP	FED	STATE LISTED
A Species of Lichen	Buellia nigra	lichen	none	endangered
American Ginseng	Panax quinquefolius	vascular plant	none	special concern
Bald Eagle	Haliaeetus leucocephalus	bird	none	special concern
Black Buffalo	Ictiobus niger	fish	none	special concern
Black Sandshell	Ligumia recta	mussel	none	special concern
Blanding's Turtle	Emydoidea blandingii	reptile	none	threatened
Blue Sucker	Cycleptus elongatus	fish	none	special concern
Buffalo Grass	Buchloe dactyloides	vascular plant	none	special concern
Butternut	Juglans cinerea	vascular plant	none	special concern
Cerulean Warbler	Dendroica cerulea	bird	none	special concern
Common Five-lined Skink	Eumeces fasciatus	reptile	none	special concern
Common Moorhen	Gallinula chloropus	bird	none	special concern
Creek Heelsplitter	Lasmigona compressa	mussel	none	special concern
Elktoe	Alasmidonta marginata	mussel	none	threatened
Few-flowered Spike-rush	Eleocharis quinqueflora	vascular plant	none	special concern
Fluted-shell	Lasmigona costata	mussel	none	special concern
Forster's Tern	Sterna forsteri	bird	none	special concern
Gophersnake	Pituophis catenifer	reptile	none	special concern
Hair-like Beak-rush	Rhynchospora capillacea	vascular plant	none	threatened
Hairy Fimbristylis	Fimbristylis puberula var. interior	vascular plant	none	endangered
Henslow's Sparrow	Ammodramus henslowii	bird	none	endangered
Hickorynut	Obovaria olivaria	mussel	none	special concern
Lake Sturgeon	Acipenser fulvescens	fish	none	special concern
Larger Water-starwort	Callitriche heterophylla	vascular plant	none	special concern
Loggerhead Shrike	Lanius ludovicianus	bird	none	threatened
Marbled Godwit	Limosa fedoa	bird	none	special concern
Monkeyface	Quadrula metanevra	mussel	none	threatened
Mucket	Actinonaias ligamentina	mussel	none	threatened
Ottoe Skipper	Hesperia ottoe	insect	none	threatened
Paddlefish	Polyodon spathula	fish	none	threatened
Pistolgrip	Tritogonia verrucosa	mussel	none	threatened
Plains Prickly Pear	Opuntia macrorhiza	vascular plant	none	special concern
Prairie Bush Clover	Lespedeza leptostachya	vascular plant	threatened	threatened
Rattlesnake-master	Eryngium yuccifolium	vascular plant	none	special concern
Regal Fritillary	Speyeria idalia	insect	none	special concern
Rock Pocketbook	Arcidens confragosus	mussel	none	endangered
Round Pigtoe	Pleurobema coccineum	mussel	none	threatened
Slender Milk-vetch	Astragalus flexuosus	vascular plant	none	special concern
Small White Lady's-slipper	Cypripedium candidum	vascular plant	none	special concern
Smooth Softshell	Apalone mutica	reptile	none	special concern
Snow Trillium	Trillium nivale	vascular plant	none	special concern
Spike	Elliptio dilatata	mussel	none	special concern
Sullivant's Milkweed	Asclepias sullivantii	vascular plant	none	threatened
Trumpeter Swan	Cygnus buccinator	bird	none	threatened
Tuberous Indian-plantain	Arnoglossum plantagineum	vascular plant	none	threatened
Tumblegrass	Schedonnardus paniculatus	vascular plant	none	special concern
Twig-rush	Cladium mariscoides	vascular plant	none	special concern
Wartyback	Quadrula nodulata	mussel	none	endangered
Water-hyssop	Bacopa rotundifolia	vascular plant	none	special concern
Whorled Nut-rush	Scleria verticillata	vascular plant	none	threatened
Wilson's Phalarope	Phalaropus tricolor	bird	none	threatened
Yellow Sandshell	Lampsilis teres	mussel	none	endangered

Stream Classifications

The TMDL evaluation is a method of addressing and assessing the waters that exceed the state standard for fecal coliform. All waters of Minnesota are assigned classes, based on their suitability for the following beneficial uses (Minn. Rules part 7050.0200):

- Class 1 – Domestic consumption
- Class 2 – Aquatic life and recreation
- Class 3 – Industrial consumption
- Class 4 – Agriculture and wildlife
- Class 5 – Aesthetic enjoyment and navigation
- Class 6 – Other uses
- Class 7 – Limited resource value

All surface waters of the state that are not specifically listed in Chapter 7050 and are not wetlands, which include most lakes and streams in Minnesota, are classified as Class 2B, 4A, 5 and 6 waters (Minn. R. ch. 7050.0430). Table 3-15 lists reaches in this study specifically mentioned in MN Chapter 7050.[24]

- <u>Class1B</u>: For domestic consumption following approved disinfection, such as simple chlorination or its equivalent.
- <u>Class 2C</u>: Aquatic life support and recreation includes boating and other forms of recreation for which the water may be suitable (i.e., swimming). Class 2C waters may also support indigenous aquatic life, but not necessarily sport or commercial fish.
- <u>Class 2A</u>: Aquatic life support refers to cold water sport or commercial fish and associated aquatic life, and their habitats. Recreation support refers to aquatic recreation of all kinds, including bathing, for which the waters may be usable. Class 2A also is protected as a source of drinking water.
- <u>Class 7</u>: Limited resources value usually associated with point source discharge waters or deteriorated conditions.

Table 3-15: MPCA Stream Classifications

Name	Location (Section)	Classification
Hindeman Creek (Spring Creek)	(T.111, R.32, S.19, 20; T.111, R.33, S.24)	1B, 2A, 3B
John's Creek	(T.110, R.32, S.1; T.111, R.31, S.31; T.111, R.32, S.36)	1B, 2A, 3B
Crow Creek	(T.112, R.35)	2C
Spring Creek (JD 29)	(T.110, 111, R.33, 34)	2C
Wabasha Creek	(T.112, R.34)	2C
CD 109	(T.111, R.34, S.4, 5, 8, 17; T.112, R.34, S.22, 23, 27, 28, 33)	7
Spring Creek (JD 29) (Excludes Trout Waters)	(T.110, R.33, S.6; T.111, R.33, S.21, 22, 28, 31, 32, 33)	7
JD 29 (Spring Creek Lateral)	(T.110, 111, R.33, 34)	7

[24] MR 7050.0470, 7050.0430, and 7050.220; MPCA, Classification of Waters of the State.

Hindeman Creek and John's Creek, described above, are designated trout streams and classified as marginal trout waters. They drain about 45 square miles in Redwood and Brown Counties and are influenced by several county and judicial ditch systems. The long range goal had been to provide a put-and-take Brown Trout fishery and to acquire fishing easements along the designated portion of stream, according to the Department of Natural Resources.

Wildlife Management Areas

There are about 1,600 acres of state wildlife management areas in the project area affording access to natural landscapes and areas for recreation within the study area.

Table 3-16: Wildlife Management Areas

Name	Size (acres)	Location (T-R-S)
Boesch WMA - Brown County	225	Milford (110,111 - 31) Sec. 3, 4, 31N, 33N, 34N
River Valley WMA - Brown County	260	Milford (110,111 - 31) Sec. 2, 3, 35N
Rosenau-Lambrecht WMA - Brown County*	about 40*	Milford (110 - 31) Sec. 16, 17
Somson WMA - Brown County	49	Milford (110 - 31) Sec. 14
Cedar Mountain WMA - Redwood County	166	Sherman (112 - 34) Sec. 14, 23
Leuscher-Barnum WMA - Redwood County	130	New Avon (111 - 36) Sec. 4, 9
Tiger Lake WMA - Redwood County	734	Honner (113 - 35) Sec. 27, 28, 33, 34, 35, 36

* Partially in the study area

Scientific and Natural Areas

The Cedar Mountain Scientific and Natural Area (SNA) is located near Franklin in Redwood County (T 112N, R 34W, Ss 14, 15, 23). Cedar Mountain lies on bedrock knobs and ridges that, at 3.4 billion years old, include some of the oldest rocks known to occur in North America. These knobs were once islands in Glacial River Warren, the huge river that drained Glacial Lake Agassiz at the end of the last glacial period and cut the valley now occupied by the Minnesota River. The central knob in the area includes two rock types known only from this site; Cedar Mountain Gabbro and Cedar Mountain Granodiorite. The SNA supports areas of native dry and mesic prairie, rock outcrops, flood plain forest, and oak woodland habitats. The high quality prairies and rock outcrops of Cedar Mountain are uncommon in Minnesota and becoming increasingly rare due mostly to human activities. They also contain several rare plant populations, including the state and federal threatened prairie bush clover *(Lespedeza leptostachya)*; a state endangered lichen, *Buellia nigra*; and three rare plant species found in Minnesota almost exclusively on rock outcrops; plains prickly pear cactus *(Opuntia macrorhiza)*, water hyssop *(Bacopa rotundifolia)*, and Carolina foxtail *(Alepocurus carolinianus)*.[25]

[25] DNR, Scientific and Natural Areas, Cedar Mountain SNA (http://www.dnr.state.mn.us/snas/SNA02034/index.html)

Chapter 4: Results and Discussion

Sampling Results

Sampling stations were established on six of the first order streams to the Minnesota River in Redwood and Brown County. Flow monitoring stations were established at four of those six sampling sites.

The first site reviewed here is Crow Creek (MMCC1). Crow Creek originates as a ditch south of Redwood Falls, and runs through the city before merging with another ditch system and just downstream of this merger it becomes a natural stream. The sampling site is located a few hundred feet downstream of the merger between the two ditch systems and about a quarter-mile above where it enters the Minnesota River. The dominate condition of this watershed is a ditch system, though the sample site is a natural stream.

Sampling commenced at MMCC1 on April 9th and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 24th. The 2009 season was very dry while the 2010 season was very wet. Close to ninety percent of the total flow volume for the two year period was during the 2010 season. A total of 49 samples were taken from 2009 to 2010. There were 21 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 28 samples with a good mix of base flow and storm flow events. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-1 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-1: MMCC1 Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	27.75	6.4	140	1	39
TSS	mg/L	35.29	9	236	1	42
TSVS	mg/L	6.62	2.5	36	1	42
N-NO2+NO3	mg/L	9.22	10.4	17.8	0.1	42
TKN	mg/L	1.46	1.3	3.4	0.1	42
N-NH3	mg/L	0.098	0.08	0.51	0.08	41
P-PO4	mg/L	0.158	0.139	0.701	0.0025	39
TP	mg/L	0.223	0.167	0.904	0.018	42
E-coli	/100ml	825.3	547.5	2419.6	17.3	30

The second site reviewed here is Wabasha Creek (MMWC). Wabasha Creek originates as a ditch south of Redwood Falls and runs east for about sixteen miles before transitioning to a natural stream and merging with another ditch system that also drains the Lower Sioux Indian Reservation wastewater treatment facility. Once Wabasha Creek passes through the Dakota Ridge Golf Course it merges with another natural stream that was ditched for most of its length and drains the city of Morgan's wastewater treatment facility. The sampling site is located about a half mile upstream from where Wabasha Creek empties into the Minnesota River. Twice during the two years this stream was monitored, the Minnesota River was out of bank during the spring flood season and was able to run overland and enter Wabasha Creek above the sampling site. The dominate condition of this watershed is a ditch system with roughly 41 miles of ditch, though the sample site is a natural stream, which represents about 16 miles of this system.

Sampling commenced at MMWC on April 9th and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 24th. Sampling was suspended in 2010 from March 18th to April 12th due to the Minnesota River flowing into Wabasha Creek upstream of the sample site. The 2009 season was very dry while the 2010 season was very wet. Over eighty percent of the total flow volume for the two year period was during the 2010 season. A total of 48 samples were taken from 2009 to 2010. There were 21 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 27 samples with a good mix of base flow and storm flow events. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-2 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-2: MMWC Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	48.54	6.9	460	1.8	38
TSS	mg/L	85.00	12	1040	1	41
TSVS	mg/L	13.00	4	117	1	41
N-NO2+NO3	mg/L	7.45	7.26	18.9	0.1	41
TKN	mg/L	1.64	1.4	4.9	0.1	41
N-NH3	mg/L	0.084	0.08	0.23	0.08	40
P-PO4	mg/L	0.185	0.165	0.51	0.0025	38
TP	mg/L	0.318	0.210	1.31	0.038	41
E-coli	/100ml	931.5	552.05	2419.6	1	30

The third site reviewed here is North Eden Creek (MMNE). North Eden Creek originates as a ditch East of Morgan and runs east for just under five miles before transitioning to a natural stream and merging with another ditch system. A couple of miles downstream of this merger, the creek joins up with another natural stream that was ditched for most of its length. The sampling site is located about a third of a mile upstream from where North Eden Creek empties into the Minnesota River. The dominate condition of this watershed is a ditch and underground tile system with just under 10 miles of ditch and an undeterminable but considerable length of underground tile, though the sample site is a natural stream, which represents about 5 miles of this system.

Sampling commenced at MMNE on April 9th and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 24th. The 2009 season was very dry while the 2010 season was very wet. Well over ninety percent of the total flow volume for the two year period was during the 2010 season. A total of 49 samples were taken from 2009 to 2010. There were 21 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 28 samples with a good mix of base flow and storm flow events. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-3 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-3: MMNE Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	42.25	3.3	430	0.8	39
TSS	mg/L	89.24	5	1150	1	42
TSVS	mg/L	10.64	1.5	137	1	42
N-NO2+NO3	mg/L	9.20	8.11	20	0.1	42
TKN	mg/L	1.32	1.2	4.6	0.1	42
N-NH3	mg/L	0.080	0.08	0.08	0.08	41
P-PO4	mg/L	0.119	0.074	0.616	0.0025	39
TP	mg/L	0.200	0.082	1.15	0.016	42
E-coli	/100ml	616.4	194.1	2419.6	4.1	30

The fourth site reviewed here is Spring Creek (MMSC). Spring Creek originates as a ditch about one mile south of Morgan. This is an extensive ditch system and runs east for about eight miles before transitioning to a natural stream. This creek joins up with a small natural stream that was ditched for most of its length. The sampling site is located about a half mile upstream from where Spring Creek empties into the Minnesota River. The dominate condition of this watershed is a ditch system with close to 38 miles of ditch, though the sample site is a natural stream, which represents about 11 miles of this system.

Sampling commenced at MMSC on April 9th and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 24th. The 2009 season was very dry while the 2010 season was very wet. Close to ninety percent of the total flow volume for the two year period was during the 2010 season. A total of 49 samples were taken from 2009 to 2010. There were 21 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 28 samples with a good mix of base flow and storm flow events. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-4 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-4: MMSC Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	46.48	6.8	400	0.7	39
TSS	mg/L	107.81	8.5	1110	1	42
TSVS	mg/L	12.67	2	132	1	42
N-NO2+NO3	mg/L	7.80	6.82	16.8	0.99	42
TKN	mg/L	1.56	1.3	6	0.1	42
N-NH3	mg/L	0.094	0.08	0.51	0.08	41
P-PO4	mg/L	0.115	0.068	0.678	0.0025	39
TP	mg/L	0.224	0.093	1.14	0.018	42
E-coli	/100ml	562.0	196.6	2419.6	4.1	30

The fifth site reviewed here is County Ditch #13 (COD13). County Ditch #13 originates as a ditch about one mile north of Sleepy Eye. There are multiple branches of this ditch, which resumes a natural stream setting just before entering into the Minnesota River Valley. The natural stream begins about two and a half miles upstream of its confluence with the Minnesota River. The sampling site is located a few hundred feet downstream from the start of the natural stream characteristics. Overall, there are about 11.5 miles of ditch and around 4 miles of natural stream, almost all of which occurs in the bluff area where the grassland prairie transitions into the Minnesota River Valley.

Sampling commenced at COD13 on April 21st and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 23rd. The 2009 season was very dry while the 2010 season was very wet. Without stage monitoring data, we can only compare the watershed to its neighbors, but we estimate eighty to ninety percent of the total flow volume for the two year period was during the 2010 season. A total of 39 samples were taken from 2009 to 2010. There were 19 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 20 samples. Without equipment to monitor the stream level, there is no need to take storm samples as incomplete information can be more misleading as to the water quality than no information. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-5 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-5: COD13 Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	9.95	2.45	110	1.2	28
TSS	mg/L	18.84	4	286	1	31
TSVS	mg/L	4.10	2	34	1	31
N-NO2+NO3	mg/L	8.40	7.18	18.1	0.51	31
TKN	mg/L	1.49	1.4	3.9	0.7	31
N-NH3	mg/L	0.106	0.08	0.65	0.08	30
P-PO4	mg/L	0.195	0.136	0.853	0.006	28
TP	mg/L	0.280	0.185	0.948	0.027	31
E-coli	/100ml	839.0	511.85	2419.6	98.8	30

The sixth site reviewed here is County Ditch #10 (COD10) or John's Creek. County Ditch #10 originates as a ditch about a mile or so northeast of Sleepy Eye. This is an extensive ditch system and runs north and a little east for about five miles before transitioning to a natural stream. There are a couple of ravines draining into this creek as it enters the Minnesota River Valley. The sampling site is located above the Minnesota River Valley, about two and a half miles upstream from where County Ditch #10 empties into the Minnesota River. The dominate condition of this watershed is a ditch and underground tile system with just under 10 miles of ditch and an undeterminable but considerable length of underground tile, though the sample site is a natural stream, which represents about 4 miles of this system. The last 3.8 miles of this creek are classified as a trout stream by the Minnesota Department of Natural Resources (DNR).

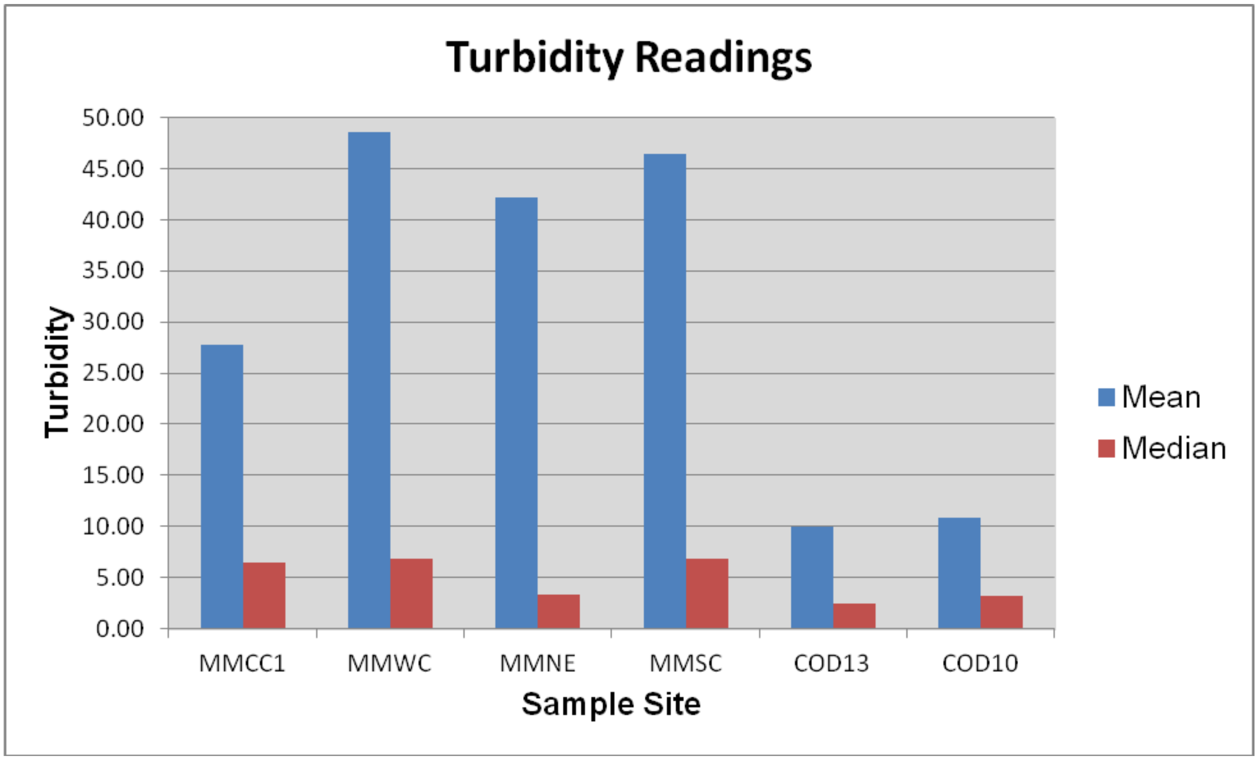
Sampling commenced at COD10 on April 9th and ran through October 13th for the 2009 season. The 2010 sampling season ran from March 16th to September 24th. The 2009 season was very dry while the 2010 season was very wet. Without stage monitoring data, we can only compare the watershed to its neighbors, but we estimate eighty to ninety percent of the total flow volume for the two year period was during the 2010 season. A total of 38 samples were taken from 2009 to 2010. There were 17 samples taken during the 2009 season with most of these being base flow samples. The 2010 season produced 21 samples with a good mix of base flow and storm flow events. Samples were analyzed for turbidity, total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorus (TP), soluble phosphorus (P-PO4), ammonia (N-NH3), nitrate + nitrite (N-NO2 + NO3), total kjeldahl nitrogen (TKN). To determine the monthly loading for E-coli, five samples during each month were collected over the two year period. Table 4-6 provides a summary of sampling results including mean, median, maximum, and minimum concentrations. A complete listing of laboratory results is contained in Appendix D.

Table 4-6: COD10 Summary of Monitoring Data (2009-2010)

Analyte	Units	Mean	Median	Max	Min	# Samples
Turbidity	mg/L	10.86	3.2	76	1.1	27
TSS	mg/L	19.07	6	182	1	29
TSVS	mg/L	4.21	3	17	1	29
N-NO2+NO3	mg/L	14.27	13.90	21.9	3.14	29
TKN	mg/L	1.49	1.4	3.2	0.7	29
N-NH3	mg/L	0.085	0.08	0.23	0.08	28
P-PO4	mg/L	0.175	0.124	0.76	0.033	27
TP	mg/L	0.248	0.170	0.873	0.049	29
E-coli	/100ml	878.3	435.2	3609	13.4	29

Observations of note: The first four sites listed had stream gage monitoring sites to monitor and record stream levels and determine flow for the sample season. This allowed for storm based sampling whereas the last two sites listed didn't have this equipment and were not sampled for storm events. When the sample data is processed using the FLUX32 program, the storm samples are weighted by flow at the time of sampling compared to the samples taken at base flow conditions. Collecting sample data without the corresponding flow data will not present an accurate picture of the conditions of the stream. This conflict in data collection is illustrated when comparing the results presented in the above tables. The median values are the midpoint in the data set (half the data has a higher value and half has a lower value), the mean values shows the sum of all results divided by the number of samples. The storm samples collected at the first four sites had a large impact (raised) on the mean values in the table but little effect on the median values. The lack of storm samples at the last two sites kept the mean values closer to the median values. Mean values for some analytes from the first four sites were much higher than mean values at the last two sites due to the effect of the storm samples on mean values. This is most noticeable for the turbidity, TSS & TSVS values. The chart below (Figure 4-1) illustrates this for the turbidity values.

Figure 4-1: Turbidity Mean vs. Median



Fishery Assessments

Hindeman (Spring) Creek (trout stream portion)

An initial stream survey was done on Hindeman Creek by the DNR in 1953 and again in 1978. Follow-up surveys were done in 1981, 1988, 1993, and 2003. Special sampling was done in 1979, 1980-1982, 2006, 2007, and 2008. Population assessments were done in 2000 and 2005.

Since 1953, the 4.8 mile designated trout stream had been stocked with brown trout yearlings to maintain marginal angling to support a "put and take" stocking strategy. The stream was stocked with rainbow trout as well from time to time. The portion of Spring Creek that is designated as a trout stream is cooled in the mid-summer owing to spring fed waters. Only in 2003 was there a fish that may be considered "naturally reproduced" in the stream, otherwise no reproduction has been documented.

Temperature measurements within the trout stream designation have shown the stream is marginally suitable for this stocking/angling method and fish surveys show that there is carryover of stocked fish from year to year in small numbers. Larger adult fish were stocked starting in 2006 and subsequent monitoring show that the fish are holding in the area and are carrying over from year to year in better numbers and in more areas.

The general assessment is that this trout stream's health is marginal due to flashiness and runoff amounts of the contributing waters coming from drainage systems in this heavy agricultural area. Management recommendations in 2008 include increased monitoring for angler use, carryover numbers and late-summer survival numbers. Recommendations also include re-writing the stream management plan for this stream.

Easements had been purchased on the trout stream section of Spring Creek in 2002 and citizen/DNR collaboration for awareness of the trout stream is ongoing as of 2011. Some of the later survey material for this site can be found in Appendix F.

John's Creek (trout stream portion)

An initial stream survey was done on Hindeman Creek by the DNR in 1981. A follow-up survey was done in 1987. Special sampling was done in 1979, 1981-1983, 2007, and 2009. Population assessments were done in 1982 and 2005.

From 1961 to 1995, the 3.8 mile designated trout stream had been stocked with brown trout yearlings. The stream was stocked with rainbow trout as well from time to time. Assessments have been made periodically for "put and take" fishery suitability. The portion of John's Creek that is designated as a trout stream is cooled in the mid-summer owing to springs and deciduous vegetation cover. "Naturally reproduced" trout in the stream have been found in assessments since 1995 as adults of multiple year classes.

Temperature measurements within the trout stream designation have shown the stream is suitable for this stocking/angling method and fish surveys show that there is carryover of fish from year to year.

The general assessment is that this trout stream's health is marginal due to flashiness and runoff amounts of the contributing waters coming from drainage systems in this heavy agricultural area and the fact that this stream dries down for most of its length in late-summer periods leaving few pools for trout habitat. Management recommendations in 2009 and 2010 include trying to increase habitat opportunity by removing snags and creating pools. Stocking was not suggested and its value as a put in take out fishery were questionable as there is no direct public access to the trout stream portion of John's Creek as well as overexploitation if an easement was provided. Survey material for this site can be found in Appendix F.

Tailored Integrated Stream Watershed Assessment (TISWA)

The Tailored Integrated Stream Watershed Assessment (TISWA) is a screening tool that combines varying degrees of existing estimated and observed data. The purpose is to rank sub-watersheds of a watershed in order to determine areas which have higher pollution potential. Using this study, there can be a focus on a particular area of a watershed with a scientific basis for choosing these locations, or target areas, for best management practice implementation. In conjunction with other factors such as highly erodible soils, water quality sampling results, and loading estimates, areas associated with poorer water quality can be addressed first in the most economical and environmentally beneficial way.

In 2011, a TISWA survey was conducted in the project area. Staff from the Redwood-Cottonwood Rivers Control Area conducted the survey. Before the actual field survey was conducted, relevant information was gathered from maps and GIS systems to determine survey locations and background information of the area. Map 4-1 shows the results of the TISWA survey. The map indicates the location of each TISWA point and impairment rating for that location. A minimum of three to four locations were identified in each of the 6 sub-watersheds. The survey points were conducted on tributaries and the main stem of the streams in the study area. TISWA Survey locations were located where a tributary or the main-stem of the streams traversed a public roadway. Again, the conditions of the site only reflect the vicinity within viewing distance of the observer. Conditions of sampling point using the below criteria are subjective. Impairment ratings were determined from the total range of scores within each category. An example of a field worksheet used for scoring can be found in Appendix E. Using the TISWA survey questions, the study addressed four categories:

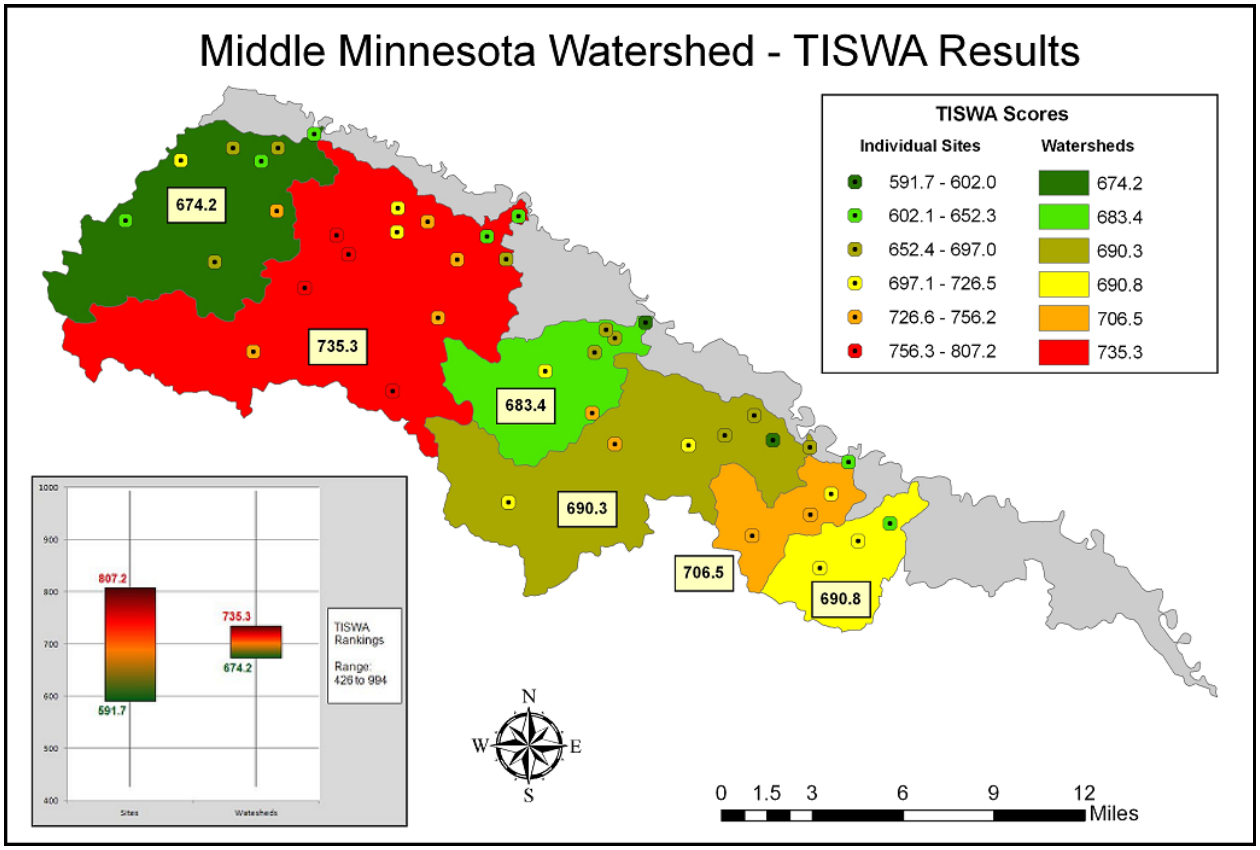
- Land-use/Landscape. Depending on the percentages of land use/land cover at the site location, the potential for contaminants to be carried to specified creeks can be determined.
- Pollutant Sources. This section relates to the number and condition of feedlots, point source facilities and septic systems.
- Riparian Zone and Channel Morphology. This section attempts to document the general condition of the riparian zone.
- Biotic and Abiotic Indicators. This section estimates the overall biological and biochemical condition of the watershed.

Results of TISWA Survey

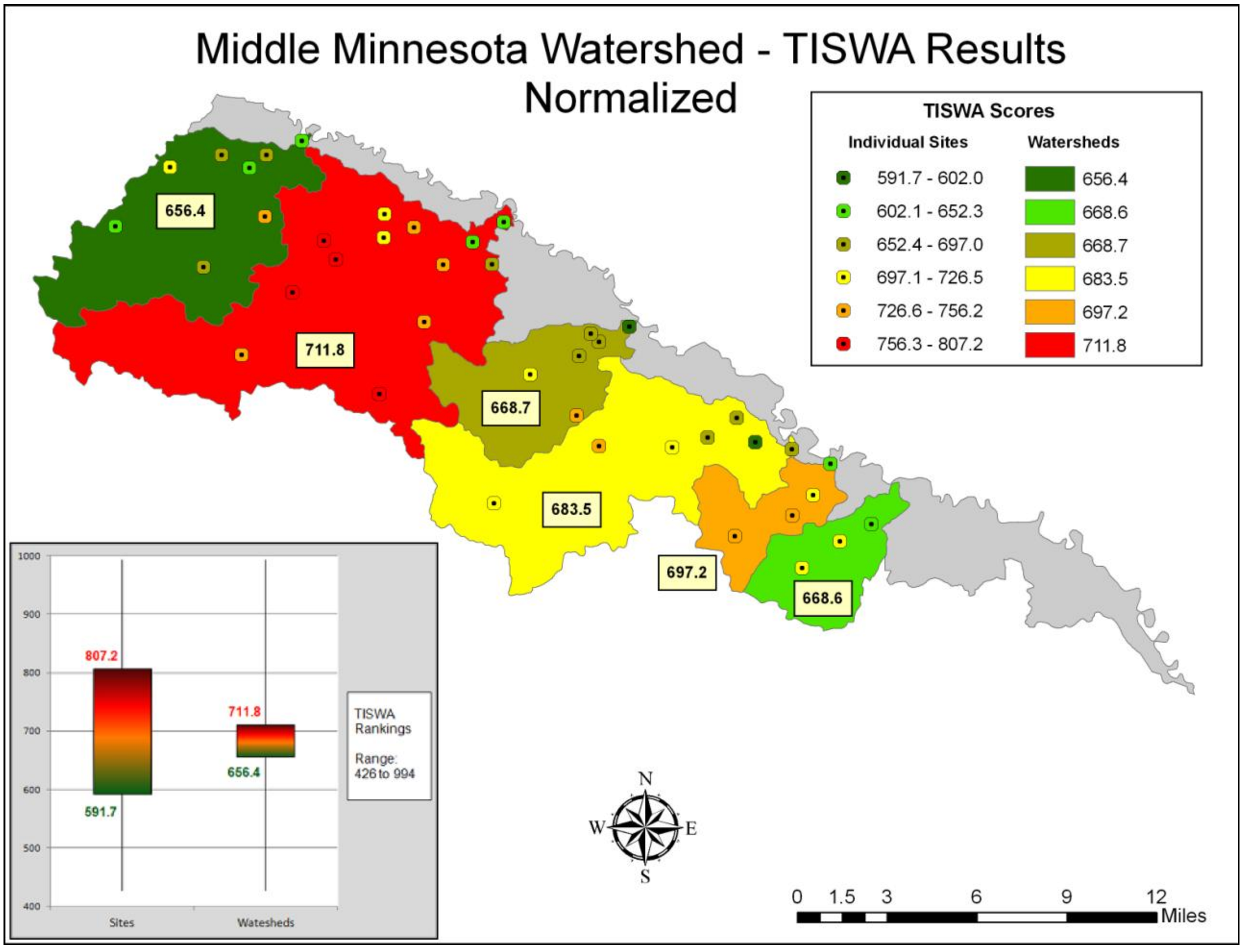
The TISWA survey was conducted at multiple locations within each watershed. Some watersheds, most notably the Brown County Ditches (COD10 & COD13) had a limited number of locations to perform the survey. The TISWA score at each location is the total of all four categories in the survey. TISWA scores can range from 426 on the low end (best score available) to 994 on the high end, which would be the worst possible score. Individual locations returned scores ranging from 591 to 807. This reflects the wide range of conditions within the watersheds. All individual scores were averaged to determine the watershed score. Watershed scores varied from 674.2 in Crow Creek to 735.3 in Wabasha Creek. The four highest (poorest) individual scores were also located in Wabasha Creek. Individual and watershed scores were color coded from lowest (dark green) to highest (red). A map (4-1) of the TISWA survey results shows the relative values between watersheds and individual sites and map (4-2) shows the results as they were normalized due to differing numbers of sample points.

Some observations noted during the survey indicate that the lower reaches of these watersheds appear to be in relatively good shape, as they are often still in a natural, albeit likely widened, condition with little or no modifications and much natural vegetation. The transition areas (between the uplands and lowlands) were also observed to be in relatively good condition. Best Management Practices (BMPs) were often noted in these areas if the land was not in a natural condition. The uplands were dominated by row-crop agriculture and drainage ditches, many without the recommended one rod buffer. The survey provides guidance on where to focus our limited resources to generate the best return on our investment. A summary listing of each survey location is in Appendix E.

Map 4-1: TISWA Survey Results



Map 4-2: TISWA Survey Results – Normalized



RUSLE Results

The process of running RUSLE was covered in chapter three. Results from the RUSLE analysis are reported here. RUSLE was run on each of the six sampled watersheds. Table 4-7 shows the amount of soil loss per acre each year, in tons. The lowest soil loss values were reported by Spring Creek (MMSC) and North Eden Creek (MMNE), which aligns with the TISWA results as well. The surprising result is in Crow Creek (MMCC1) which was our lowest scoring watershed in TISWA but reported the second highest soil loss value among the six watersheds using RUSLE. RUSLE is a model ran by predetermined values assigned to each type of land use and soil type within the watershed. There is no adjustment for how well or poorly a landowner takes care of his land. The TISWA survey is our subjective assessment of how well or poorly the land is taken care of at each assessment location. That may explain the differences in the results for Crow Creek with each different assessment tool. When Crow Creek is viewed using the FLUX data, the TISWA assessment seems to be the more accurate model of the two used (TISWA & RUSLE). The FLUX data shows Crow Creek to be in the best shape of the four watersheds assessed with FLUX.

Table 4-7: RUSLE Results

Site	Tons of soil loss per acre per year
MMCC1	1.4896
MMWC	1.4671
MMNE	1.1425
MMSC	1.1068
COD13	1.4678
COD10	1.5306

FLUX results

FLUX results are reported by Flow Weighted Mean Concentration (FWMC), which refers to the total load divided by the total discharge for a specified time period. The four flow monitored watersheds were analyzed with FLUX. The four pollutants that were analyzed with FLUX were Total Suspended Solids (TSS), Nitrates (N-NO2+NO3 or N+N), Total Phosphorus (TP) and Ortho-Phosphorus (OP). Table 4-8 shows the FLUX results as an average yield in pounds per acre per year. Table 4-9 shows the FLUX results as the total amount of each analyte moving out of the watershed in tons per year. More information regarding the FLUX results for each watershed is covered under the discussion assessment of water quality. Table 4-3 shows the average amount (in pounds per acre) of a pollutant in the water and Table 4-4 shows the total amount of a pollutant passing the sample point per year, in tons.

Table 4-8: Watershed Loadings Average Yield

Average Yield/Acre/Lbs/year				
Site	TSS	N+N	TP	OP
MMCC1	55.5	11.25	0.47	0.29
MMWC	597.4	33.80	3.89	2.43
MMNE	350.6	20.80	0.89	0.44
MMSC	550.5	14.31	1.10	0.49

Table 4-9: Watershed Loadings

Watershed tons/year				
Site	TSS	N+N	TP	OP
MMCC1	649.2	131.54	5.52	3.43
MMWC	13,287.3	751.84	86.60	54.07
MMNE	2,229.7	132.26	5.68	2.82
MMSC	7,916.1	205.78	15.88	7.09

Assessment of Water Quality

The Middle Minnesota River Watershed, between Redwood Falls and New Ulm, began as unsettled, untilled prairie land covered with many marshes, lakes and other small bodies of water. These conditions were documented by survey crews completing the Township Land Surveys that took place between 1858 and 1871. The general water quality of the lakes and streams at that time were described as “clear, pure and good.” The natural aging process for prairie lakes and streams was greatly accelerated in the years immediately following the land surveys. Rapid settlement of the area led to the introduction of livestock and tillage of prairie lands for agricultural production, so that today, over eighty percent of the Middle Minnesota River Watershed (between Redwood Falls and New Ulm) is devoted to crop production. About ninety percent of the cropland is planted to corn and soybeans.

Conversion of prairie to cropland also introduced the practice of artificial drainage. In the early 1900s, counties began implementing public ditching and drainage programs to help reduce ponding and remove excess subsurface water. Records show that most of the small lakes and marshes across southern Minnesota, including the Middle Minnesota River Watershed, were ditched and drained at about that time. Estimates vary, but it is generally accepted that, within the Minnesota River Basin, about eighty percent of the naturally occurring wetlands have been drained. Much of this drainage occurred at the turn of the twentieth century. Today this watershed is characterized by an extensive artificial drainage system consisting of open ditches and subsurface tile lines. Portions of many streams have been channeled, so that only remnants of the natural waterways remain. Throughout a majority of the watershed most naturally occurring streams are now classified as judicial or county ditches.

Water quality implications brought about by this profound transformation of the landscape are significant, yet difficult to quantify. Drainage has clearly had a beneficial impact on the agricultural industry, bringing into production millions of acres that otherwise could not have yielded crops. This has contributed to a healthy and vital regional economy. But, alterations to the hydrologic system have also contributed to increased flood damages, loss of topsoil, and elevated nutrient and sediment concentrations within the Minnesota River Watershed. Peak flows, total runoff, and pollutant loads have all increased through introduction of highly efficient drainage systems.

Research shows that in watersheds such as the Minnesota, most sediment is transported after storms erode fine grained soils exposed by heavy cultivation. Up to ninety percent of the annual sediment load typically occurs between the months of March and September. Consequently, large rainfall events at critical times of the year have a major effect on pollutant loads in the river.

Crow Creek (MMCC1)

The Crow Creek Watershed lies wholly within the Western Corn Belt Plains (WCBP) ecoregion. Principal water quality problems in these regions are sedimentation and nutrient enrichment thought to be associated with agricultural and fertilization practices. *E. coli.* bacteria is another pollutant of concern for Crow Creek.

Concentrations of total phosphorus (TP) in Crow Creek during the study period were quite variable, ranging from 0.104 during the dry 2009 season, to 0.458 during the wet 2010 season. The flow-weighted mean concentration of TP for the entire two-year project was 0.423 mg/l. This reflects the differences in precipitation and flow between the two years and how the high flow year will have a larger impact on the final numbers than a low flow year. This is somewhat higher than expected for streams in the Western Corn Belt Plains (WCBP) ecoregion.

Ortho-Phosphorus (OP) samples also reflected the different sample seasons, 2009 being dry and 2010 being wet. The FWMC of OP was .084 mg/l in 2009 and .282 mg/l in 2010. The large volume of water moving through the watershed in 2010 had a strong impact on the two-year FWMC, which was .262 mg/l. The OP analyte was a much larger percentage of TP during 2009 than during 2010. The increase in TSS may have introduced more of the non-soluble phosphorus than was present during 2009.

Total Suspended Solids (TSS) was generally low compared to the other watersheds. The FWMC for TSS during 2009 was 19.6 mg/l and went up to 53.1 mg/l during the 2010 sample season. Even with the increase between 2009 and 2010, Crow Creek returned some of the lowest levels of TSS in the assessment area. The two-year FWMC was 49.8 mg/l.

Nitrate concentrations (N-NO2+NO3) on Crow Creek do not show a long-term positive correlation with flow such as seen with TSS and TP. Nitrate-nitrogen concentrations actually displayed an inverse relationship as the "dry year" 2009 concentrations were higher (11.3 mg/l) than the "wet year" 2010 (9.9 mg/l). They remained fairly constant throughout the sampling season, though values tended to be lower in 2010 than in 2009. The flow-weighted mean concentration at the sampling site for the two year monitoring period was 10.1 mg/l, placing them well above the 75_{th} percentile value of 6.5 mg/L for ecoregion streams. There was a slight increase in readings in response to storm events with base flows averaging 8.7 mg/l and storm flows averaging 9.9 mg/l.

Water quality of Crow Creek is clearly affected by rainfall events. Increased concentrations of total suspended solids and nutrients were observed during storm events sampled during the study period. For example, for the monitoring period (2009 – 2010) under base flow conditions, TP concentrations were consistently low, averaging 0.108 mg/l. During storm events, concentrations were consistently greater than 0.362 mg/l.

Crow Creek is also affected by *E. coli.* bacteria at various times. Monthly geometric means for *E. coli.* are above the impairment standard of 126 cfu/100ml for all sample months with the exception of April.

Wabasha Creek (MMWC)

For some of the analytes, event samples collected from Wabasha Creek (MMWC) show the creek to exhibit the same type of responsiveness to stream flow as shown in Crow Creek (MMCC1). Total suspended solids (TSS) and total phosphorus (TP) concentrations generally were in the normal range during base flows (average TSS=11.7, TP=0.175), but with increased stream flow (average TSS=178.6, TP=0.502), concentrations of both rose significantly. The Flow Weighted Mean Concentration (FWMC) for TSS varied greatly, from 8.4 mg/l in the dry 2009 season but rose to 110 during the wet 2010 year and settled in at 93.3 mg/l for the 2 year sample period. The FWMC for TP also reflected the higher flows in 2010. The value for 2009 was 0.22 mg/l and 0.688 in 2010. This created a 2-year concentration value of 0.616 for TP. Ortho-phosphorus comprised about two-thirds of the TP during both sample years. This was a different response than was found in the other monitored watersheds. The 2009 FWMC of OP was .171 mg/l and rose to .421 mg/l during the 2010 season.

Wabasha Creek does differ from Crow Creek in its nitrate-nitrogen (N-NO2+NO3) response, with Wabasha Creek showing a different average concentration when comparing base flows (6.15 mg/L) to storm flows (9.12 mg/L). The (FWMC) flow-weighted mean concentration at the sampling site for the two year monitoring period was 5.28 mg/L. Ammonia (N-NH3) readings were in line with other creeks studied here. All ammonia readings were below the detection level of <0.16 with the exception of a 0.23 mg/l reading recorded during the snowmelt in March of 2010.

Wabasha Creek is also affected by *E. coli.* bacteria at various times. Monthly geometric means for *E. coli.* are above the impairment standard of 126 cfu/100ml for all sample months with the exception of April.

North Eden Creek (MMNE)

Total suspended solids (TSS) and total phosphorus (TP) in North Eden Creek, as in Crow Creek and Wabasha Creek, vary according to flow. The average TSS value during a storm event was about 192 mg/l compared to an average value of 4.5 mg/l during base flows. Sample results for TP showed a similar pattern with storm samples averaging 0.378 mg/l while base flows averaged 0.054 mg/l. Nitrate-nitrogen (N-NO2+NO3) showed less variation between base and storm flows. Strom flow samples averaged 10.46 mg/l and base flows averaged 8.16 mg/l.

The flow weighted mean concentrations (FWMC) for this site reflected the low flows and lack of water during 2009 and the increased flow and quantity of water in 2010. Total suspended solids (TSS) by FWMC were 4.1 mg/l during 2009 but spiked to 220 mg/l during 2010. The large quantity of water moving through the system during 2010 contributed to a two year FWMC of 210.5 mg/l. Similar results were found in TP concentrations with 2009 having a FWMC of 0.101 mg/l while 2010 had 0.557 mg/l and a two-year concentration of 0.537 mg/l. Ortho-phosphorus accounted for almost all of the TP during the 2009 season, with a FWMC of .098mg/l. During the 2010 season, OP made up only about half of the TP measured. The 2010 OP FWMC was .275 mg/l. Nitrate-nitrogen results varied less between the two years, but like other pollutants, the 2010 year had a larger effect on the final concentration. The FMWC in 2009 was 10.2 mg/l and 2010 was 12.6 mg/l and the two year concentration was 12.5 mg/l. Ammonia (N-NH3) readings were similar to other creeks studied here. All ammonia readings were below the detection level of <0.16.

North Eden Creek is also affected by *E. coli.* bacteria at various times. Monthly geometric means for *E. coli.* are above the impairment standard of 126 cfu/100ml for all sample months with the exception of April and May.

Spring Creek (MMSC)

Concentrations of total phosphorus (TP) in Spring Creek during the study period had a wide range of variability, from 0.139 mg/l during the dry 2009 season, to 0.709 mg/l during the wet 2010 season. The flow-weighted mean concentration of TP for the entire two-year project was 0.649 mg/l. This reflects the differences in precipitation and flow between the two years and how the high flow year will have a larger impact on the final numbers than a low flow year. The average test result during base flows was 0.053 mg/l and went up to 0.430 mg/l during storm events. Ortho-phosphorus readings also increased from 2009 to 2010, but as a percentage of TP, the OP readings were reduced in 2010. The FWMC of OP in 2009 was .096 mg/l and increased to .313 mg/l during 2010.

Total suspended solids (TSS) results were similar to TP in how they responded to increases in stream flow. For example, for the monitoring period (2009 – 2010) under base flow conditions, TSS concentrations were consistently low, averaging 6.0 mg/L. During storm events, average concentrations were 231.0 mg/L. The FWMC during the dry 2009 season was 14.5 mg/l while the wet 2010 season FWMC was 287.0 mg/l. The quantity of water moving through this creek in 2010 dwarfed 2009, and resulted in a two-year FWMC of 263.6 mg/l.

Nitrate concentrations (N-NO2+NO3) on Spring Creek, like Crow Creek, do not show a positive correlation with wet and dry years such as seen with TSS and TP. Nitrate-nitrogen

(FWMC) concentrations actually displayed an inverse relationship as 2009 concentrations were higher (8.84 mg/l) than 2010 (8.37 mg/l). The flow-weighted mean concentration at the sampling site for the two year monitoring period was 8.42 mg/L, placing them above the 75th percentile value of 6.5 mg/L for ecoregion streams. There was a noticeable increase in readings in response to storm events with base flows averaging 6.3 mg/l and storm flows averaging 9.6 mg/l. Ammonia (N-NH3) readings were similar to other creeks studied here. All ammonia readings were below the detection level of <0.16 mg/l with the exception of 0.23 mg/l and 0.51 mg/l readings recorded during the snowmelt in March of 2010.

Water quality of Spring Creek is clearly affected by rainfall events. Increased concentrations of total suspended solids and nutrients were observed during storm events sampled during the study period. A strong positive correlation between concentrations of total suspended solids (TSS) and total phosphorus (TP) during storm events suggests that a significant portion of the TP load results from surface sources. Spring Creek is also affected by *E. coli.* bacteria at various times. Monthly geometric means for *E. coli.* are above the impairment standard of 126 cfu/100ml for all but two of the months with the exception being April and May.

County Ditch #13 (COD13)

The last two sites covered (COD13 and COD10) did not have flow monitoring equipment installed during the sampling period. The lack of flow data prevents generating a flow weighted mean concentration (FWMC) value for various pollutants that we sampled for. RCRCA staff used a method to weigh sample results by correlating the COD13 flow with the flow in a measured river close by. This provided another data set of pollutant readings to report, and will be referred to as the FWMC-Equivalent. Average and median concentrations can be reported but don't have the same value as a FWMC does. Another consideration regarding the data collected for the county ditches (COD13 & COD10) is that without the flow monitoring equipment there was no purpose in sampling storm events. The sampling regime for the county ditches were simply every two weeks, so we did end up with some storm samples in the data set, but base flow data point outnumber storm flow data points by greater than a two to one ratio.

Total suspended solids (TSS), was found to average 4.4 mg/l during base flows and rose to 49.1 mg/l during storm flows. The FWMC-Equivalent for COD13 TSS was 89.9 mg/l.
Total Phosphorous (TP) averaged 0.237 mg/l during base flows and 0.370 mg/l during storm flows. The FWMC-Equivalent for TP was 0.457 mg/l.

County Ditch #13 Nitrate concentrations (N-NO2+NO3) ranged from ~0.50 mg/l to over 18.0 mg/l. Average concentrations during base flows were 7.2 mg/l, while storm flows averaged 10.9 mg/l. The FWMC-Equivalent at this site was 10.29 mg/l for Nitrates.

Ammonia (N-NH3) readings were similar to other creeks studied here. Most ammonia readings were below the detection level of <0.16. There was one reading over the detection level each year of sampling. In 2009, an early October test for ammonia came back at 0.29 mg/l and a snowmelt sample during March of 2010 reported back as a 0.65 mg/l concentration.

E. coli. was a persistent issue for the whole sample season. Every month sampled returned a geometric mean above the Minnesota state standard for *E. coli.*, from April to September. Unlike most of the other sites monitored in this report, the geometric means were very consistent over the year ranging from a low of 435 CFU/100 mL in May to a high of 606 CFU/100 mL in June.

County Ditch #10 (COD10)

As mentioned above, the last two sites covered (COD13 and COD10) did not have flow monitoring equipment installed during the sampling period. The lack of flow data prevents generating a flow weighted mean concentration (FWMC) value for various pollutants that we sampled for. RCRCA staff used a method to weigh sample results by correlating the COD10 flow with the flow in a measured river close by. This provided another data set of pollutant readings to report, and will be referred to as the FWMC-Equivalent. Average and median concentrations can be reported but don't have the same value as a FWMC does. Another consideration regarding the data collected for the county ditches (COD13 & COD10) is that without the flow monitoring equipment there was no purpose in sampling storm events. The sampling regime for the county ditches were simply every two weeks, so we did end up with some storm samples in the data set, but base flow data point outnumber storm flow data points by almost a two to one ratio.

Total suspended solids (TSS), was found to average 4.3 mg/l during base flows and rose to 43.2 mg/l during storm flows. The FWMC-Equivalent for COD10 TSS was 70.7 mg/l.
Total Phosphorous (TP) averaged 0.120 mg/l during base flows and 0.457 mg/l during storm flows. The FWMC-Equivalent for TP was 0.437 mg/l.

Nitrate concentrations (N-NO2+NO3) in county ditch #10 were consistently high over the two year sample period, of the 29 samples collected, only 5 came back under 10 mg/l for Nitrates. Nitrate concentrations ranged from 3.1 mg/l to 21.9 mg/l. Nitrate concentrations in this system displayed an inverse correlation with flow, that is to say, that concentrations generally went down as the flow in the system increased. Average concentrations during base flows were 14.8 mg/l, while storm flows averaged 13.3 mg/l. The FWMC-Equivalent at this site was 13.83 mg/l for Nitrates.

Ammonia (N-NH3) readings were similar to other creeks studied here. Ammonia readings were below the detection level of <0.16, with the exception of one sample collected in March of 2010, which recorded a reading of 0.23 mg/l.

E. coli. readings were very variable in this system. Geometric means by month ranged from just 24.7 CFU/100mL in April to 1270.1 CFU/100 mL in August. Every month sampled from May to September returned a geometric mean above the Minnesota state standard for *E. coli*. *E. coli*. readings gradually increased over the course of the sample season, starting out from 24 to 175 CFU/100mL for April and May. Geometric means for June and July jumped up to the 425 to 525 CFU/100mL range and moved over 1150 CFU/100mL for August and September.

Summary of Pollutant Loads

A primary goal of this study was to examine specific pollutants, the processes affecting their transport, and appropriate measures to reduce their delivery to the Minnesota River. Implicit in this examination are determinations of the relative pollutant contributions of various portions of the watershed. Study findings reveal large discrepancies in average annual pollutant loadings and yields at watershed sampling stations. The study indicates that precipitation and stream flow have a large impact on water quality in these first-order tributaries to the Minnesota River.

Chapter 5: Conclusions and Goals

The purpose of the resource investigation phase of the Middle Minnesota Major Watershed First Order Streams of Redwood and Brown County Project was to document factors affecting sediment and nutrient transport to the Minnesota River through the first order tributaries of the Middle Minnesota River in Brown and Redwood counties, and to determine reductions necessary to meet both main stem and tributary goals. This was accomplished through a combination of watershed assessments that examined the relationship between land use characteristics and water quality. This study had the benefit of having a large variety of flow conditions and extreme variability over the two year period. Study findings suggest that runoff during high flow conditions, periodically during the growing season (April-June), result in high sediment and nutrient loads, and that during the remainder of the duration these loads are substantially reduced. Further, sampling data collected during the course of the study indicate that each separate sub-shed shows variability in water quality, and in their contribution to the condition of the river. Some carry very high sediment and phosphorus loads, others exhibit high nitrate nitrogen concentrations, and others carry very low pollutant loads. A correlation in streams with more land area in the upper, flatter portion of the study area and higher nitrate nitrogen loads exists in the study area. There also seems to be a positive correlation between systems that are heavily ditched and pollutant loads. *E. coli* bacteria are a concern in all waters of the study area, underscoring the need to doubly ensure the implementation of manure and nutrient management practices, replace non-compliant septic systems, and maintain NPDES permits on point source discharges. The goal for these tributaries is to reduce the pollutant load to be in compliance with state standards according to Minnesota Rules Chapter 7050.

In all likelihood, the waters investigated in this diagnostic study area will be listed on the federal 303(d) list in accordance to the Clean Water Act. These stretches would also be subject to a TMDL investigation study in the next few years. One goal of this project was to set the groundwork and perhaps expedite the process of TMDLs for the separate reaches involved. This study should serve to complement the information needed in the coming statewide intensive watershed monitoring strategy for the Middle Minnesota River Basin.

Based on watershed assessments, the goals to obtain water quality compliance with state standards can be accomplished through a combination of best management practices and stream restoration measures applied within priority management areas. The connection between water quality and the hydrologic system is readily apparent in area watersheds, and measures to reduce runoff will play a central role in improving water quality in the small streams of this diagnostic study area. Slowing down the rate of runoff will not only improve water quality, but it will also provide more stable flow to enhance fishery resources, and make the river more useable for water-based recreational activities such as canoeing. Practices that reduce polluted runoff such as conservation tillage, storm drain holding ponds, restored wetlands, buffer strips, etc., provide an equally valuable stream flow control function so that multiple benefits are obtained from these practices. Appropriate best management practices focused on selected watershed areas can provide the means for achieving water quality goals.

Goals

Water quality goals are often times confused with standards. Standards prescribe the quality or properties of water that are necessary to protect a water body's designated use. The Minnesota Pollution Control Agency (MPCA), acting as a representative of the Environmental Protection Agency (EPA) assigns classifications to all waters of the state.[26] The classification of most waters in this study "permits the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. It is suitable for aquatic recreation of all kinds." If a water quality standard is exceeded, then the designated use is not met. Depending on the frequency of violations, the water body is described as partially supporting or not supporting its designated use. Standards have been established for *Escherichia coli*, mercury, ammonia, dissolved oxygen, and turbidity. Standards have not been developed for total suspended solids, total phosphorus or nitrogen.[27] For example, the *E. coli* standard for class 2B waters in Minnesota based on their designated use is a monthly geometric mean value of 126 organisms/100 ml of water with not less than 5 samples per month.[28] As noted earlier in this report, violations of this standard have occurred in all reaches of the study. Hence, these particular reaches will be listed as not supporting for their designated use. An overall goal for the study area is development of habitat conducive to fishery populations. This includes restoration of riparian vegetation and wetlands along with maintenance of the river's banks. Another important goal is to achieve the surface water designated uses by meeting the turbidity and *Escherichia coli* standards. Activities and structures that help with manure management, sediment reduction, and water retention would help to achieve these goals.

Water quality goals, in contrast to standards, are not defined by statute nor are they based on strict numerical criteria. In addition to stating what is desirable for a water body, goals must also reflect what is attainable. At best, water quality goals should be set high enough to achieve designated uses. Achieving the designated uses for all study reaches will require an increase in dissolved oxygen, a reduction in *E. coli* bacteria, and turbidity, etc. according to the state standards.

However, there are other pollutants besides bacteria, turbidity and diminished dissolved oxygen that are degrading these streams. Because standards are not set for those pollutants (TSS, TP, N-NO2+NO3), other methods need to be applied to decide appropriate limits and to determine the level of water quality that is achievable. Minnesota ecoregion criteria provide one method for establishing water quality goals in Minnesota surface waters. The state's aquatic ecoregion framework is based on a comparison of land use, soils, topography, and natural vegetation. Seven ecoregions were determined by integrating key geographical variables which identify regions in the state with similar characteristics. This study area is wholly within the Western Corn Belt Plains (WCBP) ecoregion. Agricultural practices are well developed, and represent the dominant land use. Small towns and extensive alterations to the natural drainage patterns (wetland drainage, tiles and channel modifications) support the row crop agriculture of the watershed area. Intensive agricultural practices, and associated impacts on water quality, are common throughout the WCBP ecoregion. The concentrations of several water quality parameters (total suspended solids, turbidity, *E. coli* bacteria, nitrate-nitrite nitrogen, and total

[26] *MR7050, MPCA, Classification of Waters of the State.*

[27] *There are limits on point source discharges of phosphorus to lakes and reservoirs, but not to rivers.*

[28] *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List; 2010 Assessment Cycle*

phosphorus) are relatively high. Although these water quality parameters are all a concern, nitrate-nitrite nitrogen levels in the WCBP ecoregion are exceptionally high, relative to the other ecoregions. High nitrate-nitrite nitrogen levels are likely associated with row crop (corn and soybeans) fertilization activities and the well developed agricultural drainage patterns (tiles and ditches) in the ecoregion.[29] A summary of water quality criteria for minimally impacted stream sites in the WCBP ecoregion can be found in Table 5-1. The summary provides an estimate of the best obtainable water quality for the ecoregion. This information can be used as a basis of comparison for parameters not subject to standards. The 75th percentile is recommended as the basis for establishing minimum water quality values and to assess water quality impacts in the ecoregion. Selecting the 25th to the 75th percentile interquartile range as the basis for comparison over some other measure recognizes the natural variability of water quality, and is utilized as the range for "typical" observations within the ecoregion.[30]

Table 5-1: Water Quality of Minimally Impacted Streams in the Western Corn-belt Plains

	Unit	25^{th} to 75^{th} Percentile
TSS	mg/L	26.0 - 75.5
TP	mg/L	0.21 - 0.35
Nit-Nit	mg/L	0.89 - 6.50
N-NH3 (Ammonia)	mg/L	0.11 - 0.20
e. coli*	/100 mL	81.9 - 756
Conductivity	µmhos(S)/cm	530 - 810

* Converted from fecal coliform (FC * 0.63 = *E. coli*)

The database establishing these values includes water quality data collected from 1970 to 1992. Value ranges are meant to apply to summer months (June to September), the time period most closely aligned with this study's sampling season. Results of samples collected from 2009-2010 show that total phosphorus (TP) flow weighted mean concentrations at all sampling stations used in this study stayed above the 75th percentile for minimally impacted streams. The state of Minnesota has set a goal, albeit not a standard, of 0.10 mg/L for surface waters in the Minnesota River Basin. The thought behind limiting phosphorus to this particular level is that waters with phosphorus at this level do not promote algae growth (and therefore help with turbidity and dissolved oxygen amounts). Data from all six monitoring sites used for this diagnostic exceed this goal concentration by a factor of 4 to 6 times.

Mean nitrate nitrogen (N-NO2+NO3) concentrations for the same time period exceed the 75th percentile value of minimally impacted streams in the Western Corn-belt Plains apart from Wabasha Creek [31] All streams except Wabasha and Spring Creeks exceed the 10 mg/L limit for drinking water set by the environmental protection agency[32]. Mean concentrations of ammonia (N-NH3), on the other hand, are well below the target range. Mean concentrations of total suspended solids (TSS) during the study period exceed the 75th percentile in all streams but CD

[29] *See MPCA, Descriptive Characteristics of the Seven Ecoregions in Minnesota, March 1988 for a complete discussion of the methodology used to select ecoregions and the factors affecting water quality in each ecoregion.*

[30] *MPCA, Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions, Addendum to: Descriptive Characteristics of the Seven Ecoregions of Minnesota, February 1993.*

[31] *5.28 mg/L mean concentration*

[32] *EPA – National Primary Drinking Water Regulations (EPA 816-F-09-004 May 2009)*

#10 (John's Creek) and Crow Creek. It is important to note that the results at the Spring Creek and North Eden Creek sites may have been affected by the Minnesota River briefly during the very high flows of 2010. The results during the few samples taken during the heavy snow melt and late fall storms are very much higher than the rest of the year.

Mean turbidity results for the Wabasha Creek, Crow Creek, North Eden, and Spring Creek show that between 20% and 30% of the samples taken were over the 25 NTU standard used for the assessment of streams in Minnesota. These levels would mean that the watercourses are not supporting of aquatic life and will likely be listed on the EPA 303(d) list of impaired waters. The waters of Brown County Ditch #10 were below the 25 NTU level 14.28% of the time (4 samples of 28) and should be listed as well. The only reach that should not be listed as impaired for turbidity should be Brown County Ditch #13. Since turbidity is not a measure that can be quantified in a concentration, a calculable value needs to be derived. Turbidity readings and TSS concentration testing taken at the same time can be paired and correlated using a method outlined in MPCAs Turbidity TMDL Protocol[33]. Because there aren't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for the streams in this study. More monitoring associated with a TMDL will result in a larger dataset that will reveal a surrogate that can be used to calculate a reduction to achieve turbidity standards.

Table 5-2 shows how sample concentrations obtained during the study period compare to the 75th percentile values for ecoregion streams.

Table 5-2: Study Findings Compared to Ecoregion Values (75th percentile)

STATION	TSS	TP	N-NO2+ NO3	N-NH3	*E. Coli*
CROW CREEK East of Redwood Falls (MMCC)	well <	>	well>	<	>
WABASHA CREEK near Franklin (MMWC)	close>	well >	<	<	>
NORTH EDEN CREEK near Franklin (MMNE)	well >	well >	well >	<	<
SPRING CREEK north of Sleepy Eye (MMSC)	well >	well >	>	<	<
BROWN CD #13 (COD13)	close>	>	well >	<	close <
JOHN's CREEK (COD10)	close<	>	well>	<	>

As noted earlier in this report, there is a strong positive correlation between TSS and TP concentrations, with both rising during rainfall events. Data obtained to assign ecoregion values for minimally impacted streams were not based on the same methodology used for this study, and consequently the ecoregion values may underestimate the "typical" sediment and phosphorus load in ecoregion streams. As noted previously, ecoregion values for minimally impacted streams provide a useful but limited means for establishing water quality goals. In relation to ecoregion criteria, it has been shown that the streams of this study carry pollutant loads in excess of what could be considered typical for regional streams. This study has also shown, however, that under most flow conditions, streams in the watershed exhibit water quality conditions that are very acceptable. These findings are consistent with those of other watershed studies in the Minnesota River Basin, and point out the difficulty of attaining goals related to

[33] *In order to minimize the variability found in the measurement of turbidity, the data is to be filtered to only include data sets where the turbidity is less than 40 NTU and the TSS is greater than 10 mg/L - MPCA Turbidity TMDL Protocol (MPCA, 2007).*

minimally impacted streams. The findings also highlight the importance of implementing measures that reduce runoff during the critical growing season months.

Given the results of testing in the study area and the desired concentrations of water pollutants, whether by assessment standards, ecoregion water quality, or reduction of algal growth; phosphorus, nitrate-nitrite, and bacteria reduction will be the driving force of goals in the six streams of the diagnostic study. Some goals for specific reaches in the study area follow:

Crow Creek

A realistic water quality goal for the Crow Creek watershed is to achieve the annual total phosphorus (TP) flow-weighted mean concentration of less than .10 mg/L. During the duration of this study, Crow Creek had a flow weighted mean concentration of 0.423 mg/L (average yield of 0.00024 tons/acre) of total phosphorus. To reach 0.10 mg/L will require about a seventy-five percent reduction (average yield of 0.00018 tons/acre) in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. A seventy-five percent reduction in mean TSS concentration should work toward bringing Crow Creek below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream met the nitrate-nitrite drinking water standard of 10 mg/L but exceeds the ecoregion 75^{th} percentile of 6.50 mg/L. Crow Creek had a flow weighted mean concentration of 10.07 mg/L (average yield of 0.00625 tons/acre). This will require about a thirty-five percent reduction (average yield of 0.00219 tons/acre) in the river's nitrate-nitrite concentration to meet the goal according to results of this study. The *E. coli.* results for Crow Creek through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in May, June, July, August, and September. A reduction goal of 14.5%, 80.3%, 82.1%, 86.3%, and 90.5%, respectively would need to occur to meet the *E. coli.* bacteria standard.

Wabasha Creek

A realistic water quality goal for the Wabasha Creek watershed is to achieve the annual total phosphorus (TP) flow-weighted mean concentration of less than .10 mg/L. During the duration of this study, Wabasha Creek had a flow weighted mean concentration of .616 mg/L (average yield of 0.00205 tons/acre). This will require about a eighty-four percent reduction (average yield of 0.00172 tons/acre) in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. An eighty-four percent reduction in mean TSS concentration should work toward bringing Wabasha Creek below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream met the nitrate-nitrite drinking water standard of 10 mg/L but exceeds the ecoregion 75th percentile of 6.50 mg/L. Wabasha Creek had a flow weighted mean concentration of 5.28 mg/L (average yield of 0.019 tons/acre). It appears the river's nitrate-nitrite concentration meets the goal according to results of this study but one must consider the amount of water that came through the system in 2010 as a dilution factor. The *E. coli.* results for Wabasha Creek through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in May, June, July, August, and September. A reduction goal of 50.2%, 88.1%, 74.0%, 85.5%, and 90.4%, respectively would need to occur to meet the *E. coli.* bacteria standard.

North Eden Creek

A realistic water quality goal for the North Eden Creek watershed is to achieve the annual total phosphorus (TP) flow-weighted mean concentration of less than .10 mg/L. During the duration of this study, North Eden Creek had a flow weighted mean concentration of 0.537 mg/L (average yield of 0.00045 tons/acre). This will require about an eighty-two percent reduction (average yield of 0.00037 tons/acre) in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. An eighty-two percent reduction in mean TSS concentration should work toward bringing North Eden Creek below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream met the nitrate-nitrite drinking water standard of 10 mg/L but exceeds the ecoregion 75th percentile of 6.50 mg/L. North Eden Creek had a flow weighted mean concentration of 12.5 mg/L (average yield of 0.01076 tons/acre). This will require about a fifty percent reduction (average yield of 0.00538 tons/acre) in the river's nitrate-nitrite concentration to meet the goal according to results of this study. The *E. coli.* results for North Eden Creek through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in June, July, August, and September. A reduction goal of 71.3%, 77.8%, 76.3%, and 81.4%, respectively would need to occur to meet the *E. coli.* bacteria standard.

Spring (Hindeman) Creek

A realistic water quality goal for the Spring Creek watershed is to achieve the annual total phosphorus (TP) flow-weighted mean concentration of less than .10 mg/L. During the duration of this study, Spring Creek had a flow weighted mean concentration of 0.649 mg/L (average yield of 0.00056 tons/acre). This will require about a eighty-five percent reduction (average yield of 0.00048 tons/acre) in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. An eighty-five percent reduction in mean TSS concentration should work toward bringing Spring Creek below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream met the nitrate-nitrite drinking water standard of 10 mg/L but exceeds the ecoregion 75th percentile of 6.50 mg/L. Spring Creek had a flow weighted mean concentration of 8.42 mg/L (average yield of 0.00795 tons/acre). This will require about a twenty-three percent reduction (average yield of 0.00193 tons/acre) in the river's nitrate-nitrite concentration to meet the goal according to results of this study. The *E. coli.* results for Spring Creek through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in June, July, August, and September. A reduction goal of 75.3%, 62.6%, 71.9%, and 80.8%, respectively would need to occur to meet the *E. coli.* bacteria standard.

Brown County Ditch #13

Brown County Ditch #13 had no flow measurements so mass calculations couldn't be exacted. An attempt to arrive at a flow weighted concentration was calculated using the flow values of North Eden Creek which is most like CD #13 of the four streams where flow measurements existed. By calculating the percentage of daily flow as it relates to the total flow volume of water and applying those ratios to the sample set taken at site COD13, we can approximate the flow weighted mean concentrations for the two year period. For example, the period between 3/16/2010 and 3/22/2010 had 45% of the flow during the two-year period of sampling data, therefore the samples taken during that period would receive 45% of the weight of calculation for the period.

A realistic water quality goal for the CD #13 watershed is to achieve the annual total phosphorus (TP) mean concentration of less than .10 mg/L. During the duration of this study, CD #13 had a flow weighted mean concentration of 0.457 mg/L. This will require about an eighty percent reduction in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. An eighty percent reduction in mean TSS concentration would go well beyond bringing CD #13 below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream exceeds the nitrate-nitrite drinking water standard of 10 mg/L as well as the ecoregion 75th percentile of 6.50 mg/L. CD #13 had a flow weighted mean concentration of 10.29 mg/L. This will require about a forty percent reduction in the river's nitrate-nitrite concentration to meet the goal according to results of this study. The *E. coli.* results for CD #13 through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in April, May, June, July, August, and September. A reduction goal of 51.0%, 72.0%, 66.9%, 80.1%, 73.7%, and 87.1%, respectively would need to occur to meet the *E. coli.* bacteria standard.

Brown County Ditch #10 (John's Creek)

Brown County Ditch #10 had no flow measurements so mass calculations couldn't be exacted. An attempt to arrive at a flow weighted concentration was calculated using the flow values of North Eden Creek which is most like CD #10 of the four streams where flow measurements existed. By calculating the percentage of daily flow as it relates to the total flow volume of water and applying those ratios to the sample set taken at site COD10, we can approximate the flow weighted mean concentrations for the two year period. For example, the period between 3/16/2010 and 3/22/2010 had 45% of the flow during the two-year period of sampling data, therefore the samples taken during that period would receive 45% of the weight of calculation for the period.

A realistic water quality goal for the CD #10 watershed is to achieve the annual total phosphorus (TP) flow-weighted mean concentration of less than .10 mg/L. During the duration of this study, CD #10 had a flow weighted mean concentration of .457 mg/L. This will require nearly an eighty percent reduction in the river's total phosphorus concentration to meet the goal according to results of this study. A reduction of this magnitude will have a corresponding effect on the total suspended solids (TSS) load carried by the river, given the correlation between TSS and TP. Measures to reduce one will also help reduce the other. An eighty percent reduction in mean TSS concentration should work toward bringing CD #10 below the turbidity standard as well. As mentioned above, because there isn't an appreciable amount of usable TSS readings for turbidity/TSS pairing analysis (TSS values exceeding 10 mg/L), it is hard to derive a TSS surrogate for this stream. During the study period, the flow weighted mean concentration for this stream exceeded the nitrate-nitrite drinking water standard of 10 mg/L as well as the ecoregion 75^{th} percentile of 6.50 mg/L. CD #10 had a flow weighted mean concentration of 13.83 mg/L. This will require about a fifty-two percent reduction in the river's nitrate-nitrite concentration to meet the goal according to results of this study. The *E. coli.* results for CD #10 through 2009-2010 exceeded the standard monthly geometric mean of 126 coliforming units (CFU)/100 mL in May, June, July, August, and September. A reduction goal of 24.3%, 88.3%, 77.9%, 84.5%, and 84.2%, respectively would need to occur to meet the *E. coli.* bacteria standard. Table 5-3 displays the numbers used to calculate reductions. Table 5-4 summarizes reductions needed to meet main stem and tributary water quality goals.

Table 5-3: Flow Weighted Mean Concentrations

AVE FWMC	CROW CREEK	WABASHA CREEK	NORTH EDEN CREEK	SPRING CREEK	BROWN CD #13	JOHN's CREEK (CD10)
TSS	49.76	93.31	210.54	263.56	89.90	70.70
TP	0.423	0.616	0.537	0.649	0.457	0.457
NIT	10.08	5.28	12.49	8.42	10.29	13.83

Table 5-4: Reductions to Meet Goals

WATERSHED	ACRES of WATERSHED	TSS	TP	Nit-Nit as N	*E. coli**	Turb.**
CROW CREEK	23,390.25	-	76.4%	35.5%	59.0%	N/A
WABASHA CREEK	44,484.09	19.1%	83.8%	-	64.7%	N/A
NORTH EDEN CREEK	12,718.94	64.1%	81.4%	48.0%	51.1%	N/A
SPRING CREEK	28,759.52	71.4%	84.6%	22.8%	48.4%	N/A
BROWN CD #13	7,256.99	16.0%	78.1%	36.8%	71.8%	N/A
JOHN's CREEK (CD10)	8,514.11	-	78.1%	53.0%	59.9%	N/A

*Based on average set of monthly reductions, **Not enough data to derive a TSS surrogate for reduction.

Chapter 6: Implementation Plan

Introduction

The Middle Minnesota Basin covers 1,347 square miles in parts of 8 counties in South Central Minnesota. The basin ranks sixth in area of the twelve major watersheds supplying the Minnesota River. The Middle Minnesota River Watershed defines a large irregular-shaped area that drains into the Minnesota River through a number of relatively small streams, seeps and small springs. The Middle Minnesota minor watersheds differ from most of the other watersheds of the Minnesota River basin in that they are defined more by the main stem of the Minnesota River than by any particular tributary. That makes this basin somewhat unique; the rest of the 11 basins all have identifying central rivers. This unique feature of the watershed can pose difficulty in making water quality assessments and implementation since there are a large number of first and second order streams.

The project area of this assessment consists of 159,935 acres or about 18.5% of Middle Minnesota Watershed. The area is between the outlets of the Redwood River and the Cottonwood River draining portions of Brown and Redwood counties in south-central Minnesota. This area consists of first order streams: Crow Creek, Wabasha Creek, North Eden Creek, Spring Creek, Brown CD #13, and Brown CD #10. These streams generally orient from southwest to northeast as they drop into the Minnesota River valley to meet the Minnesota River. Smaller streams in the project area which are essentially confined to direct draws and seeps that contribute directly to the Minnesota River proper are included in the area description figure but were not assessed in the diagnostic study.

Generally high *E. coli* bacteria and nitrate-nitrogen loads are associated with the assessed streams during the growing season. This is predominantly the result of rainfall-driven polluted runoff that occurs throughout most of the watershed. The reaches are affected by bacteria and are, at the least, exceeding the acute *E. coli* bacteria standard and will be subject to a total maximum daily load (TMDL) study in the next few years. The usefulness and aesthetic qualities of the streams are impaired, and conditions are unlikely to improve unless changes are made in land use and water management practices within the watershed. These changes can be accomplished through an implementation plan that reflects real problems occurring on the landscape, and clearly identifies solutions to those problems while developing and organizing sufficient resources to attain meaningful and effective solutions. One thing the study area has going for it in trying to formulate a plan to enhance water quality is the size of the project area. At 250 mi^2, and 159,935 acres, the study area presents a relatively small area to work with, though each individual reach is not connected as is the case with the larger watersheds in the Minnesota River Watershed. One of the drawbacks of this small, rural study area is the limited calculable pollutant point sources involved that could easily describe a portion of the loadings in the small streams. Because nonpoint source pollution is the principal determinant of water quality in the study region, and nonpoint source pollution by definition is dispersed, this increases the difficulty of achieving quick, measurable results. There is simply too much area to cover for the time and resources allowed. Another challenge that is partly related to the small stream sizes is actively involving people in the lengthy process needed to clean up the streams. Most watershed residents do not see these streams as large traditional rivers, nor do they use them for recreational or other purposes. Yet, the nature of the problem is such that nearly everyone in the sub-watersheds, through their actions, affects the condition of them and the Minnesota River on the whole. Moreover, water quality improvements will require efforts on behalf of large numbers of people within the area, the same people who do not use the river now and who do not understand how their actions are connected to its fate. The implementation plan for the 1st order streams of the Minnesota River in Redwood and Brown counties acknowledge the complex nature of nonpoint source pollution and the central role played by watershed residents in achieving water quality improvements. It is based, in part, on experiences gained through the Redwood River Clean Water Project and the Cottonwood River Restoration Project. These plans emphasize best management practices (BMPs) on agricultural land supported by an information and education program that uses a variety of techniques to achieve participation. Because the studied area is very similar to the Redwood and Cottonwood Watersheds in terms of land use, topography, soils, and climate, it is likely that the successfully applied accelerated BMP program in the Redwood and Cottonwood Watersheds will also be successful in this smaller area. It is also reasonable to expect that techniques used to increase participation rates in the Redwood and Cottonwood Watersheds will also work in the small tributaries of this area. Finally, these streams, like the Redwood and Cottonwood Watersheds and other tributaries to the Minnesota River, have long been thought of primarily as a drainage system, a means for conveying excess water from the landscape, and have not been valued as a resource for its own sake or for other uses. One intent of this implementation plan is to change this perception by developing and promoting alternative uses for these small scenic streams thereby exposing residents to a more complete understanding and appreciation of their value. This, in turn, may instill a greater sense of the communities and commitment to the future protection and enhancement of these streams and water quality in the Minnesota River as a whole.

Goals and Objectives

Goals and objectives for the Middle Minnesota Watershed portion of Brown and Redwood County are based on sampling results, land use assessments, and judgments about reasonable expectations for rivers and streams in this region of the state. In setting goals and objectives, consideration is given to four important watershed characteristics. First, agriculture is the predominant land use in the watershed and improvements to water quality will necessarily require changes in agricultural practices. Second, pollutant transport in the watershed is primarily affected by uncontrolled runoff. Third, the area holds potential for being a cultural and recreational resource, but past and present conditions prevent it from being used to its full potential. And, fourth, watershed residents through their involvement and actions hold the key to protecting and enhancing the waters of the area.

Ten-year goals of the Middle Minnesota River 1st Order Streams of Redwood & Brown Counties Restoration Project are:

1. To achieve the highest water quality attainable for ecoregion streams/TMDL standards;
2. To have area residents take an active role in enhancing and protecting the small streams outlined in this study.

3. To develop this portion of the Minnesota River valley and its major tributaries as a recreational and cultural resource for the area.

A number of objectives have been selected to help achieve these goals. Objectives are to:

__ Increase game fish populations in the trout stream and lower portions of Wabasha, Crow, Spring, North Eden, and John's Creek

__ Establish, train, and support a group of volunteers to monitor watershed health

__ Accelerate adoption of best management practices (BMPs) in high priority areas

__ Help watershed residents understand the connection between their actions and water quality

__ Strengthen cooperation between agencies and units of government that address water quality issues

__ Collect and distribute credible information about water resources in the watershed

__ Develop and implement plans to address total maximum daily load (TMDL) Requirements

BEST MANAGEMENT PRACTICE (BMP) ALTERNATIVES AND ANALYSIS

Best management practices (BMPs) are defined as those practices, techniques, or measures for preventing or reducing nonpoint source pollution to a level compatible with water quality goals. These practices are often discussed in terms of systems, recognizing that individual BMPs have limited effectiveness, but combinations, or systems, can achieve significant nonpoint source reduction benefits.

NONPOINT SOURCE MANAGEMENT MEASURES, ALTERNATIVES, AND ANALYSIS

This section provides implementation strategies targeted towards reduction of nutrients, *E. coli* bacteria, and turbidity. There are many implementation strategies that would work for nutrient, *E. coli* bacteria, and turbidity impairments. As nutrients, *E. coli* bacteria, and turbidity have several sources and pathways in common, many of the suggestions have the common goal of addressing all pollutants. This list is not an all inclusive list as there are hundreds of management methods.

Livestock Waste Management /Manure Management

Livestock waste management refers to storage facilities, but it also includes practices such as buffer strips and livestock exclusion, where appropriate. If manure is not handled properly, it is a source of bacteria, nutrients, ammonia and total suspended solids. The impact of feedlot runoff on surface waters depends on size and location, although feedlots distant from surface water can contribute pollution if runoff becomes channelized or reaches a ditch or tile. Generally, if a feedlot is large and close to a lake or stream, the impact is significant. If the feedlot is small and a long distance from a surface water body, the impact may be minimal. A waste management system is a combination of practices used to temporarily store manure until it can be properly applied to cropland. Examples include waste storage ponds, waste storage structures, and solid waste storage areas. Storage ponds are earthen structures that usually require liquid manure handling equipment for agitation, hauling, and field application. Storage structures are fabricated containment areas such as a pit below a confinement building or an above-ground structure. These also require equipment to handle liquid manure. Solid storage areas are usually concrete slabs designed to store solids and allow liquids to run off. They require some type of runoff containment to prevent polluted runoff from leaving the site. Waste management systems typically achieve pollutant reductions in the range of 50% to 75%. Systems that totally control runoff can eliminate all pollutant discharges. Careful consideration must be given to design and construction of these systems to prevent groundwater contamination. Even with proper construction, however, a certain amount of seepage is expected from earthen ponds. Waste management systems can be relatively complex and expensive and, therefore, are not an attractive alternative to many farmers. Runoff from feedlots can be controlled with several practices that may or may not be used in conjunction with a waste management system. Some activities related to Livestock management include:

Feedlot fixes - There are approximately 175 feedlots in the study area. They range from a few livestock to thousands of animals. Twelve feedlots have greater than 1,000 animal units and are not eligible for cost share dollars for corrections. State and federal requirements address several issues but there are still many feedlots that are operating at a level that could be contributing bacteria to nearby water bodies. Providing assistance for the repair and upgrade of these feedlots is essential to correcting the problem sites in a timely manner. Correcting the runoff would be 90 to 100 percent effective in reducing bacteria and can assist producers in better managing their manure. A drawback is the cost, and in some cases not having adequate space to install a runoff control structure. Costs for installing runoff control structures can range from $20,000-$100,000+ which is prohibitive for many feedlot owners. Engineering and technical assistance can add 5-10 percent to the cost of a project.

Inspections - A Level III Feedlot inspection requires a site visit and the use of the MinnFarm runoff evaluation model for open lots. Through this inspection process, feedlots needing corrective measures would be identified. This knowledge will assist in prioritizing sites needing correction. There are no drawbacks to performing the inspections, but there may be some trepidation on the feedlot owner’s part in allowing site visits. Performing 175 site visits and analysis of each would cost approximately $35,000.00 to $40,000.00.

Level III Land Application Inspections - Conducting a Level III Land Application Inspection on fields with manure application in sensitive areas would be a process to educate and evaluate correct manure application. Each County is required to inspect 7% of their registered feedlots each year. Focusing these inspections in the northern sections of Redwood and Brown county areas of the Middle Minnesota River Watershed and performing a Level III Land Application inspection could be conducted at the same time a Level III feedlot inspection is performed. The cost to ensure setbacks are being met, best management practices are being followed as well as verifying that the correct amount of manure is being applied would add costs in additional time during site visits.

Development of Manure Management Plans (MMP) - A MMP is a document that assists producers in managing rate, timing, location, form and method of all nutrient applications. Any producer with more than 300 animal units is required to complete a MMP. These plans are beneficial in that they match crop needs with correct application rate of each manure source and detail how application will be handled in special protection areas. The drawbacks are expense of writing or hiring the writing of a plan, time to record applications and to make changes as applications of nutrients change from the original plan. The cost to complete a MMP can vary from $500.00 to $3,000 for an initial plan and $200.00 to $2,000.00 per year to update, depending on size of operation and complexity of cropping rotation.

Implementing the following best management practices of a manure management plan would significantly reduce the amount of fecal material entering water bodies and also reduce available nutrients and sediment that would cause turbidity. Research shows that incorporating all or some of these components can reduce bacteria from 50% to 90%. Costs of incorporating a manure management plan and best management practices can vary greatly. Costs will vary depending on factors such as cost of commercial fertilizer application in areas with limited manure application allowed, the cost of replacing a cash crop with a grass buffer and whether the cooperator has a use for forage, or even the cost of total containment structures for feedlots that cannot winter apply. Depending on the situation, the following best management practices and Minnesota State Feedlot Rule requirements could also be relatively inexpensive.

Observing setbacks - The MPCA has defined the following setbacks to perennial and intermittent streams, lakes, and drainage ditches for application of manure: 25 feet- no application, 25-300 feet- inject or incorporate within 24 hours. 0 to 300 foot from an open tile intake requires injection or incorporation within 24 hours also. It is fairly common to see these setbacks not being followed. The drawbacks would be the need for separate application of nutrients within the 25 feet of the water surface and adequate time to incorporate surface applied manure within 24 hours.

Winter manure application - Winter application of manure can be a strong contributor of *E. coli* bacteria during snow melt if manure is not correctly applied. Applying too close to surface water, too high a rate of application or applying on fields that have slopes over 2% for liquid manure or 4% for solid manure can cause problems. Drawbacks to proper winter application include not being able to spread in certain fields or not being able to spread manure over a complete field.

Vegetative buffers - Vegetative buffers can be a very efficient method to filter runoff from fields with manure application. The permanent grass vegetation will trap nutrient laden sediment, fecal material and at the same time utilize the nutrients. One of the stronger deterrents to installing vegetative buffers is the loss of production acres.

Incorporation of Manure - Immediate incorporation of manure or incorporating the manure within 24 hours will reduce the potential of fecal material runoff to surface water. Incorporation has a financial benefit by stopping loss of nitrogen. Research has shown that incorporation can also improve soil structure, which would help water infiltration and prevent runoff. Incorporation of manure within 24 hours is required for areas 25-300 feet from of a waterbody and within 300 feet of an open tile intake. The drawbacks would be additional time required to incorporate and possibly causing more potential bacteria since incorporation does not allow sunlight to kill the bacteria in the manure.

Calibration of equipment - Calibration of manure application equipment will assist producers in making correct application of manure. Manure volume and density can vary greatly and calibration would prevent over application and still provide adequate nutrients for the crops grown. Technical assistance and scales would help producers weigh and calibrate their application equipment.

Pasture Management

Pasture management involves proper use and treatment of pasture so that the life of desirable forage species is prolonged, and the quality and quantity of forage is increased.

Improving the quality of forage on pastures protects soil and minimizes runoff. If the pasture has gully erosion problems, structural practices such as diversions, grassed waterways, or grade stabilization structures may be needed. Other pasture management techniques to consider include: rotational grazing, which involves short-term grazing followed by a rest period; seasonal grazing, where warm and cool season grasses are pastured in their particular season of growth; and liming and fertilizing, which provide proper soil fertility for forage production.

Pastures near streams or with surface waters outletting from them should be of special concern. Livestock pastured with access to streams pose a major risk of contaminating waters through direct deposit of fecal material either in the stream or along the banks. Livestock can also cause instability of stream banks, which leads to greater turbidity during higher flows. Research has shown that exclusion of livestock through fencing or controlled access can reduce *E. coli* bacteria and turbidity in the pastures by as much as 80 percent. The USDA Environmental Quality Incentive Program has funding for rotational grazing systems but it has had limited acceptance due to the program's numerous requirements. A simpler, less complicated system could be offered with better acceptance. This simpler system would have a stream crossing or remote watering component, a vegetative management component and a stream bank erosion component. Stream crossings in pasture systems have shown to reduce sediment delivery from bank erosion and stream bed degradation. The cost to offer this type of program would be approximately $90,000.00. The drawbacks to these systems would be the labor and expense of establishing and maintaining fencing along the stream corridor.

Structural Practices

Research has shown that tile intake replacement structures, grade stabilization structures, water and sediment control basins, terraces, and stream barbs are all structural practices that can reduce runoff and soil erosion to reduce water turbidity by 50% - 90% in river systems. Current cost share programs include the Environmental Quality Insurance Program (EQIP) that can provide prescribed cost share depending on the practice and federal 319 implementation funds which provide up to 75% cost share and are awarded on a competitive basis from project completion probability to environmental benefit. The US Fish and Wildlife Service had provided up to 90 percent cost share for stream bank stabilization and J-hooks in other areas but has very limited funding, sometimes taking 2-3 years to get funding for a project. Some structural practices include:

Terraces - Terraces can be effective at reducing overland runoff that carries sediment and nutrients. Average costs for terraces usually run $7.50 per foot. A terrace is an earthen embankment that is constructed across a slope to intercept runoff. Terraces are best suited to uniform, gently to moderately sloping fields (2% to 12% slopes) that have erosion problems. There are two basic types of terraces. Storage terraces collect water and store it until it can infiltrate into the ground or be released through a stable outlet. Gradient terraces are designed as a channel to slow runoff water and carry it to a stable outlet like a grassed waterway. Properly designed, installed, and maintained terraces can be very effective at reducing erosion and trapping sediment and nutrients. Studies of storage terraces show reductions of 95% for sediment, 84% for soluble nitrogen, 93% for attached nitrogen, 73% for soluble phosphorus, and 93% for attached phosphorus. Gradient terraces provide less infiltration, and therefore, fewer benefits. Terraces are not recommended on fields with very stony, steep, or shallow soils, nor are they recommended on fields with very irregular topography and short slopes. They are also relatively expensive to install, and require a substantial amount of time to design and construct.

Water and Sediment Control Basins - Water and sediment control basins are earthen embankments constructed across a depression area of concentrated runoff. They perform a function very similar to that of terraces. These basins trap sediment and water running off farmland above the structure. These structures help reduce gully erosion by controlling water flow within a drainage area. Drainage areas controlled by these structures should be less than 40 acres. In many cases, a series of basins is needed to properly control erosion, and to be compatible with farm machinery. This practice is very effective at preventing gully erosion, trapping sediment, and reducing downstream peak flows. They are capable of trapping up to 60% of total suspended solids contained in runoff. However, they are not effective at removing soluble pollutants. Water and sediment basin costs can range from $2,000.00 to $5,000.00 per structure depending on the design.

Streambank and Shoreland Protection/Restoration - Streambank erosion is a continually occurring natural condition that can be greatly accelerated by human activity. Over time, natural streams tend to reach equilibrium so that erosion at one location is roughly balanced by deposition at another. Human alterations to hydrologic and streamflow patterns can, however, upset this balance and lead to severe consequences. Streambank failure, defined as the collapse or slippage of a large mass of bank material into the stream, is one example of what happens when this balance is upset. Because of the complexity of physical processes affecting streams, there is not one single type of streambank failure, but many different types. Consequently, streambank protection or restoration practices must be tailored to the specific causes of the streambank problem. Through an understanding of the problem's cause and selection of the proper bank protection method, the likelihood of protecting an eroding streambank is significantly increased. One of the most common techniques used for streambank protection is rock riprap the stream bank toe and install stream barbs. It is a very effective method when used properly, but it is also very expensive. Stream barbs or J-hooks are installed where stream bank erosion is occurring. When installed, the barbs re-direct the energy of the stream back into the channel, reducing further stream bank erosion. Research has shown that eliminating stream bank erosion can reduce turbidity by 90 percent. The drawbacks to stream barbs or J-hooks are that they are expensive to install and need technical assistance for correct placement. Bioengineering represents an attractive alternative to the use of rock riprap for streambank protection. This approach combines mechanical, biological, and ecological concepts to arrest and prevent shallow slope failures and erosion. Immediate soil reinforcement is achieved by specific plant arrangements at the site. Structures stabilize slopes during the critical time for seed germination and root growth. A well-established root zone will provide shear strength and resistance to sliding. Overall benefits of bioengineering practices include slope stabilization, improved infiltration, runoff filtration, excess moisture transpiration, ground temperature moderation, habitat improvement, and aesthetic enhancement. Bioengineering techniques can be used to develop sustainable systems for slope or streambank protection. The combination of correct assessments of stream corridors along with bioengineering practices has proven to be cost effective and environmentally sensitive. Installations can be labor intensive, but less costly than conventional engineering solutions. Installing enough J-hooks or stream barbs could cost $17.2 million with $1,720,000.00 in technical assistance. J-hooks can range in cost from $3,000 per structure to $5,000 depending on the size.

Diversion - A diversion is an earthen channel constructed across a slope to collect water and prevent damage to an area below. Diversions act much like a terrace, but their purpose is to direct or divert runoff water from an area. A diversion is often built at the base of a slope to divert runoff away from bottomlands. These structures may also be used to divert runoff from a feedlot or to collect and direct water to a pond. On cropland, properly located diversions can reduce soil erosion by 30% to 60%. Used in conjunction with a waste management system, they are very effective at preventing unpolluted runoff from entering a feedlot.

Grade Control Structure - These structures involve pipe outlets or drop spillways and are used to allow water to drop to a lower elevation while protecting the soil from gully erosion or scouring. While they are expensive to design and construct, grade control structures can be a very necessary component of an overall management plan. They are often used at the outlet of a grassed waterway to stabilize the waterway outlet. Sediment originating from unstable areas can be reduced from 75% to 90% with grade control structures, but they are only effective for very localized erosion control.

Rock Inlets - Surface, or open tile, inlets are believed to be a direct pathway for sediment and nutrients to reach surface water. Although they are a useful component of cropland drainage systems, they do not allow for adequate filtration of runoff. A counter practice to surface inlets is that of rock inlets. There are several configurations of this practice, but most commonly, it requires a fabric-covered perforated tile placed in a trench and connected to the existing tile line. The trench is filled with varying sizes of rock to one foot above ground level. This system eliminates the above-ground tile inlet. Normally this trench is approximately twelve feet long by three feet wide and three feet deep. Runoff from the surrounding landscape is filtered through the trench rather than drained through a pipe as before. Preliminary research indicates that approximately one-half of the sediment delivered through surface inlets is delivered through rock inlets. Because rock inlets do not substantially interfere with use of farm machinery, they are well received within the farming community. Crops can be planted over the inlets, but care should be taken around them when doing tillage. Maintenance needs are limited to removing and replacing the top twelve inches of rock after drainage efficiencies have decreased.

Vegetative Practices

Vegetative practices minimize bacteria and sediment runoff from agricultural lands through increased infiltration and decreased pollutant transport and are able to take up excess nutrients that may be in the runoff received. Research shows that these practices can reduce sediment ranging from 50% to 90%. Although not a grass based practice, conservation tillage will provide benefits that will ultimately reduce turbidity. Currently the US Fish and Wildlife offers financial assistance for wetland restorations with approximately 50% cost share. Practices that prevent soil erosion such as waterways and buffers may qualify for the NRCS's Environmental Quality Insurance Program (EQIP) and could receive up to 50% in cost share dollars. The EQIP program also provides incentives for residue management and conservation tillage. Vegetative conservation practices would include:

Wetland Restoration - Wetland restoration or development can be achieved through use of small structures such as dikes to retain water or regulate water levels in an existing wetland. Restoration can also be achieved by filling a surface drain or removing a subsurface drain. County or judicial ditches can also be modified to temporarily impound water. This practice is consistent with M.S. 103E, and can be accomplished in a way that does not impede drainage functions. Wetlands are natural swamps, bogs, sloughs, potholes or marshes that have saturated soils and water loving plants. Wetlands are important as they provide wildlife habitat and serve as natural filter for agricultural and urban runoff. Wetlands are efficient sediment traps, preventing soil particles and attached pollutants from reaching lakes and streams. They also provide some removal of dissolved nutrients from runoff during the growing season. Wetlands provide habitat for waterfowl and other wildlife species and serve an important storage function in the watershed to help reduce peak streamflow. Wetland restoration could range in cost from $10,000 for a simple, small acreage site to $30,000 for a larger more complicated site.

Filter Strips, Grass Buffers, and Riparian Buffer Strips - Buffers consist of trees and other vegetation located in areas adjacent to and up gradient from streams and ditches. Filter strips are strips of grass and trees and/or shrubs that slow water flow and intercept surface runoff and remove nutrients, sediment, organic matter, pesticides and other pollutants prior to entry to surface waters. Filter strips are often constructed along ditches, thus moving row crop operations farther from the stream. Riparian buffers also serve an important bank stabilization function, particularly when used in combination with in-stream restoration practices. Sediment delivery reductions up to 80% have been reported on 4% slopes where buffers have been installed. The USDA's Conservation Reserve Program offers incentives based on soil types to place sensitive acres along streams and waterways in permanent grass for 10 years and has a seeding and establishment component.

Grassed Waterway - A grassed waterway is where a natural drainage way is graded and shaped to form a smooth, bowl shaped channel. This area is seeded to sod-forming grasses. Runoff water that flows in the drainage way flows across the more stable grass rather than tearing away soil and forming a larger gully. The grass cover protects the drainage way from gully erosion and can act as a filter to absorb some of the chemicals and nutrients in the runoff water. Grassed waterways are estimated to reduce sediment losses from the flow area by 60% to 80%. Like most BMPs, the watershed above a waterway should be treated to control erosion before construction to prevent the waterway from prematurely filling in with sediment. One drawback to waterway construction is the vegetation may be difficult to establish in a waterway, so erosion control barriers or mulching may be needed during vegetative establishment. Also, care needs to be taken when tilling near waterways so that the natural flow is allowed to use the waterway and not by diverted around the area which can cause additional gullies. Grass waterways can range in cost from $5.50 per foot to $9.50 per foot depending on the width.

Nutrient Management - Nutrient management involves careful management of all aspects of soil fertility, so that crop needs are met while minimizing losses to surface and groundwater supplies. This requires management of nutrients applied to the soil including commercial fertilizers and manure as well as in-place nutrients. Soil tests to determine existing nutrient levels are essential to nutrient management, and are necessary to determine the appropriate fertilizer requirements for a specific soil. The fertilizer application rate should be calculated by using soil test results and Minnesota Extension Service recommendations. The fertilizer application rate should consider the crop, soil type, previous crops, history of manure application, and method of fertilizer placement. Nutrient management has been shown to have a very beneficial effect on water quality. Through use of proper rates, placement and timing of fertilizer application, loss of nitrogen and phosphorus can be reduced by 50% to 90%. It is easily the most effective way to reduce transport of soluble forms of nutrients to surface and groundwater. Sound nutrient management also reduces input costs, thereby increasing the profitability of crop production.

Residue Management - Residue management is the practice of leaving last year's crop residue on the soil surface by limiting tillage. Tillage practices (conservation tillage) that leave at least 30% of the soil surface covered with crop residue are suitable to achieve adequate residue management. No-till, mulch till, and ridge till are three of the various techniques used to meet the 30% residue coverage rate. Conservation tillage is effective for controlling soil erosion and helps control loss of nutrients that are attached to soil particles. Time, energy and labor savings from fewer tillage trips are related benefits of reduced tillage. These savings can offset the cost of tillage equipment needed to achieve adequate residue management. Residue management also helps maintain or develop good soil health, improve water infiltration and reduce evaporation from the soil surface while providing food and cover for wildlife. The practice of residue management (>30% residue) does create additional challenges for the farmer. Factors such as crop sequence, soil texture and drainage, and climate must be considered. Under heavy residue conditions, well-drained soils are generally better suited to reduced tillage than poorly drained soils. Soil warming and drying can be delayed in the spring if high levels of residue are left on poorly drained soils.

Contour Farming - Contour farming is farming with row patterns around the slopes rather than up and down the slopes. Ridges built by tilling and planting on the contour create hundreds of small dams that slow water flow and increase infiltration which reduces erosion by as much as 50%. No special equipment is necessary for this practice, but design can be enhanced by engineering supervision.

Urban Practices - In towns and cities, as in rural areas, what we do on the land is reflected in our water. When rain falls or snow melts, the runoff washes pollutants off streets, parking lots, lawns and construction sites. The water becomes polluted when it picks up grass clippings, leaves, pesticides, excess nutrients, motor oil and pet waste. Efficient drainage systems carry the polluted runoff to ditches, tributaries and rivers without any treatment. Although there is much less urban than rural area in the project area, urban areas have more impervious surfaces that allow for faster and easier runoff. Pollutants found in urban runoff are similar to rural runoff and include sediment, nutrients, oxygen-demanding materials, and bacteria. The following is a list of best management practices that will help reduce polluted runoff in urban areas.

- Used oil from cars and motors should be carefully removed and put into a leak-proof container. Every county has a hazardous waste removal day that the used oil can be disposed at to eliminate improper dumping.
- Runoff from roofs that eliminate water quickly also wash pollutants into storm drains. When the water is directed onto a lawn, it irrigates the lawn and provides an opportunity for slowing the water down by soaking into the grass where a natural filtering process takes place. Rain gardens and retention ponds are a way of completely trapping rainwater and allowing evaporation to take the water away slowly. Also, trapping rain water in cisterns or rain barrels for later use in gardens and lawns will reduce yard runoff.
- Water in the form of runoff picks up contaminants from paved areas and carries them directly to a river or tributary. By keeping paved areas free of litter and chemicals, it is possible to eliminate some of the pollutant loading from runoff.
- Fluids from automobiles pollute water when they leak from the car and enter the river or tributary from a water source. It is possible to eliminate this by checking for leaks and keeping a schedule of tune-ups to insure a proper running car. Recycle auto fluids such as oil, antifreeze, and transmission fluid.

- Leave grass clippings on the lawn. Soil testing before applying fertilizer will provide the best use of chemicals, minimizing the amount that could runoff into the river or water source. Grass clippings left on the lawn are equal to one fertilizer application per year. When leaves or grass clippings are left on paved surfaces, they get washed into storm drains and are delivered directly to a water source. As they decay, nutrients are released, which provide food for unwanted growth in rivers, streams and lakes.
- Pet waste carries disease-causing bacteria. It should be thrown in the trash, flushed down the toilet or buried.
- Properly dispose of car oil, antifreeze, thinners, solvents, paints, pesticides, and don't purchase more than what is necessary for the job. Do not wash brushes under running water in the sink. Use hazardous waste pick-ups to eliminate storing and possible leakage.
- Wash cars on the lawn or at a car wash to reduce the amount of runoff directly to a storm drain, wash the car on the lawn so waste water has an opportunity to slowly filter through soil and vegetation. Dirty water from a commercial car wash goes to a wastewater treatment plant where pollutants are removed.
- Erosion control is important for public building as well as private building. Without erosion control measures, every acre under construction delivers about a dump truck and a half of soil into a nearby water source.

POINT SOURCE MANAGEMENT MEASURES, ALTERNATIVES, AND ANALYSIS

This section provides implementation strategies targeted towards reduction of nutrients, *E. coli* bacteria, and turbidity. There are many implementation strategies that would work for nutrient, *E. coli* bacteria, and turbidity impairments. As nutrients, *E. coli* bacteria, and turbidity have several sources and pathways in common, many of the suggestions have the common goal of addressing all pollutants. This list is not an all inclusive list as there are hundreds of management methods.

Subsurface Sewage Treatment Systems (Septic Systems)

Septic systems are recognized as an acceptable means for treating wastewater. The system consists of a septic tank and drain field. The septic tank provides a place for large solids to settle and to be decomposed by microorganisms. The drain field removes fine solids and destroys accompanying bacteria. Effluent from a septic tank contains solids, phosphorus, nitrogen, chloride, bacteria, viruses, and organic chemicals. For this reason, it is illegal to discharge a septic tank directly to a tile line or other surface water. Pollutants from a properly sited, installed, and maintained septic system will be adequately treated within two to three feet below the drain field. Soil characteristics are important considerations in the design and installation of septic systems. A poorly functioning septic system is a threat to the water quality of nearby streams, lakes, and groundwater. Routine maintenance is critical to prevent septic system failure. The tank should be inspected at least once every year, and, with ordinary use and care, the tank should be pumped every one to three years. Subsurface Sewage Treatment Systems, or SSTS, treat sewage from individual dwellings. Research has shown that replacing a non-conforming system with proper drain fields would be 100% effective by providing nearly complete treatment of *E. coli* bacteria. Acceptable designs are described in Minn. R. ch. 7080. All counties in the state of Minnesota are responsible for enforcing these rules. Failing and non-compliant septic systems are a low contributor of *E. coli* bacteria load to area rivers during wet conditions, but are a moderate contributor of the load during the periods between storms. The major deterrent would be cost and financing of the system. SSTS systems can range in cost from $6,000.00 for a simple design to $14,000.00 for a mound design. Financing of these systems can be difficult, especially for low-income households.

Municipal Sewage Control

The impaired stream reaches in this diagnostic study and implementation receive wastewater treatment facility discharge from three communities. Morgan is a continuous discharge facility. The communities of Evan and the Lower Sioux Indian Community of Minnesota utilize treatment ponds that can discharge from April 1 to June 15 and September 15 to December 15. These communities monitor their discharges and are regulated directly by Minnesota Pollution Control Agency. They are held to the allowable discharge limits for multiple pollutants under Minnesota State Rules. New Ulm and Redwood Falls, two communities located partially in the watershed, discharge effluent outside the study boundary.

MS4 Communities – Stormwater

Cities with populations greater than 5,000 are required to have Municipal Separate Storm Sewer System (MS4) stormwater permits. The city of Redwood Falls, which is partially in the Crow Creek watershed, is larger than the 5,000 population threshold and is required to have a MS4 permit. In the unlikely event that any other town or area becomes large enough to need an MS4 permit, an implementation plan revision may be needed. Urban storm water discharges that carry *E. coli* bacteria and turbidity causing sediments and nutrients as a result of pet waste can be addressed through better site design (or low impact development) and the use of Best Management Practices in urban areas.

National Pollutant Discharge Elimination System (NPDES) Livestock Facilities

Livestock facilities that have been issued NPDES permits are allowed zero discharge and are permitted by Minnesota Pollution Control Agency. As of the writing of the implementation plan, the project area had 12 livestock facilities that have been issued NPDES permits. Land application of manure from these sites is regulated by the requirements of their permit. Discharge of *E. coli* bacteria from fields where manure has been land applied may occur at times. Such discharges are covered under Manure Management and Planning area of the non-point source section of this plan.

BMP Selection and Justification

Principal nonpoint source pollutants identified in the project area are total suspended solids, *E. coli* bacteria, and nitrate nitrogen. Land use practices and the highly developed hydrologic system in the watershed affect concentrations and delivery rates of these pollutants. Best management practices (BMPs) can play an important role in reducing the sediment and nutrient load in the selected sub-sheds, particularly when they are concentrated within priority management areas and are chosen for their ability to address the main problems within these areas. Although BMPs can help improve water quality in the project area, there are limitations affecting their adoption and use. For example, some practices are expensive, requiring investments in equipment and materials, or loss of income producing cropland. Certain other practices require considerable technical assistance such as design or engineering assistance before they can be constructed. Some BMPs require a fundamental change in management style for landowners that may be difficult to undertake. And, finally, a common limitation with several BMPs is landowner acceptability related to cultural or social norms. Among landowners within geographic areas, some types of practices are more accepted than others. So, even though BMPs are a desirable means for attaining water quality improvements, how readily and extensively they are adopted is influenced by such factors as cost, ease of adoption, and social acceptability. In recognition of the difficulties related to use of BMPs, public incentives have arisen to help reduce or offset costs that may be incurred by landowners. Cost-share, incentive payments, loans, and easement payments are methods used to transfer a major portion of the cost related to a BMP from the landowner to the general public. This is done mainly because most of the water quality benefits associated with the use of BMPs occur off-site or downstream, not at the site of their use. Public benefits in the form of cleaner water imply that the public ought to pay landowners to use practices that may have little direct benefit to the landowner. Sometimes incentive payments, cost-share or other economic inducements are sufficient to achieve land use changes. Other times, these methods need to be supplemented with additional measures. Success of the Conservation Reserve Program (CRP), the Reinvest in Minnesota Program (RIM), and programs that cost-share seventy-five percent on certain structural BMPs suggests that economic incentives can be a necessary and very useful tool. For instance, it is doubtful that very many landowners would voluntarily relinquish cropland to protect water quality and improve wildlife habitat. Generous payment rates, however, have made this transition a popular choice. Similarly, erosion that does not affect productivity but does degrade downstream water quality is much more likely to receive landowner attention if someone else pays most of the cost. Without cost-share, it would be easy to delay taking corrective action on a problem lacking direct consequences. There are many instances, however, where economic incentives alone are ineffectual. In these cases, other measures are required if people are to be persuaded to use BMPs. As an example, regulatory controls can be used to increase participation. This approach is being used with some success in other watersheds to encourage landowners to upgrade septic systems and feedlots. It is an especially effective method when combined with economic incentives such as cost-share or low interest loans. Regulatory controls combined with economic incentives do not always result in compliance, however. Within the watershed, there are many septic systems and feedlots that remain out of compliance for reasons not easily defined or understood. Additional inspection and enforcement action may be needed, along with more attractive financial incentives, to effectively deal with septic and feedlot problems. Education is another proven method for increasing BMP adoption rates. Research demonstrates that many landowners lack knowledge about land use effects on water quality, and about various practices that can be used to reduce pollution. Again, when combined with economic incentives, accurate information presented in an unbiased manner will influence people to make wise land use decisions. Selection of appropriate BMPs to enhance water quality must therefore be based on recognition of factors limiting their use and factors that overcome or negate these limits. Technical solutions such as BMPs are only effective if people are willing to use and maintain them. Because this willingness is conditioned by many factors, some of which are poorly defined or unknown, selecting appropriate practices is a difficult task. Following is a list, by priority management area, of BMPs selected to achieve water quality objectives. Selection is based both on the inherent ability of these practices to alleviate primary pollutant sources and acceptability of these practices to the local community.

Priority Management Areas

Priority management areas represent the individual watersheds or portions of the watershed determined to contribute a significant share of the pollutant load, in their own right, to the Minnesota River. Directing attention toward these areas will result in the greatest benefit at the least cost. Selection of these priority areas is based upon watershed assessments and inventories completed during the course of the diagnostic study. It is not practical to expect that best management practices (BMPs) will be applied equally throughout these minor watersheds, even though the entire area is viewed as being a contributor of nonpoint source pollution. To get maximum results, it may be necessary to treat only the most critical portions of the priority management area. This will require additional research in the form of water quality and watershed assessments. The diagnostic study began the process of refining the scope of areas in need of BMPs and the implementation phase will continue the process through several different approaches. First, additional water quality data will be collected through continuation of a monitoring program. Second, there are ongoing multi-agency efforts to update pollutant source inventories within these counties. Characteristics between the watersheds in this diagnostic study come in the frequency in events or watersheds. And, finally, evaluations of the sediment and phosphorus reduction potential of BMPs for specific land areas will be completed prior to the approval and installation of the practices. This procedure has been proven to work in area watershed projects such as the Cottonwood River Restoration project and the Redwood River Clean Water project, and will be immediately instituted for all BMPs that are started in the implementation phase of this project. In this way, water quality effectiveness of BMPs will be enhanced.

Nonpoint source pollution in all sub-watersheds of this study area appears to be related to nitrate and phosphorus loss from agricultural land devoted to row crops. Livestock and discharges from septic systems are also likely contributors of *E. coli* bacteria and nutrient pollution found, to some degree, in all streams of the study. Discerning priority areas depend on the extent of which pollutant concentrations exceed regional goals or state standards. Wabasha Creek and Crow Creek share many characteristics including point sources from communities, being thoroughly drained by ditch systems and tile, and almost exclusively agricultural land use. Both creeks are relatively flat watersheds with a low percentage of erodible soils throughout the upland and transitional portions of the watersheds. Phosphorus concentrations during the 2009-10 sampling seasons were marginally within the regional norms and suspended solids averaged below ecoregional averages, occasionally exceeding turbidity standards through quick response to drainage following storm events. *E. coli* bacteria sample values were consistently elevated in both of the watersheds in the summer months and the streams fail to meet standards for bacteria making them unsuitable for swimming, which is one of their designated uses as a water of the state. Sampling in these watersheds also shows that nitrate-nitrite concentrations were frequently above 10 mg/L in 2010 but rarely in 2009, reflecting the large hydrologic differences between the two years (very wet in 2010; very dry in 2009). Several isolated bank erosion sites have been documented on the reaches, and are scheduled for repair as funds become available. These sites, and others, are undoubtedly contributing to the rivers' high sediment load. A more thorough investigation of bank erosion characteristics, assessments of overland runoff, and determinations of bacteria sources are needed to fully evaluate this reach, however.

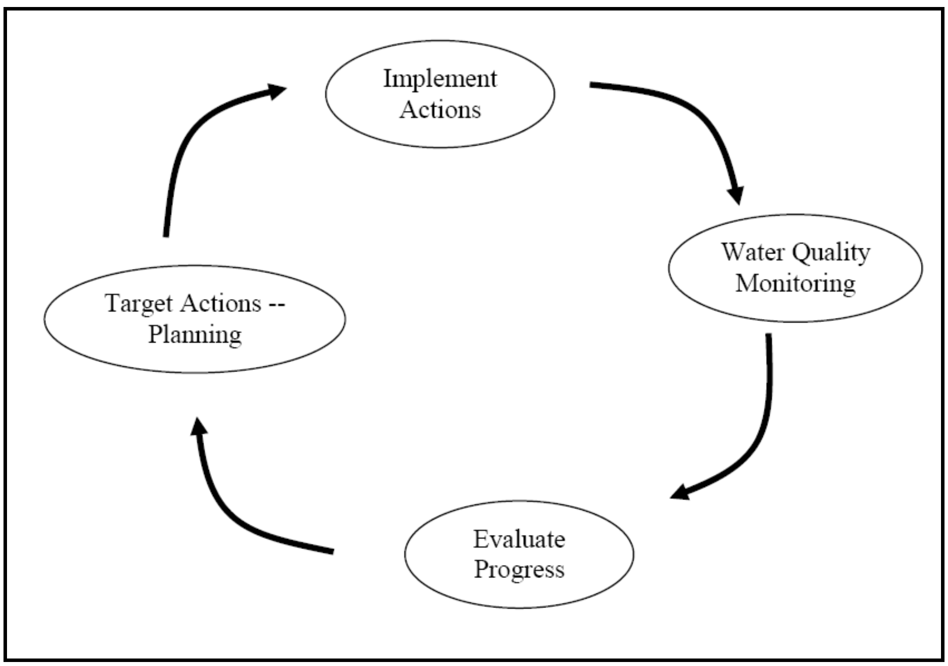
Both Spring Creek and John's Creek (CD #10) have portions designated as trout streams. Both streams represent a very important recreational opportunity, but their value as a fishery resource could be substantially compromised as a result of excessive nutrients levels. Both reaches violate the *E. coli* bacteria standards, making them unsuitable for swimming, another one of their designated uses. Fertilization practices, manure management, and the manner in which nitrates are transported by the drainage system are the variables most in need of attention in these subwatersheds. Additional research is needed to examine the frequency of buffer strips and tile intakes, presence and condition of septic systems, and the fertilization and tillage practices occurring in these watersheds.

Although we do not know specific non-point contributions from each sub-watershed, the small watersheds of Wabasha Creek and Crow Creek are likely to be listed for multiple impairments. These areas may need special attention to meet overall goals on the watershed. These sentiments are echoed in the Brown and Redwood county water plans.

Current and future water monitoring, along with advances in evaluation modeling, may assist with fine-tuning priority areas in the future to ensure targeted BMP implementation. RCRCA's goal is to help make these changes happen through education, training, and monetary incentives.

Adaptive Management Process – Implementation, Monitoring, and Evaluation

The implementation actions outlined in this management plan will decrease the turbidity, nutrient, and *E. coli* bacteria loading to the steams of the study area. However, at this stage it is not known exactly how many practices will be installed, and what those practices will consist of. Since the cumulative effect on water quality therefore is also unknown, a continual process must happen that evaluates in-stream water quality and then tailors the implementation actions to the findings. As practices are being implemented in the watershed, in-stream water quality will be monitored to evaluate the impact that the implementation actions have on turbidity, nutrient, and *E. coli* bacteria concentrations in the same reaches. If water quality is improving, this suggests that the current approach is working and the same course will be followed. If water quality is not improving, this suggests that the approach being taken is not sufficient, or is targeted to the wrong sources. In this case, the approach will be evaluated and adjusted so that tangible in-stream water quality improvements can be realized. This process is referred to as adaptive management.



To be successful, this plan must be adaptable to data from current and future research. Practices or programs that are proven successful in reducing *E. coli* bacteria and or turbidity in other watersheds will need to be incorporated into this plan. There may be programs that are not even in the planning stages that may be offered and will need to be analyzed and possibly incorporated. The best analysis of effects, public perception and ultimately the success of each current or future objective would come with participation of our technical and advisory committees. As funding is secured and objectives are accomplished, a meeting of this workgroup would assist in analyzing the successes and future steps of the program.

Evaluation

Evaluation is considered to be a major component of the implementation plan. Its purpose is to help us understand how effective our programs and actions are at achieving project goals. In order to do this, it is necessary to use several evaluation methods or tools that are designed to measure different variables from different perspectives. To evaluate the project, sampling data will be collected to measure changes in water quality, statistics will be kept on land use changes, attitudes of watershed residents will be assessed, and specific implementation programs will be periodically reviewed and assessed. This comprehensive approach will provide a variety of assessments about project effectiveness in terms of water quality impacts, land use changes, citizen attitudes, and program delivery. Information gathered will be used as a guide for future program adjustments.

Water Quality Monitoring

When funding becomes available and it is feasible within the organization, RCRCA shall implement a monitoring plan. The monitoring program is designed to be a continuation of water quality data collection procedures initiated during the diagnostic study phase of the 1st order streams of the Middle Minnesota River in Redwood and Brown Counties Project. Information gathered through the program will improve loading estimate accuracy, and will also help to assess water quality trends within the watershed. Adjustments will be made to the monitoring network used in 2009. First, sampling at the CD#13 and North Eden Creek site will most likely be reduced to minimal monitoring for TMDL assessment or discontinued altogether. Another adjustment would be the addition of sampling sites in Wabasha Creek and Crow Creek to differentiate major drainage system loadings for further prioritization of funds to be used in implementation. Sampling stations MMCC (Crow Creek), MMWC (Wabasha Creek), MMSC (Spring Creek), and COD10 (John's Creek) will be retained. Bi-monthly base flow samples will be collected at each station between April and September. At least two storm events equal to a five-year frequency will be sampled at each location. The water analysis will be a continuation of the monitoring performed during the diagnostic study. Laboratory testing parameters utilized for the monitoring plan will include total suspended solids (TSS), total suspended volatile solids (TSVS), total phosphorous (TP), soluble phosphorous (P-PO4), turbidity, and nitrate nitrogen (N-NO2+NO3). *E. coli* bacteria grab samples will be collected five times per month between April and September as part of a total maximum daily load (TMDL) process if needed. Field testing parameters utilized for the monitoring plan will include dissolved oxygen, specific conductance, water temperature, pH, and water level measurements.

Program Evaluation

Several evaluation methods, in addition to the monitoring program discussed above, are necessary to measure project success. Methods used in the implementation plan have been selected to evaluate different components and outcomes of the plan in different ways. A best management practice (BMP) tracking system will be used to measure BMP adoption rates within priority management areas. Information contained in this system will include records of initial contacts with landowners or operators; the status of each BMP from initial sign-up to construction; and the potential sediment and nutrient reduction obtained as a result of the BMP. This information will be entered into the watershed GIS system maintained by RCRCA. Tillage transect surveys will be conducted by Soil and Water Conservation District (SWCD) staff. This information will provide one indicator of residue management trends within the watershed.

Program evaluation tools will be developed to evaluate other key activities within each program element of the implementation plan. For example, an evaluation of watershed assessment teams will be undertaken to determine how effective they are at meeting their intended purpose. Events and tours will be evaluated shortly after their completion, and evaluations will be made of investments in each media area. Program evaluations will be ongoing and will help guide decisions throughout the course of the Project.

Roles and Responsibilities of Project Partners

Considerable expertise and resources are available in the watershed to carry out major portions of the implementation plan. Participating local, state, and federal agencies administer nearly all of the programs necessary to accomplish project goals and objectives. This includes programs and funding to design and install best management practices (BMPs), collect and analyze water quality data, perform research on BMP alternatives, and inform watershed residents of project activities. Admittedly, some program and work plan activities are better funded than others, and some functions are more easily accomplished than others given financial, social, and political constraints. It is very clear, however, that program availability is not the limiting factor in water quality protection. Focusing programs on critical watershed problems and encouraging people to participate will lead to a successful watershed project. A central theme of successful watershed-based nonpoint source projects is a unified approach to achieve mutually agreed upon goals. The challenge is to bring together the whole range of programs and agencies and focus them on the intended outcome. The way this can be achieved is for all participants to clearly understand their own and each other's obligation to the project, and to be held accountable for carrying out this obligation. Roles and responsibilities of organizations, agencies, and groups involved in the Middle Minnesota project are briefly summarized below.

REDWOOD-COTTONWOOD RIVERS CONTROL AREA (RCRCA)

Responsibilities include: overall work plan administration and fiscal management, supervision of project staff and coordination /completion of all individual work plan phases and steps. Staff that will be assisting with this implementation plan include: The Executive Director, a Watershed Technician/GIS/Outreach Technician, an Engineering Technician, and an Administrative Officer. Activities of the group will commit to the implementation plan for the purpose of protecting and improving water quality and quantity in the project area. These activities would range from reducing pollutant loadings, improving water quality, restoring wildlife species, increasing public awareness, monitor the effects of efforts on the streams of the study area through sampling, and will provide technical and engineering services for many of the objectives listed in the implementation plan including; feedlots, stream bank stabilization, and other structural practices. All legal requirements of the executed Grant and Loan Agreements are the responsibility of the project sponsor.

SOIL & WATER CONSERVATION DISTRICTS (SWCD) and COUNTY ENVIRONMENTAL SERVICES (CES): Each County SWCD and CES of Brown and Redwood Counties will support and commit its departments to activities assigned to them by the project's implementation plan for the purpose of protecting and improving water quality and quantity in the first order streams of the Minnesota River Watershed. These activities would range from reducing pollutant loadings, improving water quality, restoring wildlife species, and increasing public awareness as well as a matching fund source for grant funds. Each county SWCD and CES will be responsible for technical assistance in the design and installation of BMPs, for developing and carrying out a tracking system to help evaluate the effectiveness of BMPs, for conducting an annual tillage survey, sustaining work on CREP, CRP and RIM, watershed assessments and inventories, and distributing project-related information.

FARM SERVICE AGENCY (FSA)
The principal responsibility of FSA is working with the implementation team to secure BMP cost-share funds. Processing BMP applications for CRP, EQIP or CREP is another important responsibility of FSA.

BOARD OF WATER AND SOIL RESOURCES (BWSR): The BWSR will provide technical resources in restoration of wetlands, buffer programs, feedlot design, and match funds as well as outcome reporting. BWSR will also serve an integral part of the project responsible for working with SWCD staff to ensure efficient completion of costshare agreements. Staff will also participate on an inter-agency advisory team.

AREA II MINNESOTA RIVER BASIN PROJECT, INC. (AREA II) Area II will support and commit to activities in the project's implementation plan for the purpose of protecting and improving water quality and quantity in the Minnesota River Watershed and its tributaries. Activities will include stabilization and water retention structure engineering and planning according to planning.

NATURAL RESOURCES CONSERVATION SERVICE (NRCS): The NRCS offices in Brown and Redwood Counties support the project Implementation Plan as a means to improve and protect water quality and quantity in the 1st order streams associated with this project. They will also provide input as well as offer and administer USDA programs that address the tasks outlined in the Implementation Plan. The NRCS will provide final BMP technical review through services of a staff engineer. They will also assist with annual planning activities by participating on an inter-agency advisory committee.

DEPARTMENT OF NATURAL RESOURCES (DNR): The DNR supports the Implementation Plan. DNR will participate in activities that promote environmental educational efforts and application of those practices within the work plan, as well as assist in monitoring the effects upon the streams of this study on fish and endangered species. DNR staff will be part of an inter-agency advisory committee team, and will assist in project evaluation activities. The DNR also has permitting authority over in-stream restoration work and will be involved in assessments and acquisition of property devoted to trails and accesses. They may also provide limited equipment needed to perform streambank restoration work.

SOUTHWEST REASEARCH and OUTREACH CENTER (SW-ROC)/UNIVERSITY OF MINNESOTA EXTENSION: The University of Minnesota Southwest Research and Outreach Center and County Extension Offices provide research and information on best management practices, assist in education through publications and workshops, and serve as an information resource.

MINNESOTA POLLUTION CONTROL AGENCY: The MPCA will be a valuable resource during the implementation phase. They offer grant and loan programs for restoration, provide oversight and regulatory roles in feedlots, SSTS, stormwater and WWTP actions, monitor water quality, and provide expertise in monitoring. The MPCA also serves as a member on the Technical Committee.

MINNESOTA DEPARTMENT of AGRICULTURE (MDA): The MDA will continue their role in licensing Commercial Waste Applicators by providing training, recertification and oversight in the licensure of the custom manure applicators. The MDA will also continue promoting and providing education on best management practices for preventing sedimentation, erosion, and manure application.

COUNTIES (Brown, Redwood): The counties of the Middle Minnesota River 1st Order Streams of Redwood & Brown Counties Restoration Project support the implementation plan through their representation on the Project technical advisory team and RCRCA board. The board members oversee the participation and oversight of the Implementation Plan funds and support of the RCRCA organization through appropriations and matching funds. Counties will provide local project matching funds. County water plan implementation groups will assist with outreach activities. County staff will assist in processing applications for low interest loans and take responsibility for design and inspection of septic systems.

BMP Operation and Maintenance Plan

Nearly all best management practices (BMPs) recommended in the implementation plan are subject to ten-year operation and maintenance requirements. This is a contractual agreement between the funding source (state or federal) and the landowner. Failure to comply with contracts results in repayment of a portion of the funds obtained to install the practice. Other resource implementation practices including trails and canoe accesses will be subject to operation and maintenance plans as determined by the state of Minnesota and the county within which they are located. It is expected that all trails and accesses will be the property of the county or the state of Minnesota.

Information and Outreach Program

Education provides awareness and knowledge, which are both key agents of change. A clear program directed to involve stakeholders encourages ownership, change and ultimately sustainability of the programs. For change to take place, research has shown a minimum of nine contacts. Contacts could be a variety of elements such as personal visits, newsletters, radio programs or presentations to existing groups.

The Outreach Program will serve as a unifying component to achieve the identified objectives for the Middle Minnesota River 1st Order Streams of Redwood & Brown Counties Restoration Project. This program element will identify communication, technical and educational needs of watershed residents, community groups and professional groups. After identification, services, materials and products will be provided that directly correlate with the three goals of the Middle Minnesota River 1st Order Streams of Redwood & Brown Counties Restoration Project. Recognizing that boundaries are points of contact and not definitions of limits, RCRCA will work with existing Soil and Water Conservation Districts, Natural Resources Conservation Service, Minnesota Pollution Control Agency, Board of Water and Soil Resources, Minnesota Extension Service, Southwest Research and Outreach Center, and Minnesota Department of Natural Resources to develop an informational network for enhancing land use changes that work to improve water quality.

Media

Background and current information will be distributed through a mix of media sources including but not exclusive to radio, newsletters and news releases. Working with partners and specified experts, we will provide information to watershed residents and special interest groups that will encourage directed awareness to the issues surrounding water quality issues. Moveable and reusable items such as displays will be developed to be interactive, and to provide a wide audience with the information they need to become familiar with the watershed project.

Materials

As the needs and interests of watershed residents become identified, materials for distribution and training will be developed and used. The development and use of materials will be a cooperative effort between RCRCA, partners and professionals in the field. Specific materials will be developed as needed for program elements. One useful tool will be to develop maps of the watershed and the river. Maps can be used to encourage recreation as well as interaction with the river and will be developed for defined activities and projects. After projects have been implemented, maps will allow residents to self-tour the improvements and the recreation possibilities. Studies have determined that showing people examples and allowing them to become involved with the example is necessary to change attitudes and heighten awareness.

Publications

Timely specialty publications describing key issues within specific areas of the project objectives using our own research to provide watershed residents with facts about local water quality conditions will be produced. Publications will be produced at least four times during the year as part of an already established regimen and written for a defined audience about a specific topic. Topics may include issues identified within the program elements, or, of interest and concern to watershed residents. Audience for publications may include landowners, absent landowners, agri-business professionals, production agriculture, town residents or interest groups. They may show accomplishments as well as problems. Due to the timely nature of this type of publication, production dates and distribution will be dependent on issues, audience and calendar. Publications will provide local examples of water quality practices along with visibility, project identity and generate awareness of water quality problems and solutions.

Legal Authorities and Permits Required for Completion of Project

Redwood-Cottonwood Rivers Control Area (RCRCA), the project sponsor, is a joint powers organization established pursuant to Minnesota Statutes 471.59. Counties belonging to RCRCA, including Brown and Redwood, represent the area of study and vested in these counties are all necessary authorities related to taxation and ordinance adoption and enforcement. Permits from the Department of Natural Resources (DNR) and, in some cases, the U.S. Army Corps of Engineers (COE), will be required to remove channel obstructions and to undertake certain streambank stabilization procedures. Redwood-Cottonwood Rivers Control Area (RCRCA) or the appropriate county will apply for these permits as needed. Permits from the Minnesota Pollution Control Agency (MPCA) will be required prior to construction of agricultural waste management systems. These permits, however, are the responsibility of the feedlot owner. Trails and canoe accesses may be subject to permit requirements of the local jurisdiction and the state of Minnesota. These will be obtained by the appropriate local unit of government.

	Responsible Agency			
Permit	County	DNR	MPCA	COE
Floodplain/Shoreland	X	X		
Protected Waters		X		
Section 404				X
Septic Systems	X			
Waste Management Systems	X		X	
Section 401			X	

Identification and Summary of Implementation Objectives and Action Items

Objective 1) Non-point Source Management

Task A: Feedlot Management/Runoff Control Practices

Sub-task 1: Manure Management Workshops - Educate producers on the importance of planning manure application by hosting workshops five different times over ten years.

- Timeframe: Every other year 1st, 3rd, 5th, 7th, and 9th year
- Groups responsible: County SWCD, Environmental Offices, NRCS, and University of MN Extension Offices
- Total Costs: **$2,750.00**
    - Cash: **$1,000.00** (20 attendees/workshop x $10.00 x 5 workshops)
    - In-kind: **$1,750.00** (10 hrs/workshop x $35.00/hr x 5 workshops)

Sub-task 2: Pasture/Manure Management Field Days – Conduct tours of installed practices, showcasing effective pasture management, manure application, and livestock exclusion strategies.

- Timeframe: Every other year 2nd, 4th, 6th, 8th, and 10th year
- Groups responsible: County SWCD, Environmental Offices, NRCS, and University of MN Extension Offices
- Total Costs: **$4,500.00**
    - Cash: **$1,000.00** (20 attendees/workshop x $10.00 x 5 workshops)
    - In-kind: **$3,500.00** (20 hrs/workshop x $35.00/hr x 5 workshops)

Sub-task 3: Feedlot Runoff Control Practices – Provide Cost-share to fix feedlot runoff issues for sites not requiring feedlot permits (less than 1,000 Animal Units)

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County SWCD, Environmental Offices, NRCS, and University of MN Extension Offices
- Total Costs: **$110,000.00**
    - Cash: **$50,000.00** (5 fixes x $10,000.00)
    - In-kind: **$10,000.00** ($2,000.00/site x 5 sites, tech time)
    - In-kind: **$50,000.00** (Landowner cost for 5 fixes x $10,000.00)

Sub-task 4: Level III Land Application Inspections - Conduct Level III land application inspections along with the feedlot inspections that each county is required to complete every year.

- Timeframe: 2012-2021
- Groups responsible: County SWCDs, Environmental Offices, and NRCS Offices
- Total Costs: **$9,490.00**
    - Cash: **$0.00**
    - In-kind: **$9,490.00** (1.5 hrs/site x $35.00/hr x 180 feedlots)

Sub-task 5: Comprehensive Nutrient Management Plan Incentives – Provide incentives to landowners to employ a Comprehensive Nutrient Management Plan for owners with feedlots of less than 1000 animal units

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: RCRCA, County SWCD and NRCS Offices
- Total Costs: **$62,100.00**
    - Cash: **$60,000.00** (60 plans x $1,000.00 incentives)
    - In-kind: **$2,100.00** (1 hr/plan x $35.00/hr x 60 plans)

Task A Cost: Cash Funds - $112,000.00 In-Kind Funds - $76,840.00

Task B: Structural BMP Installation

Sub-task 1: Install Structural Best Management Practices (BMP) – Promote cost share availability and identify erosion sensitive projects in priority areas and implementation of structural projects to keep sediment, bacteria, and associated nutrients from surface waters. Provide up to 75% cost-share for structural BMPs

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County SWCD, NRCS, AREA II, and RCRCA Offices
- Total Costs: **$716,667.00**
    - Cash: **$500,000.00**
        - 2,050 ft. Streambank and Shoreline Stabilization; Barbs and J-hooks x $80.00/ft. = **$164,000.00**
        - 10 Water and Sediment Control Basins x $4,000.00/structure = **$40,000.00**
        - 1,000 ft. Clean Water Diversions x $6.00/ft = **$6,000.00**
        - 2,000 ft. Terraces x $7.50/ft = **$15,000.00**
        - 10 Grade Stabilization Structures x $20,000.00/Structure = **$200,000.00**
        - 100 Open Tile Intake Replacements x $450.00/Structure = **$45,000.00**
        - 20 In-Tile Drainage Control Structures x $1,500.00/Structure = **$30,000.00**
    - Cash: **$50,000.00** (10% Technician Cost)
    - In-kind: **$166,667.00** (25% Landowner Contribution)

Task B Cost: Cash Funds - $550,000.00 In-Kind Funds - $166,667.00

Task C: Vegetative BMP Installation

Sub-task 1: Install Vegetative Best Management Practices (BMP) – Promote cost share availability and identify erosion sensitive projects in priority areas and implementation of vegetative management projects to keep sediment, bacteria, and associated nutrients from surface waters. Provide up to 75% cost-share for vegetative BMPs and cash incentives for grass filter strips, buffers, riparian buffers, conservation tillage, residue management, and spring nitrogen application.

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County SWCD, NRCS, and RCRCA Offices

- Total Costs: **$451,117.00**
  - Cash: **$280,000.00**
    - 10,000 ft. Grassed Waterways x $6.00/ft. = **$60,000.00**
    - 100 acres Pasture Management Plans x $100.00/ac incentive = **$10,000.00**
    - 10 Wetland Restorations x $10,000.00 = **$100,000.00**
    - 2,000 acres Conservation Tillage/High Residue Management x $10.00/ac incentive = **$20,000.00**
    - 20 Urban Storm Water Control Projects (Rain Gardens, Rain barrels, etc.) x $1,000.00/Project = **$20,000.00**
    - 600 acres Vegetative Buffers x $50.00/ac incentive = **$30,000.00**
    - 2,000 acres Spring Nutrient Application x $20.00/ac = **$40,000.00**
  - Cash: **$28,000.00** (Technician est. 10% BMP Cost)
  - In-kind: **$16,450.00** (Technician est. 0.1 hr/ac x $35.00/hr x 4,700 acres)
  - In-kind: **$126,667.00** (Landowner Contribution)

Task C Cost: Grant Funds - $308,000.00 In-Kind Funds - $143,117.00

Objective 1 Cost: Cash: $970,000.00 In-Kind: $386,623.00 Total: $1,356,623.00

Objective 2) Point Source Management

Task A: Subsurface Sewage Treatment System (SSTS) Upgrades (Low Income Residences)

Sub-task 1: SSTS Financial Assistance for Low-Income Homeowners - It is estimated that 10 percent of the households within the project area are below the poverty level and would not be able to afford replacing their SSTS. This would equate to 50 systems. This action would finance the total cost of the system.

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County Environmental/Planning and Zoning Offices and RCRCA
- Total Costs: **$407,000.00**
  - Cash: **$400,000.00** (50 systems x $8,000.00/system)
  - In-kind: **$7,000.00** (4 hours/SSTS for design and inspection x 50 SSTS x $35.00/hour)

Task A Cost: Cash Funds - $400,000.00 In-Kind Funds - $7,000.00

Task B: Subsurface Sewage Treatment System (SSTS) Upgrades

Sub-task 1: SSTS Low Interest Loan Programs for Homeowners – Provide loan funds for septic system upgrades in Brown and Redwood Counties for areas of the Middle Minnesota River Watershed in this study.

- Timeframe: 2012-2021 (when funding may become available)

- Groups responsible: 2 County Environmental/Planning and Zoning Offices, SWCDs, and RCRCA
- Total Costs: **$3,663,000.00**
    - Cash: **$0.00**
    - In-kind: **$63,000.00** (4 hours/SSTS for design and inspection x 450 SSTS x $35.00/hour)
    - Loan Funds: **$3,600,000.00** (450 systems x $8,000.00/system)

Task B Cost: Cash Funds - $0.00 In-Kind Funds - $63,000.00 Loan Funds - $3,600,000.00

Objective 2 Cost: Cash: $400,000 In-Kind: $70,000 Loan: $3,600,000 Total: $4,070,000

Objective 3) Education and Outreach

Task A: Multi-media Materials

Sub-task 1: Web Hosting – Development of Middle Minnesota Project Component of RCRCA Web-site and update on-line links to RCRCA's web-page to include efforts in other counties, SWCD offices, and the MPCA

- Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: RCRCA
- Total Costs: **$3,700.00**
    - In-kind: **$2,500.00** (10 hours/yr x $25.00/hr x 10 years for updates)
    - In-kind: **$1,200.00** ($120/yr x 10 years web hosting)

Sub-task 2: Newsletters and Newspaper Articles - The RCRCA would publish a newsletter annually and include information to update the watershed residents about the project Implementation process in newspaper articles.

- Timeframe: Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County SWCD, RCRCA
- Total Costs: **$15,000.00**
    - Cash: **$5,000.00** (20 hrs/yr x $25.00/hr x 10 years; Staff time)
    - In-Kind: **$5,000.00** (20 hrs/yr x $25.00/hr x 10 years; Staff time)
    - In-Kind: **$5,000.00** ($500/yr x 10 years; Printing and postage)

Sub-task 3: Events and Promotion – RCRCA and SWCD will host public outings and education days for education and general public awareness. Part of the overall theme for the environmental field days will be the promotion of implementation techniques outlined in this implementation plan.

- Timeframe: Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: County SWCD, RCRCA, and NRCS
- Total Costs: **$30,000.00**
    - Cash: **$10,000.00** (1,000.00/yr x 10 years; Promotional materials)
    - Cash: **$10,000.00** (40 hrs/yr x $25.00/hr x 10 years)

- In-kind: **$10,000.00** (40 hrs/yr x $25.00/hr x 10 years)

Task A Cost: Cash Funds - $25,000.00 In-Kind Funds - $23,700.00

Objective 3 Cost: Cash: $25,000.00 In-Kind: $23,700.00 Total: $48,700.00

Objective 4) Monitoring/Evaluation

Task A: Long-Term Water Quality Monitoring

Sub-task 1: Sample Costs - Conduct monitoring to determine improvements in water quality. Monthly sampling from April-September for *E. coli* bacteria, total suspended solids, total suspended volatile solids, turbidity, total phosphorus, total nitrate-nitrite nitrogen, and soluble phosphorus as well as field tests of dissolved oxygen, pH, temperature, water height and visual observations at key points in the streams of this study. Lab analysis is estimated at $100.00 per sample; 20 samples/site.

- Timeframe: Timeframe: 2012-2021 (when funding may become available)
- Groups responsible: RCRCA
- Total Costs: **$140,000.00**
    - Cash: **$120,000.00** ($100.00/sample x 20 samples/yr/site x 6 sites x 10 yr)
    - Cash: **$14,000.00** (2 hr/day x $35.00/hr x 20 day/yr x 10 yr)
    - Cash: **$6,000.00** ($0.50/mile x 60 miles/sample day x 20 day/yr x 10 yr)

Task A Cost: Cash Funds - $140,000.00 In-Kind Funds - $0.00

Task B: Effectiveness Monitoring

Sub-task 1: Sample Costs - Conduct monitoring to determine improvements in water quality at 6 locations on prior to their entry to the Minnesota River. Five samples would be taken monthly from April-October for *E. coli* bacteria, turbidity, total suspended solids, total suspended volatile solids as well as field tests of dissolved oxygen, pH, temperature, water height and visual observations at these key points on the first order streams of this study. Sampling will commence at the year 5 and 10 mark of the implementation plan. Lab analysis is estimated at $45.00 per sample; 35 samples/site.

- Timeframe: 5th and 10th year (when funding may become available)
- Groups responsible: RCRCA
- Total Costs: **$25,900.00**
    - Cash: **$18,900.00** ($45.00/sample x 35 samples/yr/site x 6 sites x 2 yr)
    - Cash: **$4,900.00** (2 hr/day x $35.00/hr x 35 day/yr x 2 yr)
    - Cash: **$2,100.00** ($0.50/mile x 60 miles/sample day x 35 day/yr x 2 yr)

Task B Cost: Cash Funds - $25,900.00 In-Kind Funds - $0.00

Task C: **MPCA Intensive Watershed Monitoring**

Sub-task 1: Sample Costs - MPCA collects fish, invertebrate, water quality and habitat samples once every ten years. This monitoring is conducted throughout the watershed over a two-year period. RCRCA will assist with sampling as needed.

- Timeframe: 2020
- Groups responsible: RCRCA, Environmental Offices, MPCA
- Total Costs: **$1,400.00**
    - Cash: **$0.00**
    - In-Kind: **$1,400.00** (40 hr x $35.00/hr)

Task C Cost: Cash Funds - $0.00 In-Kind Funds - $1,400.00

Task D: Volunteer Monitoring

Sub-task 1: Sample Costs - Utilize volunteers to take transparency readings along the Minnesota River tributaries of Redwood and Brown counties of this study.

- Timeframe: 2012-2021
- Groups responsible: RCRCA, MPCA
- Total Costs: **$7,500.00**
    - Cash: **$300.00** (Supplies and promotional items)
    - In-Kind: **$7,200.00** (4 hr/mo/vol. x 2 volunteers x 60 months x $15.00/hr)

Task D Cost: Cash Funds - $300.00 In-Kind Funds - $7,200.00

Objective 4 Cost: Cash: $166,200.00 In-Kind: $8,600.00 Total: $174,800.00

Objective 5) Administration

Task A: Administration

Sub-task 1: Staffing - RCRCA has assumed the lead in development of this implementation plan. RCRCA will continue to develop grant applications, facilitate, and coordinate the Middle Minnesota River 1st Order Streams of Redwood & Brown Counties Restoration Implementation projects including work plan development, contacts, and reporting. Redwood and Brown County SWCD will fund the time needed by applying for administrative funding when possible with 50 percent grant funded activities.

- Timeframe: 2012-2021
- Groups responsible: RCRCA, County SWCDs
- Total Costs: **$300,000.00**
    - Cash: **$200,000.00** ($20,000.00/yr x 10 years)
    - In-Kind: **$100,000.00** ($10,000.00/yr x 10 years; appropriation)

Sub-task 2: Office and Equipment – Office Space, supplies, and support staff. Current equipment (vehicle, survey, monitoring, GPS, office) will be used for implementation.

- Timeframe: 2012-2021
- Groups responsible: RCRCA, MPCA
- Total Costs: **$156,000.00**
  - Cash: **$100,000.00** ($10,000.00/yr x 10 yr; Support Staff and Supplies)
  - Cash: **$56,000.00** (350 sq. ft x $16/sq. ft x 10 yr)

Task A Cost: Cash Funds - $356,000.00 In-Kind Funds - $100,000.00

Objective 5 Cost: Cash: $356,000.00 In-Kind: $100,000.00 Total: $456,000.00

TOTAL BUDGET:

Cash: $1,917,200.00 In-Kind: $588,923.00 Loan: $3,600,000.00 Total: $6,106,123.00

Milestone Schedule

Years 2012-2021										
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Objective 1 - Nonpoint Source Management										
Task A - Feedlot Management/Runoff Control Practices	X	X	X	X	X	X	X	X	X	X
Sub-task 1 - Manure Management Workshops	X		X		X		X		X	
Sub-task 2 - Pasture/Manure Management Field Days		X		X		X		X		X
Sub-task 3 - Feedlot Runoff Control Practices	X	X	X	X	X	X	X	X	X	X
Sub-task 4 - Level III Land Application Inspections	X	X	X	X	X	X	X	X	X	X
Sub-task 5 - Comprehensive Nutrient Management Plan Incentives	X	X	X	X	X	X	X	X	X	X
Task B - Structural BMP Installation	X	X	X	X	X	X	X	X	X	X
Task C - Vegetative BMP Installation	X	X	X	X	X	X	X	X	X	X
Objective 2 - Point Source Management										
Task A - SSTS Upgrades (Low Income Systems)	X	X	X	X	X	X	X	X	X	X
Task B - SSTS Upgrades	X	X	X	X	X	X	X	X	X	X
Objective 3 - Nonpoint Source Management										
Task A - Multi-Media Materials	X	X	X	X	X	X	X	X	X	X
Objective 4 - Nonpoint Source Management										
Task A - Long-Term Quality Monitoring	X	X	X	X	X	X	X	X	X	X
Task B - Effectiveness Monitoring					X					X
Task C - MPCA Intensive Watershed Monitoring									X	
Task D - Volunteer Monitoring	X	X	X	X	X	X	X	X	X	X
Objective 5 - Nonpoint Source Management										
Task A - Administration	X	X	X	X	X	X	X	X	X	X
Task B - Office and Equipment	X	X	X	X	X	X	X	X	X	X

Budget

PROJECT TITLE: Middle Minnesota River, Redwood & Brown Counties, Implementation Plan Budget

Objectives	unit cost	unit	quantity	cost	In-Kind Funds	Grant/Cash Funds	Loan Funds	Total Budgeted
Objective 1) Nonpoint Source Management								
Task A: Feedlot Management/Runoff Control Practices								
- Manure Management Workshops	$200.00	per	5	$1,000.00		$1,000.00		**$1,000.00**
- Pasture Management Field Days	$200.00	per	5	$1,000.00		$1,000.00		**$1,000.00**
- Feedlot Runoff Control Practices	$20,000.00	per	5	$100,000.00	$50,000.00	$50,000.00		**$100,000.00**
- Level III Land Application Inspections	(tech time)	per	180	$0.00		$0.00		**$0.00**
- Comprehensive Nutrient Management Plan Incentives	$1,000.00	per	60	$60,000.00		$60,000.00		**$60,000.00**
- Tech Time	$35.00	hour	766.857	$26,840.00	$26,840.00			**$26,840.00**
Task B: Structural BMP Installation								
- Streambank and Shoreline Stabilization with Stream Barbs/J-hooks	$106.67	foot	2050	$218,666.67	$54,666.67	$164,000.00		**$218,666.67**
- Water and Sediment Control Basin	$5,333.33	per	10	$53,333.33	$13,333.33	$40,000.00		**$53,333.33**
- Clean Water Diversion	$7.33	foot	1000	$8,000.00	$2,000.00	$6,000.00		**$8,000.00**
- Terraces	$10.00	foot	2000	$20,000.00	$5,000.00	$15,000.00		**$20,000.00**
- Grade Stabilization Structures	$26,666.67	per	10	$266,666.67	$66,666.67	$200,000.00		**$266,666.67**
- Open Tile Intake Replacements	$600.00	per	100	$60,000.00	$15,000.00	$45,000.00		**$60,000.00**
- In-Tile Water Level Control Structures	$2,000.00	per	20	$40,000.00	$10,000.00	$30,000.00		**$40,000.00**
- Tech Time (10% of costs)				$50,000.00		$50,000.00		**$50,000.00**
Task C: Vegetative BMP Installation								
- Grassed Waterways	$8.00	ft	10000	$80,000.00	$20,000.00	$60,000.00		**$80,000.00**
- Pasture Management	$100.00	acre	100	$10,000.00		$10,000.00		**$10,000.00**
- Wetland Restoration	$20,000.00	per	10	$200,000.00	$100,000.00	$100,000.00		**$200,000.00**
- Conservation Tillage/Residue Management	$10.00	acre	2000	$20,000.00		$20,000.00		**$20,000.00**
- Urban Storm Water Controls (Rain gardens, Rain barrels, etc.)	$1,333.33	per	20	$26,666.67	$6,666.67	$20,000.00		**$26,666.67**
- Vegetative Buffers	$50.00	acre	600	$30,000.00		$30,000.00		**$30,000.00**
- Spring Nutrient Application	$20.00	acre	2000	$40,000.00		$40,000.00		**$40,000.00**
- Tech Time				$44,450.00	$16,450.00	$28,000.00		**$44,450.00**
Total Objective 1				$1,356,623.33	$386,623.33	$970,000.00	$0.00	**$1,356,623.33**

Objective 2) –Point Source Management								
Task A: SSTS Upgrades (Low Income Systems)								
- SSTS Grants for Low-Income Homeowners	$8,000.00	per	50	$400,000.00		$400,000.00		**$400,000.00**
- Tech Time	$35.00	hour	200	$7,000.00	$7,000.00			**$7,000.00**
Task B: SSTS Upgrades								
- SSTS Low-Interest Loan Plan	$8,000.00	per	450	$3,600,000.00			$3,600,000.00	**$3,600,000.00**
- Tech Time	$35.00	hour	1800	$63,000.00	$63,000.00			**$63,000.00**
Total Objective 2				$4,070,000.00	$70,000.00	$400,000.00	$3,600,000.00	$4,070,000.00
Objective 3) –Education and Outreach								
Task A: Multi-media Materials								
- Web Hosting	$120.00	yr	10	$1,200.00	$1,200.00			**$1,200.00**
- Newsletters and Newspaper Articles	$500.00	yr	10	$5,000.00	$5,000.00			**$5,000.00**
- Events and Promotion	$1,000.00	yr	10	$10,000.00		$10,000.00		**$10,000.00**
- Staff Time	$25.00	hour	130	$32,500.00	$17,500.00	$15,000.00		**$32,500.00**
Total Objective 3				$48,700.00	$23,700.00	$25,000.00	$0.00	**$48,700.00**
Objective 4) –Monitoring/Evaluation								
Task A: Long-Term Water Quality Monitoring								
- Lab Costs	$100.00	per sample	1200	$120,000.00		$120,000.00		**$120,000.00**
- Mileage	$0.50	per mile	12000	$6,000.00		$6,000.00		**$6,000.00**
- Staff Time	$35.00	hour	400	$14,000.00		$14,000.00		**$14,000.00**
Task B: Effectiveness Monitoring								
- Lab Costs	$45.00	per sample	420	$18,900.00		$18,900.00		**$18,900.00**
- Mileage	$0.50	per mile	4200	$2,100.00		$2,100.00		**$2,100.00**
- Staff Time	$35.00	hour	140	$4,900.00		$4,900.00		**$4,900.00**
Task C: MPCA Intensive Watershed Monitoring								
- Staff Time	$35.00	hour	40	$1,400.00	$1,400.00			**$1,400.00**
Task D: Volunteer Monitoring								
- Promotional Items and Supplies	$10.00	month	30	$300.00		$300.00		**$300.00**
- Volunteer Time	$15.00	hour	480	$7,200.00	$7,200.00			**$7,200.00**
Total Objective 4				$174,800.00	$8,600.00	$166,200.00	$0.00	**$174,800.00**

Objective 5) –Administration								
Salary	$20,000.00	yr	10	$200,000.00		$200,000.00		**$200,000.00**
Support Staff	$10,000.00	yr	10	$100,000.00		$100,000.00		**$100,000.00**
Office Supplies	$3,400.00	yr	34000	$34,000.00	$34,000.00			**$34,000.00**
Office Space	$160.00	sq/ft/10 yrs	550	$88,000.00	$32,000.00	$56,000.00		**$88,000.00**
Travel/vehicle expenses (mileage)	$3,400.00	yr	34000	$34,000.00	$34,000.00			**$34,000.00**
Total Objective 5				$456,000.00	$100,000.00	$356,000.00	$0.00	**$456,000.00**
ITEMIZED PROGRAM ELEMENT BUDGET								
	Total Element 1			**$1,356,623.33**	**$386,623.33**	**$970,000.00**	**$0.00**	**$1,356,623.33**
	Total Element 2			**$4,070,000.00**	**$70,000.00**	**$400,000.00**	**$3,600,000.00**	**$4,070,000.00**
	Total Element 3			**$48,700.00**	**$23,700.00**	**$25,000.00**	**$0.00**	**$48,700.00**
	Total Element 4			**$174,800.00**	**$8,600.00**	**$166,200.00**	**$0.00**	**$174,800.00**
	Total Element 5			**$456,000.00**	**$100,000.00**	**$356,000.00**	**$0.00**	**$456,000.00**
Project Grand Total					**$588,923.33**	**$1,917,200.00**	**$3,600,000.00**	**$6,106,123.33**

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APPENDIX A:
EXCERPT FROM THE MIDDLE MINNESOTA RIVER IN REDWOOD AND BROWN COUNTIES CWP DIAGNOSTIC PROJECT - QAPP

A6. PROJECT DESCRIPTION

A6.1 The Middle Minnesota River CWP Phase I Diagnostic Project Summary

- Work Plan Development

The work plan including monitoring and modeling plans will be developed by RCRCA staff with the assistance and advice from representatives of local, regional, state, and federal agencies involved in water and land resource programs.

- Water Quality Monitoring

Water samples will be collected approximately 25 times from April (or ice out) to October during the 2009 and 2010 sampling seasons. Samples will be analyzed by MVTL Laboratories, Inc., (MVTL) New Ulm for the parameters listed in A6.4. *E. coli* samples will be collected at a rate of five/month over two years between April and October at each of the six sites in the project area. RCRCA staff will be in charge of the collection of the samples in the sampling regime.

Base flow sampling will be conducted at least once monthly (twice monthly in non–storm event periods) from April to October to determine parameter levels during baseline conditions. In addition, sampling will be conducted for a minimum of two storm events to assess parameter levels during peak flow conditions to determine the impact of surface runoff in contributing to contaminant levels. A list of parameters and their respective maximum holding times to be analyzed by Redwood–Cottonwood Rivers Control Area (RCRCA) sampling are listed in Table 6.

- Data Analysis

All data generated will be exhibited in table form. Parameters will be measured as indicated in Table 3. The decisions to be made from the data include whether the reaches need to be listed for any parameters to be analyzed, and what actions are to be undertaken to remedy the impairments of the reaches.

Water quality data collected during 2009 and 2010 will be analyzed by RCRCA and reviewed by MPCA staff. The analysis will include the development of sediment and nutrient loading curves in the streams that ultimately contribute to the Minnesota River. FLUX, a program that uses statistical analysis methods to determine loadings given the input of flow and sample concentrations, will be used for the loading estimates on these streams.

Spatial relationships will be obtained using ArcMap and ArcGIS analysis. Most layers used for this analysis including surface hydrology, land use, non–point pollution source potential, soils, feedlots, and field gradients are readily available. Some data may need to be sought after for this particular project. Analysis of this land use information will be used to model the potential priority areas.

- Watershed Prioritization and Implementation Plan Development

Watershed assessment through GIS land use layers, tillage surveys, stream bank surveys, feedlots, drainage patterns exist for the project area. Maps can be created and analyzed to facilitate the selection of priority management areas within the area outlined in watershed maps in Work Plan Appendix A.

RCRCA working with county officials will take an active role using existing county water plans to establish priority management areas within the study area. These management areas will be selected on the basis of modeling and land use assessment results. The Best Management Practices to be utilized for each priority management area will be determined during this phase of the project.

- Information and Awareness Efforts

This program element will focus on informing the public and media about the diagnostic study being performed in the project area. Through this information, citizens will gain an awareness of water quality issues in the watersheds and will develop a sense of knowledge and usefulness of the project's outcome. Methods used will be a series of newsletters, brochures, meetings, web based media, and feature stories. This program element will form the foundation for outreach activities used in the implementation portion of the project.

- Administration

Project administration includes all duties associated with reporting requirements, fiscal management, communications, and overall coordination of the project.

A6.2 The Middle Minnesota River CWP Phase I Diagnostic Project Goal

The project area has six reaches, listed in Table 4, below. The purpose of this project is to identify and address possible source(s) of impairments, so these reaches may or may not be listed on the impaired waters 303(d) list so the waters can be protected or rectified.

Table 4. The Middle Minnesota River CWP Diagnostic – Project Phase I Reaches

Reach	AUID	Impairment
Crow Creek; Headwaters to Minnesota River	07020007-569	Unknown
Wabasha Creek; Headwaters to Minnesota River	07020007-527	Unknown
North Eden Creek; Headwaters to Minnesota River	07020007-999	Unknown
Spring Creek; below trout stream portion to Minnesota	07020007-573	Unknown

River		
Brown County Ditch #13; Headwaters to Minnesota River	07020007-999	Unknown
Brown County Ditch #10 (John's Creek)	07020007-571	Unknown

A6.3 The Middle Minnesota River CWP Phase I Diagnostic Project Milestone Schedule

Following are project milestone tasks for 2009 – 2010. For task details refer to the project Work Plan.

Table 5. The Middle Minnesota River CWP Diagnostic Project – Phase I Milestone Schedule

	April	May	June	July	August	September	October	November	December
Site Selection	●								
Staff Training	●								
Monitoring	●	●	●	●	●	●	●		
Process Data		●	●	●	●	●	●	●	●
Report									●

A6.4 Samples for Laboratory Analysis

Water quality samples will be submitted to MVTL Laboratories, Inc., New Ulm, and analyzed for the following analytes:

- *E. coli* Bacteria
- Total Phosphorus
- Ortho–phosphorus
- Ammonia Nitrogen
- Total Kjeldahl Nitrogen
- Nitrate + Nitrite Nitrogen
- Total Suspended Solids
- Total Suspended Volatile Solids
- Turbidity

A6.5 Samples for Field Analysis

The following parameters will be measured in the field through use of a multi–probe, meter, or other device:

- Dissolved Oxygen
- pH
- Temperature
- Transparency Tube

A7. QUALITY OBJECTIVES AND CRITERIA

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.

Table 6. Laboratory Analysis and Field Measurement Objectives

Analyte	Precision (% RPD)	Expected Range	Reporting Limits	Units	Holding Times
E. coli Bacteria	30%	1 – 50,000	1	MPN/100 mL	24 H*
Total Phosphorus	30%	0.04 – 0.8	0.005	mg/L	28 D
Ortho – phosphorus	30%	0.04 – 0.6	0.005	mg/L	2D
Ammonia Nitrogen	30%	0.16 – 20	0.16	mg/L	28 D
Total Kjeldahl Nitrogen	30%	0.1 – 3	0.2	mg/L	28 D
Nitrate + Nitrite	10%	0.5 – 20	0.2	mg/L	28 D
Total Suspended Solids	30%	5 – 70	2.0	mg/L	7 D
Total Suspended Volatile Solids	30%	5 – 50	2.0	mg/L	7 D
Turbidity	30%	5 – 60	0.1	NTU	2 D
Dissolved Oxygen†	——	3 – 15	0.1	mg/L	——
pH†	[0.3 Units]	6 – 9	——	Standard Units	——
Temperature†	[0.3°C]	0 – 25	——	°C	——
Transparency Tube†	——	0 – 100	1	cm	——

*8 hours if used for enforcement purposes.

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 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.

Since the sampling method for all sampling will be grab sampling, no field blanks (sampler blanks) will be taken. 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.

Representativeness – This expresses the degree to which data accurately and precisely represent parameter variations at a sampling point, or of a process or environmental condition. Representativeness of field data is 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.

Table 7. Water Quality Sample Requirements and Analytical Methods

Analyte	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
E. coli Bacteria	100 mL	Sterile Plastic	Cool to 4°C	24 H*	SM** 9223 B (Colilert)
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.1
Ortho – phosphorus	500 mL	Plastic	Cool to 4°C	2 D	EPA 365.1
Ammonia Nitrogen	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 350.1 Rev 2.0
Total Kjeldahl Nitrogen	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	SM 4500–N_{org} B / NH_3 E
Nitrate + Nitrite	250 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 353.2
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I–3765–85
Total Suspended Volatile Solids	500 mL	Plastic	Cool to 4°C	7 D	EPA 160.4
Turbidity	250 mL	Plastic	Cool to 4°C	2 D	EPA 180.1 B

*8 hrs if used for enforcement purposes; ***Standard Methods for the Examination of Water and Wastewater*.

A8. SPECIAL TRAINING/CERTIFICATION

Training of The Middle Minnesota River CWP Phase I Diagnostic Project staff, if needed, is done through assistance from knowledgeable project staff and the MPCA Project Manager. Shawn Wohnoutka is responsible for field sampling training and monitoring oversight.

Shawn Wohnoutka is responsible for ensuring key project staff have or receive adequate training to effectively and correctly perform their project duties. Key staff include the Project Administrator, Watershed Technician, Project Manager, 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 RCRCA Office. Project data are entered into STORET by MPCA staff.
Field sampling sheets are completed on–site at the time of sampling.

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

GROUP B. DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN

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

Water chemistry, biological, and physical data are collected and used to monitor project effectiveness. Samples taken during the project are considered a snapshot of current water quality conditions. Long–term monitoring programs should be established to accurately measure water quality conditions.

B2. SAMPLING METHODS

All field work for this project, including water sample collection and delivery within the required time frame to MVTL, are conducted by project staff. A certified laboratory conducts all water sample chemical and microbiological analyses. This QAPP supports the laboratory's QAM and SOPs and is specific for The Middle Minnesota River CWP Phase I Diagnostic Project.

Water chemistry and microbiology field duplicates are collected 10% of the time for the stream samples. 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, if taken, are collected in sterile polypropylene bottles. The analyzing laboratory provides the sample containers and preservatives.

Cleaning methods for the Dissolved Oxygen Meter may be found in Appendix A. Meters will be thoroughly cleaned following each use and inspected monthly for unusual wear.

None of the samples taken for this project will be investigative samples in the sense that investigative samples are typically taken in response to a spill, illegal dumping, or other event that would cause an adverse condition to occur in one or more of the reaches such as a fish kill, algae bloom, or the observance of unusual odors or colors in the waters of the reaches.

Stream Sampling

On–site physical measurements are conducted by use of a multi–probe, meter, or other device. Samples taken for laboratory analysis are collected by project staff and analyzed by MVTL.

Standard Operating Procedures (SOPs) for grab sampling while wading, reach pole sampling, and bucket and rope sampling may be found in Appendix B.

B3. SAMPLE HANDLING AND CUSTODY

Shawn Wohnoutka 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 typically delivered to MVTL within 24 hours of collection. Coolers containing samples that require ice preservation are checked periodically to ensure samples remained adequately iced so sample temperatures do not exceed 6°C.

Field conditions information such as weather, written procedures deviations, equipment operating conditions, and other relevant supplemental information are also recorded for each sampling event.

Laboratory Sample Handling

Sample containers are provided by the laboratory. Container cleanliness is verified by QA/QC procedures as specified in the laboratory's QAM and SOPs. The laboratory verifies 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, if reused. 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 $\leq 6°C$ 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 their temperature taken. The information is recorded on the sample identification sheet. The sample identification sheet information is then compared to the sample bottles information 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 are 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 times have expired or until 30 days after completion of the analysis. Samples are typically disposed of by the laboratory in an environmentally acceptable manner, however, samples are returned to the client, if requested. Samples that contain hazardous waste may at the laboratory's discretion 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 serve as an initial record of any field measurements and weather conditions at the time of sampling.

Field Notes

Field notes are used to document important information during sampling events. They are entered into a bound notebook. 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 which is filled out in its entirety. Sample containers without labels or labels that are missing information are not, as per laboratory policy, accepted by the laboratory. The sample label includes the water body code or name, the site number, the date, and time of sample collection.

Sample Transport or Shipment

All samples are packed in an ice–filled cooler for transport or shipment to the laboratory. Samples are typically transported or shipped to arrive at the laboratory in time to ensure they are analyzed within their respective maximum holding times.

Chain of Custody

A Chain of Custody (COC) form accompanies the samples when they are delivered to the laboratory by project staff. At time of delivery the COC is signed by the project staff person as samples relenquisher and by the laboratory staff person as samples receiver. The COC may be integrated into the sample field sheet. When not in the physical possession of the samplers, sample handlers, or laboratory staff, the samples are kept in a secure place with restricted accessibility.

When shipping samples by common carrier a copy of the field sheet, signed COC form, and bill of lading accompany the samples to the laboratory. The field sheet and COC form are placed in the cooler with the samples in a water–tight zip–lock type bag. A copy of the bill of lading accompanies the sample package to the laboratory and a copy is retained by the project staff person shipping the samples. The bill of lading becomes part of the project record. Upon delivery of the sample package to the laboratory the COC is signed by a laboratory staff person. A COC copy bearing both signatures is returned to the project leader and becomes part of the project record. This copy may be in paper form or scanned and sent electronically.

B4. ANALYTICAL METHODS

Analytical protocols are found in the MVTL QA/QC Manual and SOPs. Analytical accuracy is routinely checked by the laboratory's analysis of standard certified reference analytes.

TABLE 8. MVTL Laboratories, Inc. Analytical Methods

Analyte	Method
E. coli Bacteria	SM* 9223 B (Colilert)
Total Phosphorus	EPA 365.1
Ortho – phosphorus	EPA 365.1
Ammonia Nitrogen	EPA 350.1 Rev 2.0
Total Kjeldahl Nitrogen	SM 4500–N_{org} B / NH_3 E
Nitrate + Nitrite	EPA 353.2
Total Suspended Solids	USGS I–3765–85
Total Suspended Volatile Solids	EPA 160.4
Turbidity	EPA 180.1 B

**Standard Methods for the Examination of Water and Wastewater.*

All raw data generated in the laboratory are recorded in bound notebooks, on project specific raw data sheets, MVTL 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, if part of the data package, 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 is 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 batch. All stock standard solutions will be properly labeled, stored, and expiration dates recorded on the label. Certified reference standards obtained from an approved Proficiency Test (PT) Provider such as Environmental Resource Associates (ERA) or Wibby Environmental may also be used. The certified standards measurement data must fall within an acceptable range as specified by the PT Provider or a problem investigation followed by corrective actions must be taken by the laboratory.

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

Typically, one field QC grab sample duplicate for laboratory analysis is collected at the sampling site for every ten like samples taken. The field duplicate for laboratory analysis is collected to determine field sampling and laboratory analytical precision.

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.

MVTL implements specific QA/QC methods and procedures for dealing with out–of–control situations. These are documented in MVTL's QAM and SOPs.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

All hand–held instruments, when used, are inspected and tested as directed by the manufacturer in the operator manual 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. All calibration solutions are replaced with fresh solutions before the solution expiration date. Batteries for all meters are routinely checked and replaced when meters show 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 in the field notebook.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The Dissolved Oxygen Meter is calibrated before each sampling event immediately before going into the field. Thermometer accuracy is confirmed at the beginning of each sampling season. Thermometers if used during this project should be accurate to within ±0.3°C of a reference thermometer of known accuracy. All field instruments are calibrated according to the instrument manufacturer's specifications before being taken into the field. Instrument calibration is checked periodically throughout the sampling day and recalibrated, if necessary. All instrument calibration checks and procedures are documented in the instrument maintenance log or in the field notebook.

If Dissolved Oxygen field measurement values are unusually high or low according to the field analyst's experience and judgment and compared to historical data, the field analyst will recalibrate the meter on– site and retest.

B8. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables include field instrument spare parts and calibration solutions, gloves, spare sample bottles of various sizes, extra sample preservation chemicals, deionized water, Petri dishes, filter paper, batteries, cell phone, sun glasses with polarized lenses, sun screen, camera and film, and paper products. Supplies and consumables are purchased only from reputable and reliable suppliers and inspected for usability upon receipt.

B9. DATA ACQUISITION REQUIREMENTS (NON–DIRECT MEASUREMENTS)

B9.1 Basic Acceptance Criteria for Secondary Data

All secondary data used during this project must be generated through use of an approved QAPP or equivalent documentation and result from use of approved sampling and analytical methods. The analytical methods used to generate such data must have identifiable method and instrument detection and reporting limits and include uncertainty estimates such as precision and bias.
All secondary data used during this project are assessed by the Project Leader, MPCA Project Manager, other knowledgeable project staff, sponsoring organizations, stakeholders, and project consultants to ensure they are relevant to project goals and meet project data quality requirements. They establish acceptance/rejection criteria for all secondary data under consideration for use during this project and define the decisions to be made as a result of the usage of such data.

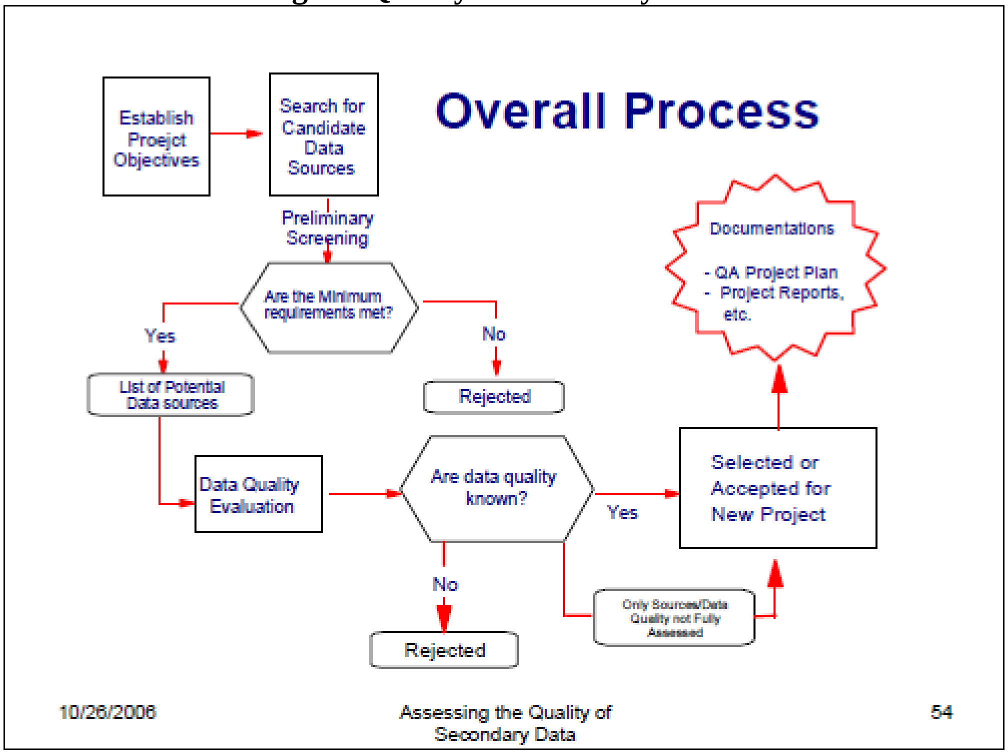
The reason(s) for accepting and/or rejecting secondary data under consideration for use in this project are thoroughly documented. Such documentation becomes part of the project final report.

B9.2 Sources of Secondary Data

Possible *sources* of secondary data that may be used during this project include:

- Publicly available databases
- Published literature, reports, and handbooks
- State and local monitoring programs
- Unpublished research data
- Model–generated data
- Pilot studies

Chart 1. Assessing the Quality of Secondary Data



B9.3 Types of Secondary Data

Possible *types* of secondary data that may be used during this project include:

- Computer databases and spreadsheets
- Laboratory analyses
- Field analyses and measurements
- Biological or ecological samples or analyses
- Peer review information
- Research data, e.g., data generated by universities or private industry
- Maps, plots, photographs, GIS data, or land surveys
- Historical data, e.g., industry, EPA, other government entities
- Data generated through federally funded grants
- Volunteer monitoring data

B10. DATA MANAGEMENT

The field sampling leader 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 Project Manager who also assists with data maintenance, reduction, and transmittal. The MPCA 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. Data may be presented in table, graph, and chart format. Unusual data are rechecked to verify their accuracy. The data are then entered into STORET by MPCA data entry personnel.

All data are collected and analyzed in accordance with this QAPP. The Watershed Technician provides the data and any modeling results to other project staff, project partners, and other interested parties and makes it available to the general public upon request.

GROUP C: ASSESSMENT AND OVERSIGHT

C1. ASSESSMENT AND RESPONSE ACTIONS

Shawn Wohnoutka as Watershed Technician 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 project findings will be prepared for the MPCA and shared with all involved watershed districts, local resource managers, and other involved parties.

The Watershed Technician submits a semi–annual report by December 1st of each project year to the
MPCA Project Manager. Problems that arise during the project are corrected and reported to all parties involved in the project.

Project staff are responsible for the reporting, tracking, and overall management of The Middle Minnesota River CWP Phase I Diagnostic Project.

All data are recorded and tracked through use of a Microsoft Excel database management or similar system. The data compiled during this project are incorporated into spreadsheets or similar formats and submitted 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 are organized electronically and filed in the MPCA STORET database. Statistical analyses on replicate samples are recorded so that the degree of certainty can be estimated.

All data are reviewed by the Watershed Technician and signed by the analyst. Copies of the data transmittal form and all pertinent records of calibration, standardization, and maintenance become part of the project data set and are 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.

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

Data generated through laboratory analysis undergoes data reduction by the laboratory QA Officer prior to the reporting of the final results. If laboratory analytical results of duplicates gives a RPD > 25% the samples are reanalyzed. If reanalysis gives the same result data are qualified as being estimated. If laboratory analytical results of sampler blanks indicate the presence of analyte at > ½ the analyte reporting limit the samples are reanalyzed. If reanalysis gives the same result data are qualified as being estimated.

The Project Leader compares the field notebook and laboratory report data with the draft final report data to ensure accuracy. He also reviews field notebook information to determine if any problems or unusual events occurred that may justify flagging or disqualifying the data. He also calculates the Relative Standard Deviation (RSD) of all the data points for each parameter.

The formal data set is reviewed by the MPCA Project Manager for errors, omissions, qualified data, and flagged data.

Laboratory analytical reports are made available to the Project Leader and MPCA Project Manager in .pdf, .mdb, or .xls electronic format and, if requested by the Project Leader, in hard–copy format. The Project Leader submits the final approved data report to the MPCA Project Manager electronically and in hard–copy .xls spreadsheet format with hard–copy laboratory analytical reports attached.

D2. VERIFICATION AND VALIDATION METHODS

Project staff follows the EPA *Guidance on Environmental Verification and Validation* (EPA QA/G–8) whereby the data are 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 are flagged and the cause of the deficiency evaluated. Any limitations on data use are detailed in the project reports and other documentation.

Project data are compared to historical data, when available, and may also be used as complementary data for other monitoring efforts within the watershed.

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 are 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.

REFERENCES CITED

1. Minnesota Valley Testing Laboratories Inc. Preservation Guide, 2001.
2. Minnesota Department of Health Quality Assurance Manual, 2004.
3. Minnesota Department of Health Environmental Laboratory Handbook, FY 2004.
4. Minnesota Pollution Control Agency Minnesota River BID, 1997
5. RCRCA Redwood River Clean Water Project; Final Report, 1993

Surface Water Sampling – Equipment Cleaning and Decontamination

Materials Needed:

Phosphate–free detergent, tap water, acetone or isopropyl alcohol, 10% HCl, deionized water, personal safety gear, chemical–free paper towels/tissues, gloves, waste storage containers, plastic ground cloth for placing clean equipment, container for cleaning equipment (plastic tub), cleaning brushes with non–contaminating bristles.

Equipment Cleaning and Decontamination Steps:

1. Detergent Wash

    - Wash the equipment initially with phosphate–free detergent and tap water to remove visible dirt and contaminants.

2. Acid/Solvent Rinse for Specific Contaminants

    - Sampling for organics: First rinse with acetone or isopropyl alcohol, then finish with a hexane rinse.
    - Sampling for metals, nutrients, and/or general parameters: Rinse with 10% HCl.
    - Sampling for organics and metals, nutrients, and/or general parameters: Rinse with 10% HCl.

3. Do a final rinse three times with deionized water.

4. Let air–dry until moisture is completely evaporated.

Other Considerations:

1. All field equipment should be thoroughly cleaned and decontaminated at least annually, ideally at the beginning of the sampling season. Also clean after each sampling event at sites with heavy contamination.

2. Collect samples from lowest to highest suspected levels of contamination to minimize the chance of cross contamination.

3. Decontaminate equipment at a separate location from the sampling site.

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:

1. sample bottle dip while wading
2. sample bottle dip through hole cut in ice

Follow bottle rinse and preservation methods as directed by the analyzing laboratory. Repeat–use sampling equipment chambers that contact sample water should be rinsed thoroughly with sample water three times before water is collected to transfer to sample containers.

When grab sampling is suitable, samples should be collected along the sample site cross–section. Sample at a point that represents the water quality of the total instantaneous flow at 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 another site should be chosen that is well mixed across the stream width.

Collect the sample at a middle 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. 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.

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), then **DO NOT WADE!**

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

Transparency Tube Field Sampling Protocol

Transparency

Collect your water sample in a clean bucket or bottle at mid–stream and depth.

1. Wading or From Stream Bank.

Always sample safely – don't wade into fast–moving water or areas of unknown depth. If you cannot sample safely, make visual observations only (Appearance). If a sample from mid–stream and depth is not possible, avoid stagnant water and sample as far from the shoreline as is safe. Try not to stir up the bottom. Face upstream as you fill your bucket. Avoid collecting sediment from the stream bottom or materials from the water surface.

2. From Atop a Bridge or Culvert.

With a rope tied to its handle, lower a bucket down to the stream and collect water. Pull the bucket back up, taking care not to bounce the rope or bucket on the side of the bridge or culvert. Take your tube readings in open conditions. Avoid direct sunlight by turning your back to the sun if necessary. Pour the water from your bucket into the tube until the symbol on the bottom is no longer visible. While looking down into your tube, open the valve at the bottom and slowly release water until you can JUST begin to make out the symbol on the bottom. Note this depth. Release a bit more water until the symbol is visible. Note this depth.

Record the average of the two depths noted in steps 3 and 4 on your data sheet to the nearest centimeter. If the symbol is still visible when your tube is full, indicate this on the data sheet (e.g., > 60 cm).

Stream Stage

Estimate the water level each time you sample. L=low; N=normal; H=high

Appearance

Each day that you sample, record the one number that best describes the appearance of stream water within one meter of your sampling site.

1 = Clear (crystal clear, transparent water)
2 = Milky (not quite crystal clear; cloudy white or gray)
3 = Foamy (natural or from pollution; generally detergents, nutrients or dissolved organic material) Several inches of foam that does not brush apart easily is generally due to pollution of some sort.
4 = Tea–colored (clear but tea–colored due to wetland or bog influences)
5 = Muddy (cloudy brown due to high sediment levels)
6 = Green (may indicate excess nutrients released into the stream)

7 = Green **or** Muddy **plus one or more of the following**:

- extensive floating scum on the stream surface or washed up on shore
- strong foul odor

Recreational Suitability

Use the one number each day that you sample that best describes your opinion of how suitable the stream water is for recreation and enjoyment.

1 = Beautiful, could not be better
2 = Very minor aesthetic problems. Excellent for body–contact recreation, e.g., swimming, wading, frog–catching
3 = Body–contact recreation and aesthetic enjoyment slightly impaired
4 = Recreation potential and level of enjoyment of the stream substantially reduced, e.g., you would not swim but would boat or canoe
5 = Swimming and aesthetic enjoyment of the stream is nearly impossible

Dissolved Oxygen Meter General Instructions

Meter Preparation

- Turn meter on and allow to stabilize for at least 15 minutes before use
- Inspect the probe
- Zero salinity, as needed
- Zero the meter (mechanical and/or electronic)
- Check battery voltage(s) (red line)
- Shake water droplets from membrane, if present
- Place probe in calibration chamber
- Calculate calibration setting using one of the following: 1) temperature and barometric pressure or altitude or 2) titrate using the Winkler kit
- Allow meter to stabilize for at least 15 minutes

Precalibration

- Adjust readout to calibration setting, if necessary
- Record calibration data

Testing Sample

- Place probe in sample
- Continuously stir sample
- Record test result

Postcalibration

- Do after each sample batch or every two hours, whichever comes first
- Place probe in calibration chamber
- Record calibration data

Table 9. Oxygen Solubility Table

Oxygen Solubility Table (elevation)

Dissolved-oxygen concentration (mg/L) in water as a function of temperature and barometric pressure (salinity = 0 ppt).

	Barometric pressure, millimeters of mercury									
Temp. (°C)	735	740	745	750	755	760*	765	770	775	780
0	14.12	14.22	14.31	14.41	14.51	14.60	14.70	14.80	14.89	14.99
1	13.73	13.82	13.92	14.01	14.10	14.20	14.29	14.39	14.48	14.57
2	13.36	13.45	13.54	13.63	13.72	13.81	13.90	14.00	14.09	14.18
3	13.00	13.09	13.18	13.27	13.36	13.45	13.53	13.62	13.71	13.80
4	12.66	12.75	12.83	12.92	13.01	13.09	13.18	13.27	13.35	13.44
5	12.33	12.42	12.50	12.59	12.67	12.76	12.84	12.93	13.01	13.10
6	12.02	12.11	12.19	12.27	12.35	12.44	12.52	12.60	12.68	12.77
7	11.72	11.80	11.89	11.97	12.05	12.13	12.21	12.29	12.37	12.45
8	11.44	11.52	11.60	11.67	11.75	11.83	11.91	11.99	12.07	12.15
9	11.16	11.24	11.32	11.40	11.47	11.55	11.63	11.70	11.78	11.86
10	10.90	10.98	11.05	11.13	11.20	11.28	11.35	11.43	11.50	11.58
11	10.65	10.72	10.80	10.87	10.94	11.02	11.09	11.16	11.24	11.31
12	10.41	10.48	10.55	10.62	10.69	10.77	10.84	10.91	10.98	11.05
13	10.17	10.24	10.31	10.38	10.46	10.53	10.60	10.67	10.74	10.81
14	9.95	10.02	10.09	10.16	10.23	10.29	10.36	10.43	10.50	10.57
15	9.73	9.80	9.87	9.94	10.00	10.07	10.14	10.21	10.27	10.34
16	9.53	9.59	9.66	9.73	9.79	9.86	9.92	9.99	10.06	10.12
17	9.33	9.39	9.46	9.52	9.59	9.65	9.72	9.78	9.85	9.91
18	9.14	9.20	9.26	9.33	9.39	9.45	9.52	9.58	9.64	9.71
19	8.95	9.01	9.07	9.14	9.20	9.26	9.32	9.39	9.45	9.51
20	8.77	8.83	8.89	8.95	9.02	9.08	9.14	9.20	9.26	9.32
21	8.60	8.66	8.72	8.78	8.84	8.90	8.96	9.02	9.08	9.14
22	8.43	8.49	8.55	8.61	8.67	8.73	8.79	8.84	8.90	8.96
23	8.27	8.33	8.39	8.44	8.50	8.56	8.62	8.68	8.73	8.79
24	8.11	8.17	8.23	8.29	8.34	8.40	8.46	8.51	8.57	8.63
25	7.96	8.02	8.08	8.13	8.19	8.24	8.30	8.36	8.41	8.47
26	7.82	7.87	7.93	7.98	8.04	8.09	8.15	8.20	8.26	8.31
27	7.68	7.73	7.79	7.84	7.89	7.95	8.00	8.06	8.11	8.17
28	7.54	7.59	7.65	7.70	7.75	7.81	7.86	7.91	7.97	8.02
29	7.41	7.46	7.51	7.57	7.62	7.67	7.72	7.78	7.83	7.88
30	7.28	7.33	7.38	7.44	7.49	7.54	7.59	7.64	7.69	7.75
31	7.16	7.21	7.26	7.31	7.36	7.41	7.46	7.51	7.56	7.62
32	7.04	7.09	7.14	7.19	7.24	7.29	7.34	7.39	7.44	7.49
33	6.92	6.97	7.02	7.07	7.12	7.17	7.22	7.27	7.31	7.36
34	6.80	6.85	6.90	6.95	7.00	7.05	7.10	7.15	7.20	7.24
35	6.69	6.74	6.79	6.84	6.89	6.93	6.98	7.03	7.08	7.13
36	6.59	6.63	6.68	6.73	6.78	6.82	6.87	6.92	6.97	7.01
37	6.48	6.53	6.57	6.62	6.67	6.72	6.76	6.81	6.86	6.90
38	6.38	6.43	6.47	6.52	6.56	6.61	6.66	6.70	6.75	6.80
39	6.28	6.33	6.37	6.42	6.46	6.51	6.56	6.60	6.65	6.69
40	6.18	6.23	6.27	6.32	6.36	6.41	6.46	6.50	6.55	6.59

A barometric pressure of 760 millimeters of mercury is considered sea level.

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.

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

Process field blanks before collecting the water sample:

1. Rinse sterile sampling equipment and containers with sterile buffered water.
2. Process sterile buffered water through sampling equipment and into sterile sample bottle and analyze for colony growth. If no growth is observed, the sample was collected using sterile procedures.

Hand–Dip Method

If the stream depth and (or) velocity is not sufficient to use a depth–and–width integrating method, collect a sample by a hand–dip method. Sampling still water or sampling at depth in lakes, reservoirs, estuaries, and oceans requires a sterile point sampler. Niskin, ZoBell, and Wheaton samplers hold a sterilizable bottle or bag. To collect a hand–dipped sample:

1. 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.
2. 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.
3. Remove the bottle with the opening pointed upward from the water and tightly cap it, allowing about 2.5 to 5 cm of headspace. This procedure minimizes collection of surface film and avoids

contact with the streambed.

As with surface water, most bacteria in ground and well water are associated with solid particles. Stable values of field measurements (turbidity, temperature, dissolved–oxygen concentration, pH, and specific electrical conductance) are important criteria for judging if a well has been sufficiently purged for collection of a representative ground–water sample for indicator bacteria analysis.

Sample Preservation and Storage

After collection, immediately chill samples in an ice chest or refrigerator at 1° to 4° C. Do not freeze samples. Begin analysis as quickly as possible, preferably within 1 hour but not more than 6 hours after sample collection*, to minimize changes in the concentration of indicator bacteria*.

Appendix B:
Excerpt From MPCA - Guidance Manual For Assessing The Quality Of Minnesota Surface Waters

a) Low dissolved oxygen

Dissolved oxygen (DO) is required for essentially all aquatic organisms to live. DO is not a toxicant and, in general, the more DO in the water, up to about 110 percent of saturation, the better, for aquatic organisms. If DO drops below acceptable levels, desirable aquatic organisms, such as fish, can be killed or harmed. Dissolved oxygen standards differ depending on the use class of the water:

Class 2A. Not less than 7 mg/L as a daily minimum
Class 2Bd, 2B, 2C. Not less than 5 mg/L as a daily minimum
Class 2D. Maintain background
Class 7. Not less than 1 mg/L as a daily average, provided that measurable concentrations are present at all times

DO concentrations go through a diurnal cycle in most rivers and streams; concentrations generally reach their maximum in late afternoon and their minimum just after sunrise. Photosynthesis by algae and other green plants during the day gives off oxygen to the water which increases DO concentrations. At nightfall photosynthesis stops, but the continued respiration of living things, including green plants and bacteria, uses oxygen faster than it is replaced. This causes a gradual decline in DO levels throughout the night that usually culminates an hour or so after sunrise. For this reason, measurements of dissolved oxygen to be compared to the daily minimum standard are best taken no later than two hours after sunrise. DO measurements taken later in the day are not likely to represent the low point in the daily DO cycle. Timing is not as critical in the winter because daily DO cycles are not as pronounced as they are in the summer.

In Minnesota the critical conditions for stream DO usually occur during the late summer season when water temperatures are high and stream flows are normally low. During winter months, ice cover inhibits atmospheric re-aeration, and groundwater inflows contribute to low DO concentrations. When this is combined with oxygen-demanding loadings from eutrophication or point sources, winter low DO concentrations can occur.

Because of the seasonal and diurnal variability in DO concentrations, data sets of only 10 independent observations are seldom sufficient to display the pattern of dynamic DO in a stream and provide the basis for a confident assessment. For this reason, a total of 20 independent observations (rather than 10) are now required for DO assessments. In non-winter months (April through November) measurements should be made before 9:00 am in order to measure the lowest diurnal DO concentration.

Under revised assessment criteria beginning with the 2010 assessment cycle, the DO standard must be met at least 90 percent of the time during both the 5-month period of May through September and the 7-month period of October through April. Accordingly, no more than 10 percent of DO measurements can violate the standard in either of the two periods.

Further, measurements taken after 9:00 in the morning during the 5-month period of May through September are no longer considered to represent daily minimums, and thus measurements of > 5 DO later in the day are no longer considered to be indications that a stream is meeting the standard.

A stream is considered impaired if 1) more than 10 percent of the "suitable" (taken before 9:00) May through September measurements, or more than 10 percent of the total May through September measurements, or more than 10 percent of the October through April measurements violate the standard, and 2) there are at least three total violations.

A designation of "full support" for DO requires at least 20 "suitable" measurements from a set of monitoring data that give a representative, unbiased picture of DO levels over at least two different years.

b) pH

The pH of water is a measure of the degree of its acid or alkaline reaction. A pH of 7.0 is neutral; pH below 7 is acid, above 7 is alkaline. The applicable pH standard for most Class 2 waters is a minimum of 6.5 and a maximum of 8.5, based on the more stringent of the standards for the applicable multiple beneficial uses. pH values that are either too high or too low can be harmful to aquatic organisms; however, natural waters can exhibit a very broad range of pH values. pH values that are outside the range of the standard because of natural causes are not considered exceedances.

c) Turbidity

Turbidity in water is caused by suspended soil particles, algae, etc., that scatter light in the water column making the water appear cloudy. Excess turbidity can significantly degrade the aesthetic qualities of waterbodies. People are less likely to recreate in waters degraded by excess turbidity. Also, turbidity can make the water more expensive to treat for drinking or food processing uses. Turbidity values that exceed the standard can harm aquatic life. Aquatic organisms may have trouble finding food, gill function may be affected, and spawning beds may be covered.

Turbidity is measured in nephelometric turbidity units (NTU). The standards are shown below:

10 NTU, Class 2A waters
25 NTU, Class 2Bd, B, C, D waters

Transparency and total suspended solids (TSS) values reliably predict turbidity and can serve as surrogates at sites where there are an inadequate number of turbidity observations. Large sets of monitoring data have been used to develop transparency and TSS thresholds which will identify the large majority of waters with turbidity impairments while minimizing the number of waterbodies falsely identified. For transparency, a transparency tube measurement of less than 20 centimeters indicates a violation of the 25 NTU turbidity standard. For TSS, a measurement of more than 60 mg/L in the Western Corn Belt Plains (WCBP) and Northern Glaciated Plains (NGP) ecoregions or more than 100 mg/L in the North Central Hardwood Forest (NCHF) ecoregion indicates a violation.

Turbidity is a highly variable water quality measure. Because of this variability, and the use of TSS and transparency as surrogates, a total of 20 independent observations (rather than 10) are now required for a turbidity assessment. If sufficient turbidity measurements exist, only turbidity measurements will be used to determine impairment. If there are insufficient turbidity measurements, any combination of independent turbidity, transparency, and total suspended solids observations may be combined to meet assessment criteria. If there are multiple observations of a single parameter in one day, the mean of the values will be used in the assessment process.

If there are observations of more than one of the three parameters in a single day, the hierarchy of consideration for assessment purposes will be turbidity, then transparency, then total suspended solids. For a water body to be listed as impaired for turbidity, at least three observations and 10 percent of observations must be in violation of the turbidity standard. This is an increase in the number of violations required, which was previously 10 percent of 10 required observations.

Previously (2006 and 2008), assessments that took into account volunteer-collected transparency tube observations required corroboration by the judgment of MPCA staff and by local resource and/or watershed project staff, if available. Corroboration of volunteer-collected transparency tube data is no longer required, based on the following rationale:

Corroboration of transparency tube data is inconsistent with assessment requirements for all other volunteer collected data.

Professional Judgment Group (PJG) meetings provide a forum for reviewing all data; this process should be sufficient for volunteer-collected transparency tube data.

Considerable time is spent trying to locate local corroborators, processing review documents, and tracking comments.

Lack of a local partner willing to review the data for assessment purposes has lead to a significant amount of transparency tube data being excluded from assessments.

The MPCA has not analyzed enough data on Class 2A waters to determine transparency or TSS thresholds for violation of the 10 NTU standard. If turbidity related data (turbidity, t-tube, TSS) data indicate impairment on a Class 2A water (based on the 25 NTU standard), the waterbody is assessed as impaired for turbidity. If turbidity related data indicate a Class 2A water is in full support, the water body is considered “not assessed” since it is based on the transparency and TSS thresholds for the 25 NTU, and not the 10 NTU standard.

d) Temperature

High water temperatures, or rapid elevations of temperature above ambient, can be very detrimental to fish. The actual temperature that is harmful depends on the kind of fish, the time of year, and the life stage of the fish at the time. Cold water fish such as trout are particularly intolerant of high temperatures. The temperature standard for Class 2A cold water sport fish is a narrative nondegradation statement of “no material increase”. This standard is interpreted in a straight forward quantitative way. A demonstration of a “material increase” means that temperature data must show a statistically significant increase when measured, for example, upstream and downstream of a stream modification, upstream and downstream of a point or nonpoint heat source, or before and after a modification that might impact stream temperature. Temperatures must be for similar time frames such as weeks or seasons. Normally the Student’s t-test is used to test for significance of the temperature change over time. Specifically, the Student's t-test tests the hypothesis that the means of two groups of observations are equal. This test assumes that each of the two groups consists of independent and normally distributed observations. If either set of temperature data is not normally distributed, an appropriate analogous test, such as the Mann-Whitney U test, will be used. The larger the data set, the finer the precision in determining whether a material increase in stream temperature has occurred.

Currently the MPCA is evaluating only cold water fisheries for temperature caused impairment because of the special sensitivity of cold water fish to elevations in temperature, and because increases in temperature appear to be a major factor in the degradation of stream trout populations.

The same information is used to assess conventional pollutants for both 305(b) use support and 303(d) impaired waters determinations (Table 5). Reaches assessed using the impairment thresholds listed in Table 5 as not supporting for the integrated narrative report are identified as candidates for the 303(d) list. These reaches are presented to the appropriate professional judgment team for the basin in which the reach is located. The professional judgment team reviews the monitoring data for the most recent 10 years, and any information they have about actions taken in the watershed that might invalidate earlier data. They also consider the times of year and the number of years monitoring was done, and the magnitude and duration of any violations noted, and information about naturally occurring conditions known to influence water quality (see Section V.E). The MPCA makes a final determination on use support for integrated narrative reporting, and for inclusion on the 303(d) list.

The 10 percent and 25 percent exceedance thresholds for conventional pollutants (Table 5) are based on EPA guidance (EPA 1997) and have been used by the MPCA in assessments for many years. The MPCA feels these thresholds are appropriate for the "conventional" category of pollutants for several reasons. None is "toxic" (or bioaccumulative) in the traditional sense, unlike the toxicants discussed in Section VIII. All are subject to periodic "exceedances" because of natural causes. For example, turbidity typically increases in streams after a rain event even in relatively undisturbed parts of the state and dissolved oxygen can drop below the standard in rivers and streams for reasons that have nothing to do with pollution. These potential pollutants are also natural characteristics of surface waters, the fluctuations of which aquatic organisms have adapted to cope with over eons of time. The extent of these natural exceedances will be considered by the professional judgment teams as part of the assessments.

In the 2006 assessment, the judgment teams solidified an approach to assessing full support on streams with data sets that are limited to only one or a few types of data. Subject to the judgment of the team considering all the usual factors, an index of biotic integrity (IBI) score or a turbidity ["turbidity" includes transparency tube data with corroboration and total suspended solids data for the WCBP and NGP, and NCHF eco-regions] or dissolved oxygen dataset will each be sufficient alone to make an assessment of full support. Temperature, pH, ammonia, chloride, etc. are each not enough alone. Any combination is sufficient if it includes an IBI score, or turbidity or dissolved oxygen. If the PJG is aware that the timing of collection in a particular dataset might not well represent the conditions for that parameter, it could decide to "not assess".

This approach improves both consistency and efficiency as the number of reaches under consideration has increased dramatically. In order to use all readily accessible and credible data, the assessment process includes data sets that contain any one of the measurements for which water quality standards are in place. Data sets with few types, or only one type, of measurement, such as ammonia, are valuable for recognizing impairments, but are relatively independent of other influences, and may not be adequate alone to make an assessment of supporting simply because there are not many exceedances. Some types of water quality data better reflect overall aquatic biota health in a stream, while others is usually inadequate alone. In general, a fully supporting IBI score or turbidity or dissolved oxygen data set can reflect a complex of common degradation factors in Minnesota streams.

Table 5. Summary of data requirements and exceedance thresholds for assessment of conventional pollutants and water quality characteristics for the integrated narrative report and the 303d list. Period of Record	**Minimum No. of Data Points**	**Use Support or Listing Category Based on Chronic Standard Exceedances**		
Chronic Standard Exceedance Thresholds →		**≤ 10 %**	**10 – 25 %**	**> 25 %**
Most recent 10 years	20	Not Listed	Listed	Listed

e) E. coli bacteria

Maintaining Minnesota's lakes, rivers and streams in a swimmable condition, where this use is attainable, is the other half of the national CWA goal of providing fishable/ swimmable waters. To protect surface waters for water recreation, it is useful to divide recreational activities into two categories: primary and secondary body contact. Primary body contact includes swimming, diving, water skiing, windsurfing, or any form of water recreation where immersion in the water and the possibility of inadvertently ingesting some water is likely.

Secondary body contact recreation includes forms of water recreation where the likelihood of ingesting water is much smaller. Secondary body contact recreation typically includes boating, fishing, sailing, canoeing, and wading by adults. Wading in surface waters by children can be considered primary body contact recreation because children are more likely to put their hands in their mouths, wade in "too far" or fall in. Whitewater kayaking and riding personal water craft are usually considered secondary body contact even though the chances of ingesting water is probably greater than it is with typical boating or canoeing.

The numeric standards in Minn. R. ch. 7050 that directly protects for primary and secondary body contact are the *E. coli* standards shown in Table 10. *E. coli* standards are applicable only during the warm months since there is very little swimming in Minnesota in the non-summer months. Exceedances of the *E. coli* standard mean the recreational use is not being met

The MPCA has replaced the fecal coliform standard with an *E. coli* (*Escherichia coli*) standard based on a geometric mean EPA criterion of 126 *E. coli* colony forming units (cfu) per 100ml. *E. coli* has been determined by EPA to be the preferred indicator of the potential presence of waterborne pathogens. The *E. coli* standard is in Minnesota rule, and there is a considerable amount of *E. coli* data available. For assessment purposes, only *E. coli* measurements will be used. This change has been made because of the variability in the *E. coli*/fecal coliform statistical relationship and to emphasize that current and future monitoring for aquatic recreations use support should be based on the newly adopted *E. coli* standard. Exceptions to the exclusive use of *E. coli* data will be made only in special cases, using a ratio of 200 to 126 to convert fecal coliform to *E. coli*. Given recent monitoring data, this ratio is felt to be conservative and should result in relatively few false positive indications of impairment.

Research is underway in Minnesota and elsewhere in the United States on the use of DNA "fingerprinting" techniques to identify the source of *E. coli* bacteria. The goal of this work is an affordable method to determine if the *E. coli* bacteria in surface waters originated from humans or from animals. If this tool can be perfected, it will be very valuable in helping to direct *E. coli* contamination reduction efforts where they will be most effective.

Given the fact that the *E. coli* standard is a geometric mean of not less than five samples collected in a month, and that typical monitoring programs very rarely sample more often than once per month, a method of data assessment was needed that maximized the usefulness of the available data. An analysis of all fecal coliform data was done to determine the impact of collecting fewer than five samples per month (Markus 1999). This analysis showed that, for any given monitoring site, there was less variability for a given month across years than there was for all months within a year. The conclusion was that, although the most desirable approach was to collect at least five samples per month, we could reflect the intent of the standard using our current resources by aggregating data for a given month across all years.

Table 9. E. coli water quality standards for Class 2 and Class 7 waters. Use Class	**Standard No. of Organisms Per 100 mL of Water**		**Applicable Season**	**Use**
	Monthly Geometric Mean*	**10 % of Samples Maximum****	**Body Contact**	
2A, trout streams and lakes	126	1260	April 1 – October 31	Primary
2Bd, 2B, 2C, non-trout (warm) waters	126	1260	April 1 – October 31	Primary
2D, wetlands	126	1260	April 1 – October 31	Primary, if the use is suitable
7, limited resource value waters	630	1260	May 1 – October 31	Secondary

* Not to be exceeded as the geometric mean of not less than 5 samples in a calendar month.

** Not to be exceeded by 10% of all samples taken in a calendar month, individually.

The MPCA uses *E. coli* data collected by the MPCA, other government agencies, and by volunteers. All data used must satisfy QA/QC requirements, meet EPA guidelines, and be analyzed using an EPA approved method. The data must be entered into STORET.

Where multiple bacteria/pathogen samples have been taken on the same day on an assessment unit, then the geometric mean of all the measurements will be used for the assessment analysis.

Data over the full 10-year period are aggregated by individual month, as mentioned above (e.g., all April values for all 10 years, all May values, etc.). A minimum of five values for each month is ideal, but is not always necessary to make a determination. If the geometric mean of the aggregated monthly values for one or more months exceed 126 organisms per 100 ml, that reach is placed on the 305(b) not supporting list and on the 303(d) impaired list. Also, a waterbody is considered impaired if more than 10 percent of individual values over the 10-year period (independent of month) exceed 1260 organisms per 100 ml This assessment methodology more closely approximates the five-samples-per-month requirement of the standard while recognizing typical sampling frequencies, which rarely provide five samples in a single month and usually only one. Table 10 summarizes the assessment process.

Table 10. Assessment of waterbodies for impairment of swimming use - data requirements and exceedance thresholds for E. coli bacteria for the integrated narrative report and the 303d list. Period of Record	**Minimum No. of Data Points**	**Use Support or Listing Category Based on Exceedances of The *E. coli* Standard**		
Standard Exceedance Thresholds → Monthly geometric mean > 126 orgs/100 mL (Class 2) > 630 orgs/100 mL (Class 7)		**No months**	**1 or 2 months**	**More than 2 months**
Most recent 10 years	see text	Not Listed	Listed	Listed
Standard Exceedance Thresholds → Exceeds 1260 orgs/100 ml*		**< 10 %**	**10 - 25 %**	**> 25 %**
Most recent 10 years	10	Not Listed	Listed	Listed

* In full data set over 10 years.

f) nitrates

Class 1 waters are protected as a source of drinking water. In Minnesota, all groundwater and selected surface waters are designated Class 1. The assessment of groundwater (Class 1A) for potential impairment of the drinking water use is outside the scope of this Guidance. However, the assessment of Class 1B and 1C listed surface waters for potential impairment by nitrate nitrogen is discussed in this Section. Incorporated by reference, the federal Safe Drinking Water standards apply to these waters (Minn. R. ch. 7050.0221).

Class 7 (Limited Resource Waters)

Limited resource value waters include surface waters of the state that have been subject to a use attainability analysis and have been found to have limited value as a water resource. These waters are specifically listed in rule (Minn. R. ch. 7050.0470) and are protected so as to allow secondary body contact use, to preserve the groundwater for use as a potable water supply, and to protect aesthetic qualities of the water.

Standards for limited resource value waters include the following:

Escherichia (E.) coli: Not to exceed 630 organisms per 100 mL as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1260 organisms per 100 mL. The standard applies between May 1 and October 31. Assessment methodology is described in detail in Section X. Assessment Based on Numeric Standard for Protection of Aquatic Recreation A. *E.coli* bacteria.

Dissolved Oxygen: At concentrations which will avoid odors or putrid conditions or at concentrations not less than 1 mg/L as a daily average, provided that measurable concentrations are present at all times.

pH: minimum value 6.0 maximum value 9.0

Toxic pollutants not allowed in such quantities or concentrations that will impair the specified uses.

Application of toxic standards to Class 7 waters includes applying the Maximum Standard (MS) for most pollutants or 100 times the Chronic Standard (CS), whichever is lower (Minn. R. ch. 7050.0222 subp.7, item E). However, for bioaccumulative pollutants (BCF>5000) the CS would apply. Because Class 7 waters may be used by game fish for spawning and/or maintaining minnow populations during brief periods in the spring, a special protection against bioaccumulative pollutants is needed.

Ammonia example: The chronic standard for un-ionized ammonia is 0.04 mg/L. There is no FAV in rule, but an FAV value of 1 mg/L un-ionized was derived from data at pH 8 for a number of different fish species. Because the MS is equal to one half the FAV, a value of 0.5 mg/L un-ionized was used for determining the assessment status of Class 7 waters.

Chloride example: The chronic standard for chloride is 230 mg/L, the maximum standard is 860 mg/L, and the FAV is 1720 mg

Middle Minnesota Major Watershed
First Order Streams of Redwood and Brown County

APPENDIX C: INITIAL SITE SURVEY

Sampling Site Visit Summary

November 6, 2008
MPCA: Mark Hanson, Kelli Daberkow
RCRCA: Doug Goodrich, Shawn Wohnoutka

Visited ten sites. Site numbering is based on map on last page of this document. Sites with gray text boxes were visited but not selected for monitoring based on notes below.

Site 1-Crow Creek: Travel Highway 19 east of Redwood Falls to Noble Ave, creek is located ½ mile south of intersection. Site is a prime candidate for an ultrasonic transducer; bridge is constructed of wood. This site is out of the valley. There is one bridge downstream but has influence from backwater flooding of the Minnesota River.

Looking W, Upstream

Looking E, Downstream

Looking SW, Upstream

Looking NE, Downstream

Looking NW, Upstream

Looking SE, Downstream

Site 2-Wabasha Creek: Looked at two locations. First site was up on the ridge, east of Dakota Ridge Golf Course on 305th Street. Two round culverts with water is pooled upstream and downstream. There is also an active fenced cattle crossing downstream. This was not an ideal location. Drove to site located one mile closer to the MN River on County Road 11. Good bridge. Gravel bottom. Bridge is constructed of steel rails with wooden posts. An ultrasonic transducer would work for this site.

1st site-Looking NW, DS

1st site-Looking SE, US

Site 3-North Eden Creek: Looked at two locations. First site was on a minimum maintenance road that was more like a grassy/dirt path. Based on soggy soil conditions, we looked at the site closest to the Minnesota River. There are two round culverts with minimum flow. Automatic samplers were discussed. Channel has many boulders. This site would require a submersible transducer.

2nd site-Looking NW, DS

2nd site-Looking SW, US

2nd site-Looking NE, US

Site 4- did not visit.

Site 5-Hinderman Creek/Spring Creek: This is a designated trout stream. Visited two sites; first site was okay, several broken bottles at site. The second site is closest to the MN River. There are two round culverts (flow in only one of the culverts). There is a defined channel upstream with cropland on both sides and flat, wide channel with forested land downstream.

1st site-Looking E, DS

1st site-Looking W, US

2nd site: Looking DS

2nd site: Looking DS

2nd site: Looking US

Site 6-County Ditch 13: Located near Ron Meyer farm. This site is located on a steep bank on the ridge. There is one box culvert with minimal flow. Because of the nature of the site, it was decided that no flow measurements would be gathered here. Grab water samples may be collected, depending on work plan budget.

Looking South, US

Looking North, DS

Site 7- County Ditch 13: Didn't visit

Site 8-County Ditch 10: Located near Joe Hoffmann place on County Road 29 on the ridge. There is one box/round culvert with steep banks and little flow. It was decided this site is not suitable for flow measurements. Grab water samples may be collected, depending on work plan budget.

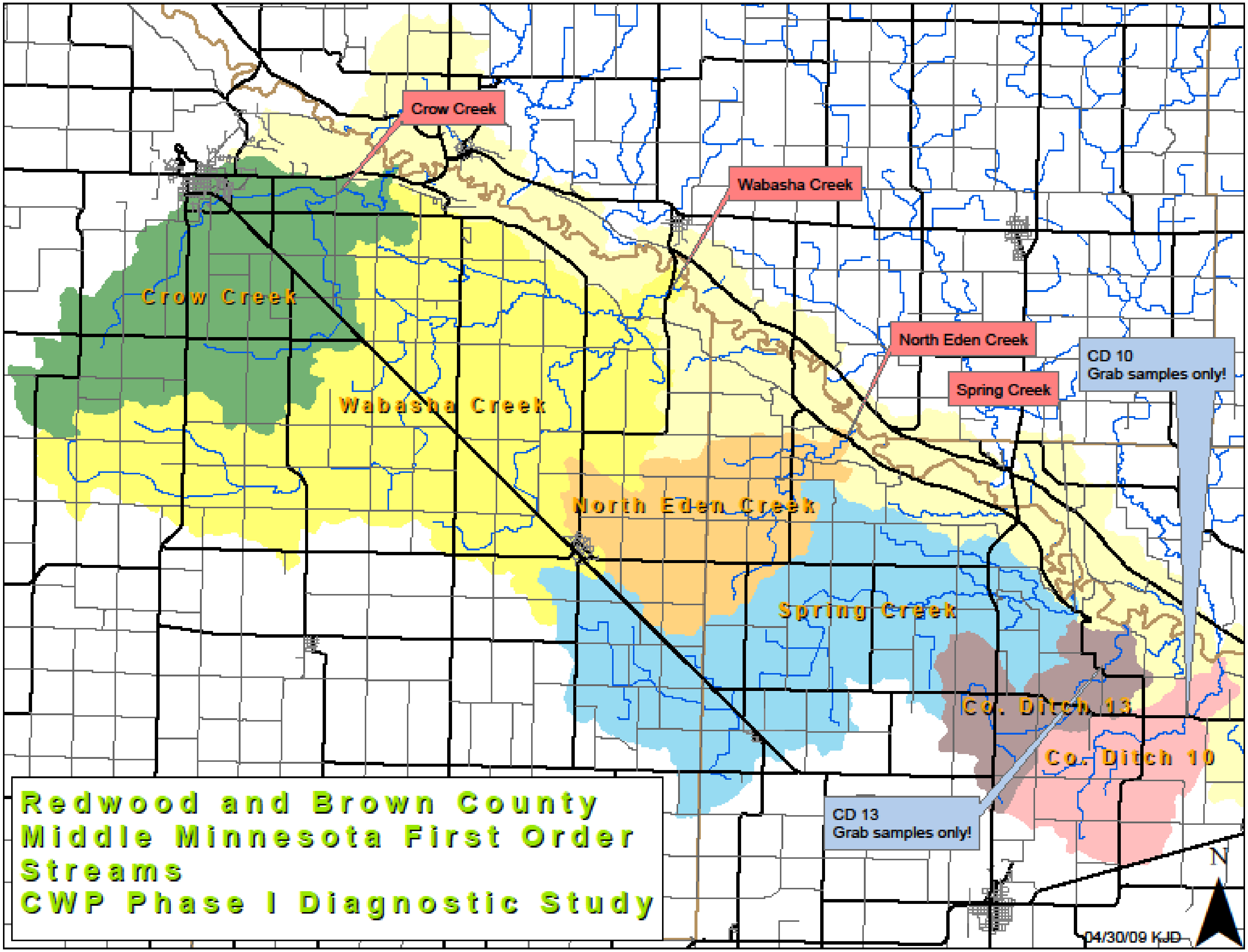
Looking South, US

Looking NE, DS

Site 9-County Ditch 10: Located on Harley Vogel farm in MN River valley. Farm located on watercourse; pastured on both sides. Harley mentioned that the DNR conducted some monitoring in the past. He will get RCRCA the information. There was decent flow but some reluctance to bother homeowner.

After visiting all potential sites, the following items were discussed.

1. There is $104,000 to spend for monitoring.
2. Monitoring will be conducted in 2009 and 2010.
3. Install four full gauging sites at:
    a. Crow Creek, Ultrasonic transducer
    b. Wabasha Creek, Ultrasonic transducer
    c. North Eden Creek, Submersible transducer
    d. Hinderman Creek/Spring Creek, Submersible transducer
4. Flow gauging will be done by DNR and paid for through the PCA/DNR contract.
5. Water samples will be collected approximately 25 times from April (or ice out) to October. Samples will be analyzed by MVTL for turbidity, TSS, TSVS, TP, OP, NO2_NO3, TKN, NH3, and *E. coli*.
6. Optional depending on budget:
    a. Collect water samples at County Ditch 13 (Site 6) and County Ditch 10 (Site 8) using the same sampling regime identified above. There will be no flow gauging conducted because of site limitations. A tape down or staff gage will be used instead.
7. Equipment:
    a. RCRCA equipment: CR10s, pressure transducers
    b. Need: Two full site set ups (minus the CR10s) for Crow Creek and Wabasha Creek (bridge mounts, ultra sonic, rain gauge, etc).
8. This plan will be developed more fully in the CWP Phase 1 work plan in early 2009.



Crow Creek
Wabasha Creek
North Eden Creek
Spring Creek
CD 10
Grab samples only!
Crow Creek
Wabasha Creek
North Eden Creek
Spring Creek
Co. Ditch 13
Co. Ditch 10
CD 13
Grab samples only!
Redwood and Brown County
Middle Minnesota First Order
Streams
CWP Phase I Diagnostic Study
N
04/30/09 KJD

Description of Sampling Sites

- **MMCC:**
  - Primary Site on Crow Creek near Redwood Falls, MN. Location: Lat. 44.535636 Long. -95.047577, in Paxton Township Section 03 T. 112N, R. 35W, Redwood County, at bridge on Noble Avenue, 3 miles east of Redwood Falls.

- **MMWC:**
  - Primary site on Wabasha Creek near Franklin, MN. Location: Lat. 44.505894, Long. -94.885831, in Sherman Township, Section 13, T. 112N, R. 34W, Redwood County, at bridge on county road 11, 2 miles south of Franklin.

- **MMNE:**
  - Primary site on North Eden Creek near Morgan, MN. Location: Lat. 44.456438, Long. -94.799014, in Eden Township, Section 34N, T. 112N, R. 33W, Brown County, at culverts on county road 10, 8 miles northeast of Morgan.

- **MMSC:**
  - Primary site on Spring (Hinderman) Creek near Essig, MN. Location: Lat. 44.398466, Long. -94.688001, in Home 'N' Township, Section 21, T. 111N, R. 32W, Brown County, at culverts on county road 10, 8 miles northwest of Essig.

- **COD13:**
  - Primary site on Brown County Ditch 13 near Essig, MN. Location: Lat. 44.376635, Long. -94.673041, in Home 'N' Township, Section 34, T. 111N, R. 32W, Brown County, at culverts on county road 10, 6 miles northwest of Essig

- **COD10:**
  - Primary site on Brown County Ditch 10 near Essig, MN. Location: Lat. 44.363277, Long. -94.633318, in Home Township, Section 01, T. 110N, R. 32W, Brown County, at culverts on county road 29, 3.5 miles north by northwest of Essig

Middle Minnesota Major Watershed
First Order Streams of Redwood and Brown County

APPENDIX D: MONITORING DATA

FIELD and LAB/CHEMICAL SAMPLE DATA

Field Data - Measurements taken on-site, 2009

MMCC1 - Middle Minnesota Watershed - Crow Creek at Noble Ave. -

Storet Code - S005-628

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Base Flow	4/9/2009		7:45	3.5	13.45	8.42	60+
Base Flow	4/21/2009		7:50	3.7	14.75	8.4	60+
Base Flow	4/29/2009		9:30	8.8	11.92	8.23	60+
Base Flow	5/1/2009		10:05	9.5	15.17	8.46	60+
Base Flow	5/12/2009		9:50	11.7	14.88	8.54	60+
Base Flow	5/26/2009		8:10	15.3	6.97	8.21	60+
Base Flow	6/2/2009		8:25	15.9	6.40	8.26	60+
Storm Flow	6/8/2009		8:25	10.9	9.42	8.51	13.6
Storm Flow	6/11/2009		9:05	12.0	10.52	8.79	60
Base Flow	6/19/2009		7:45	17.6	7.8	8.74	60+
Base Flow	6/26/2009		8:15	18.8	7.53	8.15	60+
Base Flow	7/10/2009		8:15	19.9	6.34	8.17	60+
Base Flow	7/21/2009		8:05	18.3	5.98	8.17	60+
Base Flow	8/8/2009		9:15	19.2	3.72	7.97	57.2
Base Flow	8/21/2009		8:10	16.7	3.74	8.18	54.4
Base Flow	9/3/2009		8:10	15.0	3.41	8.13	60+
Base Flow	9/24/2009		8:20	15.8	3.09	7.94	60+
Storm Flow	10/2/2009		8:05	11.9	6.48	8.09	31.9
Storm Flow	10/3/2009		10:05	10.4	4.76	8.16	60+
Storm Flow	10/8/2009		9:35	9.2	4.77	8.36	60+
Storm Flow	10/13/2009		8:25	3.5	5.52	8.58	60+

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

MMCC1 - Middle Minnesota Watershed - Crow Creek at Noble Ave.

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STORET CODE - S005-628

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/9/2009	7:45	09-A12881	2*	2*	0.7	12.8	0.105	0.097		5	< 0.16
Base Flow	Grab	4/21/2009	7:50	09-A15276	<2	<2	1.3	12.8	0.023	0.018	37.4*	3	<0.16
Base Flow	Grab	4/29/2009	9:30	09-A17042							90.6		
Base Flow	Grab	5/1/2009	10:05	09-A17727	3*	3*	1.3	12.5	0.025	0.025	36.4	3*	<0.16
Base Flow	Grab	5/12/2009	9:50	09-A19645	<2	<2	2.4	13.3	0.019	0.023	155.3	1.5	<0.16
Base Flow	Grab	5/26/2009	8:10	09-A22097							290.9*		
Base Flow	Grab	6/2/2009	8:25	09-A23462	4	<2	2.1	6.72	0.046*	0.058	410.6*	2.1	<0.16
Storm Flow	Grab	6/8/2009	8:25	09-A24380	111	16	1.9	12.4	0.139	0.242 ^	> 2419.6*	63	<0.16
Storm Flow	Grab	6/11/2009	9:05	09-A25413	7	<2	2.5	15.8	0.092	0.065		6.4	<0.16
Base Flow	Grab	6/19/2009	7:45	09-A26927	9	<2	2.6	13.4	0.097	0.077	285.1*	3.3	<0.16
Base Flow	Grab	6/26/2009	8:15	09-A28219	6	2	1.3	11.0	0.126	0.102		4.1	<0.16
Base Flow	Grab	7/10/2009	8:15	09-A30653	7	6	1.0	3.51	0.17	0.152	770.1*	4.6	<0.16
Base Flow	Grab	7/21/2009	8:05	09-A32493	8	7	2.0	1.7	0.134	0.162	613.1*	7.9	<0.16
Base Flow	Grab	8/8/2009	9:15	09-A36171	10	5	1.0	0.64		0.268 ^			<0.16
Base Flow	Grab	8/21/2009	8:10	09-A39349	9	3	0.7	0.84	0.384 ^	0.360 ^	980.4*	9.5	<0.16
Base Flow	Grab	9/3/2009	8:10	09-A41333	9	4	0.7	0.25	0.143	0.144	1413.6*	8.8	<0.16
Base Flow	Grab	9/24/2009	8:20	09-A44696	<2	<2	0.6	<0.2	0.139	0.188	547.5	7.2	<0.16
Storm Flow	Grab	10/2/2009	8:05	09-A46095	22	3	0.3	0.81		0.191			<0.16
Storm Flow	Grab	10/3/2009	10:05	09-A46180	5	<2	0.3	1.10		0.244 ^			<0.16
Storm Flow	Grab	10/8/2009	9:35	09-A47262	4	<2	0.7	8.6	0.15	0.178		4.9	<0.16
Storm Flow	Grab	10/13/2009	8:25	09-A47999	6	3	1.3	10.5	0.097	0.113		4.1	<0.16

Field Data - Measurements taken on-site, 2010

MMCC1 - Middle Minnesota Watershed - Crow Creek at Noble Ave. -

Storet Code - S005-628

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
snowmelt	3/16/2010		18:50	1.4	13.41	7.87	14.1
snowmelt	3/17/2010		10:30	1.0	12.41	7.97	15.6
snowmelt	3/25/2010		11:50	4.4	11.12	8.17	28.0
Base Flow	4/13/2010		11:30	10.2	13.37	8.31	60+
Base Flow	4/27/2010		9:20	8.3	10.65	8.30	60+
Base Flow	5/5/2010		9:15	8.4	10.88	8.36	60+
Base Flow	5/19/2010		9:20	9.8	10.69	8.23	60+
Base Flow	6/2/2010		9:30	13.7	9.21	8.26	60+
Storm Flow	6/11/2010		10:10	E9	E4	7.72	5.4
Storm Flow	6/11/2010		15:55				9.1
Storm Flow	6/14/2010		10:45	13.4?	E5	7.85	52.6
Storm Flow	6/18/2010		9:55	E9	E4	8.04	60+
Storm Flow	6/28/2010		18:45	E9	E4	7.76	19.2
Storm Flow	6/29/2010		10:30	16.3	7.76	7.13	22.0
Base Flow	7/8/2010		8:55	15.9?	E5	8.16	60+
Base Flow	7/14/2010		10:35				60+
Base Flow	7/30/2010		9:40	E9	E4	8.19	60+
Base Flow	8/5/2010		9:40	E9	E4	8.20	60+
Base Flow	8/17/2010		9:20	E9	E4	8.22	60+
Base Flow	8/24/2010		9:30				49.7
Base Flow	8/31/2010		11:25				58.8
Base Flow	9/2/2010		11:10	18.7	7.42	7.92	22.5
Base Flow	9/7/2010		12:45				60+
Storm Flow	9/16/2010		9:35	14.4	8.18	7.97	13.6
Storm Flow	9/23/2010		11:25	16.2	7.19	7.78	6.1
Storm Flow	9/23/2010		17:40	17.5	6.93		6.2
Storm Flow	9/24/2010		7:40	14.7	7.10	7.68	6.5

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

MMCC1 - Middle Minnesota Watershed - Crow Creek at Noble Ave. -

STORET CODE - S005-628

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	18:50	10-A9361	140	16	3.4	6.71	0.594^	0.904		55	
Snowmelt	Grab	3/17/2010	10:30	10-A9350	96	14	3.3	6.61	0.567^	0.894		47	0.51
Snowmelt	Grab	3/25/2010	11:50	10-A10956	26	5	2.4	10.5	0.701	0.749		21	0.37
Base Flow	Grab	4/13/2010	11:30	10-A14096	4	<2	1.1	13.8	0.008	0.024	28.1*	1.9	<0.16
Base Flow	Grab	4/19/2010	13:05	10-A15375							17.3		
Base Flow	Grab	4/27/2010	9:20	10-A17077	5	2	<0.2	13.6	<0.005	0.025	93.3*	1.0	<0.16
Base Flow	Grab	5/5/2010	9:15	10-A18853	<2	<2	0.7	13.7	<0.005	0.022	209.8*	1.4	<0.16
Base Flow	Grab	5/19/2010	9:20	10-A21901	8	<2	0.7	16.8	0.006	0.030	201.4	3.3	<0.16
Base Flow	Grab	6/2/2010	9:30	10-A24391	<2	<2	0.5	14.8	0.010	0.030	156.5*	2.0	<0.16
Storm Flow	Grab	6/11/2010	10:10	10-A26166	173	28	2.7	10.3	0.180	0.442^	>2419.6	140	<0.16
Storm Flow	Grab	6/11/2010	15:55	10-A26382	98	14	2.0	15.9	0.214*	0.356^		77*	<0.16
Storm Flow	Grab	6/14/2010	10:45	10-A26386	15	2	1.1	16.8	0.162	0.199^		11	<0.16
Storm Flow	Grab	6/18/2010	9:55	10-A27837	11	<2	2.7	17.8	0.097	0.130		7.9	<0.16
Storm Flow	Grab	6/28/2010	18:45	10-A29770	22	<2	1.4	11.8	0.195^	0.302^		37	<0.16
Storm Flow	Grab	6/29/2010	10:30	10-A29683	20	20	1.5	13.5	0.18	0.234^		21	<0.16
Base Flow	Grab	7/8/2010	8:55	10-A31709	11	<2	1.3	15.4	0.066	0.096	770.1*	5.5	<0.16
Base Flow	Grab	7/14/2010	10:35	10-A32948							866.4*		
Base Flow	Grab	7/30/2010	9:40	10-A36592	9	4	1.1	10.3	0.088	0.115	547.5	2.7	<0.16
Base Flow	Grab	8/5/2010	9:40	10-A38036	5	2	0.7	7.43	0.071	0.109	186.0*	3.3	<0.16
Base Flow	Grab	8/17/2010	9:20	10-A40207	2	<2	0.7	3.58	0.143	0.171	613.1*	4.8	<0.16
Base Flow	Grab	8/24/2010	9:30	10-A41360							2419.6*		
Base Flow	Grab	8/31/2010	11:25	10-A42640							> 2419.6*		
Base Flow	Grab	9/2/2010	11:10	10-A43299	27	8	1.0	1.11	0.139	0.196	2419.6*	36	<0.16
Base Flow	Grab	9/7/2010	12:45	10-A43678							920.8		
Storm Flow	Grab	9/16/2010	9:35	10-A45911	48	10	1.2	7.23	0.184	0.261	>2419.6*	55	<0.16
Storm Flow	Grab	9/23/2010	11:25	10-A47288	236	36	2.6	8.57	0.205^	0.464		140	<0.16
Storm Flow	Grab	9/23/2010	17:40	10-A47429	204	32	2.2	5.95	0.204^	0.465		140	<0.16
Storm Flow	Grab	9/24/2010	7:40	10-A47424	95	15	2.1	6.34	0.238^	0.442		130	<0.16

Field Data - Measurements taken on-site, 2009

MMWC - Middle Minnesota Watershed - Wabasha Creek at Co. Hwy 11 in MN River Valley -

Storet Code - S005-627

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1	TT2
Flood Flow	4/9/2009		8:30	4.9	10.84	8.13	27.8	
Base Flow	4/21/2009		8:30	5.4	11.47	8.35	60+	
Base Flow	4/29/2009		10:10	10	11.22	8.41	60+	
Base Flow	5/1/2009		11:00	12.3	13.59	8.56	47.0	
Base Flow	5/12/2009		10:40	13.4	13.43	8.82	60+	
Base Flow	5/26/2009		9:30	16.7	8.27	8.52	60+	
Base Flow	6/2/2009		10:00	16.8	9.21	8.64	60+	
Storm Flow	6/8/2009		9:15	11.9	9.73	8.86	60+	
Storm Flow	6/11/2009		9:50	14.9	9.95	9.11	60	
Base Flow	6/19/2009		8:20	20.8	7.76	9.10	60+	
Base Flow	6/26/2009		9:00	22.1	7.98	8.39	60+	
Base Flow	7/10/2009		9:10	20.7	8.14	8.37	60+	
Base Flow	7/21/2009		8:55	19.7	8.31	8.34	60+	
Base Flow	8/8/2009		8:45	20.2	4.43	8.32	60	
Base Flow	8/21/2009		8:50	16.8	3.91	8.43	60+	
Base Flow	9/3/2009		9:05	16.0	3.54	8.32	60+	
Base Flow	9/24/2009		9:10	16.7	3.27	8.25	50.0	
Storm Flow	10/2/2009		8:45	11.6	4.16	8.34	60+	
Storm Flow	10/3/2009		10:40	10.5	4.52	8.36	60+	
Storm Flow	10/8/2009		10:15	9.2	4.90	8.52	45.0	
Storm Flow	10/13/2009		8:55	2.8	5.47	8.68	60+	

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

MMWC - Middle Minnesota Watershed - Wabasha Creek at Co. Hwy 11 in MN River Valley -

STORET CODE - S005-627

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/9/2009	8:30	09-A12882	10*	8*	1.1	2.70	0.214	0.262^		32	< 0.16
Base Flow	Grab	4/21/2009	8:30	09-A15277	3	3	1	7.47	0.022	0.038	290.9*	5	< 0.16
Base Flow	Grab	4/29/2009	10:10	09-A17043							517.2		
Base Flow	Grab	5/1/2009	11:00	09-A17728	13*	8*	2.5	7.26	0.143	0.266^	218.7	6*	<0.16
Base Flow	Grab	5/12/2009	10:40	09-A19646	5	<2	2.4	9.41	0.020	0.043	148.3	2.8	<0.16
Base Flow	Grab	5/26/2009	9:30	09-A22098							2419.6*		
Base Flow	Grab	6/2/2009	10:00	09-A23463	3	2	0.9	1.25	0.173^	0.182	770.1	1.8	<0.16
Storm Flow	Grab	6/8/2009	9:15	09-A24381	12	6	0.7	1.52	0.204^	0.227^	> 2419.6*	7.7	<0.16
Storm Flow	Grab	6/11/2009	9:50	09-A25414	14	2	2.2	15.50	0.162	0.143		6.1	<0.16
Base Flow	Grab	6/19/2009	8:20	09-A26928	11	5	2.4	9.25	0.357^	0.439^	1732.9	5.1	<0.16
Base Flow	Grab	6/26/2009	9:00	09-A28220	5	<2	1.2	5.07	0.200^	0.210^		3	<0.16
Base Flow	Grab	7/10/2009	9:10	09-A30654	3	<2	0.6	0.60	0.232^	0.220^	285.1*	2	<0.16
Base Flow	Grab	7/21/2009	8:55	09-A32494	<2	<2	1	<0.2	0.162	0.166	344.8*	3.3	<0.16
Base Flow	Grab	8/8/2009	8:45	09-A36170	4	2	0.4	<0.2		0.169			<0.16
Base Flow	Grab	8/21/2009	8:50	09-A39350	6	3	0.6	<0.2	0.234^	0.241^	1413.6	3.6	<0.16
Base Flow	Grab	9/3/2009	9:05	09-A41334	6	2	0.7	<0.2	0.119	0.117	524.7*	4.2	<0.16
Base Flow	Grab	9/24/2009	9:10	09-A44697	<2	<2	<0.2	<0.2	0.102	0.136	517.2	9.1	<0.16
Storm Flow	Grab	10/2/2009	8:45	09-A46096	5	<2	<0.2	0.31		0.247^			<0.16
Storm Flow	Grab	10/3/2009	10:40	09-A46181	6	4	0.7	2.51		0.427^			<0.16
Storm Flow	Grab	10/8/2009	10:15	09-A47263	12	4	1.4	8.30	0.507^	0.662^		14	<0.16
Storm Flow	Grab	10/13/2009	8:55	09-A48000	3	<2	1.9	10.40	0.123	0.145		1.8	<0.16

Field Data - Measurements taken on-site, 2010

MMWC - Middle Minnesota Watershed - Wabasha Creek at Co. Hwy 11 in MN River Valley -

Storet Code - S005-627

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1	TT2
snowmelt	3/16/2010		18:20	1.1	13.92	8.04	10.2	
snowmelt	3/17/2010		11:10	0.6	12.42	8.11	11.2	
MN R Affected	4/13/2010		12:15	12.4	12.63	8.78	41.8	
MN R Affected	4/27/2010		9:55	9.6	9.65	8.35	60+	
Base Flow	5/5/2010		10:00	10.0	9.49	8.39	60+	
Base Flow	5/19/2010		10:05	12.9	9.09	8.31	52.7	
Base Flow	6/2/2010		10:10	16.1	8.81	8.37	60+	
Storm Flow	6/11/2010		10:50	E9	E4	8.18	3.9	
Storm Flow	6/11/2010		15:30				8.3	
Storm Flow	6/14/2010		11:25	14.0	9.32	8.27	28.7	
Storm Flow	6/18/2010		10:30	17	E4	8.36	43.1	
Storm Flow	6/28/2010		18:20	E9	E4	8.10	14.6	
Storm Flow	6/29/2010		11:45	19.9	6.95	7.52	17.0	
Base Flow	7/8/2010		9:30	18.6	7.34	8.35	46.0	
Base Flow	7/14/2010		10:00				60+	
Base Flow	7/30/2010		10:10	E9	E4	8.38	60+	
Base Flow	8/5/2010		10:15	E9	E4	8.35	60+	
Base Flow	8/17/2010		10:05	E9	E4	8.35	60+	
Base Flow	8/24/2010		10:05				60+	
Base Flow	8/31/2010		10:40				60+	
Base Flow	9/2/2010		12:00	18.9	8.13	8.29	13.8	
Base Flow	9/7/2010		13:25				60+	
Storm Flow	9/16/2010		10:20	14.4	9.31	8.43	16.1	
Storm Flow	9/23/2010		10:35	16.2	8.32	8.10	3.1	
Storm Flow	9/23/2010		17:15				2.3	
Storm Flow	9/24/2010		8:25	15.2	9.19	7.99	4.4	

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

MMWC - Middle Minnesota Watershed - Wabasha Creek at Co. Hwy 11 in MN River Valley -

STORET CODE - S005-627

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	18:20	10-A9360	126	14	2.6	5.03	0.500^	0.763		74	
Snowmelt	Grab	3/17/2010	11:10	10-A9351	73	10	2.7	4.85	0.510^	0.732		57	0.23
MN River Affect	Grab	4/13/2010	12:15	10-A14097	13	8	1.6	1.83	<0.005	0.105	1.0*	5.9	<0.16
MN River Affect	Grab	4/19/2010	13:35	10-A15376							17.3		
MN River Affect	Grab	4/27/2010	9:55	10-A17078	7	3	0.4	12.80	0.009	0.042	81.3*	2.1	<0.16
Base Flow	Grab	5/5/2010	10:00	10-A18854	6	<2	0.8	13.20	0.009	0.041	95.9*	3.8	<0.16
Base Flow	Grab	5/19/2010	10:05	10-A21902	23	3	0.8	17.40	0.073	0.141	137.6*	10	<0.16
Base Flow	Grab	6/2/2010	10:10	10-A24392	<2	<2	0.8	14.70	0.025	0.052	172.5*	5	<0.16
Storm Flow	Grab	6/11/2010	10:50	10-A26167	378	56	3.7	10.60	0.168	0.658^	>2419.6	220	<0.16
Storm Flow	Grab	6/11/2010	15:30	10-A26383	205	25	2.9	18.50	0.221*	0.490^		100*	<0.16
Storm Flow	Grab	6/14/2010	11:25	10-A26387	40	5	1.3	18.90	0.123	0.192^		23	<0.16
Storm Flow	Grab	6/18/2010	10:30	10-A27838	23	4	3.0	18.90	0.091	0.156		12	<0.16
Storm Flow	Grab	6/28/2010	18:20	10-A29769	77	15	1.8	9.83	0.217^	0.353^		48	<0.16
Storm Flow	Grab	6/29/2010	11:45	10-A29684	42	11	1.7	9.68	0.205^	0.293^		25	<0.16
Base Flow	Grab	7/8/2010	9:30	10-A31710	28	4	1.4	14.10	0.098	0.166	613.1*	11	<0.16
Base Flow	Grab	7/14/2010	10:00	10-A32947							579.4*		
Base Flow	Grab	7/30/2010	10:10	10-A36593	16	5	1.1	9.59	0.138	0.198	770.1	4.2	<0.16
Base Flow	Grab	8/5/2010	10:15	10-A38037	11	2	1.4	5.72	0.118	0.188	579.4*	5.1	<0.16
Base Flow	Grab	8/17/2010	10:05	10-A40208	5	5	1.4	5.99	0.134	0.174	275.5*	2.8	<0.16
Base Flow	Grab	8/24/2010	10:05	10-A41361							920.8*		
Base Flow	Grab	8/31/2010	10:40	10-A42641							>2419.6*		
Base Flow	Grab	9/2/2010	12:00	10-A43300	89	17	1.4	2.63	0.319	0.424^	>2419.6*	62	<0.16
Base Flow	Grab	9/7/2010	13:25	10-A43679							2419.6		
Storm Flow	Grab	9/16/2010	10:20	10-A45912	108	22	2.1	11.3	0.207^	0.388^	>2419.6*	56	<0.16
Storm Flow	Grab	9/23/2010	10:35	10-A47289	663	97	4.9	8.17	0.347^	1.10		320	<0.16
Storm Flow	Grab	9/23/2010	17:15	10-A47430	1040	117	4.8	5.24	0.259^	1.31		460	<0.16
Storm Flow	Grab	9/24/2010	8:25	10-A47425	388	52	2.8	4.53	0.296^	0.742		230	<0.16

Field Data - Measurements taken on-site, 2009

MMNE - Middle Minnesota Watershed - North Eden Creek at Co. Hwy 10 in MN River Valley

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Storet Code - S005-626

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Base Flow	4/9/2009		8:50	3.2	15.66	8.52	60+
Base Flow	4/21/2009		9:00	5.5	14.80	8.44	60+
Base Flow	4/29/2009		10:30	9.5	13.74	8.40	60+
Base Flow	5/1/2009		11:25	13.2	14.03	8.67	60+
Base Flow	5/12/2009		11:10	13.5	11.75	8.83	60+
Base Flow	5/26/2009		9:50	15.4	9.46	8.58	60+
Base Flow	6/2/2009		10:30	15.0	9.76	8.72	60+
Storm Flow	6/8/2009		9:45	11.4	10.61	8.90	60+
Storm Flow	6/11/2009		10:20	14.9	9.95	9.17	60+
Base Flow	6/19/2009		8:55	19.2	8.80	9.19	60+
Base Flow	6/26/2009		9:30	20.0	8.88	8.43	60+
Base Flow	7/10/2009		9:35	20.0	8.49	8.36	60+
Base Flow	7/21/2009		9:25	17.1	9.15	8.30	60+
Base Flow	8/8/2009		8:25	18.8	4.57	8.33	60+
Base Flow	8/21/2009		9:15	15.3	4.02	8.40	60+
Base Flow	9/3/2009		9:35	13.9	3.93	8.31	60+
Base Flow	9/24/2009		9:35	15.9	3.89	8.28	60+
Storm Flow	10/2/2009		9:05	11.2	4.46	8.37	60+
Storm Flow	10/3/2009		11:00	10.3	4.48	8.47	60+
Storm Flow	10/8/2009		10:40	9.2	5.25	8.58	60+
Storm Flow	10/13/2009		9:25	2.8	5.46	8.67	60+

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

MMNE - Middle Minnesota Watershed - North Eden Creek at Co. Hwy 10 in MN River Valley -

STORET CODE - S005-626

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/9/2009	8:50	09-A12883	<2*	<2*	1.3	9.16	0.087	0.081		7	< 0.16
Base Flow	Grab	4/21/2009	9:00	09-A15278	<2	<2	1	6.24	0.015	0.016	14.8*	5	< 0.16
Base Flow	Grab	4/29/2009	10:00	09-A17044							6.3		
Base Flow	Grab	5/1/2009	11:25	09-A17729	5*	2*	1.5	6.39	0.015	0.022	4.1	3^	<0.16
Base Flow	Grab	5/12/2009	11:10	09-A19647	5	2	2.6	12.20	0.011	0.017	44.3	2.5	<0.16
Base Flow	Grab	5/26/2009	9:50	09-A22099							122.3		
Base Flow	Grab	6/2/2009	10:30	09-A23464	4	2	1.2	2.84	0.063	0.054	81.6	1.4	<0.16
Storm Flow	Grab	6/8/2009	9:45	09-A24382	24	5	1.3	5.25	0.086	0.096	2419.6	24	<0.16
Storm Flow	Grab	6/11/2009	10:20	09-A25415	8	<2	2.2	16.20	0.088	0.068		2.6	<0.16
Base Flow	Grab	6/19/2009	8:55	09-A26929	5	3	2.1	12.10	0.096	0.073	410.6	1.5	<0.16
Base Flow	Grab	6/26/2009	9:30	09-A28221	4	<2	1.2	6.94	0.106	0.082		2.6	<0.16
Base Flow	Grab	7/10/2009	9:35	09-A30655	3	2	0.7	0.61	0.092	0.065	165.8*	1.2	<0.16
Base Flow	Grab	7/21/2009	9:25	09-A32496	<2	<2	0.6	0.26	0.050	0.034	151.5*	1.6	<0.16
Base Flow	Grab	8/8/2009	8:25	09-A36169	<2	<2	0.3	0.29		0.039			<0.16
Base Flow	Grab	8/21/2009	9:15	09-A39351	4	<2	<0.2	0.25	0.070	0.039	517.2	1.3	<0.16
Base Flow	Grab	9/3/2009	9:35	09-A41335	<2	<2	0.4	0.22	0.066	0.031	2419.6	1.0	<0.16
Base Flow	Grab	9/24/2009	9:35	09-A44698	12	<2	<0.2	<0.2	0.025	0.038	222.4	1.3	<0.16
Storm Flow	Grab	10/2/2009	9:05	09-A46097	<2	<2	<0.2	<0.2		0.072			<0.16
Storm Flow	Grab	10/3/2009	11:00	09-A46182	<2	<2	0.3	<0.2		0.082			<0.16
Storm Flow	Grab	10/8/2009	10:40	09-A47264	2	<2	1.1	16.40	0.242^	0.290^		3.5	<0.16
Storm Flow	Grab	10/13/2009	9:25	09-A48001	<2	<2	1.3	14.60	0.082	0.096		1	<0.16

Field Data - Measurements taken on-site, 2010

MMNE - Middle Minnesota Watershed - North Eden Creek at Co. Hwy 10 in MN River Valley -

Storet Code - S005-626

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
snowmelt	3/16/2010		17:55	1.0		8.11	5.4
snowmelt	3/17/2010		11:40	0.9	14.34	8.13	7.9
snowmelt	3/19/2010		12:20	3.5	13.28	8.28	9.4
base flow	4/13/2010		12:45	12.5	11.23	8.60	60+
base flow	4/27/2010		10:30	9.6	11.17	8.46	60+
base flow	5/5/2010		10:30	9.9	10.72	8.48	60+
base flow	5/19/2010		10:30	11.8	10.22	8.41	60+
base flow	6/2/2010		10:40	15.1	E5	8.46	60+
Storm Flow	6/11/2010		11:10	E9	E4	8.35	52.1
Storm Flow	6/11/2010		15:05				58.2
Storm Flow	6/14/2010		11:55	13.4	9.99	8.38	51.0
Storm Flow	6/18/2010		10:50	E9	E4	8.44	60+
Storm Flow	6/28/2010		17:40	E9	E4	8.20	11.0
Storm Flow	6/29/2010		12:15	17.3	9.18	7.74	16.0
base flow	7/8/2010		9:55	E9	E4	8.42	60+
base flow	7/14/2010		9:40				60+
base flow	7/30/2010		10:40	E9	E4	8.39	60+
base flow	8/5/2010		10:40	E9	E4	8.33	60+
base flow	8/17/2010		14:55	E9	E4	8.36	60+
base flow	8/24/2010		10:25				60+
base flow	8/31/2010		10:15				60+
base flow	9/2/2010		12:30	17.9	8.95	8.35	60
base flow	9/7/2010		13:45				60+
Storm Flow	9/16/2010		10:50	13.4	9.86	8.44	60+
Storm Flow	9/23/2010		10:05	15.7	9.19	8.25	2.7
Storm Flow	9/23/2010		17:00				2.1
Storm Flow	9/24/2010		8:50	15.3	9.60	8.12	4.9

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

MMNE - Middle Minnesota Watershed - North Eden Creek at Co. Hwy 10 in MN River Valley -

STORET CODE - S005-626

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	17:55	10-A9359	488	40	3.0	6.32	0.420^	0.808		180	
Snowmelt	Grab	3/17/2010	11:40	10-A9352	285	22	2.4	6.88	0.475^	0.824		100	<0.16
Snowmelt	Grab	3/19/2010	12:20	10-A10027	221	19	2.7	8.22	0.616^	0.801		96	<0.16
Base Flow	Grab	4/13/2010	12:45	10-A14098	17	15	1.4	15.70	0.006	0.020	5.2*	2	<0.16
Base Flow	Grab	4/19/2010	13:50	10-A15377							12.1		
Base Flow	Grab	4/27/2010	10:30	10-A17079	3	2	<0.2	17.10	<0.005	0.018	18.7*	1.3	<0.16
Base Flow	Grab	5/5/2010	10:30	10-A18855	<2	<2	0.5	17.10	<0.005	0.019	42.6*	2.1	<0.16
Base Flow	Grab	5/19/2010	10:30	10-A21903	9	<2	0.5	20.00	0.013	0.029	83.6*	3.8	<0.16
Base Flow	Grab	6/2/2010	10:40	10-A24393	<2	<2	0.7	17.10	0.020	0.041	115.3*	2.1	<0.16
Storm Flow	Grab	6/11/2010	11:10	10-A26168	10	4	1.5	13.90	0.058	0.109	1732.9	8.6	<0.16
Storm Flow	Grab	6/11/2010	15:05	10-A26384	23	<2	0.9	14.10	0.073*	0.129		12*	<0.16
Storm Flow	Grab	6/14/2010	11:55	10-A26388	19	2	<0.2	19.20	0.084	0.125		10	<0.16
Storm Flow	Grab	6/18/2010	10:50	10-A27839	11	<2	2.7	19.5^	0.061	0.096		5.1	<0.16
Storm Flow	Grab	6/28/2010	17:40	10-A29768	86	13	2.0	14.30	0.221^	0.356^		64	<0.16
Storm Flow	Grab	6/29/2010	12:15	10-A29685	54	10	1.7	15.40	0.182	0.283^		41	<0.16
Base Flow	Grab	7/8/2010	9:55	10-A31711	9	<2	1.2	16.90	0.103	0.122	>2419.6*	3.4	<0.16
Base Flow	Grab	7/14/2010	9:40	10-A32946							1986.3*		
Base Flow	Grab	7/30/2010	10:40	10-A36594	6	4	1.2	13.00	0.076	0.110	488.4	1.9	<0.16
Base Flow	Grab	8/5/2010	10:40	10-A38038	2	<2	1.0	7.99	0.026	0.058	1203.3*	1.4	<0.16
Base Flow	Grab	8/17/2010	14:55	10-A40209	<2	<2	0.5	4.43	0.074	0.108	151.5	0.8	<0.16
Base Flow	Grab	8/24/2010	10:25	10-A41362							547.5*		
Base Flow	Grab	8/31/2010	10:15	10-A42642							816.4*		
Base Flow	Grab	9/2/2010	12:30	10-A43301	8	3	0.7	0.65	0.072	0.119	980.4*	8.3	<0.16
Base Flow	Grab	9/7/2010	13:45	10-A43680							261.3		
Storm Flow	Grab	9/16/2010	10:50	10-A45913	5	3	0.5	4.46	0.061	0.087	1046.2*	3.3	<0.16
Storm Flow	Grab	9/23/2010	10:05	10-A47290	1150	137	4.6	10.5	0.185	1.15		410	<0.16
Storm Flow	Grab	9/23/2010	17:00	10-A47431	987	100	3.7	7.21	0.232^	1.02		430	<0.16
Storm Flow	Grab	9/24/2010	8:50	10-A47426	268	36	2.3	6.04	0.390^	0.689		200	<0.16

Field Data - Measurements taken on-site, 2009

MMSC - Middle Minnesota Watershed - Spring Creek @ Co. Hwy 10 in MN River Valley

Storet Code - S005-625

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Base Flow	4/9/2009		9:30	4.5	15.45	8.53	60+
Base Flow	4/21/2009		9:30	6.6	15.96	8.49	60+
Base Flow	4/29/2009		11:30	10.1	14.72	8.50	60+
Base Flow	5/1/2009		11:50	13.7	17.52	8.64	60+
Base Flow	5/12/2009		11:45	13.9	11.83	8.73	60+
Base Flow	5/27/2009		14:00	15.1	11.75	9.06	60+
Base Flow	6/2/2009		11:00	16.8	11.49	8.95	60+
Storm Flow	6/8/2009		10:05	11.4	10.61	8.95	31.4
Storm Flow	6/11/2009		10:50	15.1	10.15	9.15	60
Base Flow	6/19/2009		9:25	19.3	9.18	9.18	60+
Base Flow	6/26/2009		10:00	21.1	9.31	8.43	60+
Base Flow	7/10/2009		10:00	20.3	9.39	8.40	60+
Base Flow	7/21/2009		9:45	18.6	9.61	8.41	60+
Base Flow	8/8/2009		8:05	18.2	4.65	8.38	60+
Base Flow	8/21/2009		9:40	16.0	4.16	8.47	60+
Base Flow	9/3/2009		10:00	14.9	4.01	8.43	60+
Base Flow	9/24/2009		10:00	15.9	4.14	8.40	60+
Storm Flow	10/2/2009		9:30	11.9	4.39	8.42	18.2
Storm Flow	10/3/2009		11:25	10.8	4.42	8.56	60+
Storm Flow	10/8/2009		11:05	10.3	5.15	8.57	47.6
Storm Flow	10/13/2009		9:45	4.1	5.29	8.74	60+

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

MMSC - Middle Minnesota Watershed - Spring Creek @ Co. Hwy 10 in MN River Valley

STORET CODE - S005-625

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/9/2009	9:30	09-A12884	<2*	<2*	1.3	6.89	0.046*	0.054		7	< 0.16
Base Flow	Grab	4/21/2009	9:30	09-A15279	2	2	1.3	4.45	0.019	0.018	7.5*	9	< 0.16
Base Flow	Grab	4/29/2009	11:30	09-A17045							4.1		
Base Flow	Grab	5/1/2009	11:50	09-A17730	6	<2	1.5	5.03	0.012	0.025	4.1	2^	<0.16
Base Flow	Grab	5/12/2009	11:45	09-A19648	<2	<2	2.9	9.53	0.019	0.022	73.8	3.8	<0.16
Base Flow	Grab	5/27/2009	14:00	09-A22492							90.6		
Base Flow	Grab	6/2/2009	11:00	09-A23465	4	3	0.9	2.06	0.068	0.059	81.3	1	<0.16
Storm Flow	Grab	6/8/2009	10:05	09-A24383	39	11	1.2	3.95	0.125	0.15	> 2419.6	29	<0.16
Storm Flow	Grab	6/11/2009	10:50	09-A25416	27	5	1.6	14.7	0.108	0.096		12	<0.16
Base Flow	Grab	6/19/2009	9:25	09-A26930	9	<2	1.8	7.78	0.085	0.074	613.1	5.6	<0.16
Base Flow	Grab	6/26/2009	10:00	09-A28222	4	<2	1.0	5.38	0.096	0.07		2.4	<0.16
Base Flow	Grab	7/10/2009	10:00	09-A30656	<2	<2	0.7	1.49	0.072	0.044	146.7*	0.9	<0.16
Base Flow	Grab	7/21/2009	9:45	09-A32497	<2	<2	0.7	1.53	0.04	0.024	191.8*	2.1	<0.16
Base Flow	Grab	8/8/2009	8:05	09-A36168	<2	<2	0.4	0.99		0.031			<0.16
Base Flow	Grab	8/21/2009	9:40	09-A39352	<2	<2	0.6	2.49	0.056	0.028	1789	0.9	<0.16
Base Flow	Grab	9/3/2009	10:00	09-A41336	<2	<2	0.4	1.03	0.048	0.024	210.5	0.7	<0.16
Base Flow	Grab	9/24/2009	10:00	09-A44699	<2	<2	<0.2	1.03	0.015	0.028	307.6	1.2	<0.16
Storm Flow	Grab	10/2/2009	9:30	09-A46098	37	7	1.6	9.66		0.374 ^			<0.16
Storm Flow	Grab	10/3/2009	11:25	09-A46183	6	4	1.4	8.03		0.184			<0.16
Storm Flow	Grab	10/8/2009	11:05	09-A47279	16	3	1.4	12	0.152	0.198		22	<0.16
Storm Flow	Grab	10/13/2009	9:45	09-A48002	6	3	0.7	12.3	0.09	0.106		3.2	<0.16

Field Data - Measurements taken on-site, 2010

MMSC - Middle Minnesota Watershed - Spring Creek @ Co. Hwy 10 in MN River Valley

Storet Code - S005-625

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Snowmelt	3/16/2010		17:30	1.4	15.56	8.03	6.4
Snowmelt	3/17/2010		12:00	1.3	14.11	8.08	7.4
Snowmelt	3/19/2010		12:50	0.7	13.96	8.22	5.1
Base Flow	4/13/2010		13:10	12.9	12.72	8.47	60+
Base Flow	4/27/2010		11:00	10.7	12.31	8.38	60+
Base Flow	5/5/2010		11:00	10.7	10.39	8.39	60+
Base Flow	5/19/2010		11:00	13.8	9.45	8.28	60
Base Flow	6/2/2010		11:10	16.2?	10.43?	8.33	60+
Storm Flow	6/11/2010		11:45	17.1	8.88?	8.31	35.5
Storm Flow	6/11/2010		14:45				52.4
Storm Flow	6/14/2010		12:30	E9	E4	8.32	37.3
Storm Flow	6/18/2010		11:20	18.2	E4	8.32	50.6
Storm Flow	6/28/2010		17:15	E9	E4	8.11	9.5
Storm Flow	6/29/2010		13:45	19.7	8.7	7.73	14
Base Flow	7/8/2010		10:20	E9	E4	8.32	60
Base Flow	7/14/2010		15:35				60+
Base Flow	7/30/2010		11:00	E9	E4	8.40	60+
Base Flow	8/5/2010		11:00	E9	E4	8.28	60+
Base Flow	8/17/2010		15:20			8.34	60+
Base Flow	8/24/2010		10:45				60+
Base Flow	8/31/2010		9:55				60+
Base Flow	9/2/2010		12:55	18.2	9.03	8.38	32.7
Base Flow	9/7/2010		14:00				60+
Storm Flow	9/16/2010		11:15	13.6	9.76	8.47	60+
Storm Flow	9/23/2010		9:30	16.0	8.59	8.19	3.3
Storm Flow	9/23/2010		16:35	17.3	8.21		2.8
Storm Flow	9/24/2010		9:20	15.6	9.09	8.00	4.3

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

MMSC - Middle Minnesota Watershed - Spring Creek @ Co. Hwy 10 in MN River Valley

STORET CODE - S005-625

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	17:30	10-A9358	371	32	3.6	6.43	0.438^	0.871		160	
Snowmelt	Grab	3/17/2010	12:00	10-A9353	377	29	3.6	6.52	0.489^	0.917		130	0.51
Snowmelt	Grab	3/19/2010	12:50	10-A10028	600	39	3.4	6.48	0.678^	1.14		200	0.23
Base Flow	Grab	4/13/2010	13:10	10-A14099	25	16	1.3	13.1	<0.005	0.027	21.6*	2.7	<0.16
Base Flow	Grab	4/19/2010	14:05	10-A15378							16.0		
Base Flow	Grab	4/27/2010	11:00	10-A17080	5	2	1.2	13.1	<0.005	0.020	24.6*	1.4	<0.16
Base Flow	Grab	5/5/2010	11:00	10-A18856	<2	<2	1.1	13.5	0.006	0.022	41.0*	2.0	<0.16
Base Flow	Grab	5/19/2010	11:00	10-A21904	18	<2	0.5	16.8	0.015	0.045	159.7*	6.8	<0.16
Base Flow	Grab	6/2/2010	11:10	10-A24394	<2	<2	0.5	11.9	0.009	0.030	201.4*	1.8	<0.16
Storm Flow	Grab	6/11/2010	11:45	10-A26169	30	6	1.7	8.14	0.047	0.114	1413.6	19	<0.16
Storm Flow	Grab	6/11/2010	14:45	10-A26385	24	<2	1.3	10.2	0.059*	0.112		15*	<0.16
Storm Flow	Grab	6/14/2010	12:30	10-A26393	51	5	0.7	15.9	0.084	0.152		19	<0.16
Storm Flow	Grab	6/18/2010	11:20	10-A27840	28	3	2.7	16.5	0.051	0.102		12	<0.16
Storm Flow	Grab	6/28/2010	17:15	10-A29767	140	18	2.0	14.4	0.204^	0.351^		73	<0.16
Storm Flow	Grab	6/29/2010	13:45	10-A29686	94	13	1.7	15.5	0.177	0.274^		37	<0.16
Base Flow	Grab	7/8/2010	10:20	10-A31712	18	<2	1.0	11.4	0.073	0.117	579.4*	8.4	<0.16
Base Flow	Grab	7/14/2010	15:35	10-A32949							410.6		
Base Flow	Grab	7/30/2010	11:00	10-A36595	8	2	1.1	8.08	0.122	0.191	648.8	3.8	<0.16
Base Flow	Grab	8/5/2010	11:00	10-A38039	3	<2	1.4	3.63	0.023	0.049	133.4*	2.3	<0.16
Base Flow	Grab	8/17/2010	15:20	10-A40210	3	<2	0.7	1.86	0.040	0.079	56.3	0.9	<0.16
Base Flow	Grab	8/24/2010	10:45	10-A41363							866.4*		
Base Flow	Grab	8/31/2010	9:55	10-A42643							1553.1*		
Base Flow	Grab	9/2/2010	12:55	10-A43302	24	6	0.8	1.92	0.100	0.140	1986.3*	21	<0.16
Base Flow	Grab	9/7/2010	14:00	10-A43681							387.3		
Storm Flow	Grab	9/16/2010	11:15	10-A45914	3	2	0.4	2.93	0.054	0.089	2419.6*	3.8	<0.16
Storm Flow	Grab	9/23/2010	9:30	10-A47291	880	113	6.0	6.65	0.230^	1.05		340	<0.16
Storm Flow	Grab	9/23/2010	16:35	10-A47432	1110	132	4.3	6.74	0.256^	1.11		400	<0.16
Storm Flow	Grab	9/24/2010	9:20	10-A47427	550	58	2.9	5.66	0.279^	0.784		250	<0.16

Field Data - Measurements taken on-site, 2009

County Ditch 13 - Middle Minnesota Watershed - @ Co Hwy 10 -

Storet Code - S005-624

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Base Flow	4/21/2009		10:00	5.7	16.71	8.55	60+
Base Flow	4/29/2009		11:50	9	13.03	8.39	60+
Base Flow	5/1/2009		12:15	12.2	15.34	8.58	60+
Base Flow	5/12/2009		12:05	12.4	12.33	8.53	60+
Base Flow	5/27/2009		14:30	13.2	8.92	8.58	60+
Base Flow	6/2/2009		11:25	16.2	7.43	8.49	60+
Storm Flow	6/8/2009		10:35	10.6	9.65	8.91	53.8
Storm Flow	6/11/2009		11:15	14.1	9.89	8.88	60+
Base Flow	6/19/2009		9:50	18.1	8.01	8.78	60+
Base Flow	6/26/2009		10:25	19.3	7.49	8.16	60+
Base Flow	7/10/2009		10:30	20.3	6.89	8.21	60+
Base Flow	7/21/2009		10:10	18	6.94	8.26	60+
Base Flow	8/8/2009		7:45	18.6	4.19	8.27	60+
Base Flow	8/21/2009		10:00	16.3	3.8	8.28	60+
Base Flow	9/3/2009		10:20	14.5	3.83	8.39	60+
Zero Flow	9/24/2009						
Storm Flow	10/2/2009		9:45	12.3	3.84	7.88	26.0
Storm Flow	10/3/2009		11:40	11.5	4.11	7.98	57.6
Storm Flow	10/8/2009		11:25	11.1	5.43	7.98	42.3
Storm Flow	10/13/2009		10:05	6.6	5.41	8.34	60+

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

County Ditch 13 - Middle Minnesota Watershed - @ Co Hwy 10 -

STORET CODE - S005-624

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/21/2009	10:00	09-A15280	< 2	< 2	1.1	5.94	0.026	0.039	613.1*	6	< 0.16
Base Flow	Grab	4/29/2009	11:50	09-A17046							1119.9		
Base Flow	Grab	5/1/2009	12:15	09-A17731	4	<2	1.3	6.61	0.023	0.037	98.8	5^	<0.16
Base Flow	Grab	5/12/2009	12:05	09-A19649	2	<2	2.3	8.48	0.026	0.041	261.3	1.2	<0.16
Base Flow	Grab	5/27/2009	14:30	09-A22494							387.3		
Base Flow	Grab	6/2/2009	11:25	09-A23466	4	3	1.8	3.53	0.131^	0.141	235.9	1.2	<0.16
Storm Flow	Grab	6/8/2009	10:35	09-A24384	30	6	0.7	11.1	0.148	0.141	1046.2	15	<0.16
Storm Flow	Grab	6/11/2009	11:15	09-A25417	4	2	1.5	12.6	0.076	0.055		2	<0.16
Base Flow	Grab	6/19/2009	9:50	09-A26931	<2	<2	2.1	7.18	0.099	0.083	> 2419.6	1..2	<0.16
Base Flow	Grab	6/26/2009	10:25	09-A28223	4	<2	1.6	5.00	0.249^	0.234^		2.2	<0.16
Base Flow	Grab	7/10/2009	10:30	09-A30657	<2	<2	1.3	2.79	0.351^	0.334^	980.4*	2.1	<0.16
Base Flow	Grab	7/21/2009	10:10	09-A32498	3	2	1.2	2.00	0.374^	0.335^	1413.6*	3.8	<0.16
Base Flow	Grab	8/8/2009	7:45	09-A36167	7	<2	1.5	0.73		0.743^			<0.16
Base Flow	Grab	8/21/2009	10:00	09-A39353	4	3	0.9	0.51	0.805^	0.829^	387.3	2.7	<0.16
Base Flow	Grab	9/3/2009	10:20	09-A41337	2	2	1.0	0.58	0.853^	0.790^	104.6	3.0	<0.16
Zero Flow		9/24/2009											
Storm Flow	Grab	10/2/2009	9:45	09-A46099	27	11	3.0	12.9		0.720^			0.29
Storm Flow	Grab	10/3/2009	11:40	09-A46184	12	5	1.7	10.5		0.297^			<0.16
Storm Flow	Grab	10/8/2009	11:25	09-A47280	10	3	1.6	12.6	0.179	0.227^		31	<0.16
Storm Flow	Grab	10/13/2009	10:05	09-A48003	5	2	1.1	16	0.136	0.146		2.2	<0.16

Field Data - Measurements taken on-site, 2010

County Ditch 13 - Middle Minnesota Watershed - @ Co Hwy 10 -

Storet Code - S005-624

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Snowmelt	3/16/2010		17:15	0.6	13.83	7.89	6.6
Snowmelt	3/17/2010		12:15	0.8	12.73	7.98	11.2
Base Flow	4/13/2010		13:35	12.1	14.23	8.46	60+
Base Flow	4/27/2010		11:20	10.1	11.42	8.21	60+
Base Flow	5/5/2010		11:30	9.0	10.77	8.30	60+
Base Flow	5/19/2010		11:20	12.8	10.21	8.11	60+
Base Flow	6/2/2010		11:40	E9	N/A	8.14	60+
Storm Flow	6/11/2010		12:10	E9	E5	8.00	60
Base Flow	7/8/2010		10:40	E9	E5	8.06	60+
Base Flow	7/14/2010		15:50	N/A	N/A	N/A	60+
Base Flow	7/30/2010		11:20	E9	E5	8.17	60+
Base Flow	8/5/2010		11:15	E9	E5	8.19	60+
Base Flow	8/17/2010		15:35	E9	E5	8.24	60+
Base Flow	8/24/2010		11:00				60+
Base Flow	8/31/2010		9:45				53.0
Storm Flow	9/2/2010		13:20	17.8	8.29	8.13	58.2
Base Flow	9/7/2010		14:15				60+
Base Flow	9/16/2010		11:35	14.2	8.85	8.29	60+
Storm Flow	9/23/2010		16:20				

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

County Ditch 13 - Middle Minnesota Watershed - @ Co Hwy 10 -

STORET CODE - S005-624

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	17:15	10-A9357	286	34	3.9	6.31	0.381^	0.948		110	
Snowmelt	Grab	3/17/2010	12:15	10-A9354	98	12	2.7	6.08	0.382^	0.867		48	0.65
Base Flow	Grab	4/13/2010	13:35	10-A14100	22	16	1.6	15.8	0.007	0.034	248.9*	3	<0.16
Base Flow	Grab	4/19/2010	14:20	10-A15379							290.9		
Base Flow	Grab	4/27/2010	11:20	10-A17081	<2	<2	0.9	15.0	0.006	0.027	1413.6	2.1	<0.16
Base Flow	Grab	5/5/2010	11:30	10-A18857	<2	<2	0.7	14.8	0.009	0.035	2419.6*	1.2	<0.16
Base Flow	Grab	5/19/2010	11:20	10-A21905	5	<2	1.4	18.1	0.009	0.031	648.8*	2.4	<0.16
Base Flow	Grab	6/2/2010	11:40	10-A24395	<2	<2	1.1	13.5	0.013	0.040	122.3*	2.5	<0.16
Storm Flow	Grab	6/11/2010	12:10	10-A26170	16	<2	1.7	13.6	0.054	0.113	1119.9	7.6	<0.16
Base Flow	Grab	7/8/2010	10:40	10-A31713	6	<2	1.4	14.4	0.078	0.129	410.6	2.1	<0.16
Base Flow	Grab	7/14/2010	15:50	10-A32950							344.8		
Base Flow	Grab	7/30/2010	11:20	10-A36596	6	2	1.4	5.48	0.136	0.207	387.3	2.3	<0.16
Base Flow	Grab	8/5/2010	11:15	10-A38040	2	<2	1.1	2.75	0.160	0.223	218.7*	2.1	<0.16
Base Flow	Grab	8/17/2010	15:35	10-A40211	6	2	0.7	1.23	0.228^	0.249	240	6	<0.16
Base Flow	Grab	8/24/2010	11:00	10-A41364							1046.2*		
Base Flow	Grab	8/31/2010	9:45	10-A42644							1553.1*		
Storm Flow	Grab	9/2/2010	13:20	10-A43303	10	5	1.1	7.08	0.355	0.390	2419.6	9.2	<0.16
Base Flow	Grab	9/7/2010	14:15	10-A43682							148.3		
Base Flow	Grab	9/16/2010	11:35	10-A45915	3	3	0.8	7.29	0.170	0.185	648.8*	1.5	<0.16
Storm Flow	Grab	9/23/2010	16:20	10-A47434							>2419.6*		

Field Data - Measurements taken on-site, 2009

County Ditch 10 - Middle Minnesota Watershed - @ Co. Hwy 29 -

Storet Code - S005-623

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Base Flow	4/9/2009		10:00	4.1	16.41	8.49	60+
Base Flow	4/21/2009		10:20	6.5	16.47	8.61	60+
Base Flow	4/29/2009		12:10	9.2	14.68	8.62	60+
Base Flow	5/1/2009		12:35	13.6	18.49	8.9	60+
Base Flow	5/12/2009		12:25	11.8	15.66	8.84	60+
Base Flow	5/27/2009		14:45	13.8	11.07	8.81	60+
Base Flow	6/2/2009		11:45	16.2	10.40	8.87	60+
Storm Flow	6/8/2009		11:00	11.2	10.76		60+
Storm Flow	6/11/2009		11:35	13.7	10.63	9.05	60+
Base Flow	6/19/2009		10:10	16.7	9.34	8.96	60+
Base Flow	6/26/2009		10:45	20.0	8.01	8.27	60+
Base Flow	7/10/2009		11:00	20.6	7.72	8.31	60+
Zero Flow	7/21/2009		10:30				
Zero Flow	8/8/2009		7:40				
Base Flow	8/21/2009		10:20	16.3	4.11	8.45	60+
Zero Flow	9/3/2009		10:30				
Zero Flow	9/24/2009						
Storm Flow	10/2/2009		10:10	11.3	4.22	8.14	13.0
Storm Flow	10/3/2009		12:05	10.9	4.33	8.32	60+
Storm Flow	10/8/2009		11:50	11.1	5.28	8.36	60+
Storm Flow	10/13/2009		10:30	5.9	5.11	8.56	60+

CHEMICAL DATA - Analytes tested for in a lab, 2009 - MVTL, New Ulm

County Ditch 10 - Middle Minnesota Watershed - @ Co. Hwy 29 -

STORET CODE - S005-623

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Base Flow	Grab	4/9/2009	10:00	09-A12885	<2*	<2*	1.3	11.3	0.110*	0.112		3	< 0.16
Base Flow	Grab	4/21/2009	10:20	09-A15281	<2	<2	1	11.8	0.045	0.054	14.8	8	< 0.16
Base Flow	Grab	4/29/2009	12:10	09-A17047							66.3		
Base Flow	Grab	5/1/2009	12:35	09-A17732	7	3	1	11.9	0.033	0.049	143.9	2^	<0.16
Base Flow	Grab	5/12/2009	12:25	09-A19650	3	3	3.2	13.4	0.038	0.056	166.4	2.2	<0.16
Base Flow	Grab	5/27/2009	14:45	09-A22495							547.5		
Base Flow	Grab	6/2/2009	11:45	09-A23467	4	3	1.5	11.9	0.129^	0.134	124.6	2	<0.16
Storm Flow	Grab	6/8/2009	11:00	09-A24385	12	3	1.4	13.7	0.175	0.176	488.4	8.3	<0.16
Storm Flow	Grab	6/11/2009	11:35	09-A25418	9	2	1.5	16.6	0.118	0.094		2.8	<0.16
Base Flow	Grab	6/19/2009	10:10	09-A26932	2	<2	1.6	14.7	0.139^	0.118	290.9	1.7	<0.16
Base Flow	Grab	6/26/2009	10:45	09-A28224	5	<2	1.6	13.2	0.207^	0.196^		4.2	<0.16
Base Flow	Grab	7/10/2009	11:00	09-A30658	6	3	1.9	9.9	0.255^	0.230^	770.1*	4.3	<0.16
Base Flow	Grab	8/21/2009	10:20	09-A39354	3	3	1.2	3.14	0.193^	0.208^	3609	3.6	<0.16
Storm Flow	Grab	10/2/2009	10:10	09-A46100	38	7	1.9	7.7		0.681^			<0.16
Storm Flow	Grab	10/3/2009	12:05	09-A46185	8	3	1.3	11.0		0.465^			<0.16
Storm Flow	Grab	10/8/2009	11:50	09-A47281	<2	<2	1	16.1	0.17	0.209^		8.2	<0.16
Storm Flow	Grab	10/13/2009	10:30	09-A48004	4	2	1.4	17.9	0.124	0.14		2.5	<0.16

Field Data - Measurements taken on-site, 2010

County Ditch 10 - Middle Minnesota Watershed - @ Co. Hwy 29 -

Storet Code - S005-623

Flow Type	Date	Flow	Time	Temp ©	DO	pH	TT1
Snowmelt	3/16/2010		16:50	1.3	14.16	7.97	13.4
Snowmelt	3/17/2010		12:50	1.6	12.79	7.92	17.8
Base Flow	4/13/2010		13:55	11.0	12.92	8.48	60+
Base Flow	4/27/2010		11:40	10.6	11.01	8.42	60+
Base Flow	5/5/2010		11:45	9.9	9.26	8.28	60+
Base Flow	5/19/2010		11:40	11.8	9.41	8.14	60+
Base Flow	6/2/2010		11:55	E9	N/A	8.24	60+
Storm Flow	6/11/2010		12:30	E9	E4	7.99	38.1
Base Flow	7/8/2010		10:55	E9	E4	8.14	60+
Base Flow	7/14/2010		16:00	N/A	N/A		60+
Base Flow	7/30/2010		11:35	E9	E4	8.30	60+
Base Flow	8/5/2010		11:35	E9	E4	8.31	60+
Base Flow	8/17/2010		15:55			8.32	60+
Base Flow	8/24/2010		11:15				60+
Base Flow	8/31/2010		9:30				57.1
Storm Flow	9/2/2010		13:45	17.2	8.67	8.15	9.3
Base Flow	9/7/2010		14:25				60+
Storm Flow	9/16/2010		11:55	13.5	9.04	8.32	25.2
Storm Flow	9/23/2010		16:10				
Storm Flow	9/24/2010		9:45				7.3

CHEMICAL DATA - Analytes tested for in a lab, 2010 - MVTL, New Ulm

County Ditch 10 - Middle Minnesota Watershed - @ Co. Hwy 29 -

STORET CODE - S005-623

FLOW TYPE	SAMP TYPE	DATE	TIME	LAB SAMPLE ID #	TSS MG/L	TSVS MG/L	TKN MG/L	N-NO2+NO3 MG/L	P-PO4 MG/L	TP MG/L	E.COLI /100mL	TURBIDITY NTU	Ammonia Mg/L
Snowmelt	Grab	3/16/2010	16:50	10-A9356	182	17	2.7	7.32	0.509^	0.854		57	
Snowmelt	Grab	3/17/2010	12:50	10-A9355	99	13	2.9	8.36	0.518^	0.778		41	0.23
Base Flow	Grab	4/13/2010	13:55	10-A14101	12	12	1.3	19.7	0.036	0.054	20.1*	1.1	<0.16
Base Flow	Grab	4/19/2010	14:30	10-A15380							13.4		
Base Flow	Grab	4/27/2010	11:40	10-A17082	3	2	0.9	19.3	0.037	0.058	34.5	2.3	<0.16
Base Flow	Grab	5/5/2010	11:45	10-A18864	2	<2	0.9	19.8	0.042	0.075	160.7	1.6	<0.16
Base Flow	Grab	5/19/2010	11:40	10-A21906	6	2	1.1	21.9^	0.044	0.064	79.4*	3.2	<0.16
Base Flow	Grab	6/2/2010	11:55	10-A24396	<2	<2	0.7	18.1	0.046	0.066	1732.9	1.2	<0.16
Storm Flow	Grab	6/11/2010	12:30	10-A26171	46	11	1.8	20.7^	0.110	0.202^	1299.7	18	<0.16
Base Flow	Grab	7/8/2010	10:55	10-A31714	11	<2	1.0	17.7^	0.100	0.133	461.1	4.6	<0.16
Base Flow	Grab	7/14/2010	16:00	10-A32951							218.7		
Base Flow	Grab	7/30/2010	11:35	10-A36597	7	3	1.1	12.2	0.117	0.173	435.2	4.4	<0.16
Base Flow	Grab	8/5/2010	11:35	10-A38041	2	<2	1.4	13.9	0.130	0.216	920.8*	2.4	<0.16
Base Flow	Grab	8/17/2010	15:55	10-A40212	2	<2	0.8	17.7	0.145	0.170	290.9	2.5	<0.16
Base Flow	Grab	8/24/2010	11:15	10-A41365							2419.6*		
Base Flow	Grab	8/31/2010	9:30	10-A42645							1413.1*		
Storm Flow	Grab	9/2/2010	13:45	10-A43304	61	13	1.6	14	0.760	0.873^	> 2419.6	76	<0.16
Base Flow	Grab	9/7/2010	14:25	10-A43683							71.7		
Storm Flow	Grab	9/16/2010	11:55	10-A45916	15	7	2.1	19.0^	0.383^	0.551^	>2419.6*	25	<0.16
Storm Flow	Grab	9/23/2010	16:10	10-A47433							>2419.6*		
Storm Flow	Grab	9/24/2010	9:45	10-A47428							>2419.6*		

Flow data for MMCC1
Crow Creek - 2009

Date	Flow (CFS)
4/2/2009	9.9
4/3/2009	8.7
4/4/2009	7.7
4/5/2009	9.8
4/6/2009	10
4/7/2009	10
4/8/2009	9.7
4/9/2009	8.4
4/10/2009	7.6
4/11/2009	7
4/12/2009	7.2
4/13/2009	7.2
4/14/2009	6.7
4/15/2009	6.5
4/16/2009	6.5
4/17/2009	6.7
4/18/2009	7.2
4/19/2009	7.3
4/20/2009	7.3
4/21/2009	6.8
4/22/2009	6.3
4/23/2009	6.5
4/24/2009	6.4
4/25/2009	5.7
4/26/2009	8.2
4/27/2009	6.7
4/28/2009	5.4
4/29/2009	7.9
4/30/2009	7.8
5/1/2009	8
5/2/2009	7.6
5/3/2009	6.6
5/4/2009	5.9
5/5/2009	7.3
5/6/2009	5.9
5/7/2009	5
5/8/2009	7.7
5/9/2009	8.3
5/10/2009	8.6
5/11/2009	8.9
5/12/2009	9.4
5/13/2009	9.5
5/14/2009	7.8

Flow data for MMCC1
Crow Creek - 2009

Date	Flow (CFS)
5/15/2009	8.9
5/16/2009	6.5
5/17/2009	6.5
5/18/2009	6.8
5/19/2009	6.8
5/20/2009	7.7
5/21/2009	10
5/22/2009	11
5/23/2009	13
5/24/2009	11
5/25/2009	11
5/26/2009	11
5/27/2009	12
5/28/2009	11
5/29/2009	9.7
5/30/2009	9.2
5/31/2009	9.6
6/1/2009	11
6/2/2009	8.7
6/3/2009	7.3
6/4/2009	7.4
6/5/2009	7.5
6/6/2009	10
6/7/2009	11
6/8/2009	50
6/9/2009	34
6/10/2009	23
6/11/2009	18
6/12/2009	16
6/13/2009	14
6/14/2009	13
6/15/2009	12
6/16/2009	11
6/17/2009	12
6/18/2009	12
6/19/2009	11
6/20/2009	10
6/21/2009	8.7
6/22/2009	9.7
6/23/2009	7.3
6/24/2009	6
6/25/2009	5.4
6/26/2009	5.5

Flow data for MMCC1
Crow Creek - 2009

Date	Flow (CFS)
6/27/2009	6.9
6/28/2009	5.3
6/29/2009	4.4
6/30/2009	3.6
7/1/2009	3.1
7/2/2009	2.7
7/3/2009	2.5
7/4/2009	2.8
7/5/2009	2.7
7/6/2009	2.2
7/7/2009	1.9
7/8/2009	1.7
7/9/2009	2
7/10/2009	1.9
7/11/2009	1.6
7/12/2009	1.5
7/13/2009	1.4
7/14/2009	1.3
7/15/2009	1.2
7/16/2009	1.5
7/17/2009	1.5
7/18/2009	1.5
7/19/2009	1.3
7/20/2009	1.3
7/21/2009	1.5
7/22/2009	1.1
7/23/2009	0.77
7/24/2009	0.87
7/25/2009	0.9
7/26/2009	0.94
7/27/2009	0.83
7/28/2009	0.51
7/29/2009	0.53
7/30/2009	0.57
7/31/2009	1.3
8/1/2009	2.2
8/2/2009	0.69
8/3/2009	0.51
8/4/2009	0.4
8/5/2009	0.32
8/6/2009	0.3
8/7/2009	0.94
8/8/2009	1

Flow data for MMCC1
Crow Creek - 2009

Date	Flow (CFS)
8/9/2009	1.3
8/10/2009	0.95
8/11/2009	0.49
8/12/2009	0.4
8/13/2009	0.38
8/14/2009	0.34
8/15/2009	0.32
8/16/2009	0.56
8/17/2009	0.32
8/18/2009	0.29
8/19/2009	0.28
8/20/2009	2.2
8/21/2009	2.5
8/22/2009	0.94
8/23/2009	0.31
8/24/2009	0.26
8/25/2009	0.27
8/26/2009	0.26
8/27/2009	0.26
8/28/2009	0.26
8/29/2009	0.26
8/30/2009	0.26
8/31/2009	0.26
9/1/2009	0.26
9/2/2009	0.26
9/3/2009	0.26
9/4/2009	0.26
9/5/2009	0.26
9/6/2009	0.26
9/7/2009	0.26
9/8/2009	0.26
9/9/2009	0.26
9/10/2009	4.1
9/11/2009	0.6
9/12/2009	2.3
9/13/2009	0.45
9/14/2009	0.42
9/15/2009	0.57
9/16/2009	0.51
9/17/2009	0.41
9/18/2009	0.37
9/19/2009	0.34
9/20/2009	0.3

Flow data for MMCC1
Crow Creek - 2009

Date	Flow (CFS)
9/21/2009	0.27
9/22/2009	0.59
9/23/2009	0.34
9/24/2009	0.3
9/25/2009	0.86
9/26/2009	11
9/27/2009	3.2
9/28/2009	1.5
9/29/2009	0.97
9/30/2009	0.78
10/1/2009	15

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
3/16/2010	387
3/17/2010	339
3/18/2010	308
3/19/2010	258
3/20/2010	223
3/21/2010	193
3/22/2010	164
3/23/2010	144
3/24/2010	127
3/25/2010	102
3/26/2010	77
3/27/2010	63
3/28/2010	52
3/29/2010	43
3/30/2010	36
3/31/2010	27
4/1/2010	22
4/2/2010	20
4/3/2010	16
4/4/2010	14
4/5/2010	13
4/6/2010	13
4/7/2010	11

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
4/8/2010	11
4/9/2010	10
4/10/2010	9.1
4/11/2010	8.5
4/12/2010	9.5
4/13/2010	9.2
4/14/2010	9.1
4/15/2010	12
4/16/2010	11
4/17/2010	11
4/18/2010	11
4/19/2010	11
4/20/2010	11
4/21/2010	11
4/22/2010	10
4/23/2010	9.6
4/24/2010	12
4/25/2010	9.9
4/26/2010	9.1
4/27/2010	8.5
4/28/2010	8.9
4/29/2010	9.8
4/30/2010	11
5/1/2010	8.8
5/2/2010	8.3
5/3/2010	7.9
5/4/2010	8.2
5/5/2010	8
5/6/2010	7.5
5/7/2010	10
5/8/2010	12
5/9/2010	13
5/10/2010	16
5/11/2010	104
5/12/2010	81
5/13/2010	61
5/14/2010	46
5/15/2010	35

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
5/16/2010	27
5/17/2010	23
5/18/2010	20
5/19/2010	18
5/20/2010	17
5/21/2010	19
5/22/2010	26
5/23/2010	19
5/24/2010	19
5/25/2010	19
5/26/2010	19
5/27/2010	18
5/28/2010	18
5/29/2010	17
5/30/2010	17
5/31/2010	14
6/1/2010	15
6/2/2010	13
6/3/2010	12
6/4/2010	13
6/5/2010	13
6/6/2010	11
6/7/2010	10
6/8/2010	11
6/9/2010	9.5
6/10/2010	9.6
6/11/2010	244
6/12/2010	226
6/13/2010	180
6/14/2010	137
6/15/2010	118
6/16/2010	84
6/17/2010	62
6/18/2010	42
6/19/2010	30
6/20/2010	24
6/21/2010	21
6/22/2010	18

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
6/23/2010	23
6/24/2010	17
6/25/2010	30
6/26/2010	105
6/27/2010	324
6/28/2010	217
6/29/2010	147
6/30/2010	92
7/1/2010	55
7/2/2010	38
7/3/2010	29
7/4/2010	24
7/5/2010	21
7/6/2010	19
7/7/2010	17
7/8/2010	15
7/9/2010	13
7/10/2010	12
7/11/2010	18
7/12/2010	12
7/13/2010	10
7/14/2010	9.4
7/15/2010	7.6
7/16/2010	6.7
7/17/2010	6.1
7/18/2010	5.7
7/19/2010	5.1
7/20/2010	4.9
7/21/2010	4.5
7/22/2010	5.2
7/23/2010	4.7
7/24/2010	37
7/25/2010	13
7/26/2010	9.6
7/27/2010	8.8
7/28/2010	6.5
7/29/2010	5.1
7/30/2010	5

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
7/31/2010	4.9
8/1/2010	4.8
8/2/2010	5.1
8/3/2010	4.7
8/4/2010	4.4
8/5/2010	3.3
8/6/2010	2.9
8/7/2010	3.5
8/8/2010	3
8/9/2010	2.8
8/10/2010	3.7
8/11/2010	2.8
8/12/2010	3
8/13/2010	4
8/14/2010	2.5
8/15/2010	2.3
8/16/2010	1.9
8/17/2010	1.7
8/18/2010	1.9
8/19/2010	2
8/20/2010	2.7
8/21/2010	2
8/22/2010	2
8/23/2010	3.3
8/24/2010	4.5
8/25/2010	1.4
8/26/2010	1.4
8/27/2010	1.6
8/28/2010	1.6
8/29/2010	1.6
8/30/2010	1.7
8/31/2010	3.6
9/1/2010	0.9
9/2/2010	11
9/3/2010	3.4
9/4/2010	3.9
9/5/2010	3.4
9/6/2010	3.4

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
9/7/2010	3.5
9/8/2010	3.1
9/9/2010	4.2
9/10/2010	4.1
9/11/2010	3.5
9/12/2010	2.8
9/13/2010	2.5
9/14/2010	2.5
9/15/2010	28
9/16/2010	31
9/17/2010	25
9/18/2010	15
9/19/2010	11
9/20/2010	10
9/21/2010	10
9/22/2010	15
9/23/2010	353
9/24/2010	314
9/25/2010	239
9/26/2010	191
9/27/2010	150
9/28/2010	120
9/29/2010	93
9/30/2010	72
10/1/2010	55
10/2/2010	43
10/3/2010	36
10/4/2010	32
10/5/2010	28
10/6/2010	26
10/7/2010	24
10/8/2010	23
10/9/2010	23
10/10/2010	22
10/11/2010	21
10/12/2010	20
10/13/2010	19
10/14/2010	19

Flow data for MMCC1
Crow Creek - 2010

Date	Flow (CFS)
10/15/2010	19
10/16/2010	18
10/17/2010	17
10/18/2010	16
10/19/2010	16
10/20/2010	16
10/21/2010	15
10/22/2010	15
10/23/2010	15
10/24/2010	23
10/25/2010	21

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
4/2/2009	1440
4/3/2009	1310
4/4/2009	1160
4/5/2009	1040
4/6/2009	917
4/7/2009	833
4/8/2009	773
4/9/2009	726
4/10/2009	704
4/11/2009	706
4/12/2009	689
4/13/2009	646
4/14/2009	592
4/15/2009	540
4/16/2009	493
4/17/2009	451
4/18/2009	408
4/19/2009	361
4/20/2009	316
4/21/2009	278
4/22/2009	245
4/23/2009	215
4/24/2009	186
4/25/2009	155
4/26/2009	129
4/27/2009	114
4/28/2009	97
4/29/2009	86
4/30/2009	75
5/1/2009	62
5/2/2009	43
5/3/2009	31
5/4/2009	23
5/5/2009	19
5/6/2009	16
5/7/2009	13
5/8/2009	11

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
5/9/2009	12
5/10/2009	11
5/11/2009	9.5
5/12/2009	8.3
5/13/2009	6.6
5/14/2009	4.9
5/15/2009	4.1
5/16/2009	3.2
5/17/2009	2.5
5/18/2009	2.3
5/19/2009	3.4
5/20/2009	2.4
5/21/2009	1.4
5/22/2009	1.5
5/23/2009	1.2
5/24/2009	1.1
5/25/2009	0.92
5/26/2009	0.91
5/27/2009	0.96
5/28/2009	0.7
5/29/2009	0.52
5/30/2009	0.48
5/31/2009	0.47
6/1/2009	0.52
6/2/2009	0.37
6/3/2009	0.29
6/4/2009	0.28
6/5/2009	0.31
6/6/2009	0.46
6/7/2009	0.93
6/8/2009	24
6/9/2009	60
6/10/2009	42
6/11/2009	31
6/12/2009	26
6/13/2009	22
6/14/2009	19
6/15/2009	18

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
6/16/2009	18
6/17/2009	19
6/18/2009	19
6/19/2009	19
6/20/2009	15
6/21/2009	14
6/22/2009	13
6/23/2009	12
6/24/2009	12
6/25/2009	10
6/26/2009	9.9
6/27/2009	9.4
6/28/2009	7.8
6/29/2009	7
6/30/2009	6.4
7/1/2009	5.7
7/2/2009	4.9
7/3/2009	5
7/4/2009	5.4
7/5/2009	4.3
7/6/2009	3.8
7/7/2009	3.9
7/8/2009	3.8
7/9/2009	3.7
7/10/2009	3.2
7/11/2009	2.5
7/12/2009	2.3
7/13/2009	2.2
7/14/2009	2.2
7/15/2009	1.7
7/16/2009	1.4
7/17/2009	1.4
7/18/2009	1.3
7/19/2009	1.1
7/20/2009	1.2
7/21/2009	1.1
7/22/2009	0.88
7/23/2009	1

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
7/24/2009	1.2
7/25/2009	0.83
7/26/2009	0.69
7/27/2009	0.61
7/28/2009	0.49
7/29/2009	0.43
7/30/2009	0.47
7/31/2009	0.58
8/1/2009	0.76
8/2/2009	0.55
8/3/2009	0.75
8/4/2009	0.64
8/5/2009	0.4
8/6/2009	0.46
8/7/2009	1.5
8/8/2009	1.5
8/9/2009	2.3
8/10/2009	1.3
8/11/2009	0.76
8/12/2009	0.6
8/13/2009	0.76
8/14/2009	0.6
8/15/2009	0.9
8/16/2009	1.4
8/17/2009	0.84
8/18/2009	0.91
8/19/2009	2.7
8/20/2009	3.5
8/21/2009	5.2
8/22/2009	3.4
8/23/2009	2.2
8/24/2009	1.7
8/25/2009	1.2
8/26/2009	0.91
8/27/2009	0.37
8/28/2009	0.5
8/29/2009	1.1
8/30/2009	0.96

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
8/31/2009	1.2
9/1/2009	1.4
9/2/2009	0.65
9/3/2009	2.3
9/4/2009	0.64
9/5/2009	0.8
9/6/2009	0.59
9/7/2009	0.69
9/8/2009	0.87
9/9/2009	1
9/10/2009	0.93
9/11/2009	1.7
9/12/2009	2.6
9/13/2009	1.8
9/14/2009	1.9
9/15/2009	2.2
9/16/2009	1.6
9/17/2009	1.6
9/18/2009	0.6
9/19/2009	0.96
9/20/2009	1.3
9/21/2009	1.5
9/22/2009	1.6
9/23/2009	1.5
9/24/2009	1.8
9/25/2009	1.8
9/26/2009	1.3
9/27/2009	0.91
9/28/2009	0.63
9/29/2009	0.5
9/30/2009	0.54
10/1/2009	19
10/2/2009	29
10/3/2009	26
10/4/2009	19
10/5/2009	35
10/6/2009	40
10/7/2009	38

Flow data for MMWC
Wabasha Creek - 2009

Date	Flow (CFS)
10/8/2009	28
10/9/2009	23
10/10/2009	19
10/11/2009	13
10/12/2009	13
10/13/2009	13
10/14/2009	23
10/15/2009	30
10/16/2009	33
10/17/2009	28
10/18/2009	27
10/19/2009	26
10/20/2009	22
10/21/2009	27
10/22/2009	31
10/23/2009	31
10/24/2009	26
10/25/2009	22
10/26/2009	17
10/27/2009	15
10/28/2009	14
10/29/2009	13
10/30/2009	16
10/31/2009	21
11/1/2009	21
11/2/2009	24

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
3/13/2010	406
3/14/2010	618
3/15/2010	921
3/16/2010	1270
3/17/2010	1490
3/18/2010	2240
3/19/2010	3040

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
3/20/2010	3160
3/21/2010	2880
3/22/2010	3110
3/23/2010	3900
3/24/2010	4780
3/25/2010	5440
3/26/2010	5600
3/27/2010	4840
3/28/2010	3940
3/29/2010	3410
3/30/2010	2920
3/31/2010	2440
4/1/2010	1910
4/2/2010	1700
4/3/2010	1480
4/4/2010	1290
4/5/2010	1100
4/6/2010	958
4/7/2010	847
4/8/2010	753
4/9/2010	663
4/10/2010	584
4/11/2010	512
4/12/2010	442
4/13/2010	373
4/14/2010	305
4/15/2010	259
4/16/2010	224
4/17/2010	185
4/18/2010	152
4/19/2010	124
4/20/2010	95
4/21/2010	67
4/22/2010	45
4/23/2010	29
4/24/2010	17
4/25/2010	8.5
4/26/2010	4.1

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
4/27/2010	1.6
4/28/2010	3
4/29/2010	4
4/30/2010	4.7
5/1/2010	6.5
5/2/2010	7.7
5/3/2010	9
5/4/2010	11
5/5/2010	12
5/6/2010	13
5/7/2010	13
5/8/2010	13
5/9/2010	15
5/10/2010	16
5/11/2010	5.7
5/12/2010	7.2
5/13/2010	12
5/14/2010	15
5/15/2010	17
5/16/2010	18
5/17/2010	21
5/18/2010	23
5/19/2010	27
5/20/2010	30
5/21/2010	32
5/22/2010	32
5/23/2010	30
5/24/2010	32
5/25/2010	34
5/26/2010	36
5/27/2010	37
5/28/2010	36
5/29/2010	35
5/30/2010	34
5/31/2010	34
6/1/2010	33
6/2/2010	32
6/3/2010	31

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
6/4/2010	30
6/5/2010	29
6/6/2010	28
6/7/2010	27
6/8/2010	27
6/9/2010	26
6/10/2010	25
6/11/2010	31
6/12/2010	37
6/13/2010	56
6/14/2010	100
6/15/2010	129
6/16/2010	141
6/17/2010	149
6/18/2010	151
6/19/2010	146
6/20/2010	136
6/21/2010	118
6/22/2010	92
6/23/2010	81
6/24/2010	89
6/25/2010	139
6/26/2010	197
6/27/2010	376
6/28/2010	464
6/29/2010	456
6/30/2010	388
7/1/2010	311
7/2/2010	248
7/3/2010	194
7/4/2010	144
7/5/2010	101
7/6/2010	82
7/7/2010	76
7/8/2010	59
7/9/2010	38
7/10/2010	32
7/11/2010	32

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
7/12/2010	33
7/13/2010	31
7/14/2010	30
7/15/2010	27
7/16/2010	24
7/17/2010	22
7/18/2010	21
7/19/2010	19
7/20/2010	18
7/21/2010	17
7/22/2010	18
7/23/2010	17
7/24/2010	43
7/25/2010	37
7/26/2010	27
7/27/2010	22
7/28/2010	18
7/29/2010	15
7/30/2010	14
7/31/2010	13
8/1/2010	12
8/2/2010	12
8/3/2010	12
8/4/2010	11
8/5/2010	9.6
8/6/2010	9.4
8/7/2010	9.6
8/8/2010	9.4
8/9/2010	9.2
8/10/2010	9.7
8/11/2010	11
8/12/2010	11
8/13/2010	11
8/14/2010	24
8/15/2010	47
8/16/2010	25
8/17/2010	9
8/18/2010	7.7

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
8/19/2010	6.5
8/20/2010	6.2
8/21/2010	5.6
8/22/2010	5.3
8/23/2010	5
8/24/2010	5.3
8/25/2010	5.8
8/26/2010	5.1
8/27/2010	4.4
8/28/2010	3.9
8/29/2010	3.7
8/30/2010	3.5
8/31/2010	4.5
9/1/2010	4
9/2/2010	16
9/3/2010	21
9/4/2010	18
9/5/2010	21
9/6/2010	21
9/7/2010	22
9/8/2010	28
9/9/2010	33
9/10/2010	34
9/11/2010	36
9/12/2010	37
9/13/2010	35
9/14/2010	27
9/15/2010	21
9/16/2010	25
9/17/2010	89
9/18/2010	166
9/19/2010	201
9/20/2010	199
9/21/2010	172
9/22/2010	142
9/23/2010	239
9/24/2010	383
9/25/2010	597

Flow data for MMWC
Wabasha Creek - 2010

Date	Flow (CFS)
9/26/2010	850
9/27/2010	1860
9/28/2010	1460
9/29/2010	892
9/30/2010	717
10/1/2010	596
10/2/2010	491
10/3/2010	379
10/4/2010	276
10/5/2010	207
10/6/2010	163
10/7/2010	134
10/8/2010	111
10/9/2010	90
10/10/2010	72
10/11/2010	53
10/12/2010	35
10/13/2010	20
10/14/2010	11
10/15/2010	10
10/16/2010	11
10/17/2010	11
10/18/2010	12
10/19/2010	13
10/20/2010	14
10/21/2010	14
10/22/2010	15
10/23/2010	16
10/24/2010	18
10/25/2010	19

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
4/2/2009	3.1
4/3/2009	2.3
4/4/2009	1.9
4/5/2009	1.6
4/6/2009	2.2
4/7/2009	3.2
4/8/2009	2
4/9/2009	1.4
4/10/2009	1.2
4/11/2009	1.1
4/12/2009	1.1
4/13/2009	1.1
4/14/2009	1.1
4/15/2009	1.1
4/16/2009	1.1
4/17/2009	1.2
4/18/2009	1.3
4/19/2009	1.5
4/20/2009	1.7
4/21/2009	1.6
4/22/2009	1.3
4/23/2009	1.1
4/24/2009	1.2
4/25/2009	0.97
4/26/2009	1.4
4/27/2009	1.5
4/28/2009	1.2
4/29/2009	1.4
4/30/2009	1.5
5/1/2009	1.5
5/2/2009	1.5
5/3/2009	1.5
5/4/2009	1.5
5/5/2009	1.8
5/6/2009	1.7
5/7/2009	1.6
5/8/2009	1.9

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
5/9/2009	3.6
5/10/2009	6.8
5/11/2009	5.7
5/12/2009	4.9
5/13/2009	4.3
5/14/2009	3
5/15/2009	2.5
5/16/2009	2.3
5/17/2009	1.8
5/18/2009	1.7
5/19/2009	1.7
5/20/2009	1.5
5/21/2009	1.3
5/22/2009	1.2
5/23/2009	1.3
5/24/2009	1.1
5/25/2009	1
5/26/2009	1.1
5/27/2009	1.1
5/28/2009	0.96
5/29/2009	0.89
5/30/2009	0.89
5/31/2009	0.91
6/1/2009	0.9
6/2/2009	0.86
6/3/2009	0.8
6/4/2009	0.68
6/5/2009	0.59
6/6/2009	0.76
6/7/2009	0.82
6/8/2009	3.3
6/9/2009	9.5
6/10/2009	11
6/11/2009	2.9
6/12/2009	2.7
6/13/2009	2.3
6/14/2009	1.5
6/15/2009	1.6

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
6/16/2009	1.6
6/17/2009	1.5
6/18/2009	1.4
6/19/2009	1.4
6/20/2009	1.2
6/21/2009	1.2
6/22/2009	1.2
6/23/2009	1.1
6/24/2009	1.1
6/25/2009	1
6/26/2009	0.95
6/27/2009	0.97
6/28/2009	0.9
6/29/2009	0.81
6/30/2009	0.8
7/1/2009	0.76
7/2/2009	0.72
7/3/2009	0.75
7/4/2009	0.81
7/5/2009	0.72
7/6/2009	0.65
7/7/2009	0.67
7/8/2009	0.69
7/9/2009	0.71
7/10/2009	0.67
7/11/2009	0.62
7/12/2009	0.58
7/13/2009	0.55
7/14/2009	0.58
7/15/2009	0.52
7/16/2009	0.49
7/17/2009	0.49
7/18/2009	0.49
7/19/2009	0.48
7/20/2009	0.49
7/21/2009	0.47
7/22/2009	0.42
7/23/2009	0.41

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
7/24/2009	0.38
7/25/2009	0.38
7/26/2009	0.34
7/27/2009	0.34
7/28/2009	0.34
7/29/2009	0.36
7/30/2009	0.36
7/31/2009	0.39
8/1/2009	0.41
8/2/2009	0.35
8/3/2009	0.33
8/4/2009	0.33
8/5/2009	0.31
8/6/2009	0.31
8/7/2009	0.51
8/8/2009	0.42
8/9/2009	0.47
8/10/2009	0.41
8/11/2009	0.35
8/12/2009	0.32
8/13/2009	0.35
8/14/2009	0.36
8/15/2009	0.41
8/16/2009	0.5
8/17/2009	0.37
8/18/2009	0.35
8/19/2009	0.62
8/20/2009	0.61
8/21/2009	0.6
8/22/2009	0.52
8/23/2009	0.43
8/24/2009	0.4
8/25/2009	0.39
8/26/2009	0.38
8/27/2009	0.35
8/28/2009	0.37
8/29/2009	0.36
8/30/2009	0.36

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
8/31/2009	0.38
9/1/2009	0.38
9/2/2009	0.38
9/3/2009	0.42
9/4/2009	0.47
9/5/2009	0.49
9/6/2009	0.48
9/7/2009	0.51
9/8/2009	0.52
9/9/2009	0.56
9/10/2009	0.55
9/11/2009	0.7
9/12/2009	0.68
9/13/2009	0.5
9/14/2009	0.44
9/15/2009	0.37
9/16/2009	0.33
9/17/2009	0.29
9/18/2009	0.27
9/19/2009	0.28
9/20/2009	0.28
9/21/2009	0.42
9/22/2009	0.38
9/23/2009	0.32
9/24/2009	0.31
9/25/2009	0.51
9/26/2009	0.32
9/27/2009	0.3
9/28/2009	0.33
9/29/2009	0.41
9/30/2009	0.42
10/1/2009	1.2
10/2/2009	1.4
10/3/2009	1.4
10/4/2009	0.99
10/5/2009	0.86
10/6/2009	1.6
10/7/2009	4.9

Flow data for MMNE
North Eden Creek - 2009

Date	Flow (CFS)
10/8/2009	6.5
10/9/2009	2.7
10/10/2009	1.6
10/11/2009	1.2
10/12/2009	1.2
10/13/2009	1.1
10/14/2009	1
10/15/2009	1.2
10/16/2009	1.3
10/17/2009	1.5
10/18/2009	1.7
10/19/2009	1.7
10/20/2009	1.6
10/21/2009	2.8
10/22/2009	9.2
10/23/2009	12
10/24/2009	9.9
10/25/2009	9.3
10/26/2009	6.1
10/27/2009	5.1
10/28/2009	4.8
10/29/2009	3.7
10/30/2009	5.9
10/31/2009	11
11/1/2009	11
11/2/2009	8.4

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
3/16/2010	464
3/17/2010	512
3/18/2010	628
3/19/2010	326
3/20/2010	222
3/21/2010	191
3/22/2010	121

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
3/23/2010	92
3/24/2010	78
3/25/2010	58
3/26/2010	42
3/27/2010	32
3/28/2010	28
3/29/2010	26
3/30/2010	18
3/31/2010	16
4/1/2010	14
4/2/2010	11
4/3/2010	12
4/4/2010	13
4/5/2010	12
4/6/2010	12
4/7/2010	11
4/8/2010	11
4/9/2010	8.8
4/10/2010	12
4/11/2010	19
4/12/2010	20
4/13/2010	19
4/14/2010	15
4/15/2010	15
4/16/2010	19
4/17/2010	17
4/18/2010	21
4/19/2010	19
4/20/2010	15
4/21/2010	15
4/22/2010	18
4/23/2010	29
4/24/2010	26
4/25/2010	26
4/26/2010	20
4/27/2010	26
4/28/2010	19
4/29/2010	15

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
4/30/2010	11
5/1/2010	5.9
5/2/2010	8.4
5/3/2010	6.2
5/4/2010	11
5/5/2010	13
5/6/2010	13
5/7/2010	13
5/8/2010	12
5/9/2010	22
5/10/2010	24
5/11/2010	33
5/12/2010	30
5/13/2010	25
5/14/2010	18
5/15/2010	18
5/16/2010	15
5/17/2010	14
5/18/2010	16
5/19/2010	17
5/20/2010	15
5/21/2010	13
5/22/2010	14
5/23/2010	11
5/24/2010	17
5/25/2010	20
5/26/2010	18
5/27/2010	16
5/28/2010	11
5/29/2010	14
5/30/2010	11
5/31/2010	8.5
6/1/2010	10
6/2/2010	9.7
6/3/2010	10
6/4/2010	9.9
6/5/2010	12
6/6/2010	10

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
6/7/2010	6.4
6/8/2010	11
6/9/2010	11
6/10/2010	11
6/11/2010	17
6/12/2010	28
6/13/2010	32
6/14/2010	26
6/15/2010	24
6/16/2010	21
6/17/2010	14
6/18/2010	14
6/19/2010	14
6/20/2010	12
6/21/2010	15
6/22/2010	13
6/23/2010	16
6/24/2010	15
6/25/2010	49
6/26/2010	90
6/27/2010	363
6/28/2010	161
6/29/2010	42
6/30/2010	31
7/1/2010	23
7/2/2010	15
7/3/2010	14
7/4/2010	13
7/5/2010	11
7/6/2010	10
7/7/2010	5.2
7/8/2010	4.7
7/9/2010	5.6
7/10/2010	6.8
7/11/2010	11
7/12/2010	9.6
7/13/2010	8.9
7/14/2010	8.1

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
7/15/2010	5.3
7/16/2010	2.6
7/17/2010	2.7
7/18/2010	2.1
7/19/2010	1.9
7/20/2010	1.6
7/21/2010	1.5
7/22/2010	2.1
7/23/2010	2.1
7/24/2010	19
7/25/2010	18
7/26/2010	12
7/27/2010	8.8
7/28/2010	8.5
7/29/2010	3.7
7/30/2010	3.4
7/31/2010	3
8/1/2010	2.9
8/2/2010	2.4
8/3/2010	2.1
8/4/2010	2
8/5/2010	1.3
8/6/2010	1.1
8/7/2010	1.1
8/8/2010	1
8/9/2010	0.9
8/10/2010	1.1
8/11/2010	0.96
8/12/2010	1.6
8/13/2010	1.5
8/14/2010	1.3
8/15/2010	1.3
8/16/2010	1.1
8/17/2010	0.96
8/18/2010	0.92
8/19/2010	0.89
8/20/2010	0.88
8/21/2010	0.82

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
8/22/2010	0.83
8/23/2010	0.83
8/24/2010	0.96
8/25/2010	0.8
8/26/2010	0.82
8/27/2010	0.79
8/28/2010	0.73
8/29/2010	0.71
8/30/2010	0.7
8/31/2010	1.2
9/1/2010	0.88
9/2/2010	2.1
9/3/2010	7.8
9/4/2010	4.4
9/5/2010	2
9/6/2010	1.7
9/7/2010	1.6
9/8/2010	1.5
9/9/2010	1.4
9/10/2010	1.3
9/11/2010	1.2
9/12/2010	1
9/13/2010	0.96
9/14/2010	0.89
9/15/2010	1.5
9/16/2010	2.1
9/17/2010	9.9
9/18/2010	6.5
9/19/2010	4.4
9/20/2010	3.8
9/21/2010	5
9/22/2010	9
9/23/2010	377
9/24/2010	340
9/25/2010	209
9/26/2010	169
9/27/2010	127
9/28/2010	103

Flow data for MMNE
North Eden Creek - 2010

Date	Flow (CFS)
9/29/2010	85
9/30/2010	65
10/1/2010	57
10/2/2010	49
10/3/2010	43
10/4/2010	35
10/5/2010	28
10/6/2010	21
10/7/2010	22
10/8/2010	23
10/9/2010	23
10/10/2010	32
10/11/2010	26
10/12/2010	31
10/13/2010	32
10/14/2010	46
10/15/2010	33
10/16/2010	30
10/17/2010	30
10/18/2010	31
10/19/2010	29
10/20/2010	20
10/21/2010	20
10/22/2010	16
10/23/2010	16
10/24/2010	18
10/25/2010	22

Flow data for MMSC Spring Creek - 2009

Date	Flow (CFS)
4/2/2009	17
4/3/2009	12
4/4/2009	20
4/5/2009	26
4/6/2009	26
4/7/2009	25
4/8/2009	16
4/9/2009	9.5
4/10/2009	7.5
4/11/2009	6.9
4/12/2009	6.4
4/13/2009	6
4/14/2009	5.7
4/15/2009	5.6
4/16/2009	5.4
4/17/2009	5.3
4/18/2009	5.3
4/19/2009	6
4/20/2009	6
4/21/2009	5.3
4/22/2009	4.8
4/23/2009	4.7
4/24/2009	5.1
4/25/2009	4.9
4/26/2009	5.9
4/27/2009	6.3
4/28/2009	6
4/29/2009	5.9
4/30/2009	6.4
5/1/2009	6.6
5/2/2009	6.6
5/3/2009	6.6
5/4/2009	6
5/5/2009	6.6
5/6/2009	6.6
5/7/2009	6.2
5/8/2009	6.7

Flow data for MMSC Spring Creek - 2009

Date	Flow (CFS)
5/9/2009	8.2
5/10/2009	10
5/11/2009	10
5/12/2009	9.7
5/13/2009	9.1
5/14/2009	8.6
5/15/2009	7.9
5/16/2009	7.6
5/17/2009	6.9
5/18/2009	6.3
5/19/2009	6
5/20/2009	5.7
5/21/2009	5.3
5/22/2009	4.9
5/23/2009	5.1
5/24/2009	5
5/25/2009	4.6
5/26/2009	4.7
5/27/2009	5
5/28/2009	4.5
5/29/2009	4
5/30/2009	3.9
5/31/2009	3.6
6/1/2009	4
6/2/2009	3.2
6/3/2009	3
6/4/2009	2.9
6/5/2009	2.7
6/6/2009	4
6/7/2009	4.4
6/8/2009	15
6/9/2009	32
6/10/2009	32
6/11/2009	24
6/12/2009	20
6/13/2009	15
6/14/2009	11
6/15/2009	9.4

Flow data for MMSC
Spring Creek - 2009

Date	Flow (CFS)
6/16/2009	9.5
6/17/2009	9.2
6/18/2009	9
6/19/2009	9
6/20/2009	8.5
6/21/2009	8.6
6/22/2009	8.5
6/23/2009	8.2
6/24/2009	8.2
6/25/2009	7.7
6/26/2009	7.4
6/27/2009	6.9
6/28/2009	6.8
6/29/2009	6.4
6/30/2009	6
7/1/2009	5.7
7/2/2009	5.2
7/3/2009	4.8
7/4/2009	4.4
7/5/2009	4
7/6/2009	3.7
7/7/2009	3.5
7/8/2009	3.3
7/9/2009	3.3
7/10/2009	3.7
7/11/2009	3.5
7/12/2009	3.4
7/13/2009	3
7/14/2009	3
7/15/2009	2.6
7/16/2009	2.4
7/17/2009	2.2
7/18/2009	2.1
7/19/2009	1.7
7/20/2009	1.7
7/21/2009	2.1
7/22/2009	1.6
7/23/2009	1.4

Flow data for MMSC
Spring Creek - 2009

Date	Flow (CFS)
7/24/2009	1.5
7/25/2009	1.5
7/26/2009	1.3
7/27/2009	1.4
7/28/2009	1.5
7/29/2009	1.4
7/30/2009	1.5
7/31/2009	1.6
8/1/2009	1.9
8/2/2009	1.5
8/3/2009	1.6
8/4/2009	1.6
8/5/2009	1.4
8/6/2009	1.6
8/7/2009	3.2
8/8/2009	2.7
8/9/2009	2.5
8/10/2009	2.4
8/11/2009	2.1
8/12/2009	1.9
8/13/2009	1.8
8/14/2009	1.7
8/15/2009	1.9
8/16/2009	2.2
8/17/2009	1.3
8/18/2009	1.1
8/19/2009	2.9
8/20/2009	3.1
8/21/2009	2.5
8/22/2009	2.3
8/23/2009	1.9
8/24/2009	1.6
8/25/2009	1.5
8/26/2009	1.2
8/27/2009	1
8/28/2009	0.77
8/29/2009	0.79
8/30/2009	0.79

Flow data for MMSC
Spring Creek - 2009

Date	Flow (CFS)
8/31/2009	0.96
9/1/2009	0.97
9/2/2009	1.1
9/3/2009	1.1
9/4/2009	0.93
9/5/2009	1.1
9/6/2009	0.91
9/7/2009	0.97
9/8/2009	1
9/9/2009	1.3
9/10/2009	1.2
9/11/2009	3.4
9/12/2009	3.2
9/13/2009	1.4
9/14/2009	1.3
9/15/2009	1.2
9/16/2009	1.3
9/17/2009	1.2
9/18/2009	1.2
9/19/2009	1.3
9/20/2009	1.2
9/21/2009	1.5
9/22/2009	1.3
9/23/2009	1.3
9/24/2009	1.4
9/25/2009	2.7
9/26/2009	1.5
9/27/2009	1.2
9/28/2009	1.3
9/29/2009	1.4
9/30/2009	1.2
10/1/2009	22
10/2/2009	29
10/3/2009	24
10/4/2009	21
10/5/2009	20
10/6/2009	45
10/7/2009	45

Flow data for MMSC Spring Creek - 2009

Date	Flow (CFS)
10/8/2009	35
10/9/2009	30
10/10/2009	27
10/11/2009	24
10/12/2009	23
10/13/2009	22
10/14/2009	21
10/15/2009	23
10/16/2009	25
10/17/2009	26
10/18/2009	26
10/19/2009	25
10/20/2009	25
10/21/2009	28
10/22/2009	36
10/23/2009	39
10/24/2009	37
10/25/2009	34
10/26/2009	31
10/27/2009	30
10/28/2009	28
10/29/2009	28
10/30/2009	31
10/31/2009	32
11/1/2009	32
11/2/2009	31

Flow data for MMSC Spring Creek - 2010

Date	Flow (CFS)
3/15/2010	470
3/16/2010	424
3/17/2010	410
3/18/2010	459
3/19/2010	429
3/20/2010	330
3/21/2010	248

Flow data for MMSC
Spring Creek - 2010

Date	Flow (CFS)
3/22/2010	181
3/23/2010	144
3/24/2010	158
3/25/2010	224
3/26/2010	236
3/27/2010	275
3/28/2010	327
3/29/2010	334
3/30/2010	336
3/31/2010	336
4/1/2010	330
4/2/2010	283
4/3/2010	222
4/4/2010	162
4/5/2010	111
4/6/2010	79
4/7/2010	65
4/8/2010	53
4/9/2010	42
4/10/2010	31
4/11/2010	23
4/12/2010	19
4/13/2010	30
4/14/2010	34
4/15/2010	39
4/16/2010	50
4/17/2010	46
4/18/2010	38
4/19/2010	32
4/20/2010	29
4/21/2010	27
4/22/2010	25
4/23/2010	24
4/24/2010	25
4/25/2010	23
4/26/2010	23
4/27/2010	23
4/28/2010	23

Flow data for MMSC Spring Creek - 2010

Date	Flow (CFS)
4/29/2010	21
4/30/2010	21
5/1/2010	19
5/2/2010	19
5/3/2010	18
5/4/2010	18
5/5/2010	18
5/6/2010	17
5/7/2010	18
5/8/2010	20
5/9/2010	22
5/10/2010	23
5/11/2010	41
5/12/2010	65
5/13/2010	53
5/14/2010	43
5/15/2010	37
5/16/2010	33
5/17/2010	31
5/18/2010	29
5/19/2010	27
5/20/2010	26
5/21/2010	26
5/22/2010	25
5/23/2010	25
5/24/2010	24
5/25/2010	23
5/26/2010	23
5/27/2010	23
5/28/2010	23
5/29/2010	23
5/30/2010	23
5/31/2010	23
6/1/2010	23
6/2/2010	23
6/3/2010	23
6/4/2010	23
6/5/2010	23

Flow data for MMSC
Spring Creek - 2010

Date	Flow (CFS)
6/6/2010	22
6/7/2010	22
6/8/2010	17
6/9/2010	14
6/10/2010	16
6/11/2010	22
6/12/2010	30
6/13/2010	44
6/14/2010	46
6/15/2010	48
6/16/2010	45
6/17/2010	38
6/18/2010	33
6/19/2010	28
6/20/2010	24
6/21/2010	22
6/22/2010	20
6/23/2010	19
6/24/2010	17
6/25/2010	19
6/26/2010	40
6/27/2010	201
6/28/2010	175
6/29/2010	96
6/30/2010	57
7/1/2010	35
7/2/2010	27
7/3/2010	23
7/4/2010	22
7/5/2010	21
7/6/2010	20
7/7/2010	19
7/8/2010	19
7/9/2010	18
7/10/2010	17
7/11/2010	17
7/12/2010	16
7/13/2010	16

Flow data for MMSC
Spring Creek - 2010

Date	Flow (CFS)
7/14/2010	16
7/15/2010	15
7/16/2010	14
7/17/2010	13
7/18/2010	12
7/19/2010	11
7/20/2010	10
7/21/2010	9.5
7/22/2010	11
7/23/2010	9.5
7/24/2010	30
7/25/2010	63
7/26/2010	33
7/27/2010	22
7/28/2010	16
7/29/2010	14
7/30/2010	13
7/31/2010	11
8/1/2010	10
8/2/2010	9
8/3/2010	7.9
8/4/2010	7
8/5/2010	6
8/6/2010	5.7
8/7/2010	5.4
8/8/2010	5.1
8/9/2010	4.6
8/10/2010	4.7
8/11/2010	4.4
8/12/2010	4.2
8/13/2010	4.2
8/14/2010	3.9
8/15/2010	3.7
8/16/2010	3.4
8/17/2010	3.3
8/18/2010	3.2
8/19/2010	3
8/20/2010	2.9

Flow data for MMSC
Spring Creek - 2010

Date	Flow (CFS)
8/21/2010	2.7
8/22/2010	2.6
8/23/2010	2.6
8/24/2010	3.1
8/25/2010	2.7
8/26/2010	2.8
8/27/2010	2.6
8/28/2010	2.4
8/29/2010	2.3
8/30/2010	2.4
8/31/2010	3.3
9/1/2010	2.4
9/2/2010	5.8
9/3/2010	6.5
9/4/2010	6.9
9/5/2010	5.6
9/6/2010	4.8
9/7/2010	4.5
9/8/2010	4.2
9/9/2010	4
9/10/2010	4
9/11/2010	4.5
9/12/2010	4.1
9/13/2010	3.8
9/14/2010	3.4
9/15/2010	4.4
9/16/2010	5.2
9/17/2010	11
9/18/2010	10
9/19/2010	7.7
9/20/2010	6.1
9/21/2010	5.2
9/22/2010	9.3
9/23/2010	429
9/24/2010	632
9/25/2010	431
9/26/2010	381
9/27/2010	480

Flow data for MMSC
Spring Creek - 2010

Date	Flow (CFS)
9/28/2010	611
9/29/2010	691
9/30/2010	631
10/1/2010	519
10/2/2010	392
10/3/2010	272
10/4/2010	162
10/5/2010	72
10/6/2010	33
10/7/2010	24
10/8/2010	20
10/9/2010	18
10/10/2010	17
10/11/2010	16
10/12/2010	16
10/13/2010	16
10/14/2010	16
10/15/2010	16
10/16/2010	15
10/17/2010	15
10/18/2010	15
10/19/2010	15
10/20/2010	15
10/21/2010	15
10/22/2010	15
10/23/2010	15
10/24/2010	16

Appendix E: TISWA Material

TISWA Survey Results

SITE_ID	CAT_A	CAT_B	CAT_C	CAT_D	TISWA_RANK	SUB_SHED
COD10-1T	338.3	66.0	174.3	50.7	629.3	COD10
COD10-1U	397.7	66.0	192.8	66.7	723.2	COD10
COD10-2U	380.7	66.0	206.7	66.7	720.0	COD10
COD13-1L	334.5	68.0	187.8	62.0	652.3	COD13
COD13-2T	356.5	68.0	227.3	53.0	704.8	COD13
COD13-1U	390.5	68.0	213.2	61.3	733.0	COD13
COD13-2U	392.0	68.0	201.0	74.7	735.7	COD13
MMSC-1L	346.2	76.0	197.3	60.3	679.8	MMSC
MMSC-2L	309.0	76.0	161.7	55.3	602.0	MMSC
MMSC-1T	361.5	76.0	176.0	54.0	667.5	MMSC
MMSC-2T	363.5	76.0	193.7	57.3	690.5	MMSC
MMSC-1U	379.0	76.0	200.8	57.3	713.2	MMSC
MMSC-2U	410.0	76.0	204.8	65.3	756.2	MMSC
MMSC-3U	384.5	76.0	194.3	68.0	722.8	MMSC
MMNE-1L	315.2	66.0	156.8	53.7	591.7	MMNE
MMNE-1T	352.0	66.0	217.3	57.7	693.0	MMNE
MMNE-2T	349.9	66.0	205.5	56.3	677.7	MMNE
MMNE-3T	345.2	66.0	200.3	57.3	668.8	MMNE
MMNE-1U	393.2	66.0	216.5	70.0	745.7	MMNE
MMNE-2U	393.7	66.0	190.2	73.3	723.2	MMNE
MMWC-6U	387.0	80.0	235.0	72.0	774.0	MMWC
MMWC-5U	380.2	80.0	214.0	69.3	743.5	MMWC
MMWC-2T	366.5	80.0	228.8	64.7	740.0	MMWC
MMWC-1T	343.8	80.0	196.5	58.3	678.7	MMWC
MMWC-2L	316.3	80.0	191.8	59.0	647.2	MMWC
MMWC-1L	291.5	80.0	205.5	62.3	639.3	MMWC
MMWC-3T	370.0	80.0	234.1	68.3	752.4	MMWC
MMWC-4T	363.2	80.0	213.3	70.0	726.5	MMWC
MMWC-7U	382.7	80.0	178.5	68.7	709.8	MMWC
MMWC-3U	399.7	80.0	240.8	68.7	789.2	MMWC
MMWC-1U	400.0	80.0	235.5	79.3	794.8	MMWC
MMWC-2U	412.0	80.0	241.8	73.3	807.2	MMWC
MMWC-4U	391.0	80.0	216.7	68.0	755.7	MMWC
MMCC1-2U	340.0	60.0	205.5	72.7	678.2	MMCC1

MMCC1-3U	333.0	60.0	181.5	63.3		637.8	MMCC1
MMCC1-4U	370.3	60.0	210.8	75.3		716.5	MMCC1
MMCC1-1U	356.5	60.0	248.2	69.3		734.0	MMCC1
MMCC1-5U	358.5	60.0	217.8	60.7		697.0	MMCC1
MMCC1-2T	316.5	60.0	205.2	61.3		643.0	MMCC1
MMCC1-1T	334.7	60.0	203.0	66.0		663.7	MMCC1
MMCC1-1L	296.0	60.0	207.0	60.0		623.0	MMCC1

TISWA ASSESSMENT WORKSHEET

Assessment Point ____________________ Date: ____________________

Tailored Integrated Stream/Ditch Assessment Worksheet (TISWA)

Stream/Ditch name: ____________________ Major Watershed 28000

Topo Location: (Upland - Transition Zone - Lowland) Subshed ID #28________

Field Crew: ____________________

County: ____________ Season/Climatic Conditions: ____________________

Good < = 30 pt	Poor < = 50 pt	Bad < = 70 pt	Terrible > 70 pt

A. - Landuse and Landscape **Site Rank** **Comments**

1. - Estimate of % of perennial vegetation ____________________
2. - Estimate the % of crop residue in Spring ____________________
3. - Estimate the % of wetlands and surface water storage ____________________
4. - Estimate the drainage network density ____________________
5. - Estimate the current % of conservation practices ____________________
6. - Feedlot density, # of open lots ____________________
7. - Feedlot density, # of closed lots ____________________
8. - Estimate the surface tile intake density ____________________
9. - Estimate the % of Highly Erodible Soils ____________________

B. - Pollutant Sources **Site Rank** **Comments**

1. - Estimate amount of manure generation ____________________
2. - Estimate # of unsewered homes ____________________
3. - Estimate of point source facilities ____________________
4. - Estimate unsewered communities ____________________

Photo info: ____________________

____

Assessment Point ______________________ Date: ______________

Tailored Integrated Stream/Ditch Assessment Worksheet (TISWA)

Good < = 30 pt	Poor < = 50 pt	Bad < = 70 pt	Terrible > 70 pt

C. - Riparian Zone and Channel Morphology	Site Rank	Comments
1. - Estimate of riparian buffer zone		
2. - Estimate of eroded banks		
3.-Estimate of down-cutting, undercutting or widening of channel		
4. - Estimate of structural damage from water to bridge		
5. - Estimate of aggraded reaches (Sediment showing or is the river flowing freely and not depositing)?		
6. - Does this stretch have a reachable floodplain?	Yes = 30	No = 70

D. - Biotic and Abiotic Indicators

1. - Estimate of water clarity under higher flows ______________

2. - Estimate of amount of algae in the water ______________

3. - Animal biotic indicators? ______________

Conductivity meter reading **DO:** **Temp:**

Additional Notes:

APPENDIX F: FISHERY SURVEYS

JOHN'S CREEK-1981: INITIAL SURVEY

NA-01475-01
(GF-11) Rev. 4/78
Page 1

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

RIVER OR STREAM SURVEY
DATE(S) OF FIELD WORK John's Creek various dates 1981

Initial Survey [x]
Resurvey [ ]

LEADER Gene Jeseritz
ASSISTANT(S) Delmar Kramer, Duane Williams
Nancy Flicek, Gary Barnard

NAME, LOCATION, AND FLOW CHARACTERISTICS

(1) Stream Name John's Creek
(2) Alternate Name(s) -
(3) Tributary Number M-55-106
(4) Counties Brown County
(5) Watershed Name and Number Cottonwood River 26
(6) Sequence of Waterways to Basin Minnesota River to Mississippi River

(7) Map(s) Used Brown County, Sleepy Eye Quad. 1964 and St. George Quad. 1964
(8) Length of Stream 7 miles
(9) Average Width -- Upper Station - Lower Station 8.5 ft.
(10) Mouth Location T. 111 R. 31 S. 31
(11) Flow at Mouth 1.9 cfs, Date 9-18-81
(12) Flow at Gaging Station -- Minimum - cfs Average - cfs
(13) Location of Gaging Station -
(14) Initial Source of Sustained Flow runoff section 10 and springs in sections 1 & 2
(15) Gradient 30 ft. per mile ave.
(16) Sinuosity 1.3

WATERSHED DESCRIPTION AND USE

(17) Description of Watershed (soil types, cover types, topography, land usage and ownership)

a) Entire watershed Gently rolling clay-loam soils used for agricultural purposes.

b) Land adjacent to stream Land along stream is privately owned. Lower 3 miles of stream goes through mixed hardwood as it nears the Minnesota River. The upper 4 miles is predominantly open and is nearly all ditched.

Na-01558-01
(GF-21) 4/78

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES

FISHERIES RECOMMENDATIONS FOR STREAM MANAGEMENT

Stream name John's Creek

Alternate name -

Tributary no. M-55-106 Date 3-1-82

Reach (mi. to mi.) 0-3 mile

Counties Brown County

Management recommendations:

Stocking Stock in spring and fall with 400-500 ylg brown trout

Habitat Improvement None

Land Acquisition None

Additional Survey Work Continue monitoring fishing success and physical characteristics. Back pack shock to determine over wintering success. Monitor water temps.

Submitted by Roland J. Smith Date 3-29-82
Area Fisheries Manager

Approved by G. Ohlobzgi Date 3-30-82
Regional Fisheries Manager

Department of Natural Resources
South Highway 15, P.O. Box 756
New Ulm, MN 56073

NA-01475-01
(GF-11) Rev. 4/78
Page 2

GENERAL INFORMATION ON THE STREAM

(18) Reason for Survey Current information requested by area manager

(19) Previous Investigations and Surveys Back pack shocking on the following dates: 8-12-81, 3-23-81, 4-23-80, 4-13-79

(20) Special Problems or Conditions Possible high water temps., low flows, water level flucuations, shortness of fishable waters are problems to be considered. Also, the only good access to fishable waters are on a easement basis.

(21) Sources of Pollution

Source	Loc. (mi. from mouth)	Substance discharged
agricultural runoff	upper 4 miles of creek	silt

(22) Erosion

Type	Degree	Affected reach
cattle crossings	light	1 mile up from mouth

(23) Stream Alterations (dredging, channeling) – location and date ditched upstream from county road #10

(24) Dams and other obstructions (include beaver dams)

Type	Mi. from Mouth	Head	Length of Dam	Type of Control Structure	Use	Fish Barrier	Owner	Condition or Status
none								

(25) Use of Water: Fishing X Recreation ___ Commercial navigation ___ Power ___ Irrigation ___
Livestock watering X Other (specify) ___

(26) Access (location and ownership) In section 31 near mouth the Izaak Walton League Chapter 79 of New Ulm secures annual easement from Harley Vogel for purposes of stocking and public access for fishing. Access also available off Hwy. 29, county road 10, and county road 68

(27) Shoreline Developments six farm sites along course of stream

(28) Recreational Boating – a) Navigab ...h
b) Type of boating

(29) Tributaries and Springs

Names and/or Tributary Numbers	Water Source	Bank (R or L)	Length Miles	Width at Mouth (feet)	Miles from Mouth	Flow (c.f.s.)	Stage (high, normal, low)	Temp. °F Mouth Air	Temp. °F Mouth Water	Temp. °F Source Air	Temp. °F Source Water	Time	Date
T-1	runoff	L	1.5	3'	4.1	0	low	59°	-	59	-	1430	9-18-81
T-2	"	R	1.5	3'	4.5	0	low	59	-	59	-	1445	"
T-3	"	R	.18	3'	5.6	0	low	59	-	59	-	1500	"
T-4	"	L	.57	3'	5.8	0	low	59	-	59	-	1515	"

Remarks

NA-01475-01
GF-11) Rev. 4/78
Page 3

NA-01475-01
(GF-11) Rev. 4/78
Page 4

(30) Stream Physical Characteristics *Note

a)	Station no.	1			
b)	Date	9-18-81			
c)	Loc. (mi. from mouth)	1			
d)	Length of station	1,000 ft.			
e)	% of station in:	-			
	Pools	43.9%			
	Riffles and rapids	56.1%			
	Runs	-			
	Other (list)	-			
f)	Average width (ft.)	8.5'			
g)	Average depth (ft.)	.6'			
h)	Flow (cfs)	1.9			
i)	High water mark	4'			
j)	Present stream stage (high, normal, low)	norm			
k)	Banks: immediate	-			
	Average height	4'			
	Height range	2-4'			
	Erosion (lt., mod., severe)	lt.			
	% grazed	100%			
	% ditched or channeled	-			
l)	Shade[1]	heavy			
m)	Pools[2]	-			
	Average width	8'			
	Width range	7-10'			
	Average depth	2'			
	Maximum depth	3'			
	Type – No. of each				
	A				
	B	6			
	C				
	D	7			
	Bottom type – %[3]				
	sandy-muck	100%			
n)	Riffles and rapids				
	Average width	8'			
	Width range	6-10'			
	Average depth	.6'			
	Maximum depth	2'			
	Max. velocity range (fps)	1.9'			
	Bottom type – %				
	sand-gravel	80%			
	gravel-rubble	20%			

fence crossing
and work down

*Only one station com[illegible]ed in lower reach. Station not done in Second reach because of no water.

(30) Stream Physical Characteristics (continued)

o)	Runs:	-			
	Average width				
	Width range				
	Average depth				
	Maximum depth				
	Max. velocity range (fps)				
	Bottom type – %				
	Other (describe)	-			
	Average width				
	Width range				
	Average depth				
	Maximum depth				
	Max. velocity range (fps)				
	Bottom type – %				
DATA PERTAINING TO SIMILAR REACH					
q)	Location (mi. to mi.)	0-3			
r)	Gradient (ft./mi.)	50-60ft/mi.			
s)	Sinuosity	1.1			
t)	Channel changes (slight, mod., exten.)	slight			

Remarks

[1]Shade:
- light 0-25 percent shaded
- moderate 26-75 percent shaded
- heavy over 75 percent shaded

[2]Pool types:
- Type A – Good cover, 3 ft. or deeper
- B – Good cover, less than 3 ft.
- C – Poor cover, 3 ft. or deeper
- D – Poor cover, less than 3 ft.

[3]Bottom types:
- Ledge rock – large mass of solid rock
- Boulder – over 10" in diameter
- Rubble – 3" to 10" in diameter
- Gravel – 1/8" to 3" in diameter
- Sand – less than 1/8" in diameter
- Silt – fine material with little grittiness
- Clay – compact, sticky material
- Muck – decomposed organic material, usually black
- Detritus – organic material composed of sticks, leaves, decaying plants, etc.
- Marl – calcareous material

NA-01476-01
(GF-11) Rev. 4/78
Page 6

(31) Characteristics of Water

a)	Station no.	1			
b)	Date	9-28-81			
c)	Loc. (mi. from mouth)	1			
d)	Length of station	1,000'			
e)	Time	1400			
f)	Air temp. °F.	65			
g)	Water temp. °F.	63			
h)	Color	clear			
i)	Cause of color	-			
j)	Secchi disc. (ft.)	bottom			
FIELD DETERMINATIONS:					
	Diss. oxygen (ppm)	8 ppm			
	Free carbon dioxide (ppm)	-			
FIELD DETERMINATION OR LABORATORY ANALYSIS (Indicate by F or L)					
	Total alkalinity (ppm)	403			
	Conductivity (micromhos/cm)	-			
	pH	7.7			
LABORATORY ANALYSIS					
	Total nitrogen (ppm)	-			
	NH_3 (ppm)	-			
	NO_2 (ppm)	-			
	NO_3 (ppm)	-			
	Total phosphorus (ppm)	.40			
	Orthophosphates (ppm)	-			
	Sulfate ion (ppm)	-			
	Chloride ion (ppm)	-			
	B.O.D. (ppm)	-			
	or C.O.D. (ppm)	-			
	Turbidity (JTU)	-			
	Tot. diss. solids (ppm)	572.4			

Remarks Water analysis completed 9-22-81 at Carlos Avery.

NA-01475-01
(GF-11) Rev. 4/78
Page 7

(32) Temperature Profile

Date	Location (miles from mouth)	Water Temp.	Air Temp.	Water Stage	Time	Cloud Cover
8-12-81	1	63	85	norm	1400	sunny
3-23-81	1	49	63	"	1100	sunny
9-18-81	1	50	59	"	1105	sunny

Remarks Though water temps. taken during this survey do not indicate high water temps., temps have been known to be over 70 degrees F.

(33) Biological Characteristics

a)	Station no.	1			
b)	Date	9-28-81			
c)	Loc. (miles from mouth)	1			
d)	Length of station	1,000'			

e) Aquatic plants or filamentous algae:[1]

Species	Abundance	Abundance	Abundance	Abundance
none noted				

f) Distribution of aquatic plants

g) Common invertebrates: order or family (check blank if present)

Diptera-Ceratopogonidae	C			
Pelecypoda	C			
Plecoptera-Acroneuriinae	C			
Trichoptera	C			
Ephemeroptera	C			

Remarks

[1]Plant or algae abundance:
- A — abundant
- C — common
- O — occasional
- R — rare
- P — present

(34) Fishery Characteristics

a)	Station no.	1							
b)	Date	8-12-81							
c)	Loc. (miles from mouth)	1							
d)	Length of station	1,000'							
e)	Gear	back pack shocker							
f)	Amt. of sampling effort	1 hr.							
g)	Species Present	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
	Brown Trout	7	8"-10"						
	Creek Chub	4							
	Dace	4							
	Stoneroller	1							
	Darter	1							
	Sucker	3							

h) Gamefish young-of-year

Species:								

Remarks

NA-01475-01
(GF-11) Rev. 4/78
Page 10

Total Length in Inches \ Species	Brown Trout								
3.0 – 3.4									
3.5 – 3.9									
4.0 – 4.4	1								
4.5 – 4.9									
5.0 – 5.4									
5.5 – 5.9									
6.0 – 6.4									
6.5 – 6.9									
7.0 – 7.4									
7.5 – 7.9									
8.0 – 8.4	1								
8.5 – 8.9	1								
9.0 – 9.4									
9.5 – 9.9	3								
10.0 – 10.4	1								
10.5 – 10.9									
11.0 – 11.4									
11.5 – 11.9									
12.0 – 12.4									
12.5 – 12.9									
13.0 – 13.4									
13.5 – 13.9									
14.0 – 14.9									
15.0 – 15.9									
16.0 – 16.9									
17.0 – 17.9									
18.0 – 18.9									
19.0 – 19.9									
20.0 – 20.9									
21.0 – 21.9									
22.0 – 22.9									
23.0 – 23.9									
24.0 – 24.9									
25.0 – 25.9									
26.0 – 26.9									
27.0 – 27.9									
28.0 – 28.9									
29.0 – 29.9									
30.0 – 30.9									
31.0 – 31.9									
32.0 – 32.9									
33.0 – 33.9									
34.0 – 34.9									
35.0 – 35.9									
Totals	7								

(36) Age and Growth of Gamefish

a) Age class distributions

Species	Sample size	Subsample size	Number of fish in age group							
			I	II	III	IV	V	VI	VII	VIII+

b) Growth of gamefish

Species	Calculated mean total length at time of last annulus formation							
	I (N)	II (N)	III (N)	IV (N)	V (N)	VI (N)	VII (N)	VIII (N)

*Fish taken corresponded to sizes of fish stocked so scales were not taken.

(37) Escape Cover for Gamefish

Similar reach	Type[1] and Amount[2] of Cover
0-3 mile	Fair cover for trout-LJ, OV, UB Occassional

[1]Cover types:
- LJ – log jam
- B – boulders
- OV – overhanging vegetation
- UB – undercut bank
- IV – instream vegetation

[2]Amount of cover:
- S – scarce
- O – occasional
- F – frequent

(38) Portion of Stream Suitable for Gamefish

Species	Suitable Reach (mi. to mi.)
Brown Trout	0-3 mile

(39) History of Stream and Fishing Conditions

a) Comparisons with past investigations and surveys Creek has been stocked annually since 1973 with brown and occassionally rainbow trout.

b) History of fishing conditions From local report there is utilization of trout fishing mainly by members of Izaak Walton League from New Ulm.

(39) History of Stream and Fishing Conditions (continued)

c) Records of past management

Fish stocking

Year	Species	Size	Number or Pounds
3-29-73	Brown Trout		373 ylg.
4-23-74	"		432 ylg.
5-13-75	"		400 ylg.
4-22-76	"		400 ylg.
7-20-76	"		99 ylg.
5-5-77	"	4.95/lb	400 ylg.
6-6-77	Rainbow Trout	3.1 /lb	500 ylg.
5-3-78	Brown Trout	3.3/lb	600 ylg.
5-19-78	"	3.2/lb	200 ylg.
9-9-78	"	5.6/lb	420 ylg.
10-3-78	"	1.7/lb	400 ylg.
6-5-79	"	2.43/lb	400 ylg.

~~Rough fish removal~~ stocking cont.

Year	Species	Size	Number or Pounds
9-6-79	Brown Trout	2.4/lb	400 ylg.
4-30-80	"	4.0/lb	400 ylg.
6-25-80	"	3.4/lb	408 ylg.
9-17-80	"	2.0/lb	540 ylg.
4-14-81	"	5.9/lb	400 ylg.
9-30-81	Rainbow Trout	.20/lb	400 ylg.

Special regulations

-

Habitat improvement:

Year Installed	Type and Amount	Location (mile to mile)	Cost	Present Condition
None				

(40) Discussion of Fishery

a) General characteristics John's Creek seems to be providing a fair put and take trout fishery. There has been some over-wintering but maintenance stocking is required to provide fishing. Rainbow trout were stocked in 1981. Back pack shocking will be done in 1982 to determine survival.

(40) Discussion of Fishery (continued)

b) Fish management problems Warm water temps, sijt load, water level flucuatio are problems to to monitored. High water marks were noted at over six feet. Though access can be had off of raods, only the one lower access on easement to Izaak Walton League provides access to most fishabl waters. At the time of this survey the leased private road access had no tresspassing signs on it. It is not known whether much fishing is done by the general public other than the Izaak Walton League from New Ulm.

(41) Ecological Classification of Waterway Class I-D Marginal Trout
Annual stocking is necessary to provide fishing for anglers.

(42) Summary The findings of this survey indicate that John!s Creek is a marginal trout stream with some carry over. Annual stocking provides some fishing for anglers. Additional shocking and monitoring of physical characteristics will be done in the future. More information on who is actually utilizing the trout fishing will also be gathered.

(43) Credits and Signatures

a) Funding

b) Field work by
Name of crew leader Gene Jeseritz
Name of aide(s) Gary Barnard
Delmar Kramer
Nancy Flicek
Duane Williams

c) Completed report by
Name Gene Jeseritz
Title Spec. I-Fisheries

Approved by G Ohlsbazi Date 3-30-82
Regional Fisheries Manager

Typist's Initials:

JOHN'S CREEK-1983: STREAM ASSESSMENT

copy to Ray Johannes 4-8-83

Natural Resources-Fisheries

Guy Oklobzija 3/30/83

Roland Ruths

STREAM ASSESSMENT _ Johns Creek, Brown County

Craig Berberich and Tony Slechta went to Johns Creek with the back kpack shocker to work the area stream on March 28, 1983 to do a population check for carry overs from the 1982 stocking of brown trout.

Roland R. Ruths
Roland Ruths

RR:er

JOHN's CREEK, BROWN COUNTY - STREAM SHOCKING 3/28/83

Backpacked shocked Johns Creek. Shocked 2,000 ft.. Area shocked wasfeance line crossing at lower end of pasture. Shocking was very effective, water was clear and above normal flow. Brown Trout captured - 17 total and 4 other trout observed.

Lake Johns Creek

County(ies) Brown

(30) Fish Sizes

Length — Frequency Distributions
Species and Numbers of Fish in Length Groups

Total Length in Inches	Brown Trout									
3.0 – 3.4										
3.5 – 3.9										
4.0 – 4.4										
4.5 – 4.9										
5.0 – 5.4										
5.5 – 5.9										
6.0 – 6.4										
6.5 – 6.9										
7.0 – 7.4										
7.5 – 7.9	1									
8.0 – 8.4										
8.5 – 8.9	1									
9.0 – 9.4	4									
9.5 – 9.9	5									
10.0 – 10.4	4									
10.5 – 10.9	3									
11.0 – 11.4										
11.5 – 11.9	2									
12.0 – 12.9	1									
13.0 – 13.9										
14.0 – 14.9										
15.0 – 15.9										
16.0 – 16.9										
17.0 – 17.9										
18.0 – 18.9										
19.0 – 19.9										
20.0 – 20.9										
21.0 – 21.9										
22.0 – 22.9										
23.0 – 23.9										
24.0 – 24.9										
25.0 – 25.9										
26.0 – 26.9										
27.0 – 27.9										
28.0 – 28.9										
29.0 – 29.9										
30.0 – 30.9										
31.0 – 31.9										
32.0 – 32.9										
33.0 – 33.9										
34.0 – 34.9										
35.0 – 35.9										
36.0 – 36.9										
TOTALS	21									

Four other trout were observed but not captured.

JOHN'S CREEK-1987: STREAM SURVEY

NA-01475-01
(GF-11) Rev. 4/78
Page 1

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

RIVER OR STREAM SURVEY
DATE(S) OF FIELD WORK John's Creek 8 May 1987

Initial Survey [X]
Resurvey [ ]

LEADER Duane Williams
ASSISTANT(S) Del Kramer, Bruce Pittman

NAME, LOCATION, AND FLOW CHARACTERISTICS

(1) Stream Name John's Creek
(2) Alternate Name(s) none
(3) Tributary Number M-55-106
(4) Counties Brown
(5) Watershed Name and Number Cottonwood River 26
(6) Sequence of Waterways to Basin John's Creek to Minnesota River to Mississippi River

(7) Map(s) Used USGS quads - St. George, 1964 - Essig, 1964 - Sleepy Eye, 1964
(8) Length of Stream 8.1
(9) Average Width — Upper Station 8.0 Lower Station 10.5
(10) Mouth Location T. 111 R. 31 S. 31
(11) Flow at Mouth 2.9 cfs, Date 05 12 87
(12) Flow at Gaging Station — Minimum ___ cfs Average ___ cfs
(13) Location of Gaging Station
(14) Initial Source of Sustained Flow tile outlet T. 110 R. 32 S. 22

(15) Gradient 25.9 ft./mi.
(16) Sinuosity 1.3

WATERSHED DESCRIPTION AND USE

(17) Description of Watershed (soil types, cover types, topography, land usage and ownership)

a) Entire watershed Soils consist mostly of poorly drained to moderately well drained silty clays and silty clay loams. The watershed above Brown Co. Highway #29 is level to gently rolling, privately owned agricultural lands. The watershed below Brown Co. #29 is characterized by steep hills and ravines as the stream drops into the Minnesota River valley. Much of the steeper portions of the lower watershed are forested with bottomland

b) ~~Land adjacent to stream~~ hardwoods. Some of the forested lower reach is pastured. All lands below Brown Co. #29 are also privately owned.

NA-01475-01
(GF-11) Rev. 4/78
Page 2

GENERAL INFORMATION ON THE STREAM

(18) Reason for Survey To update files for inventory and management purposes

(19) Previous Investigations and Surveys Survey 1981
Population checks of brown trout in 1979, 1980, 1981, 1982, and 1983

(20) Special Problems or Conditions Low flows during extended dry periods; extreme water level fluctuations due to extensive artificial drainage in the upper watershed; some degradation of stream due to cattle activity in lower reach.

(21) Sources of Pollution

Source	Loc. (mi. from mouth)	Substance discharged
non point	entire stream	sediments related to agric. activit
non point	entire stream	agricultural chemicals

(22) Erosion

Type	Degree	Affected reach
streambank	moderate	mile 0 - 2.3

(23) Stream Alterations (dredging, channeling) — location and date Stream is channelized above mile 3.0 - dates unknown.

(24) Dams and other obstructions (include beaver dams)

Type	Mi. from Mouth	Head	Length of Dam	Type of Control Structure	Use	Fish Barrier	Owner	Condition or Status
fixed crest	2.4	20'	8'	concrete sill		yes	MN	good
beaver	2.9	8"	10'			yes		active
"	2.6	1'	160'			yes		active
"	2.5	8"	100'			yes		active
"	2.41	8"	8'			yes		active
"	1.5	1'	10'			yes		active
"	1.44	2"	6'			yes		inactive (OVE

(25) Use of Water: Fishing X Recreation ___ Commercial navigation ___ Power ___ Irrigation ___
Livestock watering X Other (specify) ___

(26) Access (location and ownership) All lands along John's Creek are privately owned. The Izaak Walton League chapter in New Ulm secures an annual easement from Harley Vogel (mi. 4) to allow angling and fish management activities.

(27) Shoreline Developments occasional farmsteads along stream

(28) Recreational Boating — a) Navigable reach none
b) Type of boating

Type	Mi. from Mouth	Head	Length of Dam	Fish Barrier	Condition or Status
Beaver	1.42	2"	6'	yes	inactive
"	1.40	2"	6'	yes	inactive

(29) Tributaries and Springs

Names and/or Tributary Numbers	Water Source	Bank (R or L)	Length Miles	Width at Mouth (feet)	Miles from Mouth	Flow (c.f.s.)	Stage (high, normal, low)	Temp. °F				Time	Date
								Mouth		Source			
								Air	Water	Air	Water		
	drainage/ seepage	R	1.1	4'	0.6	<1	normal	87	75			4:22 pm	07 22 87
spring	seepage	R			1.15	<1		90	55			3:40 pm	"
"	"	L			0.7	<1		87	55			4:04 pm	"
"	"	L			0.5	<1		87	53			4:39 pm	"
"	"	L			0.4	<1		87	55			4:46 pm	"

Remarks

NA-01475-01
(GF-11) Rev. 4/78
Page 3

NA-01475-01
(GF-11) Rev. 4/78
Page 4

(30) Stream Physical Characteristics

a)	Station no.	1	2		
b)	Date	05 13 87	05 12 87		
c)	Loc. (mi. from mouth)	4.0	.5		
d)	Length of station	500	522		
e)	% of station in:				
	Pools	100	41		
	Riffles and rapids		59		
	Runs				
	Other (list)				
f)	Average width (ft.)	8.0	10.5		
g)	Average depth (ft.)	.6	.6		
h)	Flow (cfs)	.5	2.9		
i)	High water mark	2.5	3		
j)	Present stream stage (high, normal, low)	normal	normal		
k)	Banks:				
	Average height (ft.)	15	5		
	Height range (ft.)	8 - 20	2 - 10		
	Erosion (lt., mod., severe)	light	mod.		
	% grazed	0	100		
	% ditched or channeled	100	0		
l)	Shade[1]	light	heavy		
m)	Pools[2]				
	Average width (ft.)	8.0	11.3		
	Width range (ft.)	3.6-14.0	9.7-12.6		
	Average depth (ft.)	.6	.9		
	Maximum depth (ft.)	1.2	1.8		
	Type — No. of each				
	A				
	B		6		
	C				
	D	1			
	Bottom type — %[3] boulder		4		
	rubble		10		
	gravel		24		
	sand	4	29		
	silt	36	31		
	muck	60	2		
n)	Riffles and rapids				
	Average width (ft.)		10.0		
	Width range (ft.)		6.8-11.6		
	Average depth (ft.)		.4		
	Maximum depth (ft.)		.9		
	Max. velocity range (fps)		2.5		
	Bottom type — % boulder		5		
	rubble		23		
	gravel		36		
	sand		25		
	silt		11		

NA-01475-01
(GF-11) Rev. 4/78
Page 5

(30) Stream Physical Characteristics (continued)

o) Runs:				
Average width				
Width range				
Average depth				
Maximum depth				
Max. velocity range (fps)				
Bottom type – %				
Other (describe)				
Average width				
Width range				
Average depth				
Maximum depth				
Max. velocity range (fps)				
Bottom type – %				
DATA PERTAINING TO SIMILAR REACH				
q) Location (mi. to mi.)	8.1-2.3	2.4-0		
r) Gradient (ft./mi.)	10.3	65.2		
s) Sinuosity	1.5	1.2		
t) Channel changes (slight, mod., exten.)	extensive	slight		

Remarks

[1]Shade:
- light 0-25 percent shaded
- moderate 26-75 percent shaded
- heavy over 75 percent shaded

[2]Pool types:
- Type A – Good cover, 3 ft. or deeper
- B – Good cover, less than 3 ft.
- C – Poor cover, 3 ft. or deeper
- D – Poor cover, less than 3 ft.

[3]Bottom types:
- Ledge rock – large mass of solid rock
- Boulder – over 10" in diameter
- Rubble – 3" to 10" in diameter
- Gravel – 1/8" to 3" in diameter
- Sand – less than 1/8" in diameter
- Silt – fine material with little grittiness
- Clay – compact, sticky material
- Muck – decomposed organic material, usually black
- Detritus – organic material composed of sticks, leaves, decaying plants, etc.
- Marl – calcareous material

NA-01475-01
(GF-11) Rev. 4/78.
Page 6

(31) Characteristics of Water

a)	Station no.	1	2		
b)	Date	07 20 87	07 20 87		
c)	Loc. (mi. from mouth)	4.0	0.5		
d)	Length of station				
e)	Time	2:30	1:40		
f)	Air temp. °F.	93	85		
g)	Water temp. °F.	83	67		
h)	Color	clear	clear		
i)	Cause of color				
j)	Secchi disc. (ft.)	vis. greater	vis. greater	than total d	epth (0.9)
FIELD DETERMINATIONS:		than total d	epth (0.6)		
	Diss. oxygen (ppm)	3.2	9.8		
	Free carbon dioxide (ppm)				
FIELD DETERMINATION OR LABORATORY ANALYSIS (Indicate by F or L)					
	Total alkalinity (ppm)	346	370		
	Conductivity (micromhos/cm)				
	pH	7.70(L)	8.10(L)		
LABORATORY ANALYSIS					
	Total nitrogen (ppm)				
	NH_3 (ppm)				
	NO_2 (ppm)				
	NO_3 (ppm)				
	Total phosphorus (ppm)	0.486	0.047		
	Orthophosphates (ppm)				
	Sulfate ion (ppm)				
	Chloride ion (ppm)				
	B.O.D. (ppm)				
	or C.O.D. (ppm)				
	Turbidity (JTU)				
	Tot. diss. solids (ppm)	536	663		

Remarks

NA-01475-01
(GF-11) Rev. 4/78
Page 7

(32) Temperature Profile

Date	Location (miles from mouth)	Water Temp.	Air Temp.	Water Stage	Time	Cloud Cover
07 22 87	8.1	73	92	N	2:02 pm	clear
"	7.6	80	92	"	1:58	"
"	6.3	87	91	"	1:49	"
"	4.0	81	90	"	1:40	"
"	3.0	75	92	"	1:07	"
"	2.5	78	92	"	12:43	"
"	2.45	78	92	"	12:36	"
"	2.4	78	92	"	12:17	"
"	2.1	84	91	"	2:36	"
"	1.9	85	90	"	2:52	"
"	1.5	81	90	"	3:09	"
"	1.3	78	90	"	3:20	"
"	1.1	75	90	"	3:40	"
"	.9	73	87	"	3:49	"
"	.7	74	87	"	4:04	"
"	.6	72	87	"	4:22	"
"	.5	72	87	"	4:39	"
"	.4	71	87	"	4:46	"
"	.35	71	88	"	5:00	"
"	.3	71	91	"	2:20	"
"	.2	74	90	"	2:40	"
"	.1	74	91	"	2:51	"
"	.02	74	90	"	3:00	"

Remarks See attached sheets for additional temperature and flow information.

1987 - FLOW AND TEMPERATURE DATA AT STATION #1 (Upper)

DATE	TIME	AIR TEMP.(^{o}F.)	WATER TEMP.(^{o}F.)	FLOW(CFS)
05 08 87	11:30 am	80	62	not taken
05 12 87	11:10 am	70	57	0.41 cfs
07 23 87	1:40 pm	90	81	not enough depth for flow meter
08 27 87	3:40 pm	64	61	"
09 30 87	10:00 pm	63	58	"
10 21 87	11:35 pm	38	35	"

1987 - FLOW AND TEMPERATURE DATA AT STATION #2 (lower)

DATE	TIME	AIR TEMP.(^{o}F.)	WATER TEMP.(^{o}F.)	FLOW(CFS)
05 08 87	11:00 am	78	52	not taken
05 12 87	1:20 pm	80	58	2.91 cfs
06 29 87	10:30 am	72	60	2.07 cfs
07 23 87	1:00 pm	89	71	1.48 cfs
08 27 87	4:25 pm	64	55	0.72 cfs
09 30 87	10:30 am	60	53	1.51 cfs
10 21 87	11:00 am	38	41	1.53 cfs

(33) Biological Characteristics

a)	Station no.	1	2		
b)	Date	05 08 87	05 08 87		
c)	Loc. (miles from mouth)	4.0	.5		
d)	Length of station (ft.)	500	700		

e) Aquatic plants or filamentous algae:[1]

Species	Abundance	Abundance	Abundance	Abundance
filamentous algae	A	0		
lesser duckweed	0			
sago pondweed		0		

f) Distribution of aquatic plants The upper reach of John's Creek contains extensive growths of filamentous algae with occasional pockets of lesser duckweed. The lower reach contains few aquatic plants with just occasional areas of filamentous algae and sago pondweed.

g) Common invertebrates:
order or family (check blank if present)

Anisoptera	X			
Gastropoda	X			
Astacidae	X			
Ephemeroptera		X		
Chironomidae		X		
Tipucalidae		X		
Trichoptera		X		
Amphipoda		X		

Remarks

[1]Plant or algae abundance:
A — abundant
C — common
O — occasional
R — rare
P — present

(34) Fishery Characteristics

a) Station no.	1		2					
b) Date	05 13 87		05 12 87					
c) Loc. (miles from mouth)	4.0		0.5					
d) Length of station	500 ft.		700 ft.					
e) Gear	backpack shocker		backpack shocker					
f) Amt. of sampling effort	15 min.		30 min.					
g) Species Present	No.	Wt. (lbs.)	No.	Wt. (lbs.)	No.	Wt.	No.	Wt.
brown trout			51	23.4				
white sucker			3	--				
creek chub	26	.5	16	.3				
blacknose dace	5	--	5	.3				
fathead minnow	138	.7	8	--				
central stoneroller			9	.1				
black bullhead			1	--				
Iowa darter			1	--				
brook stickleback	1	--	1	--				

h) Gamefish young-of-year
Species:

Remarks BNT stocked on 4-9-87 were fin-clipped to enable identification of over-wintered fish during this survey. Of the 51 BNT sampled, 19 were fish that had over-wintered.

Species / Total Length in Inches	Brown trout								
3.0 – 3.4									
3.5 – 3.9									
4.0 – 4.4									
4.5 – 4.9									
5.0 – 5.4									
5.5 – 5.9									
6.0 – 6.4									
6.5 – 6.9									
7.0 – 7.4	2								
7.5 – 7.9	6								
8.0 – 8.4	8								
8.5 – 8.9	9								
9.0 – 9.4	4								
9.5 – 9.9	2								
10.0 – 10.4	2								
10.5 – 10.9	3								
11.0 – 11.4	3								
11.5 – 11.9	2								
12.0 – 12.4	2								
12.5 – 12.9	4								
13.0 – 13.4	3								
13.5 – 13.9	1								
14.0 – 14.9									
15.0 – 15.9									
16.0 – 16.9									
17.0 – 17.9									
18.0 – 18.9									
19.0 – 19.9									
20.0 – 20.9									
21.0 – 21.9									
22.0 – 22.9									
23.0 – 23.9									
24.0 – 24.9									
25.0 – 25.9									
26.0 – 26.9									
27.0 – 27.9									
28.0 – 28.9									
29.0 – 29.9									
30.0 – 30.9									
31.0 – 31.9									
32.0 – 32.9									
33.0 – 33.9									
34.0 – 34.9									
35.0 – 35.9									
Totals	51								

(36) Age and Growth of Gamefish

a) Age class distributions

Species	Sample size	Subsample size	Number of fish in age group							
			I	II	III	IV	V	VI	VII	VIII+
BNT	4	4		4						

b) Growth of gamefish

Species	Calculated mean total length at time of last annulus formation							
	I (N)	II (N)	III (N)	IV (N)	V (N)	VI (N)	VII (N)	VIII (N)
BNT		10.8(4)						

REMARKS: More than 90% of the scales taken from the sample of 19 brown trout without fin clips were regenerated. Four trout (12.0-13.2 in.) that were aged were age 2+.

(37) Escape Cover for Gamefish

Similar reach	Type[1] and Amount[2] of Cover
8.1 - 2.3	OV - O IV - F
2.3 - 0	LJ - O B - F UB - O

[1]Cover types:
- LJ — log jam
- B — boulders
- OV — overhanging vegetation
- UB — undercut bank
- IV — instream vegetation

[2]Amount of cover:
- S — scarce
- O — occasional
- F — frequent

(38) Portion of Stream Suitable for Gamefish

Species	Suitable Reach (mi. to mi.)
brown trout	about 1.8 - 0 (portions may be seasonal)

(39) History of Stream and Fishing Conditions

a) Comparisons with past investigations and surveys The results of this survey are consistent with past investigations. More trout were sampled in this survey than have been in the past, probably due to the short time between stocking (4-9-87) and the survey (5-12-87). Over-wintering conditions were also ideal, contributing to a larger spring population.

b) History of fishing conditions John's Creek has been managed as a trout stream since 1961. Conversations with anglers indicate fishing success varies considerably, probably due to stocking schedules and water levels. File correspondence indicates bullheads and northern pike are occasionally caught.

(39) History of Stream and Fishing Conditions (continued)

c) Records of past management

Fish stocking

Year	Species	Size	Number or Pounds
1987	BNT	Y	400
1986	BNT - CF	Y	612
1985	BNT	Y	396
1985	BNT	Y	400

BNT have been stocked annually since 1961.
RBT were stocked in 1977 and 1981.

Rough fish removal NONE

Year	Species	Size	Number or Pounds

Special regulations NONE

Habitat improvement: NONE

Year Installed	Type and Amount	Location (mile to mile)	Cost	Present Condition

(40) Discussion of Fishery

a) General characteristics Information obtained during this survey and from information on file indicates that John's Creek provides some trout fishing. There is evidence of some over-wintering of trout in the stream, but continual stocking will be necessary to maintain the population.

No creel information is available for John's Creek, but it is generally felt that a small number of anglers (mostly members of the New Ulm Izaak Walton League) make use of this put and take fishery.

(40) Discussion of Fishery (continued)

b) Fish management problems Water level fluctuation, beaver dams, warm water temperatures, and bank erosion caused by cattle are some of the problems we observed on John's Creek. Additionally, access is restricted to only a small section of the lower reach of the stream. Even this stream section is not used very much by the general public since no public access signs are evident and, in fact, no trespassing signs appear along the leased private road access.

Thus, it is doubtful that much fishing is done by the general public, other than the New Ulm Izaak Walton League.

(41) Ecological Classification of Waterway I - D Marginal Trout

Annual stocking will probably be necessary to provide fishing for anglers.

(42) Summary The upper reach of John's creek (about mile 3) is nearly all open drainage ditch and intensively farmed right to the banks. Gradient is relatively low; bottom types are mostly muck and silt. Four species of fish were sampled - fathead minnow, creek chub, blacknose dace, and brook stickleback.

The lower reach, below County Road 29, is a very different type of stream. It flows through a wooded valley, with pastured areas, to the Minnesota River. Gradient is very high and bottom types are mostly sand, gravel, and silt. Cover for gamefish is good. Fish species sampled were brown trout, creek chub, central stoneroller, fathead minnow, blacknose dace, white sucker, black bullhead, Iowa darter, and brook stickleback.

If trout stocking os this stream is to continue, improvements should be made in stream access and trout habitat.

(43) Credits and Signatures

a) Funding Federal Aid Project F-29-R

b) Field work by
Name of crew leader Duane Williams
Name of aide(s) Bruce Pittman
Del Kramer
Dennis Bickell, Larry Stewart

c) Completed report by
Name Duane Williams
Title Fisheries Technician

Approved by [signature] Date 25 Apr 88
Regional Fisheries Manager

Typist's Initials: BAS

JOHN'S CREEK-1990: STREAM MANAGEMENT PLAN

NA-01570-01

DEPARTMENT OF MINNESOTA NATURAL RESOURCES

STREAM
[redacted] MANAGEMENT PLAN

(Use reverse side and add additional sheets as needed)

Region	Area	Kittel [redacted] Number	County	D.O.W. Stream [redacted] Name	[redacted] Miles
4	Waterville	M-55-106	Brown	John's	8.1

Long Range Goal: Provide a put-grow-take fishery for BNT where 30% of the BNT sampled are > 10 in.

Operational Plan:

Stock 800 yearling brown trout annually.

Survey 1997 and, if conducted, the year of a creel survey.

Pursue the development of a state-owned public easement.

Replan 1997.

MAY 1990
RECEIVED DNR
NEW ULM

Mid Range Objective:

Assess success of BNT stockings.

Potential Plan:

Purchase easements along stream	$ 10,000
Conduct a creel survey with other streams	8,000
Conduct habitat improvement work	15,000
TOTAL	$ 33,000

Primary Species Management	Secondary Species Management
BNT	

Area Supervisor's Signature: David A Belford — Date: 05/26/90

Regional Supervisor's Signature: — Date: 6/04/90 (Month / Day / Year)

FOR CENTRAL OFFICE USE ONLY

Entry Date: __/__/__ — Year Resurvey: __

Stock Species – Size – Number per Acre

Pr./Sec.

Schedule — Year Beginning: __

Population Manipulation: ☐ YES ☐ NO Year __

Development: ☐ YES ☐ NO Year __

Creel or Use Survey: ☐ YES ☐ NO Year __

Other

NARRATIVE:

(Historical perspectives - various surveys; past management; social considerations; present limiting factors; survey needs; land acquisition; habitat development and protection; commercial fishery; stocking plans; other management tools; and evaluation plans)

various surveys: Population checks occurred in 1979, 1980, 1982, and 1983. Stream surveys were conducted in 1981 and 1987. Fish species found include BNT, RBT, WTS, CRC, BND, FHM, CSR, BLB, IOD, and BST.

past management: The lower 1.8 miles of John's Creek has been managed as a put-and-take trout fishery since 1961. BNT yearlings have been stocked annually with RBT yearlings also stocked in 1977 and 1981.

-OVER-

cc: Area, Regional and St. Paul Fisheries Offices social considerations: The Izaak Walton League of New Ulm is active in the management of John's Creek and annually purchases a public easement to the stream. The access is not well publicized and is probably not used frequently by the general public.

present limiting factors: Low water levels and the lack of deep water with overhead cover probably limit the number of larger BNT. Poor public access also limits the use of the stream by the general public.

survey needs: A creel survey is needed to determine the harvest and pressure by anglers.

land acquisition: A state-owned public easement that is well publicized is necessary for the resource to be adequately used.

habitat development and protection: If a state-owned public easement is acquired, work could be undertaken to improve the habitat for adult BNT.

stocking plans: Stock 800 yearling BNT annually (400 in the spring and 400 in the fall).

evaluation plans: Resurvey 1997 and, if conducted, the year of a creel survey.

JOHN'S CREEK-1992: STREAM MANAGEMENT PLAN

NA-00000-00

STREAM MANAGEMENT PLAN

REGION	AREA	STREAM NAME	TRIBUTARY NO.	LENGTH
4	440	John's Creek	M-55-106	1.8

SIMILAR REACH	STREAM MILE	STREAM TYPE	ECOLOGICAL CLASSIFICATION	SPECIES MANAGED
1	0 - 1.8	coldwater	I D	Brown trout

Long Range Goal:

Provide local trout fishing opportunities to residents of south-Central Minnesota through a put and take management program for brown trout.

RECEIVED

FEB 14 1992

D.N.R. New Ulm

Operational Plan:

A) Annually stock 400 yearling brown trout in April prior to the opening of trout season.

B) Discontinue the annual fall stocking of 400 brown trout beginning in 1993.

C) Develop a news release and local map to publicize trout fishing opportunities in the area.

D) Resurvey in 1995.

Trout stocking ceased. Last stocked 1995

Mid range Objective:

Increase public awareness and use of the designated trout stream.

Potential Plan:

Purchase easements along the designated portions of the stream $20,000

Area Supervisor's Signature	Date	Regional Manager's Signature	Date
Hugh Valiant	02 12 92	clc [illegible]	APR 20 1992

(see reverse side)

NA-00000-00

STREAM MANAGEMENT PLAN

STREAM NAME:	TRIBUTARY NO.	Date:
John's Creek	M-55-106	2-11-92

Narrative:

VARIOUS SURVEYS:
Stream surveys were completed in 1981 and 1987. Population assessments were conducted in 1979, 1980, 1982, and 1983.

PRESENT POPULATION STATUS:
Nine species of fish were collected during the 1987 resurvey. Fifty-one brown trout were captured, of which nineteen (37%) were carry-over fish from the 1986 fall stocking.

PAST MANAGEMENT:
Brown trout yearlings have been stocked on an annual basis since 1961. Rainbow trout were stocked in 1977 and 1981.

SOCIAL CONSIDERATIONS:
The Izaak Walton League of New Ulm is active in the management of John's Creek and annually purchase a public easement to the stream. The access is not well publicized and is probably not used frequently by the general public.

PRESENT LIMITING FACTORS:
Highly fluctuating water levels and lack of deep water pools probably limit the survival of brown trout in John's Creek. Fishing pressure is light due to little access and lack of public awareness about the trout fishing opportunities.

SURVEY NEEDS:
A volunteer creel survey would be useful.

LAND ACQUISITION:
A well known public access or easement is needed.

HABITAT DEVELOPMENT AND PROTECTION:
Instream habitat improvement cannot be considered until recreational use of the area increases significantly.

COMMERCIAL FISHERY: None

STOCKING PLANS:
Annual stocking of 400 brown trout yearlings in April prior to the opening of trout season. Discontinue the annual fall stocking of 400 brown trout beginning in 1993. Fall stocking could be reconsidered if it is justified by angler use.

EVALUATION PLANS:
Resurvey in 1995.

Add additional pages if needed

JOHN'S CREEK-2005: SPECIAL SAMPLING

1. Stream Name	Johns Creek
2. Alternate Names	none
3. Tributary Number	M-55-106
4. Counties	Brown
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watersheds and Numbers	County Ditch 10, 28092
9. Length of Stream	8.5 mi (13.7 km) 3.8 mi (6.1 km) Designated Trout Stream
10. Size of Watershed	13.3 sq mi (34.5 sq km)
11. Public Access	road crossings
12. Dams and Obstructions	none
13. Previous Sampling	Initial Survey 1981 Population Assessment 1982 Special Sampling 1979, 1981, 1982, 1983 Survey 1987
14. Stocking	Brown trout adults 1961 (302), annual stocking of brown trout yearlings (200-1,620) between 1962 and 1995, 1977 & 1981 rainbow trout yearlings (400-500)

15. Watershed Description and Methods

The majority of the watershed is flat to rolling agricultural land. Intensive row-cropping and drainage deposit large sediment loads into the stream, particularly in the channelized stretch. The upper stream corridor is only minimally shaded by overhanging grass, which combined with low flows contribute to high water temperatures. The lower reach is hilly and wooded. The stream has few pools and very low flow in late summer.

The stream was determined to have two similar reaches based on gradient and land use. Reach 1 is the hilly lower 3.7 miles and Reach 2 is the upstream, channelized stretch (Figure 1). Grab samples of water were taken at two sites (WQ) on 14 June for Minnesota Department of Agriculture (MDA) standard laboratory analysis. Additional samples were taken for fecal coliform count and List 1 pesticides analysis. Field measurements were made of pH, conductivity, temperature, and turbidity tube height. Two StowAway TidbiT® (Onset Computer Corporation) loggers (DL) recorded hourly temperatures from 28 April to 10 September. Physical characteristics were measured on 5 August.

16. Fish Sampling Methods

One fish sampling station was established in each of the two similar reaches. The first station (EF1) began 100 ft (30.5 m) upstream of a County Road 29, and the second station (EF2) began 100 ft (30.5 m) downstream of the same road. Station lengths were 35 times the mean stream width at each site (Lyons 1992); EF1 was 374 ft (114.0m) and EF2 was 315 ft (96.0 m). A Smith-Root Backpack Electrofisher Model 12 was used to sample fish at both sites on 29 August. The entire width of the station was shocked and attempts made to collect all fish. Water temperature, conductivity and shocking time were recorded. Species collected and their lengths and weights were recorded.

17. Summary

Water clarity is good except after snowmelt or heavy rain when sedimentation and other non-point source pollutants are high. Fecal coliform levels are high from agricultural runoff and septic systems (Table 1). Four pesticides were present; acetochlor, desethylatrazine and metolachlor were below the 0.5 μg/L minimum reporting limit. Atrazine was measured at 4.0 μ/L. The highest water temperature of 24.8°C (76.6°F) was recorded on 3 August, but the first reading of 20°C (68°F), an accepted maximum for non-native trout, occurred on 22 June (Table 2). Maximum temperatures at or above 20°C occurred almost daily beginning the first week in July (Figure 2). Silt was present throughout the stream, especially in Reach 2 (Table 3), from field runoff and moderate bank erosion. Low flows limited the usefulness of the little in-stream cover present in Reach 1. Ten species of fish from four families were collected, all of which were forage fish (Table 4).

The fishery in Johns Creek is limited by several factors. Lack of stream shading and low summer flows contribute to high water temperature that restricts the growth and survival of all but the most tolerant species. Erosion throughout the watershed impacts fish feeding and reproduction in the stream and adds to the sediment load in the Minnesota River. Unless improvements are made, even put-and-take stocking is untenable, and only infrequent sampling is recommended.

16. References

Lyons, J. 1992. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. NAJFM 12:198-203.

17. Credits and Signatures

a. Funding	F-29-R(P)-25 Federal Aid to Sportfish Restoration in Minnesota
b. Field Crew/Titles	Cam Mitchell/Fisheries Technician Bob Hogg/ Fisheries Technician Brad Koenen/ Fisheries Technician Bobbi Chapman/Fisheries Specialist
c. Report Author/Title	Bobbi Chapman/Fisheries Specialist

Approved by ______________________ 8/9/06
Area Fisheries Supervisor Date

Approved by ______________________ 8/22/2006
Regional Fisheries Manager Date

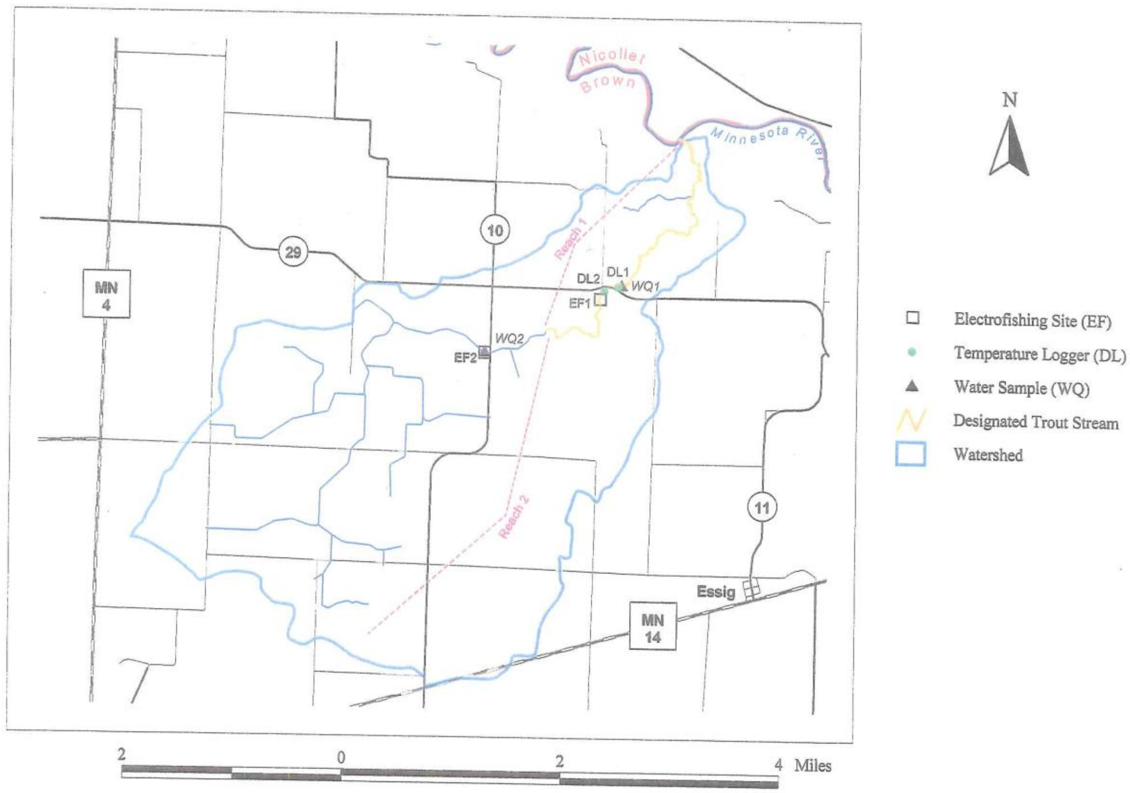

Figure 1. Johns Creek M-55-106.

4

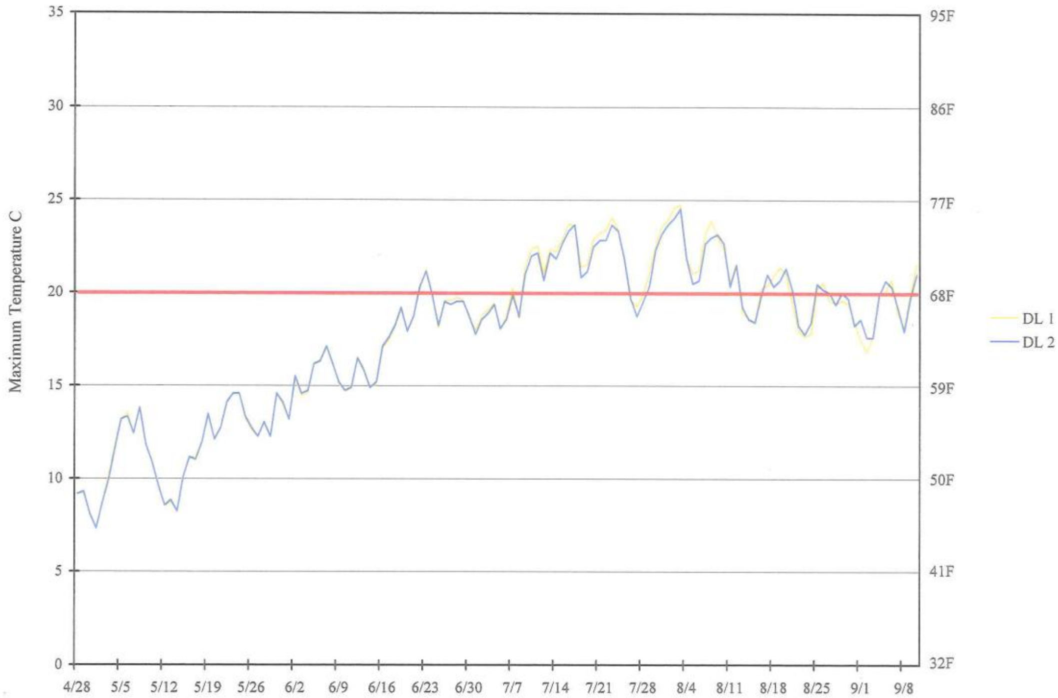

Figure 2. Johns Creek M-55-106 maximum daily water temperatures from two data loggers (DL).

Table 1. Water chemistry and pesticides.

	Station	
	WQ1	WQ2
Field Determinations 14 June 2005		
Latitude	N44°21.805	N44°21.248
Longitude	W94°38.011	W94°39.276
Dissolved Oxygen	10.00 mg / L	8.34 mg / L
pH	8.10	6.80
Conductivity	1,000 μmhos / cm	957 μmhos / cm
Water Temperature	13.5°C (56.3°F)	16.0°C (60.8°F)
Turbidity Tube Height	604 mm	502 mm
Laboratory Analysis		
pH	8.21	7.98
Conductivity	900 μmhos / cm	900 μmhos / cm
Chloride	30.1 ppm	26.9 ppm
Chlorophyll A	4.9 ppb	3.2 ppb
Total Dissolved Solids	568 ppm	544 ppm
Total Phosphorus	0.103 ppm	0.108 ppm
Total Alkalinity	299 ppm	309 ppm
Fecal Coliform	500 mpn	—
Pesticides		
Acetochlor	present < MRL*	—
Atrazine	4.00 µg/L	—
Desethylatrazine	present < MRL	—
Metolachlor	present < MRL	—

* Method Reporting Limit = 0.5 μg / L

Table 2. Water temperature summary.

	Logger 1	Logger 2
Days	136	136
Hourly Data Logger Readings	3,264	3,264
Maximum Temperature Reading Date of Maximum Reading	24.8°C (76.6°F) 3 August	24.5°C (76.1°F) 3 August
Minimum Temperature Reading Date of Minimum Reading	4.1°C (39.3°F) 2 & 3 May	4.1°C (39.3°F) 2 & 3 May
Date of First 20°C (68°F) Reading	23 June	22 June
Total Readings ≥20°C	548 (16.8%)	590 (18.1%)
Days with at Least 1 Reading ≥20°C	45 (33.1%)	46 (33.8%)
Days with Minimum Temperature ≥20°C	7 (5.2%)	7 (5.2%)

Table 3. Stream physical characteristics.

Station	EF1	EF2
Date	5 August 2005	5 August 2005
Length	374.0 ft (114.0 m)	315.0 ft (96.0 m)
Downstream Latitude	N44° 21.705	N44° 21.251
Downstream Longitude	W094° 38.054	W094° 39.300
Discharge	0.19 ft^3/s ($0.01 m^3/s$)	not measurable
Shade	50%	20%
Escape Cover	undercut bank 10%, boulder 10%, logs 5%	undercut bank 30%, overhanging grass 100%
Instream Vegetation	filamentous algae, water plantain	arrowhead, greater duckweed, water smartweed, flatstem bullrush
Banks		
Mean Height	6.5 ft (2.0 m)	13.5 ft (4.1 m)
Height Range	3.0-10.0 ft (0.9-3.0 m)	12.0-15.0 ft (3.7-4.6 m)
Erosion	moderate	light
Channelization / Grazing	0% / 0%	100% / 0%
Runs	30%	100%
Mean Width	6.5 ft (2.0 m)	7.0 ft (2.1 m)
Mean Depth	0.3 ft (0.1 m)	0.2 ft (0.01 m)
Substratum	silt 5%, sand 95%	silt 100%
Riffles	40%	
Mean Width	7.3 ft (2.2 m)	
Mean Depth	0.2 ft (0.1 m)	
Substratum	silt 15%, sand 25%, gravel 25%, coble 30%, boulder 5%	
Pools	30%	
Mean Width	14.8 ft (4.5 m)	
Mean Depth	1.2 ft (0.4 m)	
Maximum Depth	2.1 ft (0.6 m)	
Substratum	silt 15%, sand 40%, gravel 45%	

Table 4. Electrofishing catch-Station EF1.

Species	Number	Length Range (mm)
Bigmouth Shiner	26	55-79
Blacknose Dace	240	51-123
Brassy Minnow	23	41-96
Brook Stickleback	1	39
Central Stoneroller	15	82-138
Creek Chub	51	50-143
Fathead Minnow	51	41-76
Johnny Darter	29	42-64
White Sucker	2	70-207

Table 6. Electrofishing catch-Station EF2.

Species	Number	Length Range (mm)
Longnose Dace	3	36-66

John's Creek-2007: Special Sampling

1. Stream Name	Johns Creek
2. Alternate Names	none
3. Tributary Number	M-55-106
4. Counties	Brown
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watersheds and Numbers	County Ditch 10, 28092
9. Length of Stream	8.5 mi (13.7 km) 3.8 mi (6.1 km) Designated Trout Stream
10. Size of Watershed	13.3 sq mi (34.5 sq km)
11. Public Access	road crossings
12. Dams and Obstructions	none
13. Previous Sampling	Initial Survey 1981 Population Assessment 1982, 2005 Special Sampling 1979, 1981, 1982, 1983 Survey 1987
14. Stocking	Brown trout adults-1961 (302) Brown trout yearlings-1962-1995 (200-1,620) Rainbow trout yearlings-1977 & 1981 (400-500) No stocking recommended.

15. Watershed Description

The majority of the watershed is flat to rolling agricultural land, which is intensively row-cropped. Water temperatures in the upstream channelized stretch are high because of low flow, minimal shading and large sediment loads from ditch and tile drainage. The lower stretch is wooded and hilly, and the stream channel is an unaltered run.

16. Sampling Methods

Two Water Temp Pro V2® (Onset Computer Corporation) loggers (TL) were placed in pools in the designated trout area (Figure 1) and recorded hourly temperatures between 27 June and 26 September. Loggers were checked periodically throughout the 92 day deployment, and at the end of July, the upstream site was dry. The logger (TL2) was left in place, but not found at the end of the season. Surrounding landowners were contacted about the logger without success. Summary statistics were calculated and plotted in Excel 2000 (© Microsoft 1999).

17. Results

Hourly recorded water temperatures at the downstream site ranged from 7.9°C on 15 September to 20.5°C on 8 July (Table 1). Mean daily temperature was 15.28°C (STD 1.96). The mean difference between daily maximum and minimum recorded temperatures was 3.8 °C (STD 1.4), which ranged between 0.9°C on 22 August and 6.6°C on 7 July. Temperatures over 20°C, an accepted maximum for non-native trout, were recorded six times; four in July, and two in August (Figure 2). Springs in this part of the stream moderate temperatures.

18. Credits and Signatures

a. Funding F-29-R(P)-25
Federal Aid to Sportfish Restoration in Minnesota

b. Field Crew/Titles
Bob Hogg/ Fisheries Technician
Bobbi Chapman/Fisheries Specialist

c. Report Author/Title Bobbi Chapman/Fisheries Specialist

Approved by [illegible] 3/14/08
Area Fisheries Supervisor Date

Approved by Jack Lauer 8/22/2008
Regional Fisheries Manager Date

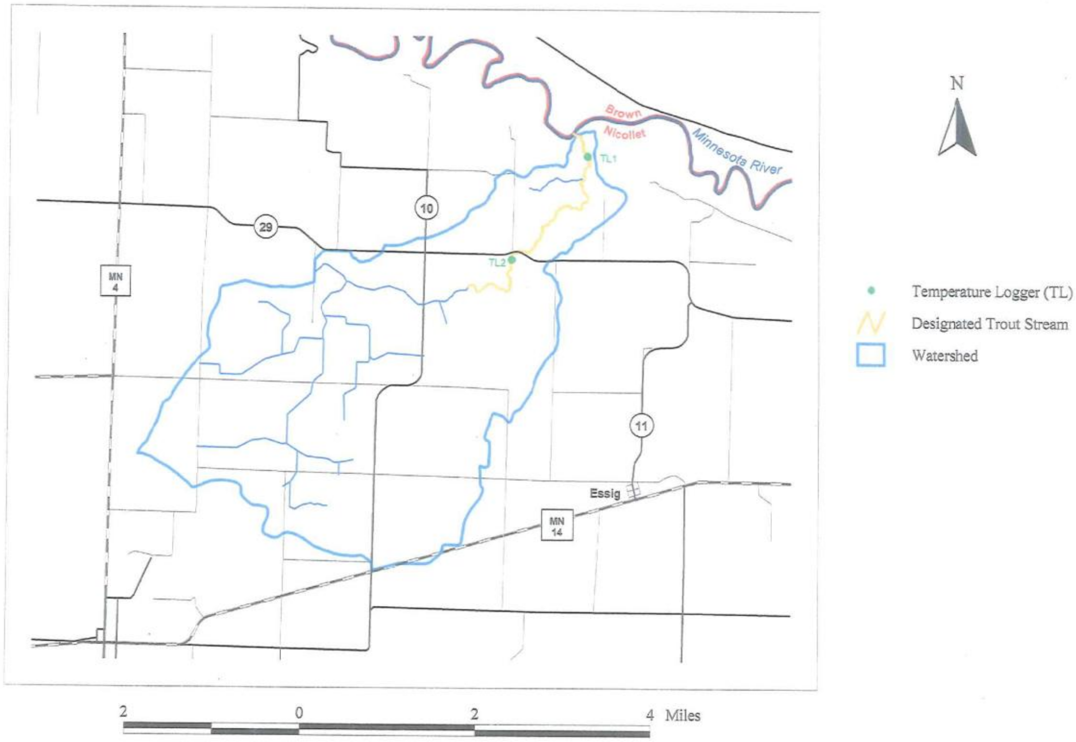

Figure 1. John's Creek temperature logger locations.

3

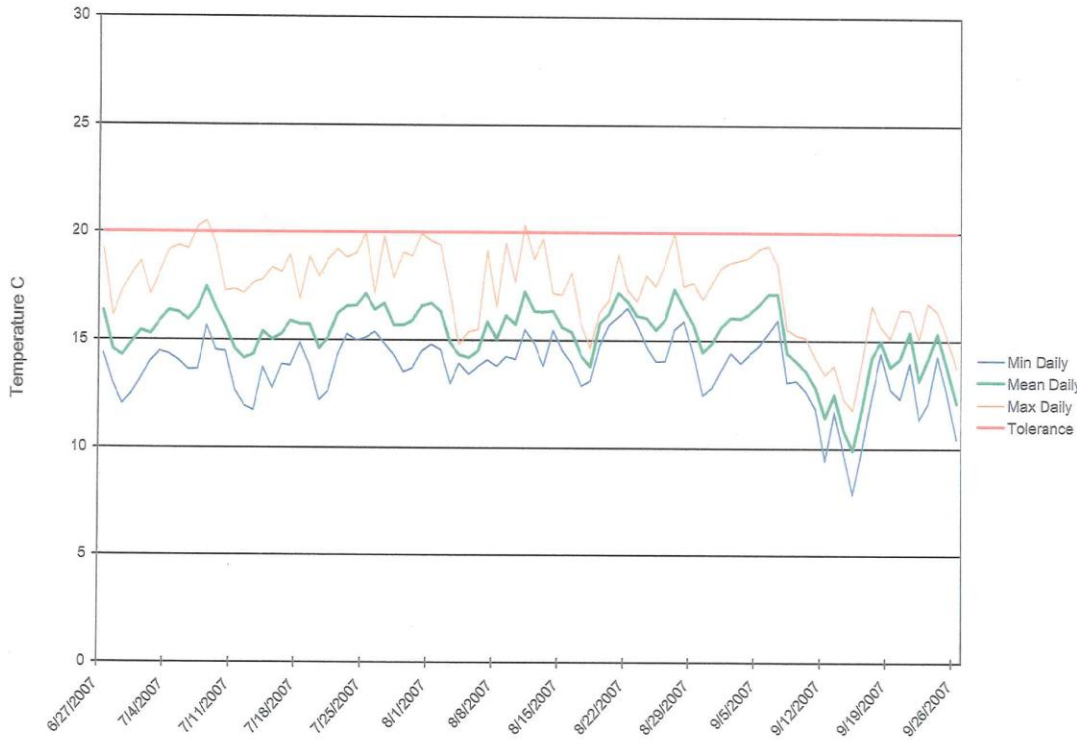

Figure 2. Johns Creek Downstream Logger

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Table 1. Recorded daily temperatures on Johns Creek (TL1).

Date	TL1		
	Minimum (°C)	Mean (°C)	Maximum (°C)
27 June 2007	14.361	16.317	19.199
28 June 2007	12.944	14.555	16.106
29 June 2007	12.025	14.276	17.296
30 June 2007	12.509	14.874	18.010
1 July 2007	13.209	15.432	18.628
2 July 2007	14.002	15.272	17.106
3 July 2007	14.481	15.872	18.105
4 July 2007	14.337	16.350	19.151
5 July 2007	14.050	16.267	19.365
6 July 2007	13.618	15.921	19.222
7 July 2007	13.642	16.466	20.246
8 July 2007	15.652	17.463	20.507
9 July 2007	14.529	16.465	19.389
10 July 2007	14.481	15.632	17.272
11 July 2007	12.654	14.591	17.344
12 July 2007	11.953	14.149	17.153
13 July 2007	11.734	14.334	17.629
14 July 2007	13.738	15.394	17.796
15 July 2007	12.751	15.023	18.343
16 July 2007	13.882	15.269	18.129
17 July 2007	13.810	15.875	18.937
18 July 2007	14.864	15.733	16.892
19 July 2007	13.810	15.720	18.842
20 July 2007	12.195	14.601	17.938
21 July 2007	12.654	15.148	18.723
22 July 2007	14.314	16.208	19.199
23 July 2007	15.270	16.561	18.818
24 July 2007	14.984	16.591	19.032
25 July 2007	15.103	17.143	19.960
26 July 2007	15.390	16.396	17.177
27 July 2007	14.840	16.692	19.817
28 July 2007	14.312	15.684	17.867
29 July 2007	13.522	15.686	19.056
30 July 2007	13.714	15.900	18.889
31 July 2007	14.505	16.581	19.936
1 August 2007	14.792	16.701	19.603
2 August 2007	14.553	16.319	19.413
3 August 2007	12.968	14.864	17.106
4 August 2007	13.930	14.327	14.792
5 August 2007	13.425	14.184	15.390
6 August 2007	13.786	14.519	15.485
7 August 2007	14.098	15.856	19.151
8 August 2007	13.786	15.049	16.487
9 August 2007	14.242	16.134	19.484
10 August 2007	14.122	15.726	17.677
11 August 2007	15.485	17.264	20.341

Table 1. Continued.

Date	TL1		
	Minimum (°C)	Mean (°C)	Maximum (°C)
12 August 2007	14.864	16.342	18.747
13 August 2007	13.810	16.307	19.698
14 August 2007	15.461	16.362	17.177
15 August 2007	14.529	15.587	17.106
16 August 2007	13.930	15.380	18.129
17 August 2007	12.871	14.305	15.796
18 August 2007	13.112	13.786	14.649
19 August 2007	14.768	15.786	16.296
20 August 2007	15.724	16.224	16.844
21 August 2007	16.106	17.223	18.985
22 August 2007	16.487	16.806	17.344
23 August 2007	15.700	16.133	16.796
24 August 2007	14.721	16.047	18.010
25 August 2007	14.026	15.484	17.510
26 August 2007	14.050	15.987	18.850
27 August 2007	15.509	17.391	19.984
28 August 2007	15.891	16.540	17.510
29 August 2007	14.385	15.741	17.677
30 August 2007	12.461	14.461	16.982
31 August 2007	12.799	14.858	17.605
1 September 2007	13.642	15.628	18.366
2 September 2007	14.433	16.043	18.604
3 September 2007	13.954	16.011	18.723
4 September 2007	14.385	16.265	18.866
5 September 2007	14.768	16.654	19.246
6 September 2007	15.342	17.157	19.389
7 September 2007	15.939	17.164	18.485
8 September 2007	13.064	14.428	15.509
9 September 2007	13.137	14.052	15.247
10 September 2007	12.654	13.596	15.127
11 September 2007	11.856	12.826	14.194
12 September 2007	9.410	11.427	13.401
13 September 2007	11.759	12.540	13.882
14 September 2007	9.780	10.871	12.316
15 September 2007	7.870	9.918	11.783
16 September 2007	10.026	11.883	14.050
17 September 2007	12.413	14.241	16.630
18 September 2007	14.433	14.977	15.652
19 September 2007	12.751	13.800	15.103
20 September 2007	12.316	14.181	16.439
21 September 2007	13.978	15.399	16.415
22 September 2007	11.346	13.137	15.031
23 September 2007	12.098	14.144	16.749
24 September 2007	14.290	15.325	16.344
25 September 2007	12.558	13.798	15.199
26 September 2007	10.443	12.130	13.762

JOHN'S CREEK-2009: SPECIAL SAMPLING

Johns Creek M-55-106 **Special Sampling** **2009**

1. Stream name	Johns Creek
2. Alternate names	None
3. Tributary Number	M-55-106
4. County	Brown
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watershed and Number	County Ditch 10, 28092
9. Length of Stream	8.5 mi (13.7 km) 3.8 mi (6.1 km) Designated Trout Stream
10. Size of Watershed	13.3 sq mi (34.5 sq km)
11. Public Access	road crossing
12. Dams and Obstructions	None
13. Previous Sampling	Initial Survey 1981 Population Assessment 1982, 2005 Special Sampling 1979, 1981-83, 2007 Survey 1987
14. Stocking	Brown trout adults 1961 (302) Brown trout yearlings 1962-95 (200-1,620) each year Rainbow trout yearlings 1977 &1981 (400-500) each year Last stocked in 1995

1

15. Watershed Description

The watershed is flat to rolling agricultural land used primarily to produce row crops (Figure 1). Drainage consists of extensive networks of underground tile discharging into an open channelized ditch. The lowermost three mile section of Johns Creek has not been aligned or dredged. The gradient through this portion is much higher as it descends 150 ft (45.7 m) into the Minnesota River Valley. Here the stream corridor is bordered with moderate to steep slopes covered with deciduous hardwoods.

16. Sampling Methods

Three HOBO (Onset Computer Corporation) Water Temp Pro V2 Loggers were deployed in Johns Creek (Figure 2). Loggers were sited to gather data within the unaltered, lowermost three mile stream section. The uppermost temperature logger (TLU) was sited immediately below the County Highway 29 crossing. This logger was positioned to monitor steam temperature prior to groundwater inputs. The middle temperature logger (TLM) was sited immediately downstream from the area providing groundwater inputs and sustained flow. The lowermost logger (TLD) was situated approximately 700 ft (213 m) upstream from confluence with the Minnesota River to determine if stream temperature increased as water flowed through the pastured flood plain. The loggers were attached to rebar with cable ties and driven into the substrate. Loggers were programmed to gather hourly temperature data between 29 April and 30 September. Loggers were checked periodically throughout deployment. Summary statistics were calculated and plotted in Excel 2000 (Microsoft Corporation 1999).

Stream discharge was recorded three times during the sampling period. On 3 July upstream and downstream flows were taken to estimate the contribution of groundwater discharge. Flows were measured using a Marsh-McBirney Portable Flowmeter Model 201D and a top-setting wader rod.

On 7 July the lower three mile portion of Johns Creek was walked to record visible groundwater discharges. Inputs were identified by visible flow and/or iron precipitate discoloration of substrates at seeps. Discharge locations (Figure 5) were recorded on a Garmin GPS 76 and visual estimates of flow were recorded at each discharge in gallons per minute.

One fish sampling station was established on 1 September immediately below the area with groundwater inputs (Figure 2). The station began within a wetted stream crossing and continued upstream 833 ft (253.8 m). Beginning and ending stream locations were recorded with a Garmin GPS 76. Conductivity, temperature and time electrofished were recorded. Attempts were made to collect all fish throughout the entire width using a Smith-Root Backpack Electrofisher Model 12. Total fish numbers were recorded for each species. Individual lengths were recorded for trout.

17. Results

Temperature information from TLU was not used. That portion of Johns creek was without flow beginning mid July. Pools stagnated or dried up. Logged temperatures on TLU simply reflected daily air temperature change. Hourly water temperatures recorded on TLM and TLD were very similar (Figures 3-4). Overall TLD averaged a 1°F temperature elevation when compared to TLM. Hourly water temperatures ranged from 43°F (6.2°C) on 2 May to 72°F (22.2°C) on 14 August. The overall mean daily temperature on TLM was 57°F (14.0°C). The overall mean daily temperature on TLD was 58°F (14.6°C).

Total stream discharge was measured as 3.1cfs on 15 May, 1.6 cfs on 3 July, and 2.7 cfs on 2 September. On 3 July measured flows were taken above the groundwater inputs and then below to calculate the contribution of groundwater. Groundwater discharge accounted for 1.4 cfs. The 2.7 cfs recorded on 2 September was also a result of groundwater inputs as the stream had no flow above the input area.

Twenty eight visible springs and seeps were recorded within the lowermost portion of Johns Creek on 7 July. The discharge area encompassed 7096 ft beginning below the County Highway 29 crossing and continued to where the stream entered the Minnesota River Valley floodplain. Flow continues to build throughout the input area. The larger springs are located in the lower one third of the input area.

Electrofishing effort totaled 833 ft and 2294 sec. Conductivity measured 923 µS/cm. Stream temperature was recorded as 52°F (11.0°C). Water clarity was unlimited. Eleven species of fish were captured including the following: 17 white sucker, 4 central stone roller, 19 blacknose dace, 8 mud minnow, 11brook stickleback, 34 creek chub, 4 Johnny darter, 2 sand shiner, 2 fantail darter, 1 black bullhead, and 87 brown trout. Lengths on brown trout ranged from 3.5 in (89 mm) to 19.9 in (505 mm) representing a minimum of three year classes (Figure 6). An estimated 25 brown trout were observed but not captured.

18. Discussion

Channel straightening, extensive drainage, and agricultural practices in the upper watershed have impacted the hydrology of Johns Creek. This activity contributes dynamic flows, increased sediment loads, and altered stream temperatures. The lowermost 3.8 mi is a designated trout stream. Various fisheries investigations beginning in 1979 have explored the validity of stocking trout as a put and take fishery. Trout stocking began in 1961 and was discontinued in 1995. An annual stream fishing easement was secured by the New Ulm Isaac Walton League along the lowermost half mile of stream from a single property owner when stocking occurred. At the present time there is no public access to Johns Creek once flow ceases.

That portion of Johns Creek above County Highway 29 ceased to flow beginning mid July. Riffles and runs were dry and pools stagnated. The same situation occurred during temperature evaluations in 2005 and 2007. Groundwater discharge through seeps and springs create a sustained flow in the lowermost 2 mi section. Inputs begin approximately two miles upstream from the confluence but do not generate sufficient flow to create and maintain trout habitat until the lower three-quarter mile of stream. The portion of Johns Creek that flows across the Minnesota River floodplain immediately upstream of the confluence also lacks trout habitat as the stream widens and pools diminish. Suitable year round trout habitat exists in an estimated 0.5 mi (0.8 km) section of Johns Creek. It does not appear stream temperature is a limiting factor within that sector. Water temperature rarely exceeded the 70°F (20°C) accepted maximum for trout survival. Those same findings occurred in 2007.

Trout stocking ended in 1995. No fish sampling occurred the past 14 years. Discussions with local landowner Harley Vogel indicated uncertainty as to the continued presence of trout. The single electrofishing run completed in early September concluded that not only were brown trout present but also reproducing. Trout were the most frequently sampled fish species. Lengths indicated a minimum of three year classes. Young of the year represented 91% of the total trout catch.

Establishment of a naturally reproducing brown trout population is a rare occurrence among tributaries to the Minnesota River. Consideration should be given to the amount of fishing pressure that could be directed toward this stream. The segment capable of sustaining trout year round is minimal. It was estimated a total of 15 to 20 small pools provide adequate depth and cover throughout this half-mile portion. At the present time Harley Vogel allows some angling on his property. The stream trout designation allocates a certain level of habitat protection. No trout stocking is recommended.

19. Management recommendations

- Visit stream with knowledgeable trout habitat consultant to discuss feasibility of instream habitat improvements
- Discuss pros/cons of providing a fishing easement
- Repeat electrofishing station in late summer of 2010 to monitor survival and growth of the 2009 brown trout year class
- No trout stocking

20. Acknowledgements

We would like to thank Harley Vogel and his family for allowing access to Johns Creek. His knowledge of the history of trout management efforts was not only informative but will benefit future management decisions. The excitement shown by his family mimicked our own at the discovery of a naturally reproducing brown trout population and should be acknowledged. It was a pleasure to see landowners genuinely excited to discover a rare and unique resource.

21. Credits and Signatures

a. Funding — F-29-R(P)-26
Federal Aid to Sportfish Restoration in Minnesota

b. Field Crew/Title — Bob Hogg/Fisheries Technician
Cam Mitchell/Fisheries Technician
Brad Koenen/Fisheries Technician

c. Report Author/Title — Brad Koenen/Fisheries Technician
Lee Sundmark/Fisheries Supervisor

Approved by ______________________ 3/22/10
Area Fisheries Supervisor — Date

Approved by ______________________ 4/8/2010
Regional Fisheries Supervisor — Date

Figure 6. Length Frequency Distribution for Brown Trout in Johns Creek.

Length in inches	Number captured
3.00-3.49	-
3.50-3.99	30
4.00-4.49	35
4.50-4.99	14
5.00-5.49	-
5.50-5.99	-
6.00-6.49	-
6.50-6.99	-
7.00-7.49	-
7.50-7.99	-
8.00-8.49	-
8.50-8.99	1
9.00-9.49	1
9.50-9.99	-
10.00-10.49	4
10.50-10.99	-
11.00-11.49	1
11.50-11.99	-
19.49-19.99	1
Total	87

JOHN'S CREEK-2010: SPECIAL SAMPLING

Johns Creek M-55-106 **Special Sampling** **2010**

1. Stream name	Johns Creek
2. Alternate names	None
3. Tributary Number	M-55-106
4. County	Brown
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watershed and Number	County Ditch 10, 28092
9. Length of Stream	8.5 mi (13.7 km) 3.8 mi (6.1 km) Designated Trout Stream
10. Size of Watershed	13.3 sq mi (34.5 sq km)
11. Public Access	road crossing
12. Dams and Obstructions	None
13. Previous Sampling	Initial Survey 1981 Population Assessment 1982, 2005 Special Sampling 1979, 1981-83, 2007, 2009 Survey 1987
14. Stocking	Brown trout adults 1961 (302) Brown trout yearlings 1962-95 (200-1,620) each year Rainbow trout yearlings 1977 &1981 (400-500) each year Last stocked in 1995

15. Watershed Description

The watershed is flat to rolling agricultural land used primarily to produce row crops (Figure 1). Drainage consists of extensive networks of underground tile discharging into an open channelized ditch. The lowermost three mile section of Johns Creek has not been aligned or dredged. The gradient through this portion is much higher as it descends 150 ft (45.7 m) into the Minnesota River Valley. Here the stream corridor is bordered with moderate to steep slopes covered with deciduous hardwoods.

16. Sampling Methods

One fish sampling station established in 2009 was reassessed on 10 September 2010 (Figure 2). The station began within a wetted stream crossing and continued upstream 833 ft (253.8 m). Beginning and ending stream locations were recorded with a Garmin GPS 76. Conductivity, temperature and time electrofished were recorded. Attempts were made to collect all trout throughout the entire width using a Smith-Root Backpack Electrofisher Model 12. Individual lengths were recorded for trout.

17. Results

Electrofishing effort totaled 833 ft and 2001 sec. Conductivity measured 934 µS/cm. Stream temperature was recorded as 55°F (13.0°C). Water clarity was unlimited. A total of 27 brown trout were captured. Lengths ranged from 8.3 in (212 mm) to 13.8 in (350 mm) representing at least two year classes (Figure 6).

18. Discussion

Channel straightening, extensive drainage, and agricultural practices in the upper watershed have impacted the hydrology of Johns Creek. This activity contributes dynamic flows, increased sediment loads, and altered stream temperatures. The lowermost 3.8 mi is a designated trout stream. Various fisheries investigations beginning in 1979 have explored the validity of stocking trout as a put and take fishery. Trout stocking began in 1961 and was discontinued in 1995. An annual stream fishing easement was secured by the New Ulm Isaac Walton League along the lowermost half mile of stream from a single property owner when stocking occurred. There is no public access to Johns Creek from public roadways once flow ceases.

Electrofishing was repeated in 2010 to assess survival of the 2009 year class and observe growth. Electrofishing in 2009 indicated at least three year classes of brown trout present in John's Creek with an abundant year class of age 0 fish comprising 91% of the catch. Lengths from 2010 indicated a minimum of two year classes with yearlings representing 95% of the catch (Figure 3). The 2009 year class grew 5 in (125 mm) on average indicating good growth. No young of the year brown trout were captured in 2010.

Management recommendations in the 2009 John's Creek report included consultation with a knowledgeable trout habitat person for advice on potential habitat improvements. Steve Klotz, Area Fisheries Manager from Lanesboro, viewed the stream in mid September 2010. His suggestions included clearing and maintenance of woody cover from point bars, repositioning of boulders, possible snag removal, and minor bank reshaping and stabilization. He also echoed concerns found in the 2009 report that there are no easements and that trout could be easily exploited over the relatively short section of stream suitable for trout.

19. Management recommendations

- Discuss pros/cons of providing a fishing easement
- No trout stocking

21. Credits and Signatures

a. Funding	F-29-R(P)-26 Federal Aid to Sportfish Restoration in Minnesota
b. Field Crew/Title	Bob Hogg/Fisheries Technician Cam Mitchell/Fisheries Technician Brad Koenen/Fisheries Technician
c. Report Author/Title	Brad Koenen/Fisheries Technician Lee Sundmark/Fisheries Supervisor

Approved by Lee A. Me
Area Fisheries Supervisor
4/6/11
Date

Approved by Jack Lauer (BS)
Regional Fisheries Supervisor
6/1/11
Date

Figure 3. Length Frequency Distribution for Brown Trout in Johns Creek.

Length in inches	Number captured
4.00-4.49	-
4.50-4.99	-
5.00-5.49	-
5.50-5.99	-
6.00-6.49	-
6.50-6.99	-
7.00-7.49	-
7.50-7.99	-
8.00-8.49	1
8.50-8.99	8
9.00-9.49	6
9.50-9.99	5
10.00-10.49	2
10.50-10.99	2
11.00-11.49	-
11.50-11.99	1
12.00-12.49	-
12.50-12.99	-
13.00-13.49	1
13.50-13.99	1
Total	27

SPRING (HINDEMAN) CREEK-2003: STREAM SURVEY

Mailed to NU 3/24/04

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
RIVER OR STREAM SURVEY

Initial Survey
Resurvey X
Pop. Assessment

Date(s) of Field Work June – September 2003
Leader Craig Berberich
Assistant(s) Owen Baird, Jack Lauer

NAME, LOCATION AND FLOW CHARACTERISTICS

1. **Stream Name:** Hindeman Creek
2. **Alternate Name(s):** Spring Creek
3. **Tributary Number:** M-55-108
4. **Counties:** Brown and Redwood
5. **Watershed Name and Number:** Cottonwood River 26
6. **Sequence of Waterways to Basin:** Hindeman Creek to Minnesota River to Mississippi River
7. **Map(s) Used:** U.S.G.S. Quads
8. **Length of Stream:** 19 miles
9. **Average Width-Upper Station:** 6.8 **Lower Station:** 11.0
10. **Mouth Location T.** 111 **R.** 32 **S.** 21
11. **Flow at Mouth:** 4.9 **cfs. Date:** 8-3-93
12. **Flow at Gaging Station - Minimum:** None **cfs Average:** None **cfs**
13. **Location of Gaging Station:** None
14. **Initial Source of Sustained Flow:** Drainage and surface runoff near Redwood and Brown County lines
15. **Gradient:** 11.7 **ft./mile**
16. **Sinuosity:** 1.78

WATERSHED DESCRIPTION AND USE

17. **Description of Watershed (soil types, cover types, topography, land use and ownership).**

a. **Entire watershed:** The watershed consists of clay-loam and silt-loam soils. Most of the watershed is subject to intensive row-crop agriculture. Some woodlot, pasture and grassy areas are present in the lower reach of the stream corridor.

b. **Land adjacent to stream:** All of the riparian land is privately owned. The state has recently acquired a 65-foot easement on both sides of the stream channel, which runs from mile 2.8 – 4.1. There is one property in this stretch in the process of acquisition.

Date(s): June – September 2003 Stream: Hindeman Creek

GENERAL INFORMATION ON THE STREAM

18. Reason for survey: For management purposes.

19. Previous investigations and surveys: An initial survey was done in 1953; stream electrofishing was done in 1979 and 1981; stream surveys were done in 1981and 1988 and a population assessment was done in 2000.

20. Special problems or conditions: Seasonal low flows, agricultural run-off and discharge from municipal septic discharge.

21. Sources of pollution:

Source	Location	Substance Discharged
Non-point	Entire stream	Agricultural chemicals, sediments, nonconforming septic systems, Evan municipal septic discharge and wastes from pastures and feedlots.

22. Erosion:

Type	Degree	Affected Reach
Agricultural lands	Moderate	0 - 19 miles

23. Stream alterations (dredging, channeling, etc.):

Type	Location	Date
Channelized	Upper 13.4 miles	Unknown

Date(s): June – September 2003 Stream: Hindeman Creek

GENERAL INFORMATION ON THE STREAM (continued)

24. Dams and other obstructions (including beaver dams):

Type	Beaver		
Mi. from mouth	Above Hwy 4, 3.0 mi.		
Head (ft)	1.5 ft.		
Length of Dam	25 ft.		
Control Structure			
Use			
Fish Barrier	Low flow		
Owner			
Status			

25. Use of Water: Fishing x_ **Recreation** _x_ **Com. Navigation**
Power __ **Irrigation** __ **Livestock Watering** x
Other (specify)

26. Access (location and ownership): Access is gained off 17 road crossings and recently acquired trout fishing easements. A 65-foot easement on both sides of the stream channel was acquired in 2003 and runs from mile 2.8 – 4.1. There is one property in this stretch in the process of acquisition.

27. Shoreline Developments:

28. Recreational Boating: None
1) Navigable reach: None
2) Type of Boating:

Date(s): June – September 2003 Stream: Hindeman Creek

(31) Characteristics of Water

a) Station No.	1	4	
b) Date	7-15-03	7-15-03	
c) Loc. (mi. from mouth)	2.2	4.1	
d) Length of Station			
e) Time	0930	1000	
f) Air Temp °F	74	74	
g) Water Temp °F	75	73	
h) Color	Clear	Clear	
i) Cause of color			
j) Secchi disc (ft.)	1.6	Bottom / 1.1	
FIELD DETERMINATIONS			
Dissolved Oxygen (ppm)	7.5	8.1	
Free carbon dioxide (ppm)			
FIELD DETERMINATION OR LABORATORY ANALYSIS (Indicate by F or L)	L	L	
Total Alkalinity (ppm)	93	93	
Conductivity (micromhos/cm)	890	835	
pH	8.39	8.34	
LABORATORY ANALYSIS			
Total nitrogen (ppm)			
NH_3 (ppm)			
NO_2 (ppm)			
NO_3 (ppm)			
Total phosphorus (ppm)	0.076	0.221	
Orthophosphates (ppm)			
Sulfate ion (ppm)			
Chloride ion (ppm)			
B.O.D. (ppm)			
or C.O.D. (ppm)			
Turbidity (JTU)			
Total dissolved solids (ppm)			
Chl a ppb	6.5	7.1	

Remarks:

Additional Pages? Yes __ No ___

Date(s): June – September 2003

Stream: Hindeman Creek

(33) Biological Characteristics

a) Station no.	1	2	3	4
b) Date	6-16-03	6-16-03	6-16-03	6-16-03
c) Loc. (miles from mouth)	2.2	2.8	3.1	4.1
d) Length of station	500 ft.	460 ft.	830 ft.	460 ft.
e) Aquatic plants or filamentous algae:	Abundance[1]	Abundance[1]	Abundance[1]	Abundance[1]
None				

[1]Plant or algae abundance: abundant (A), common (C), occasional (O), rare (R), present (P)

f) Distribution of aquatic plants:

g) Common invertebrates (check blank if present)

Order	Station 1	Station 2	Station 3	Station 4
Ephemeroptera (mayflies)		X	X	
Trichoptera (caddis flies)	X	X	X	
Diptera (flies & midges)	X	X	X	
Gastropoda (snails)	X			
Decapoda (crayfish)		X	X	

Remarks:

Additional Pages? Yes __ No ___

Date(s): June – September 2003

Stream: Hindeman Creek

(34) Fishery Characteristics

a) Station No.	1	2	3	4
b) Date	8-8-03	8-8-03	9-15-03	9-30-03
c) Loc. (miles from mouth)	2.2	2.8	3.1	4.1
d) Length of Station	500 ft.	460 ft.	2700 ft.	460 ft.
e) Gear	Smith-Root Model 12 back pack shocker, j-4, setting 400 v	Smith-Root Model 12 back pack shocker,j-4 setting 300 v	Smith-Root Model 12 back pack shocker, j-4 setting 400 v	Smith-Root Model 12 back pack shocker,j-4 setting 400 v
f) Amt. of sampling effort	18 min.	20 min.	3 runs 73 min.	16 min.

g) Species present	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Brown trout			4	0.90	14	6.00		
Creek chub	44	1.89	44	1.73	192	6.56	347	3.32
White sucker	25	7.32	29	4.14	83	16.75	9	0.40
Hornyhead chub			2	0.12				
Orangespotted sunfish			1	0.03				
Central stoneroller	102	2.69	37	1.63	21	0.64	242	2.92
Blacknose dace	51	0.84	38	0.56	86	1.00	223	1.00
Fathead minnow	1	Tr.	10	0.10			2	Tr.
Bluntnose minnow	18	0.23	2	0.01				
Brassy minnow	5	0.02	7	0.09			50	0.72
Common shiner	67	1.56	44	0.68	23	1.02		
Bigmouth shiner	3	0.01	3	0.01			11	0.08
Sand shiner							3	0.01
Johnny darter	13	0.09	21	0.09	16	0.19		
Fantail darter	39	0.26	26	0.09	7	0.09		
h) Gamefish young-of-year SPECIES:								
Brown trout			1	0.05				

Remarks:

Additional Pages? Yes __ No ___

Date(s): June – September 2003 Stream: Hindeman Creek

(35) Fish Sizes Length - Frequency Distributions

Species and Numbers of Fish in Length Groups

Total Length in inches	Brown trout	Creek chub	White sucker	Orangespotted sunfish			
< 2.0							
2.0 - 2.4		2	1	1			
2.5 - 2.9							
3.0 - 3.4	1	4					
3.5 - 3.9		8	3				
4.0 - 4.4		7	1				
4.5 - 4.9		10	1				
5.0 - 5.4		8					
5.5 - 5.9		3	3				
6.0 - 6.4		3	5				
6.5 - 6.9		5	6				
7.0 - 7.4	2	5	5				
7.5 - 7.9		3	10				
8.0 - 8.4	3	3	10				
8.5 - 8.9	2		5				
9.0 - 9.4	2	1	6				
9.5 - 9.9	1		4				
10.0 - 10.4	1	1	4				
10.5 - 10.9	1		4				
11.0 - 11.4	2		1				
11.5 - 11.9							
12.0 - 12.9	2		1				
13.0 - 13.9	1		1				
14.0 - 14.9			1				
15.0 - 15.9							
16.0 - 16.9							
17.0 - 17.9							
18.0 - 18.9							
19.0 - 19.9							
20.0 - 20.9							
21.0 - 21.9							
22.0 - 22.9							
23.0 - 23.9							
24.0 - 24.9							
25.0 - 25.9							
26.0 - 26.9							
27.0 - 27.9							
28.0 - 28.9							
Total	18	63	72	1			

Additional Pages? Yes __ No ___

Date(s): June – September 2003

Stream: Hindeman Creek

(36) **Age and Growth of Gamefish**

a) Age class distributions

Species	Sample Size	Subsample Size	Number of fish in age group 0	I	II	III	IV	V	VI	VI+
Brown trout site 2	4	4		4						
Brown trout site 3	14	6		6						

b) Growth of gamefish

Species	Calculated mean total length at time of last annulus I(N)	II(N)	III(N)	IV(N)	V(N)	VI(N)	VII(N)	VIII(N)
Brown trout site 2	9.1 (4)							
Brown trout site 3	6.5 (6)							

Remarks: A number of the trout scales from site 3 were not readable due to regeneration, particularly of all of the largest fish. Some of these may have been age two from stockings in 2002. One age-0 brown trout was captured at site 2 in August. This fish may have been from natural reproduction.

Additional Pages? Yes __ No ___

Date(s): June – September 2003 Stream: Hindeman Creek

(37) Escape Cover for Gamefish

Similar Reach	Type[1] and Amount[2] of Cover
See 1988 survey	

[1]Cover types:
LJ - log jam
B - boulders
OV - overhanging vegetation
UB - undercut bank
IV - instream vegetation

[2]Amount of cover:
S - scarce
O - occasional
F - frequent

(38) Portion of Stream Suitable for Gamefish

Species	Similar Reach
Brown trout	Reach 2 (mi. 2.64 – 4.91)

(39) History of Stream and Fishing Conditions:

a) Comparisons with past investigations and surveys: Fishing pressure seems to be light - no anglers were observed during the survey, which is consistent with previous investigations.

b) History of fishing conditions: Fishing continues to be light and primarily by a few local anglers. With the recent acquisitions of angling easements it is hoped the public's awareness will increase; increased angler use would justify habitat improvement projects.

Additional Pages? Yes __ No ___

Date(s): June – September 2003 Stream: Hindeman Creek

c) Records of past management

Fish Stocking

Year	Species	Size	Number or Pounds
1994	Brown trout	Yearlings	600
1995	"	"	400
1996	"	"	400
1997	"	"	400
1998	"	"	400
1999	"	"	400
2000	"	"	400
2001	"	"	623
2001	Rainbow trout	"	400
2002	Brown trout	"	600
2003	"	"	1000

Rough Fish Removal

Year	Species	Size	Number or Pounds
None			

Special Regulations: None

Habitat improvement:

Year Installed	Type and Amount	Location (mile to mile)	Cost	Present Condition
None				

Additional Pages? Yes __ No ___

Date(s): June – September 2003 Stream: Hindeman Creek

(40) Discussion of Fishery:

a) General characteristics: Hindeman Creek continues to support a modest put-and-take trout fishery. Temperature and fish sampling suggest a one-mile (3.2 – 4.2) stretch that supports trout. State Highway 4 bisects the stretch of suitable water. The fish sample was well represented by Minnesota River migrants with an abundance of white suckers. Resident stream fish were well represented by creek chubs, stonerollers, blacknose dace and common shiners.

b) Fish management problems: The limited amount of suitable habitat and unsuitable flashy flows in this intensively farmed watershed limit trout populations. Only one mile of stream appears to have suitable temperatures and cover to support trout. The limited put-and-take trout fishery is sustained by a spring stocking of 400 brown trout yearlings most years and occasionally surplus yearling brown trout have been added.

(41) Ecological Classification of Waterway: I-D Marginal trout

(42) Summary and Recommendations:

a) Summary: Continue to manage Hindeman Creek as a put-and-take trout fishery and try and promote the fishery; when angler use increases, explore ways to improve trout habitat

b) Additional information on stations:

Station No.1:

Station No.2:

Station No.3:

Station No.4:

Date(s): June – September 2003

Stream: Hindeman Creek

(43) **CREDITS AND SIGNATURES**

a. **Funding:** F29-R

b. **Field work by:**

Name of crew leader: Craig Berberich

Name of aide(s): Owen Baird, Jack Lauer

c. **Completed report by:**

Name: Craig Berberich

Title: Fisheries Specialist

Approved by: ______________________________ **Date:** 3-24-04
Area Fisheries Supervisor

Approved by: ______________________________ **Date:**
Regional Fisheries Manager

```
****************************************************************************************
Source file:  w:\fishsys\03dis\HID03BNT.ANU
File header:  Hindeman Creek 2003 Sept us hw4 BNT:mm  ;
Species:  Brown Trout
Body-scale constant = 1.10   N =    6
Constant, all lengths, and all length increments in inches
Data transformation:  metric to english, all
****************************************************************************************
Length at Capture in 2003 for Each Age Class, with Incremental Lengths for 2003
----------------------------------------------------------------------------------------
                     Length at Capture                   Length Increments
Year                                        Standard                     Standard
Class  Age   N  Average  Maximum  Minimum    Error        Increment     Error
----------------------------------------------------------------------------------------
2002    1    6    8.28     8.94     7.01     0.307          1.76        0.431
----------------------------------------------------------------------------------------

****************************************************************************************
Average Back-calculated Lengths for Each Age Class
 and Average Annual Increments of Back-calculated Lengths
----------------------------------------------------------------------------------------
Class  Age   N     1
----------------------------------------------------------------------------------------
2002    1    6   6.52
                 6.52
----------------------------------------------------------------------------------------
Mean Length      6.52
Mean Increment   6.52
 N           6     6
----------------------------------------------------------------------------------------
```

```
******************************************************************************************
Source file:  w:\fishsys\03dis\HIN03BT1.ANU
File header:  Hindeman Creek 2003 aug. ds hw4 BNT:mm  ;
Species:  Brown Trout
Body-scale constant = 1.10   N =    4
Constant, all lengths, and all length increments in inches
Data transformation:  log(scale distance) only; metric to english, all
******************************************************************************************

Length at Capture in 2003 for Each Age Class, with Incremental Lengths for 2003
------------------------------------------------------------------------------------------
                      Length at Capture                    Length Increments
Year                                          Standard                    Standard
Class  Age   N  Average  Maximum  Minimum    Error        Increment      Error
------------------------------------------------------------------------------------------
2002    1    4    8.70    11.14     7.20     0.852          -0.36        0.026
------------------------------------------------------------------------------------------

******************************************************************************************
Average Back-calculated Lengths for Each Age Class
 and Average Annual Increments of Back-calculated Lengths
------------------------------------------------------------------------------------------
Class  Age   N     1
------------------------------------------------------------------------------------------
2002    1    4  9.06
                9.06
------------------------------------------------------------------------------------------
Mean Length     9.06
Mean Increment  9.06
 N          4    4
------------------------------------------------------------------------------------------
```

2003 Hindeman Creek Trout Abundance Upstream of HW 4

Population Estimate	15
Approximate 95% CI	(11 - 19)
Mean Length (in.)	9.8
Maximum Length (in.)	13.3
Number per acre water	6.3
Biomass lb/acre	17.4

2700 linear ft. sampled

WATER TEMPERATURES OF SEVEN MILE CREEK, HINDEMAN CREEK, AND FT. RIDGELY CREEK IN 2003

Prepared by Owen Baird MNDNR Fisheries
March 2003

Water temperature was recorded in three Waterville Area streams that are stocked with trout. Onset Hobo Water Temp Pro temperature loggers were used to record temperatures at hourly intervals. Seven Mile Creek was the coolest stream and Ft. Ridgely Creek was the warmest stream in the summer of 2003. The upper lethal temperature for trout is around 25°C. Ft. Ridgely Creek was often warmer than 25°C, while Hindeman Creek only exceeded 25°C briefly. Seven Mile Creek was never above 23°C.

Table 1. Maximum hourly and daily mean water temperatures (°C) in three Waterville Area streams in 2003.

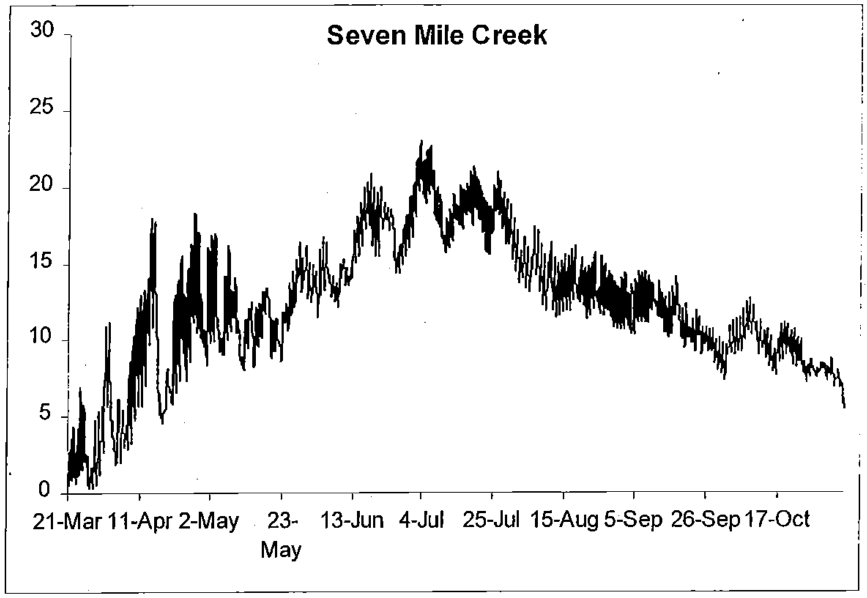
	Seven Mile	Hindeman	Ft. Ridgely
Hourly maximum	23.0	25.3	29.2
Daily maximum	21.1	22.9	25.3

Logger placement.

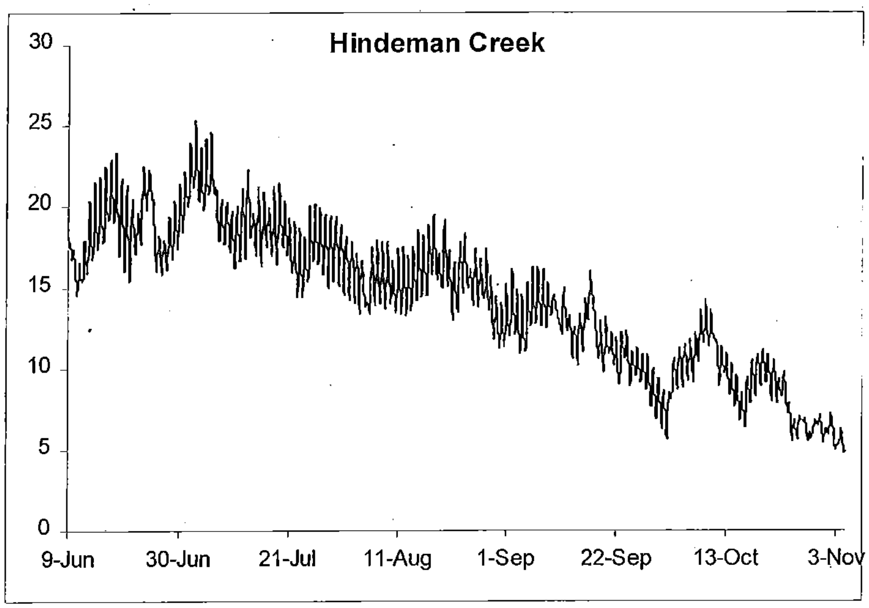
Seven Mile Creek. In county park, upstream of large pool with undercut bank and downstream of most downstream habitat work conducted in 2002 where creek is furthest from paved trail.

Hindeman Creek. Upstream of Hw. 4, about 100 ft upstream of small bridge and picnic area.

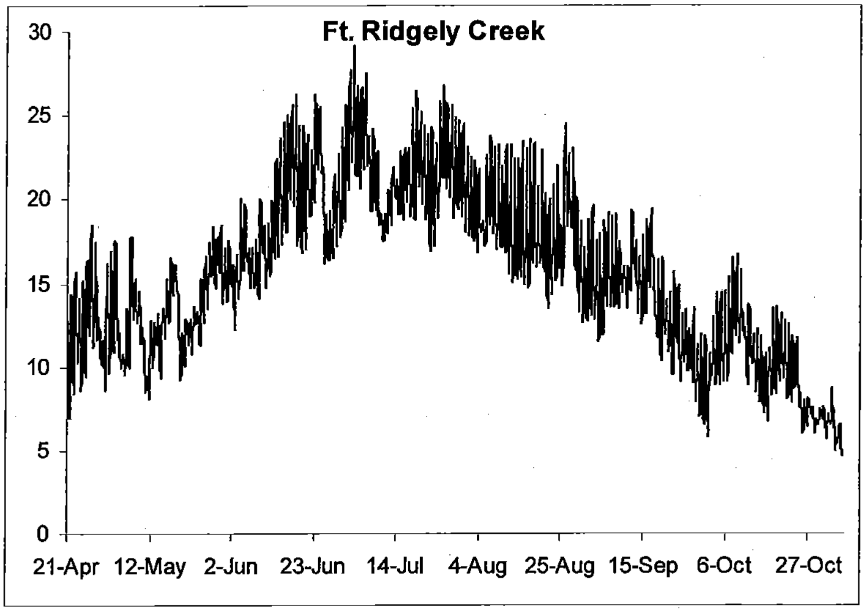
Ft. Ridgely. 250 ft. upstream of Hw. 21.

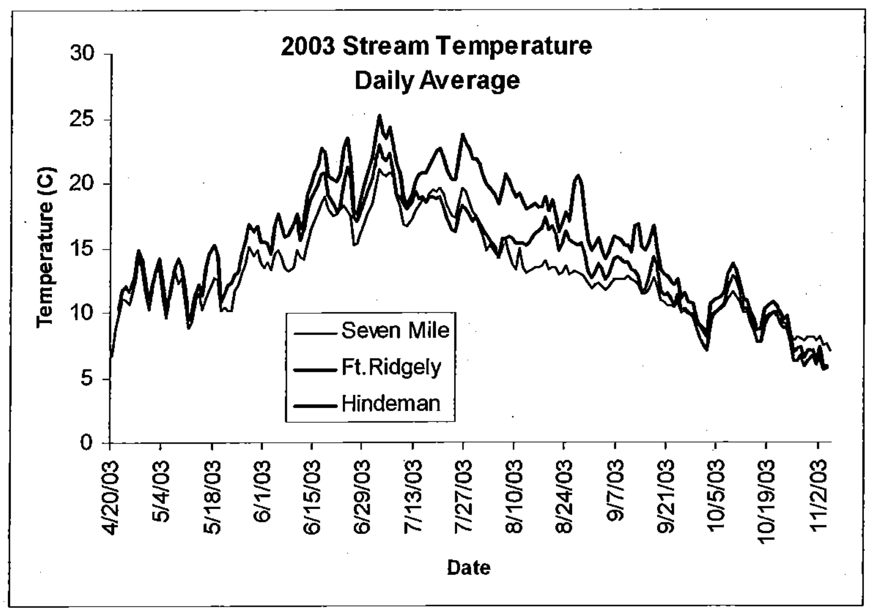


Seven Mile Creek
30
25
20
15
10
5
0
21-Mar 11-Apr 2-May 23-May 13-Jun 4-Jul 25-Jul 15-Aug 5-Sep 26-Sep 17-Oct



Hindeman Creek
30
25
20
15
10
5
0
9-Jun 30-Jun 21-Jul 11-Aug 1-Sep 22-Sep 13-Oct 3-Nov


Ft. Ridgely Creek
30
25
20
15
10
5
0
21-Apr
12-May
2-Jun
23-Jun
14-Jul
4-Aug
25-Aug
15-Sep
6-Oct
27-Oct


2003 Stream Temperature
Daily Average
Temperature (C)
30
25
20
15
10
5
0
Seven Mile
Ft. Ridgely
Hindeman
4/20/03
5/4/03
5/18/03
6/1/03
6/15/03
6/29/03
7/13/03
7/27/03
8/10/03
8/24/03
9/7/03
9/21/03
10/5/03
10/19/03
11/2/03
Date

SPRING (HINDEMAN) CREEK-2005: POPULATION ASSESSMENT

1. Stream Name	Spring Creek
2. Alternate Names	Hinderman Creek
3. Tributary Number	M-55-108
4. Counties	Brown, Redwood
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 4 (Cosmopolitan) or Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watersheds and Numbers	Spring Creek, 28094
9. Length of Stream	20.8 mi (33.8 km) 4.8 mi (7.7 km) Designated Trout Stream
10. Size of Watershed	44.9 sq mi (116.4 sq km)
11. Public Access	32 total acres of easements road crossings
12. Dams and Obstructions	none
13. Previous Sampling	Initial Survey 1978 Survey 1981, 1988, 1993, 2003 Special Sampling 1979, 1980, 1981, 1982 Population Assessment 2000
14. Stocking	Annual stocking of brown trout (various ages and numbers) 1952-1961; 400-1,676 yearlings 1962-present; 501 rainbow trout yearlings 1977

15. Watershed Description and Methods

The majority of the watershed is flat to rolling agricultural land. Intensive row-cropping and drainage deposit large sediment loads into the stream, particularly in the channelized stretch. The upper stream corridor is only minimally shaded by overhanging grass, which combined with low flows and high turbidity contribute to high water temperatures. The lower 7 mi (11 km); however, are hilly and densely covered with deciduous hardwoods. Part of this area is designated for trout and abuts cropland and riparian woods.

The stream was determined to have two similar reaches based on channelization, gradient and land use. Reach 1 is the hilly lower 7 miles, and Reach 2 is the upstream, channelized stretch (Figure 1). Grab samples of water were taken at two sites (WQ) on 14 June for Minnesota Department of Agriculture (MDA) standard laboratory analysis. Additional samples were taken for fecal coliform count and List 1 pesticides analysis. Field measurements were made of pH, conductivity, temperature and turbidity tube height. Three StowAway TidbiT® (Onset Computer Corporation) loggers (DL) recorded hourly temperatures from 28 April to 10 September. Physical characteristics were measured on 10 & 11 August.

16. Fish Sampling Methods

Three fish sampling stations were established: two in Reach 1 and one in Reach 2. The first station and second stations (EF1 & EF2) began 100 ft (30.5 m) upstream of township roads, and the third station (EF3) began 100 ft (30.5 m) upstream of County Road 8. Station lengths were 35 times the mean stream width at each site (Lyons 1992); EF1 was 420 ft (128.0 m), EF2 was 377 ft (115.0 m) and EF3 was 350 ft (107.0 m).

A Smith-Root Backpack Electrofisher Model 12 was used to sample fish at EF1 and EF2 on 31 August and EF3 on 1 September. The entire width of the station was shocked and attempts made to collect all fish. Water temperature, conductivity and shocking time were recorded. Species collected and their lengths and weights were recorded. An abbreviated creel was conducted opening weekend to roughly estimate pressure and catch.

15. Summary

Water clarity is good except after snowmelt or heavy rain when sedimentation and other non-point source pollutants are high. Fecal coliform levels are high from agricultural runoff and septic systems (Table 1). Five pesticides were present, all of which were below the 0.5 μg/L minimum reporting limit. The highest water temperature of 33.8°C (92.9°F) was recorded on 16 August, but the first reading of 20°C (68°F), an accepted maximum for non-native trout, occurred on 17 June (Table 2). Maximum temperatures at or above 20°C occurred almost daily beginning the second week in June (Figure 2). The steep gradient and faster flows changed the substratum from predominantly silt in Reach 2 to gravel, cobble and boulder in Reach 1 (Table 3). Fifteen species of fish from six families were collected (Table 4). A cool and rainy opening weekend and high stream flow limited angling and; therefore contacts by DNR personnel. Five anglers were contacted who caught no fish.

Anglers have occasionally reported catching a fish from a previous year, but high water temperatures and variable flows typically limit Spring Creek to a put-and-take trout fishery. Adult brown and rainbow trout should; therefore, be stocked instead of yearlings, since growth and carry-over are limited. In the channelized reach, high water temperatures, low flows and agricultural erosion restrict growth and survival of all but the most tolerant species.

16. References

Lyons, J. 1992. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. NAJFM 12:198-203.

17. Credits and Signatures

a. Funding	F-29-R(P)-25 Federal Aid to Sportfish Restoration in Minnesota
b. Field Crew/Titles	Cam Mitchell/Fisheries Technician Bob Hogg/ Fisheries Technician Brad Koenen/ Fisheries Technician Bobbi Chapman/Fisheries Specialist
c. Report Author/Title	Bobbi Chapman/Fisheries Specialist

Approved by Lee J. [signature] 6/23/06
Area Fisheries Supervisor Date

Approved by [signature] 8/22/2006
Regional Fisheries Manager Date

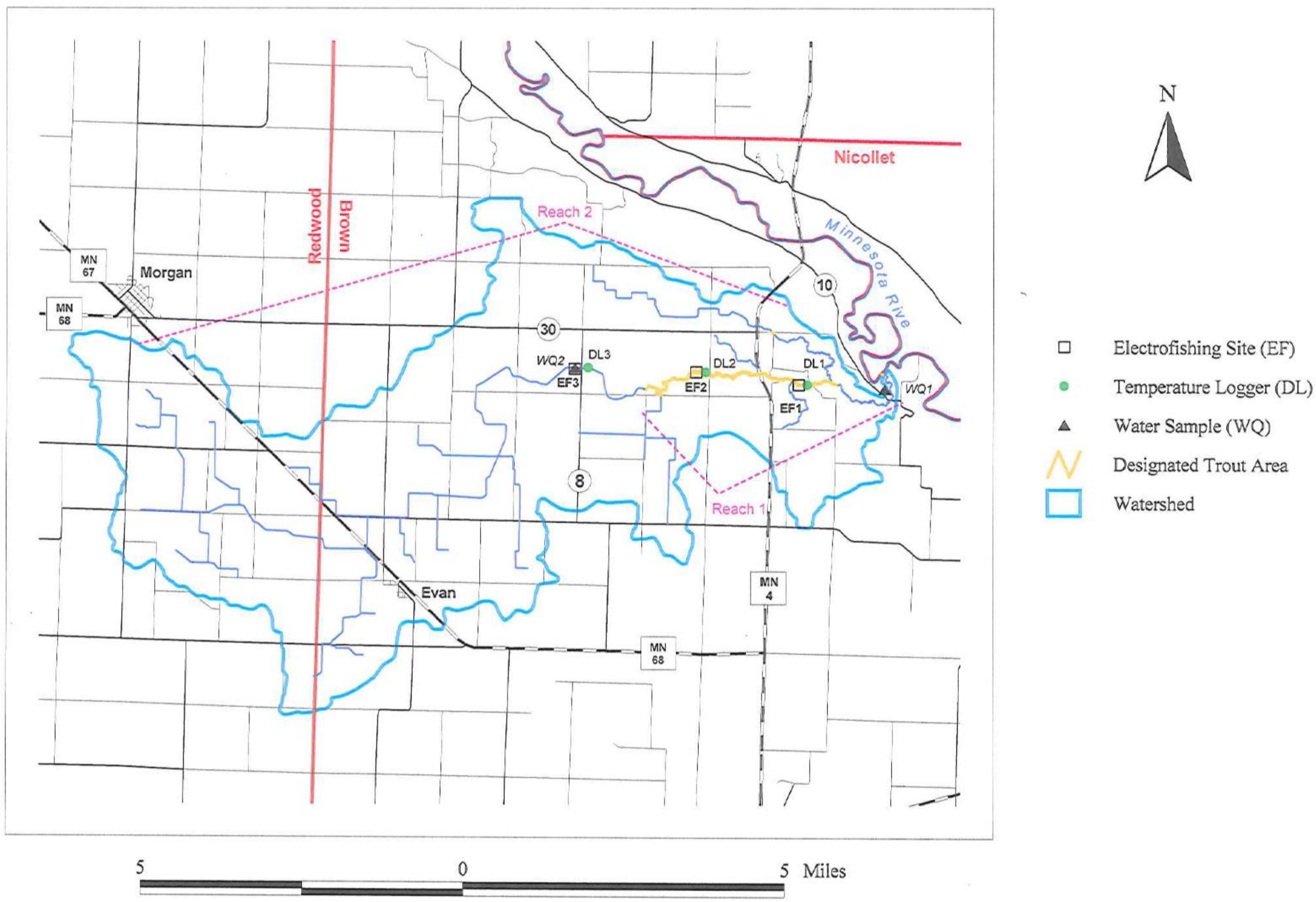


Figure 1. Spring Creek M-55-108.

4

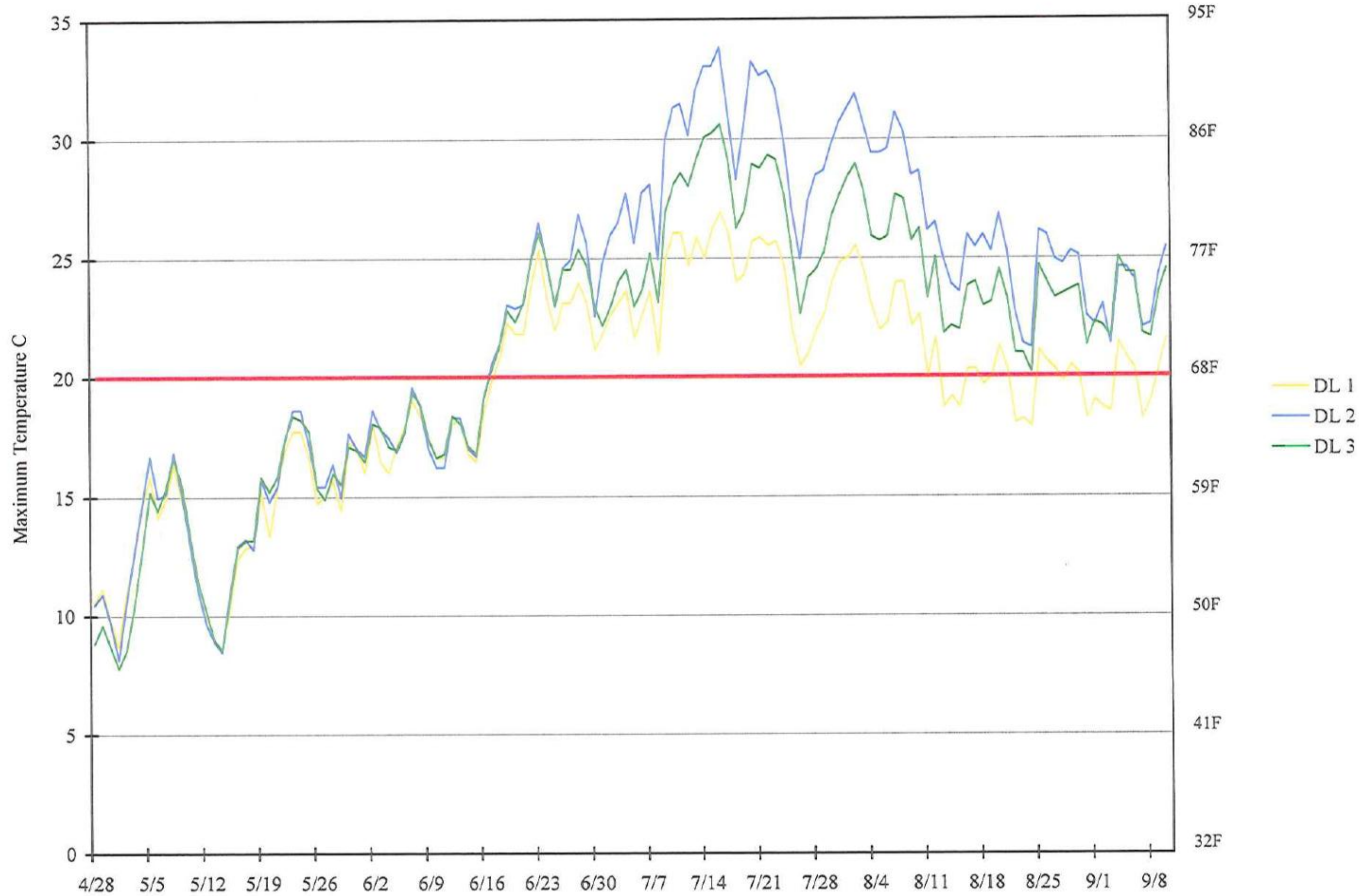


Figure 2. Spring Creek M-55-108 maximum daily water temperatures from three data loggers (DL).

5

Table 1. Water chemistry and pesticides.

	Station	
	WQ1	WQ2
Field Determinations 14 June 2005		
Latitude Longitude	N44°23.908 W94°41.280	N44°24.239 W94°47.126
Dissolved Oxygen	9.86 mg / L	7.39 mg / L
pH	7.46	7.40
Conductivity	982 μmhos / cm	1,008 μmhos / cm
Water Temperature	16.0°C (60.8°F)	15.5°C (59.9°F)
Turbidity Tube Height	414 mm	346 mm
Laboratory Analysis		
pH	8.41	7.95
Conductivity	930 μmhos / cm	800 μmhos / cm
Chloride	28.4 ppm	22.5 ppm
Chlorophyll A	7.2 ppb	7.2 ppb
Total Dissolved Solids	584 ppm	484 ppm
Total Phosphorus	0.163 ppm	0.258 ppm
Total Alkalinity	311 ppm	247 ppm
Fecal Coliform	500 mpn	—
Pesticides		
Acetochlor	present < MRL*	—
Atrazine	present < MRL	—
Desethylatrazine	present < MRL	—
Dimethenamid	present < MRL	—
Metolachlor	present < MRL	—

* Method Reporting Limit = 0.5 μg / L

Table 2. Water temperature summary.

	Logger 1	Logger 2	Logger 3
Days	136	136	136
Hourly Data Logger Readings	3,264	3,264	3,264
Maximum Temperature Reading Date of Maximum Reading	26.9°C (80.5°F) 16 July	33.8°C (92.9°F) 16 July	30.6°C (87.1°F) 16 July
Minimum Temperature Reading Date of Minimum Reading	4.5°C (40.1°F) 3 May	3.2°C (37.7°F) 2 May	4.5°C (40.1°F) 2 May
Date of First 20°C (68°F) Reading	18 June	17 June	17 June
Total Readings ≥20°C	1,005 (30.8%)	1,759 (53.9%)	1,589 (48.7%)
Days with at Least 1 Reading ≥20°C	71 (52.2%)	86 (63.2%)	86 (63.2%)
Days with Minimum Temperature ≥20°C	19 (14.0%)	50 (36.8%)	42 (30.9%)

Table 3. Stream physical characteristics.

Station	EF1	EF2	EF3
Date	10 August 2005	10 August 2005	11 August 2005
Length	420.0 ft (128.0 m)	377.0 ft (115.0 m)	350.0 ft (107.0 m)
Downstream Latitude	N44° 24.064	N44° 24.188	N44° 24.243
Downstream Longitude	W094° 42.833	W094° 44.724	W094° 47.146
Discharge	4.93 ft^3/s (0.14 m^3/s)	1.12 ft^3/s (0.03 m^3/s)	not measureable
Shade	25%	25%	25%
Escape Cover	undercut bank 35%, overhanging grass 75%, wood 20%, boulder 15%	undercut bank 25%, overhanging grass 10%, boulder 5%	undercut bank 50%, overhanging grass 100%
Instream Vegetation	none	filamentous algae, arrowhead	none
Banks			
Mean Height	8.0 ft (2.4 m)	4.0 ft (1.2 m)	19.0 ft (5.8 m)
Height Range	3.0-30.0 ft (0.9-9.1 m)	2.0-20.0 ft (0.6-6.1 m)	18.0-20.0 ft (5.5-6.1 m)
Erosion	severe	severe	light
Channelization / Grazing	0% / 0%	0% / 100%	100% / 0%
Runs	43%	27.5%	100%
Mean Width	16.0 ft (4.9 m)	10.0 ft (3.0 m)	16.0 ft (4.9 m)
Mean Depth	0.6 ft (0.17 m)	0.4 ft (0.11 m)	0.9 ft (0.28 m)
Substratum	silt 5%, sand 25%, gravel 25%, cobble 40%, boulder 5%	silt 20%, sand 25%, gravel 20%, cobble 30%, boulder 5%	silt 97%, boulder 3%
Riffles	28.5%	27.5%	
Mean Width	20.5 ft (6.2 m)	7.5 ft (2.3 m)	
Mean Depth	0.2 ft (0.08 m)	0.3 ft (0.08 m)	
Substratum	silt 5%, sand 15%, gravel 15%, cobble 40%, boulder 25%	silt 5%, sand 20%, gravel 25%, cobble 10%, boulder 40%	
Pools	28.5%	45%	
Mean Width	19.5 ft (5.9 m)	14.0 ft (4.2 m)	
Mean Depth	1.0 ft (0.3 m)	0.9 ft (0.3 m)	
Maximum Depth	1.8 ft (0.5 m)	1.5 ft (0.5 m)	
Substratum	silt 30%, sand 30%, gravel 30%, cobble 5%, boulder 5%	silt 30%, sand 15%, gravel 40%, cobble 10%, boulder 5%	

Table 4. Electrofishing catch-Station EF1.

Species	Number (YOY)	Length Range (mm)
Bigmouth Shiner	32	60-70
Blacknose Dace	172	48-93
Bluntnose Minnow	11	45-78
Central Stoneroller	57	80-151
Common Carp	4	91-314
Common Shiner	174	54-150
Creek Chub	55	37-137
Fantail Darter	23	43-62
Fathead Minnow	54	52-95
Freshwater Drum	1	100
Hybrid Sunfish	3 (3)	55-80
Johnny Darter	14	41-61
Sand Shiner	126	51-80
White Sucker	6	85-200

Table 5. Electrofishing catch-Station EF2.

Species	Number	Length Range (mm)
Bigmouth Shiner	2	66-72
Blacknose Dace	209	38-89
Central Stoneroller	22	71-142
Creek Chub	166	33-205
Fathead Minnow	132	35-77
White Sucker	19	69-98

Table 6. Electrofishing catch-Station EF3.

Species	Number	Length Range (mm)
Blacknose Dace	52	71-85
Brassy Minnow	6	76-92
Central Stoneroller	2	70-122
Creek Chub	44	43-247
Fathead Minnow	228	50-65
White Sucker	34	77-297

SPRING (HINDEMAN) CREEK-2006: SPECIAL ASSESSMENT

1. Stream Name	Spring Creek
2. Alternate Names	Hinderman Creek
3. Tributary Number	M-55-108
4. Counties	Brown, Redwood
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 4 (Cosmopolitan) or Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato, 28
8. Minor Watersheds and Numbers	Spring Creek, 28094
9. Length of Stream	20.8 mi (33.8 km) 4.8 mi (7.7 km) Designated Trout Stream
10. Size of Watershed	44.9 sq mi (116.4 sq km)
11. Public Access	32 total acres of easements road crossings
12. Dams and Obstructions	none
13. Previous Sampling	Initial Survey 1978 Survey 1981, 1988, 1993, 2003 Special Sampling 1979, 1980, 1981, 1982 Population Assessment 2000, 2005
14. Stocking	1952-1961, brown trout (various ages and numbers); 1962-2005, 400-1,676 brown trout yearlings; 1977, 501 rainbow trout yearlings 2006, 540 brown and 167 rainbow trout adults

15. Watershed Description and Methods

The majority of the watershed is flat to rolling agricultural land, but the lower 7 mi (11 km) are hilly and densely covered with deciduous hardwoods. The stream has two similar reaches based on differences in gradient, land use and channelization (Figure 1). Reach 1 is designated for trout, except the lower 2 mi (3.2 km) and abuts cropland, and riparian forest. The minimal shading and high sedimentation from extensive row-crop agriculture in Reach 2 contribute to high water temperatures.

16. Fish Sampling Methods

Four fish sampling stations were established: all in Reach 1 (Figure 1). The first station (EF1) began 100 ft (30.5 m) upstream of a township road crossing, the second (EF2) began 100 ft (30.5 m) upstream of the washed-out road crossing, the third (EF3) began began 100 ft (30.5 m) upstream of a stocking site, and the fourth (EF4) began 300 ft (91.4 m) below a township road crossing. All stations were 200 ft (61.0 m) in length. Attempts were made to collect all trout throughout the entire width of a station using a Smith-Root Backpack Electrofisher Model 12. Sampling was done on 23 June 2006 to check trout presence prior to extreme summer conditions.

Trout anglers were randomly surveyed on Ramsey, Spring and Ft. Ridgely Creeks on weekends between 15 April and 27 May 2006. Questions included frequency and duration of trout fishing, catch, and other types of fishing. Questionnaires were also distributed to area Electronic License Sales (ELS) dealers and approximately 200 anglers who had purchased trout stamps by the end of March.

15. Summary

A total of 10 brown were sampled from all four stations, primarily at the middle two stations (Table 1). No rainbow trout were caught. Ten anglers were interviewed, all prior to walleye opener on 13 May, who reported catching a total of 2 brown and 5 rainbow trout. Four of only eight questionnaires returned reported angling on Spring Creek for a total catch of 18 brown and 12 rainbow trout.

In addition to appreciating the larger trout, anglers stated they fished for many other species. This was reflected in the limited trout angling reported on the questionnaires and no angler interviews after the walleye opener.

16. Credits and Signatures

a. Funding F-29-R(P)-26
Federal Aid to Sportfish Restoration in Minnesota

b. Field Crew/Titles
Cam Mitchell/Fisheries Technician
Brad Koenen/ Fisheries Technician
Chris Foster/Fisheries Specialist
Bobbi Chapman/Fisheries Specialist

c. Report Author/Title Bobbi Chapman/Fisheries Specialist

Approved by Lee J. [signature] 3/30/07
Area Fisheries Supervisor Date

Approved by Jack Lauer 6/15/2007
Regional Fisheries Manager Date

Table 1. Length frequency distribution of trout collected.

	EF1	EF2	EF3	EF4
Length Category (in)	Brown Trout	Brown Trout	Brown Trout	Brown Trout
< 3.00				
3.00 – 3.49				
3.50 – 3.99				
4.00 – 4.49				
4.50 – 4.99				
5.00 – 5.49				
5.50 – 5.99				
6.00 – 6.49				
6.50 – 6.49				
6.50 – 6.99				
7.00 – 7.49				
7.50 – 7.99				
8.00 – 8.49				
8.50 – 8.99				
9.00 – 9.49				
9.50 – 9.99			1	
10.00 – 10.49				
10.50 – 10.99				
11.00 – 11.49				
11.50 – 11.99		3	1	1
12.00 – 12.49	1		1	
12.50 – 12.99		1	1	1
13.00 – 13.49				
13.50 – 13.99				
14.00 – 14.49				
14.50 – 14.99			1	
Total	1	4	5	2
CPUE	4.3/hr	28.6/hr	37.3/hr	12.2/hr

Spring (Hindeman) Creek-2008: Special Assessment

Spring Creek M-55-108 **Special Sampling** **2008**

1. Stream Name	Spring Creek
2. Alternate Names	Hinderman Creek, Hindeman Creek
3. Tributary Number	M-55-108
4. Counties	Brown, Redwood
5. Ecosystem Classification	Province-Prairie Parkland Section-North Central Glaciated Plains Sub-Section-Minnesota River Prairie
6. Ecological Classification	Class 1D (Marginal Trout)-Reach 1 Class 4 (Cosmopolitan) or Class 5 (Intermittent)-Reach 2
7. Major Watershed and Number	Minnesota River-Mankato,28
8. Minor Watershed Numbers	Spring Creek, 28094
9. Length of Stream	20.8 mi (33.8 km) 4.8 mi (7.7 km) Designated Trout Stream
10. Size of Watershed	44.9 sq mi (116.4 sq km)
11. Public Access	32 acres of easements Road crossings
12. Dams and Obstructions	None
13. Previous Sampling	Initial Survey 1978 Survey 1981, 1988,1993, 2003 Special Sampling 1979,1980-1982, 2006, 2007 Population Assessments 2000,2005
14. Stocking	1952-1961, brown trout (various ages and numbers); 1962-2005 400-1676 brown trout yearlings; 1977, 501 rainbow trout yearlings Beginning 2006, two-year old culled brown trout brood stock and "jumbo" rainbow trout yearlings have been stocked as available

15. Watershed Description

The 45 sq mi watershed of Spring Creek (Figure 1) is drained agricultural land used primarily for row crop production. Drainage consists of extensive networks of underground tile draining into open channelized ditches. The lower 7 mi (11 km) of Spring Creek has a higher gradient as it drops into the Minnesota River valley. The stream corridor is consists of moderate to steeply sloping embankments covered with deciduous hardwoods. This segment has numerous springs and seeps with various discharges. The 4.8 mi (7.7 km) Designated Trout Stream portion is found within this area.

16. Sampling Methods

One HOBO (Onset Computer Corporation) Water Temp Pro V2 Logger (TL) and two Water Level Loggers (WLL) which recorded absolute pressure and water temperature, were deployed in Spring Creek (Figure 2). WLL were sited to gather data at the downstream and upstream segment stocked with trout. Stream distance from the downstream Water Level Logger (WLLD) to the upstream Water Level Logger (WLLU) was 2.4 mi (3.9 km). Both WLLs were placed in stilling wells and anchored with rebar for accuracy and security. The WLLs were programmed for hourly readings between 23 April and 6 October 2008. The TL was sited downstream of the fist known major spring near the upstream portion of the stocked area. The TL was attached to rebar with cable ties and driven into the substrate. The TL was programmed for hourly readings between 2 April and 6 October 2008. Loggers were checked periodically throughout the deployment.

Discharges were estimated by measuring flows and then comparing them to concurrently logged water pressures gathered by the WLLs. Summary statistics were calculated and plotted in Excel 2000 (Microsoft Corporation 1999). Logged absolute pressures were converted to cfs using a quadratic equation generated from measured flows and then applied to logged flows. Flows were not adjusted to account for barometric pressure differences in 2008. A Marsh-McBirney Portable Flowmeter Model 201D and a top-setting wader rod, were used to measure discharge 15 times between 25 April and 30 September 2008. Water surface and thalwag elevations were measured with a laser level and stadia rod each time discharge was measured.

Four fish sampling stations were repeated from 2005-2007 on 26 and 28 August 2008 (Figure 2). Minimum station length was determined by multiplying 35 times the average stream width. The first electrofishing station (EF 1) began 100 ft (30.5 m) above Golden Gate Road and continued 619 ft (188.7 m) upstream. The second station (EF 2) began 100 ft upstream of 270th Avenue and continued upstream 790 ft (240.8 m) to the State Highway 4 crossing. The third station (EF 3) began 300 ft (91.5 m) above State Highway 4 and continued upstream 359 ft

(109.4 m). The fourth station (EF 4) began 798 ft (243.2 m) downstream township road crossing 280th Avenue and continued back upstream to 280th Avenue. Beginning downstream and ending upstream locations were recorded with a Garmin GPS 76. Conductivity, temperature, and time electrofished were recorded for each station. Attempts were made to gather all trout throughout the entire station width using a Smith-Root Backpack Model 12 Electrofisher.

17. Results

Hourly water temperatures from all three loggers ranged from 35°F (1.7°C) on 3 April to 83°F (28.3°C) on 11 July 2008. Overall mean daily temperature ranged from 61°F (16.1°C) at WLLD to 57°F (13.8°C) at TL to 63°F (17.2°C) at WLLU (Figures 3-5). Comparison of all three loggers indicated a 3.0°F mean decrease in water temperature from the upper to the lower end of the stocked area. TL indicated a 6°F mean decrease downstream of a large spring. Although July and August daytime temperatures exceeded 70°F (21.1°C), the accepted maximum for trout, nighttime temperatures stayed below 70°F throughout the stocked section of Spring Creek.

Measured discharge near WLLD ranged from 96.28 cfs on 5 May to 1.7cfs on 23 September (Figure 6). Discharge near WLLU ranged from 90.49 cubic feet per second (cfs) on 5 May to 0.03 on 23 September (Figure 7). Comparison of minimum flows indicated a 1.6 cfs average increase in discharge from upstream to downstream within the stocked area. Hourly logger recordings were not significantly different from measured flows.

Electrofishing effort totaled 2566 ft (782 m) and 1677 sec. Conductivity measured 1076 µS/cm. Stream temperature was recorded at 61°F (16.1°C). Trout stocked April 2008 were sampled in every electrofishing station. Total catch included 18 brown trout and 2 rainbow trout. Four brown trout were observed but not captured. Brown trout size ranged from 268 mm (10.6 in) to 390 mm (15.4 in). One rainbow trout was recorded at 331 mm (13.0 in) the second 350 mm (13.8 in).

18. Discussion

Extensive drainage and agricultural practices within the watershed contribute to dynamic flows, large sediment loads, high turbidity, and elevated water temperatures. A number of investigations have been completed since 1953 to assess and monitor the feasibility of a put and take trout fishery. Early reports identified the lower most 6 mi (9.7 km) portion as suitable. Subsequent reports referencing electrofishing and temperature monitoring data, have identified a 2 mi (3.2 km) section, 1 mi (1.6 km) upstream and 1 mi downstream of State Highway 4, as suitable habitat. Recent investigations have concentrated on that section using flow monitors, temperature loggers, and electrofishing. Through the 1990's, annual public fishing easements were secured along this 2 mi section.

Various stream temperature data has been gathered since the initial survey in 1953. Data ranges from single entries using a hand held thermometer to multiple hourly readings recorded by seasonally installed temperature loggers. Temperature data was used to identify the 2 mi portion now stocked with trout. The 3°F decrease in mean water temperature from the upper to lower stocked portion of Spring Creek, and the 6°F decrease in mean water temperature immediately below a large spring, indicate groundwater inputs have a significant impact on lowering water temperature. Special sampling completed July 2006, identified 13 springs located in the upper reach of the stocked area. Beginning 1 July through 1 August water temperatures at WLLU stayed above 70°F, an accepted maximum for trout. However, those temperatures were mitigated below 70°F 700 ft (233 m) downstream near TL by a significant mid channel spring. Temperature data gathered at TL and WLLD minimally exceeded 70°F in July and August. Large rainfall events elevated stream temperatures beyond 70°F. Peak flows were of such short duration that elevated temperatures did not seem to cause trout mortality or relocation. Shading also contributes to depressed stream temperatures. Mean summer temperatures recorded throughout the stocked area appear suitable for trout.

A single WLL was placed midway in the stocked portion to gather discharge data in 2007. In 2008, two loggers were used to gather flow data, one immediately upstream, the second at the downstream end of the stocked area. Extensive drainage throughout the Spring Creek watershed creates highly variable discharge. Significant rain events are flashy with peak flows rarely lasting beyond a 36 hr period. The flashy nature of rainfall events within the watershed was evident on 28 April when WLLU recorded peak flows from a significant rainfall exceeding 100 cfs for less than a 24 hr period. The flashy nature of high flows can cause extensive erosion, silt deposition, and elevated temperatures within the stocked portion of Spring Creek and are a major concern when considering in-stream habitat improvements. The 1.6 cfs increase noted between WLLU and WLLD during low flows is attributed to significant spring and seep groundwater inputs found especially at the upper end of the stocked area. Visual observation during low flows indicated suitable trout habitat throughout summer and fall. When measured flows were compared to logged flows no significant differences were noted indicating flows remained relatively stable between measured flows. Logger data suggests insufficient flow would limit trout habitat upstream of the stocked area.

Every past Fishery investigation has concluded that only the lower-most portion of Spring Creek should be considered as a put and take trout fishery. Most investigations have found that at least a small portion of an annual stocking survives as carryover. Other than a single 3 in

(76 mm) brown trout captured in 2003, trout natural reproduction has never been documented. Since 1953 predominantly yearling brown trout have been stocked in various numbers. With minimal carryover yearling brown trout provided marginal angling opportunity especially as a put and take fishery. Since 2006, two-year old culled brown trout broodstock and "jumbo" rainbow trout yearlings have been stocked to support a "put and take" stocking strategy. Electrofishing effort in 2008 yielded trout at every station, indicating trout were holding within the stocked portion throughout the summer period. Similar electrofishing results occurred in 2007. Size range suggested the presence of carryover. No effort was made to monitor or observe angler use of stocked trout in 2008. Occasional contact with anglers and conservation officers indicated an increase in angler activity since larger fish were introduced in 2006. Angler concerns have included not knowing where they could park and fish. With angler easements in place throughout most of the stocked portion there remains a need to mark the easement area with informational, designated, easement, and parking signs.

19. Management Recommendations

- Annually stock 300 larger brown trout (adults or two year old culled broodstock) and 300 rainbow trout ("jumbo" yearlings) prior to opening of the trout season
- Periodically visit the stream the first month of trout season to observe and record angler use
- Increase angler awareness through news releases and posting designated, informational, easement, and parking signs along the stocked portion of Spring Creek
- Continue temperature monitoring through 2009 with stationary temperature loggers
- Repeat electrofishing stations prior to stocking in April 2009 to document trout carryover
- Repeat electrofishing stations in late August 2009 to document survival of stocked trout
- Summarize information including temperature and flow monitoring, electrofishing results, stocking history, easement information, and informal creel results into a final report on Spring Creek by April 2010
- Rewrite stream management plan by 2011

20. References

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21. Credits and signatures

a. Funding F-29-R(P)-26
Federal Aid to Sportfish Restoration in Minnesota

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