Elm Creek WMO Watershed-wide TMDL
Work Plan

Project Contact Information:

Financial Agent:	MN Pollution Control Agency (MPCA)
Type of Organization:	State Agency
Project Manager:	Brooke Asleson
Address/Phone:	520 Lafayette Road North St. Paul, MN 55155 651-757-2205
Project Sponsor:	Elm Creek Watershed Management Commission
Type of Organization:	Joint Powers Agreement WMO
Project Representative:	Judie Anderson
Address/Phone:	Elm Creek WMO 3235 Fernbrook Lane Plymouth, MN 55447 763-553-1144
Project Partner:	Three Rivers Park District (TRPD)
Type of Organization:	Local Unit of Government
Project Representative:	Randy Lehr
Address/Phone:	12615 County Road 9, Suite 100 Plymouth, MN 55441 763-694-2061

Project Contact Information:

TMDL Project Name: Elm Creek WMO Watershed-wide TMDL (Metro)
TMDL ID: 10322
Basin: Upper Mississippi River
Target Start and End Date: 2010 - 2014

Existing Impairments addressed:

Elm Creek: Headwaters (Lk Medina 27-0146-00) to Mississippi R
AUID: 07010206-508
Pollutant: Low Oxygen
Year Listed: 2004

Rush Creek: Headwaters to Elm Cr
AUID: 07010206-528
Stressor: Fish IBI
Year Listed: 2002

Fish Lake
AUID: 27-0118-00
Pollutant: Excess Nutrients
Year Listed: 2008

Diamond Lake
AUID: 27-0125-00
Pollutant: Excess Nutrients
Year Listed: 2006

French Lake
AUID: 27-0127-00
Pollutant: Excess Nutrients
Year Listed: 2004

Henry Lake
AUID: 27-0175-00
Pollutant: Excess Nutrients
Year Listed: 2008

Potential Future Impairments addressed:
Pollutant: E. coli
Waters: Diamond (07010206-699) and Elm (07010206-508) Creeks and tributaries

Pollutant: Chloride
Waters: Diamond (07010206-699), Elm (07010206-508) and Rush (07010206-528) Creeks and tributaries

Stressor: Fish IBI
Waters: Diamond (07010206-699) Creek and tributaries

Pollutant: Low Oxygen
Waters: Rush (07010206-528) and Diamond (07010206-699) Creeks and tributaries

Pollutant: Excess Nutrients
Waters: Rice (27-0116-00) and Cowley (27-0169-00) Lakes

Unimpaired water bodies addressed:
Edward Lake
AUID: 27-0121-00

Mud Lake
AUID: 27-0112-00

Goose Lake
AUID: 27-0122-00

Lemans Lake
AUID: 27-0066-00

Hayden Lake
AUID: 27-0128-00

Laura Lake
AUID: 27-0123-00

Grass Lake
AUID: 27-0135-00

Sylvan Lake
AUID: 27-0171-00

Meadow Lake
AUID: 27-0301-00

Jubert Lake
AUID: 27-0165-00

Scott Lake
AUID: 27-1102-00

Morin Lake
AUID: 27-0423-00

Medina Lake
AUID: 27-0146-00

Cook Lake
AUID: 27-0120-00

Camelot Lake
AUID: 27-0099-00

Background

The Elm Creek watershed in northern Hennepin County is approximately 83,600 acres and drains land from 9 communities including: Champlin, Corcoran, Dayton, Greenfield, Hassan Township, Maple Grove, Medina, Plymouth and Rogers (Figure 1). Land use throughout the watershed is highly variable and ranges from rural (predominantly row crop agricultural and hobby farms) to high density urban and commercial development. Based on the current comprehensive 2030 plans for the respective communities throughout the watershed, it is anticipated that much of the currently rural land will be converted to low and medium density residential land in the next 20 years (with increasing areas of high density residential and commercial development in specific areas). The watershed includes three major stream systems (Elm, Rush, and Diamond Creeks) that total over 41 stream miles. Major lake systems within the watershed include French, Diamond, Rice, Fish, Weaver, Henry, Cowley, Hayden, Lehman's, Goose, Mud Lakes and the Mill Ponds.

To address water quality throughout the watershed, the Elm Creek Watershed Management Commission in collaboration with Three Rivers Park District, Hennepin County Environmental Services, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency (MPCA), United States Department of Geological Services (USGS) and the Metropolitan Council has conducted a series of monitoring and assessment studies. Previous studies include a: longitudinal channel stability and erosion study; fish and invertebrate Index of Biotic Integrity (IBI) studies; invertebrate monitoring through the Stream Health Evaluation Program (SHEP) and River Watch; maintenance of a long-term, USGS stream gauging/water quality monitoring station; and a watershed-wide Surface Water Assessment Grant (described in detail below). Based on the results of this work, seven waterbodies (Diamond, Fish, Weaver and French Lakes and Elm, Rush and Diamond Creeks) are currently listed as impaired for dissolved oxygen, biota, nutrients or mercury by MPCA (Figure 1).

Surface Water Assessment Grant Study 2007-2008

The most recent water quality assessment work in the Elm Creek watershed was conducted as part of a Clean Water Legacy Act - Surface Water Assessment Grant (SWAG). The goal of the SWAG was to assess the current condition of Elm Creek and identify possible pollution sources that may be contributing to the range of water quality impairments throughout the watershed. A summary of the Elm Creek SWAG study is provide below - detailed results of this study can be seen in the 2007 and 2008 annual project reports.

SWAG Sampling (2007-2008)

To assess the condition of the Elm Creek watershed, biological, chemical and physical data were collected from a series of stream and lake sites from 2007 to 2008. Chemical and physical water quality sample collection and analysis was coordinated by Three Rivers Park District and all samples were collected by Park District staff and citizen volunteers. Biological samples were collected and analyzed by volunteers from Three Rivers Park District and Hennepin County Environmental Services (SHEP and River Watch). All volunteer sample collection followed MPCA and USEPA Volunteer Monitoring guidelines. All samples collected by Park District Staff followed USEPA instream assessment protocols and manufacture recommendations (specifically for ISCO and in-lake water quality data-logging tools).

Ten stream sites were monitored for dissolved oxygen, *E. coli*, total phosphorus, soluble reactive phosphorus, total nitrogen, chloride, total suspended solids and invertebrate assemblage composition (Figure 2). Five sites were monitored weekly by citizen volunteers and sampled using standard grab sample techniques. Five sites were sampled by Park

District staff following all precipitation events using flow-automated ISCO samplers. Stream discharge was also measured at all ISCO sampler sites. Invertebrates were sampled at 10 sites (Figure 3).

Six lake sites were monitored by Three Rivers Park District staff and volunteers from the Citizen-Assisted Monitoring Program (CAMP). Park District staff monitored Diamond, Weaver and Fish Lakes and CAMP volunteers monitored Henry, Sylvan, Rice and Cowley Lakes bi-weekly from April to October in both 2007 and 2008. Lakes monitored by Park District staff were sampled for temperature, dissolved oxygen, specific conductivity, pH, secchi depth, total phosphorus, total nitrogen, chloride and chlorophyll-α. Lakes monitored by CAMP volunteers were sampled for water temperature, total phosphorus, total nitrogen and chlorophyll-α and secchi depth.

All water quality samples were analyzed at the Three Rivers Park District water quality laboratory following Standard Methods for the Examination of Water and Wastewater 21st Ed. (Table 1). All laboratory analyses followed Standard Operating Procedures (SOPs) approved by either MPCA or Minnesota Department of Health (MDH) and were part of an approved Quality Assurance Project Plan (QAPP). All stream data was analyzed using a FLUX model to estimate total downstream pollutant loading and compared to Minnesota water quality standards. All lake data was analyzed to determine trophic status and compliance with Minnesota surface water standards.

Water Quality SWAG Results (2007-2008)
Results from the SWAG study confirm the existing impaired waters listings and suggest that Elm, Rush and Diamond Creeks and Cowley and Rice Lakes may also be impaired in relation to bacteria, chloride, dissolved oxygen and/or nutrients. Of the three main subwatersheds, Rush and Elm Creeks had the highest nutrient and sediment loads and Diamond Creek had the lowest (Table 2; 2008 FLUX data are still being processed and are not presented in the tables and graphs). Chloride concentrations were highest in Elm and Rush Creeks and lowest in Diamond Creek (Figure 4). Bacteria concentrations were generally above Minnesota state surface water criteria in all three tributaries, but highest in Diamond and Rush Creeks (Table 3). Dissolved oxygen levels were below Minnesota state standards in all three tributaries, but lowest in Rush and Diamond Creeks (Figure 5). Of the lakes sampled by Park District staff, Fish (Figure 6) and Diamond (Figure 7) Lakes had the highest growing season surface water total phosphorus concentration (above Minnesota water quality standards) and Weaver Lake (Figure 8) had the lowest (below Minnesota water quality standards). Data from CAMP sampling will be available in the Metropolitan Council annual report in spring of 2009.

Biological Monitoring Results (2007-2008)
Results from the SWAG, River Watch and SHEP invertebrate monitoring efforts confirm the biological impairment listing for Rush Creek and suggest that upper Elm Creek may also be impaired in relation to biological condition. Invertebrate assemblage data from Rush and Elm Creek indicated a low occurrence of pollution sensitive Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa (Figure 9 and Figure 11) and a high occurrence of pollution tolerant taxa (Figure 10 and Figure 12). Additionally, a 1999 DNR fish biomonitoring study indentified a fish Index of Biotic Integrity (IBI) score for Diamond Creek of 10, which is lower than the current fish IBI score (35) on Rush Creek (suggesting Diamond Creek may also be impaired). A more complete discussion of invertebrate monitoring data is available in the 2007 and 2008 (to be published in spring of 2009) River Watch program report.

Results from the SWAG provided a more detailed understanding of the extent and source of water quality impairment throughout the Elm Creek watershed. To address these existing water quality impairments, we will conduct a series of detailed monitoring studies to develop a multi-parameter, watershed-wide Total Maximum Daily Load (TMDL) and Implementation Plan for the Elm Creek watershed. The details of this work plan are described below.

General Approach

The goal of this project is to develop a watershed-wide, multi-parameter Total Maximum Daily Load (TMDL) and Implementation Plan that will collectively address all water quality impairments throughout the Elm Creek watershed. Given the size and complexity of the Elm Creek watershed (both ecologically and socio-politically), TMDL development will be broken into five phases. Phases will be implemented starting in the spring of 2009 and completed in the fall of 2014. In general, Phases will be implemented sequentially (working downstream to upstream), and prioritized based on level of impairment (i.e., assessment/modeling studies will be completed in the most impaired reaches first). Phase I will characterize the dissolved oxygen impairment in lower Elm Creek and identify the relative oxygen demand (OD) loading (biological and chemical) from landscape inputs, upstream reaches and internal processes. Phase II will be conducted in the Rush Creek subwatershed and will identify the source(s) of the Biological Impairment in Rush Creek, Nutrient Impairment in Henry Lake and the downstream contribution of OD loading to lower Elm Creek. Phase III will be conducted in the upper Elm Creek subwatershed and will identify the source(s) of dissolved oxygen (DO) impairment in upper and lower Elm Creek and Nutrient Impairment in Rice and Fish Lakes. Phase IV will be conducted in the Diamond Creek subwatershed and will identify the source(s) of Nutrient Impairment in Diamond and French Lakes and OD loading to lower Elm Creek. Assessment work in each subwatershed will be completed in approximately two years. Throughout the assessment of all subwatersheds, samples will be collected and analyzed to determine the scope and magnitude of Bacteria, Chloride and Biotic Impairment (based on results from the preliminary Surface Water Assessment Grant). Standard operating procedures for the collection of these samples and environmental data that will be followed are given in the Minnesota Pollution Control Agency (2006) Water Quality Programs Sampling and Monitoring Standard Operating Procedures (SOPs) manual, and the project's Quality Assurance Project Plan (QAPP).

Following completion of the TMDL assessment work in each subwatershed, stressor-specific TMDL targets, Wasteload Allocations (WLAs), Load Allocations (LAs) and Implementation Plans will be developed (in conjunction with a concurrent stakeholder process) following MPCAs TMDL protocols and guidance to concurrently address water quality impairments in each subwatershed and the Elm Creek watershed as a whole. All TMDL targets, WLAs, LAs and Implementation Plans will be developed by combining results from instream assessment work with a series landscape and instream/in-lake models. All instream assessment work will follow MPCA, MDH and USEPA guidelines. Landscape and instream/in-lake processes will be modeled using a suite of tools. The Soil and Water Assessment Tool (SWAT) model (with a QUAL-2E submodel) will be used to characterize landscape contributions to water quality impairment in rural/agricultural areas. The Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds (P8) model and Source Loading and Management Model (SLAMM) will be used to model urban areas. AQUATOX (Release 3) will be linked to outputs from the agricultural and urban models and used to assess the instream/in-lake processes. FLUX, P8, SLAMM and SWAT will be used to characterize the relative pollutant loads and wasteload reduction goals. Results from all modeling and assessment work will be initially summarized to describe multi-stressor WLAs, LAs and load reduction goals for various stakeholder groups on a subwatershed basis and ultimately summarized into a multi-stressor, watershed-wide TMDL and Implementation Plan (Phase V). The watershed-wide Implementation plan will be holistic in that it will address management activities for all the surface waters (both impaired and those currently meeting water quality standards) in the watershed. The goal is to allow this plan to compliment the watersheds management plan.

Rationale

Phasing

The TMDL will be broken into Phases to:

1) Address financial constraints by limiting the number of sampling units and personnel necessary to complete the assessment
    a. When one Phase is completed, samplers (and staff) can be moved to new sites that will address sampling needs of the next Phase
2) Simplify the ecological and socioeconomic complexity of the Elm Creek system for model development and stakeholder involvement
    a. Many of the models being used (see the Model Selection Section below) operate in a “linked” fashion and phased model development will minimize extended model run times and the need for expanded computer infrastructure
    b. Stakeholder development that focuses on specific geographic regions will promote local involvement and facilitate the incorporation of local knowledge
3) More effectively model the impacts of multiple stressors on biological condition
    a. Although the Elm Creek watershed as a whole has a range of water quality impairments, individual subwatersheds have fewer known impairments – thus simplifying model segment development

Model Selection

Models have been selected to address the need to (1) characterize the relative importance of multiple stressors on biological impairment; (2) effectively characterize the relative contribution of different land use types (e.g., agricultural vs. urban); (3) characterize a range of hydrologic systems (i.e., stream, lakes, ditches, storm sewers…etc). To address these diverse needs, we will use a suite of linked models.

AQUATOX (Release 3) was chosen to model instream/in-lake processes. AQUATOX is a food web-based model that was designed to assess the fate, transport and relative biological impact of multiple stressors. AQUATOX also has the ability to model a wide range of hydrologic systems (e.g., streams, rivers, lakes, reservoirs…etc.) as independent model segments. Independent model segments can be linked together to facilitate a more realistic simulation of the diverse instream/in-lake conditions present throughout the Elm Creek watershed. Although AQUATOX is well suited to assess the impacts multiple stressors on biological condition, it is poorly suited to assess landscape contributions to water quality impairment and the potential role of BMPs.

To better model landscape runoff and the effectiveness of specific BMPs, AQUATOX has been designed to interface with landscape models (e.g., HSPF and SWAT) via the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) environmental analysis system. SWAT was chosen as the linked landscape model because it has been widely used in TMDL development and restoration planning in agricultural regions throughout the United State and in the Midwest in particular. Although SWAT is well suited to assess landscape contributions of various pollutants to aquatic systems, it is limited in its ability to assess the impact of urban development on water quality. Since roughly one-third of the current land use in the Elm Creek watershed is considered urban and it is anticipated that much of the current agricultural land will be converted to low and medium density urban developments, it will be important to accurately assess the relative contribution of various pollutants from the urban landscape.

To more effectively model urban landscapes, we will use a combination of the P8 and SLAMM models. P8 will be used to model more clearly defined urban drainage systems (e.g., storm sewer systems) and SLAMM will be used to model more diffuse direct urban runoff (e.g., lakeshore properties). P8 and SLAMM have been chosen because of their successful application for TMDL development and urban runoff modeling in the Midwest.

Analytical Endpoint Selection

The successful use of these modeling tools (and models in general) is dependent on the quantity and quality of input data to calibrate and validate model algorithms. To ensure appropriate datasets are available for model development, we have worked closely with EPA representatives (developer of the AQUATOX model) and model practitioners (particularly for SWAT, P8 and SLAMM) to design sampling programs that will provide sufficient data to calibrate and validate each model. To ensure all input data is of sufficient quality, all data will be developed following an approved Quality Assurance Program Plan and using SOPs approved MPCA and MDH (Table 1).

Details of the proposed work plan are described below as they correspond to the individual phases of the project.

Phase I

Timeline: Spring 2009 through Fall 2010

Objective I: Characterize the Oxygen Demand loading (OD; Biological and Chemical) to lower Elm Creek (Rice Lake to the Mississippi River Confluence)

1) Task 1.1 – Quantify the OD loading to lower Elm Creek from: 1) upper Elm Creek (Including Rice and Fish Lakes); 2) Rush Creek (Including Henry Lake); 3) Diamond Creek (Including French and Diamond Lakes); 4) Leman's Lake; 5) Instream processes (including Hayden Lake and the Mill Ponds); and 6) direct runoff (including isolated wetland complexes)
    - a) Approach:
        - i) Flow-automated cBOD sampling (composite and grab samples) upstream/downstream of major confluences and unique instream segments
            - (1) cBOD samples will be split and analyzed as "whole" and "filtered" (0.7 υm glass fiber filter) to approximate the relative contribution of organic and refractory carbon
        - ii) Characterize the relative concentration and loading of nutrients (total phosphorus, soluble reactive phosphorus, nitrate and ammonia) and total suspended solids using flow-automated ISCO samplers
            - (1) Nutrient parameters will be used within the AQUATOX model (see Task 1.3) to characterize the relative contribution of the various dissolved oxygen (DO) impairing constituents – carbonaceous (cBOD), nitrogenous (nBOD) and sediment (SOD)

    Task Cost: $18,000

2) Task 1.2 – Determine diel dissolved oxygen (DO) dynamics throughout a longitudinal profile within lower Elm Creek
    - a) Approach:
        - i) Conduct 24 hr DO monitoring at 4-6 sites throughout a longitudinal profile within lower Elm Creek, likely in conjunction with BOD/nutrient sampling stations

    Task Cost: $16,000

3) Task 1.3 – Develop a physically-based, multi-segment instream model that accurately characterizes landscape and instream influences on DO in lower Elm Creek
    - a) Approach:
        - i) Develop a SWAT/QUAL-2E model to characterize the agricultural landscape contribution to DO impairment in lower Elm Creek
        - ii) Develop P8/SLAMM model(s) to characterize the urban contributions of various pollutants to lower Elm Creek
        - iii) Link the SWAT/QUAL-2E model to a multi-segment AQUATOX model to characterize longitudinal instream DO dynamics in lower Elm Creek

    Task Cost: $18,000

4) Task 1.4 – Determine the a multi-parameter TMDL target for OD loading that will meet instream DO goals in lower Elm Creek
    - a) Approach:
        - i) Use Monte Carlo and probabilistic simulations to identify the ecosystem impacts of various OD loading scenarios in lower Elm Creek

    Task Cost: $11,000

5) Task 1.5 – Determine the relative contribution of OD loading to lower Elm Creek from the Diamond Creek (including French and Diamond Lakes), Rush Creek (including Henry Lake) and upper Elm Creek (including Rice and Fish Lakes) subwatersheds
   a) Approach:
      i) Use SWAT/QUAL-2E and FLUX models to describe the cumulative multi-parameter OD loading from the three upstream drainages to lower Elm Creek

   Task Cost: $11,000

6) Task 1.6 – Initiate the stakeholder process to develop OD Wasteload Allocations (WLAs) and Load Allocations (LAs)
   a) Approach:
      i) Work with stakeholder representatives to identify the process and criteria by which WLAs and LAs will be identified
      ii) Use FLUX and SWAT/QUAL-2E model outputs to quantify specific OD WLAs and LAs for each stakeholder group

   Task Cost: $12,000

7) Task 1.7 – Determine OD load reductions for the Diamond, Rush and upper Elm Creek subwatersheds
      i) Approach: Use FLUX and SWAT/QUAL-2E model outputs to quantify the necessary load reductions to achieve instream DO goals for lower Elm Creek

   Task Cost: $6,000

Total Objective Cost: $93,400

Deliverables: (1) subwatershed specific TMDL targets for DO impairment; (2) data upload into STORET; (3) subwatershed specific land use - water quality response model; (4) subwatershed specific OD load reduction targets; (4) summary reports to MPCA (including semi-annual reporting August 1st and February 1st)

Phase II

Timeline: Spring 2010 to Fall 2011 (possibly 2012, depending on the potential listing of Bacteria and Chloride impairment in Rush Creek)

Objective 2: Characterize the relative contribution of landscape and instream/lake processes to water quality impairment in the Rush Creek subwatershed (including Henry Lake) and the downstream DO impairment in lower Elm Creek

8) Task 2.1 – Determine the source of OD loading within the two branches of Rush Creek
   a) Approach:
      i) Flow-automated cBOD sampling (composite and grab samples) upstream/downstream of major confluences and unique instream segments
         (1) cBOD samples will be split and analyzed as “whole” and “filtered” (0.7 υm glass fiber filter) to approximate the relative contribution of organic and refractory carbon
      ii) Characterize the relative concentration and loading of nutrients (total phosphorus, soluble reactive phosphorus, nitrate and ammonia) and total suspended solids using flow-automated ISCO samplers and standard lake profile sampling techniques
         (1) Nutrient parameters will be used within the AQUATOX model (see Task 2.4) to characterize the relative contribution of the various DO impairing constituents – carbonaceous (cBOD), nitrogenous (nBOD) and sediment (SOD)

Task Cost: $14,000

9) Task 2.2 – Characterize the diel DO dynamics throughout a longitudinal profile within Rush Creek
   a) Approach:
      i) Conduct 24 hr DO monitoring at 4-6 sites throughout a longitudinal profile within the two branches of Rush Creek

   Task Cost: $10,000

10) Task 2.3 – Characterize the occurrence and magnitude of bacteria (i.e., *E. coli*) and chloride pollution in the Rush Creek subwatershed
   a) Approach:
      i) Expand the parameter set analyzed at from each autosampler to include: *E. coli* and chloride following MPCA guidance

   Task Cost: $10,000

11) Task 2.4 – Describe the biological (i.e., invertebrate and fish assemblage composition) and physical characteristics of the Rush Creek subwatershed
   a) Approach:
      i) Collaborate with Hennepin County Environmental Services, the University of Minnesota and the Minnesota Pollution Control Agency to conduct fish, invertebrate and (potentially) periphyton surveys to populate the AQUATOX model

   Task Cost: $6,000

12) Task 2.5 - Develop a physically-based, multi-segment instream model that accurately characterizes the landscape and instream influence on water quality impairment in Rush and lower Elm Creeks
   a) Approach:
      i) Develop a SWAT/QUAL-2E model to characterize the landscape contribution to biotic impairment in Rush Creek and nutrient impairment in Henry Lake
      ii) Develop P8/SLAMM model(s) to characterize the urban contributions to biotic impairment in Rush Creek and nutrient impairment in Henry Lake
      iii) Link the SWAT/QUAL-2E model to a multi-segment AQUATOX model to characterize the longitudinal instream water quality dynamics in Rush Creek and Henry Lake

   Task Cost: $10,000

13) Task 2.6 – Determine the sources and relative contribution of multiple stressors to the Biological Impairment of Rush Creek and TMDL goal for Nutrient impairment in Henry Lake
   a) Approach:
      i) Use the EPA Stressor Identification Process to develop conceptual models for the impairments with pathways, eliminate alternatives, strength of evidence analysis, identify cause on evaluate confidence, etc.
      ii) Run Monte Carlo simulations with the AQUATOX model to determine relative contribution of individual stressors identified in the stressor identification process
      iii) Compare traditional in-lake response model outputs (e.g., WLMS, BATHTUB…etc.) to Monte Carlo simulation outputs from AQUATOX

   Task Cost: $12,000

14) Task 2.7 – Initiate the stakeholder process to develop stressor-specific WLAs and LAs
   a) Approach:

    i) Work with stakeholder representatives to identify the process and criteria by which WLAs and LAs will be identified
    ii) Use FLUX and SWAT/QUAL-2E model outputs to quantify stressor-specific WLAs and LAs for each stakeholder group

  Task Cost: $12,000

15) Task 2.8 – Determine stressor-specific wasteload reductions to simultaneously achieve the TMDL goals for the Biological Impairment in Rush Creek (following the MPCAs Identification Guidance Manual & Biota Protocol for TMDL Development http://www.pca.state.mn.us/publications/wq-iw1-23.pdf), Nutrient Impairment in Henry Lake and DO impairment in lower Elm Creek
  a) Approach:
    i) Use FLUX and SWAT/QUAL-2E model outputs to quantify the necessary load reductions to achieve the TMDL goals Biological Impairment in Rush Creek, Nutrient Impairment in Henry Lake and DO in lower Elm Creek,

  Task Cost: $8,000

16) Task 2.9 – Develop a TMDL Implementation Plan to simultaneously achieve the TMDL goals for both the Biological Impairment in Rush Creek, Nutrient Impairment in Henry Lake and DO impairment in lower Elm Creek
  a) Approach:
    i) Work with stakeholder groups to identify specific Best Management Practices (BMPs) that will be used to achieve water quality goals for the Rush Creek subwatershed
    ii) Use SWAT/QUAL-2E and AQUATOX models to quantify the cumulative effectiveness of various BMP strategies for the Rush Creek subwatershed

  Task Cost: $10,000

Total Objective Cost: $96,100

Deliverables: (1) subwatershed specific TMDL and Implementation Plan; (2) data upload into STORET; (3) subwatershed specific land use - water quality response model; (4) Stressor Identification document; (5) summary reports to MPCA (including semi-annual reporting August 1^{st} and February 1^{st})

Phase III

Timeline: Spring 2011 to Fall 2012 (possibly 2013, depending on the potential listing of Elm Creek for Bacteria and Chloride impairment)

Objective 3: Characterize the relative contribution of landscape and instream/lake processes to water quality impairment within the upper Elm Creek subwatershed (including Rice and Fish Lakes) and downstream DO impairment in lower Elm Creek

17) Task 3.1 – Determine the source of OD loading within the upper Elm Creek subwatershed (including Rice and Fish Lakes)
  a) Approach:
    i) Flow-automated cBOD sampling (composite and grab samples) upstream/downstream of major confluences and unique instream segments
      (1) cBOD samples will be split and analyzed as “whole” and “filtered” (0.7 υm glass fiber filter) to approximate the relative contribution of organic and refractory carbon

ii) Characterize the relative concentration and loading of nutrients (total phosphorus, soluble reactive phosphorus, nitrate and ammonia) and total suspended solids using flow-automated ISCO samplers and standard lake profile sampling techniques
   (1) Nutrient parameters will be used within the AQUATOX model (see Task 3.4) to characterize the relative contribution of the various DO impairing constituents – carbonaceous (cBOD), nitrogenous (nBOD) and sediment (SOD)

Task Cost: $14,000

18) Task 3.2 – Characterize the diel DO dynamics throughout a longitudinal profile within the upper Elm Creek subwatershed
   a) Approach:
      i) Conduct 24 hr DO monitoring at 4-6 sites throughout a longitudinal profile within the two branches of upper Elm Creek

   Task Cost: $10,000

19) Task 3.3 – Characterize the occurrence and magnitude of bacteria (i.e., *E. coli*) and chloride pollution in the upper Elm Creek subwatershed
   a) Approach:
      i) Expand the parameter set analyzed at each autosampler to include: *E. coli* and chloride following MPCA guidance

   Task Cost: $10,000

20) Task 3.4 – Describe the biological (i.e., invertebrate and fish assemblage composition) and physical characteristics of the upper Elm Creek subwatershed
   a) Approach:
      i) Collaborate with Hennepin County Environmental Services, the University of Minnesota and the Minnesota Pollution Control Agency to conduct fish, invertebrate and (potentially) periphyton surveys to populate the AQUATOX model

   Task Cost: $6,000

21) Task 3.5 - Develop a physically-based, multi-segment instream model that accurately characterizes the landscape and instream/lake influence on water quality impairment in the upper Elm Creek subwatershed (including Rice and Fish Lakes)
   a) Approach:
      i) Develop a SWAT/QUAL-2E model to characterize the landscape contribution to DO impairment the upper Elm Creek subwatershed and the nutrient impairment in Rice and Fish lakes
      ii) Develop P8/SLAMM model(s) to characterize the urban contributions to DO impairment in upper Elm Creek subwatershed and the nutrient impairment in Rice and Fish lakes
      iii) Link the SWAT/QUAL-2E and/or model to a multi-segment AQUATOX model to characterize the longitudinal instream DO dynamics in the upper Elm Creek subwatershed and nutrient dynamics in Rice and Fish Lake

   Task Cost: $10,000

22) Task 3.6 – Determine the TMDL target for OD loading in upper Elm Creek and Nutrient Loading in Rice (likely) and Fish Lakes
   a) Approach:
      i) Use Monte Carlo and probabilistic simulations to identify the ecosystem impacts of various OD loading scenarios in upper Elm Creek

ii) Compare traditional in-lake response model outputs (e.g., WLMS, BATHTUB…etc.) to Monte Carlo simulation outputs from AQUATOX

Task Cost: $12,000

23) Task 3.7 – Initiate the stakeholder process to develop stressor-specific WLAs and LAs that will achieve the TMDL targets for the DO impairment in upper Elm Creek, Nutrient Impairment in Fish and Rice (likely) Lakes and the DO impairment in lower Elm

a) Approach:

i) Work with stakeholder representatives to identify the process and criteria by which WLAs and LAs will be identified

ii) Use FLUX and SWAT/QUAL-2E model outputs to quantify stressor-specific WLAs and LAs for each stakeholder group

Task Cost: $12,000

24) Task 3.8 – Determine stressor-specific load reductions necessary to simultaneously achieve the TMDL goals for the DO impairment in upper and lower Elm Creek and Nutrient Impairment in Fish and Rice (likely) Lakes.

i) Approach: Use FLUX and SWAT/QUAL-2E model outputs to quantify the necessary load reductions to achieve instream DO goals for upper and lower Elm Creek and nutrient goals for Fish and Rice Lakes

Task Cost: $8,000

25) Task 3.9 – Develop a TMDL Implementation Plan to simultaneously achieve the TMDL goals for the DO impairment in upper and lower Elm Creek and Nutrient Impairment in Fish and Rice (likely) Lakes.

a) Approach:

i) Work with stakeholder groups to identify specific Best Management Practices (BMPs) that will be implemented to achieve water quality goals for the upper Elm Creek subwatershed

ii) Use SWAT/QUAL-2E and AQUATOX models to quantify the cumulative effectiveness of various BMP strategies for the upper Elm Creek subwatershed

Task Cost: $10,000

Total Objective Cost: $98,900

Deliverables: (1) subwatershed specific TMDL and Implementation Plan; (2) data upload into STORET; (3) subwatershed specific land use - water quality response model; (4) summary reports to MPCA (including semi-annual reporting August 1st and February 1st)

Phase IV

Timeline: Spring 2012 to Fall 2013 (possibly 2014, dependent on the potential listing of Bacteria and Biological impairment of Diamond Creek)

Objective 4: Characterize the relative contribution of landscape and instream/lake processes to water quality impairment in the Diamond Creek subwatershed (including Diamond Lake and French Lake) and the downstream DO impairment in lower Elm Creek

26) Task 4.1 – Determine the source of OD loading within the Diamond Creek subwatershed

a) Approach:

i) Flow-automated cBOD sampling (composite and grab samples) upstream/downstream of major confluences and unique instream segments

        (1) cBOD samples will be split and analyzed as “whole” and “filtered” (0.7 υm glass fiber filter) to approximate the relative contribution of organic and refractory carbon
    ii) Characterize the relative concentration and loading of nutrients (total phosphorus, soluble reactive phosphorus, nitrate and ammonia) and total suspended solids using flow-automated ISCO samplers and standard lake profile sampling techniques
        (1) Nutrient parameters will be used within the AQUATOX model (see Task 4.4) to characterize the relative contribution of the various DO impairing constituents – carbonaceous (cBOD), nitrogenous (nBOD) and sediment (SOD)

Task Cost: $14,000

27) Task 4.2 – Characterize the diel DO dynamics throughout a longitudinal profile within Diamond Creek
    a) Approach:
        i) Conduct 24 hr DO monitoring at 4-6 sites throughout a longitudinal profile within Diamond Creek

    Task Cost: $10,000

28) Task 4.3 – Characterize the occurrence and magnitude of bacteria (i.e., *E. coli*) and chloride pollution in the Diamond Creek subwatershed
    a) Approach:
        i) Expand the parameter set analyzed at each autosampler to include: *E. coli* and chloride following MPCA guidance

    Task Cost: $10,000

29) Task 4.4 – Describe the biological (i.e., invertebrate and fish assemblage composition) and physical characteristics of the Diamond Creek sub-watershed
    a) Approach:
        i) Collaborate with Hennepin County Environmental Services, the University of Minnesota and the Minnesota Pollution Control Agency to conduct fish, invertebrate and (potentially) periphyton surveys to populate the AQUATOX model

    Task Cost: $6,000

30) Task 4.5 - Develop a physically-based, multi-segment instream model that accurately characterizes the landscape and instream influence on water quality impairment in the Diamond Creek subwatershed
    a) Approach:
        i) Develop a SWAT/QUAL-2E model to characterize the landscape contribution to DO impairment in Diamond Creek and nutrient impairment in Diamond and French Lakes.
        ii) Develop P8/SLAMM model(s) to characterize the urban contributions to DO impairment in Diamond Creek and nutrient impairment in Diamond and French Lakes.
        iii) Link the SWAT/QUAL-2E model to a multi-segment AQUATOX model to characterize the longitudinal instream DO dynamics in Diamond Creek

    Task Cost: $10,000

31) Task 4.6 – Determine the relative contribution of multiple stressors to the Biological Impairment of Diamond Creek (dependent on results from invertebrate and fish assemblage analysis; Task 4.3) and the TMDL target for Nutrient Impairment in French and Diamond Lakes

a) Approach:
   i) Run Monte Carlo simulation with the AQUATOX model to determine relative contribution of individual stressors identified in the stressor identification process
   ii) Compare traditional in-lake response model outputs (e.g., WLMS, BATHTUB…etc.) to Monte Carlo simulation outputs from AQUATOX

Task Cost: $12,000

32) Task 4.7 – Initiate the stakeholder process to develop stressor-specific WLAs and LAs for the Diamond Creek subwatershed that will achieve the TMDL goals for the Diamond and French Lake nutrient impairments (potentially Biotic Impairment in Diamond Creek) and the DO impairment in lower Elm Creek
   a) Approach:
      i) Work with stakeholder representatives to identify the process and criteria by which WLAs and LAs will be identified
      ii) Use FLUX and SWAT/QUAL-2E model outputs to quantify stressor-specific WLAs and LAs for each stakeholder group

   Task Cost: $12,000

33) Task 4.8 – Determine stressor-specific wasteload reductions to simultaneously achieve the TMDL goals for the Diamond and French Lake nutrient impairments (potentially Biotic and Bacteria Impairment in Diamond Creek) and the DO impairment in lower Elm Creek
      i) Approach: Use FLUX and SWAT/QUAL-2E model outputs to quantify the necessary load reductions to achieve the TMDL goals for both the Diamond Creek subwatershed and lower Elm Creek

   Task Cost: $8,000

34) Task 4.9 – Develop a TMDL Implementation Plan to simultaneously achieve the TMDL goals for the Diamond and French Lake nutrient impairments (potentially Biotic and Bacteria Impairment in Diamond Creek) and the DO impairment in lower Elm Creek
   a) Approach:
      i) Work with stakeholder groups to identify specific Best Management Practices (BMPs) that will be implemented to achieve water quality goals for the Diamond Creek subwatershed
      ii) Use SWAT/QUAL-2E and AQUATOX models to quantify the cumulative effectiveness of various BMP strategies for the Diamond Creek subwatershed

   Task Cost: $10,000

Total Objective Cost: $101,700

Deliverables: (1) subwatershed specific TMDL and Implementation Plan; (2) data upload into STORET; (3) subwatershed specific land use - water quality response model; (4) summary reports to MPCA (including semi-annual reporting August 1st and February 1st)

Phase V

Timeline: Spring 2013 to Fall 2014 (possibly 2015, dependent on the potential listing of Bacteria, Biota and Chloride impairments throughout various subwatershed assessed in Phases II through IV)

Objective 5: Compile and summarize all WLAs and LAs and Implementation Plan documentation and recommendations into a single, multi-stressor, watershed-wide TMDL for the entire Elm Creek watershed

35) Task 5.1 – Synthesize all subwatershed TMDLs and Implementation Plans
   a) Approach:
      i) Gather and organize all existing documents
      ii) Summarize results from combined watershed model results (see Task 5.2 and 5.3 for more detail)
   Task Cost: $14,000

36) Task 5.2 – Link all subwatershed modeled segments into a complete watershed model
   a) Approach:
      i) Work with USEPA representative to link all subwatershed-specific models into a watershed wide model
      ii) Refine the SWAT-AQUATOX linkage process via BASINS
   Task Cost: $18,000

37) Task 5.3 – Confirm all subwatershed BMP scenarios in the context of watershed wide water quality goals
   a) Approach:
      i) Run all subwatershed BMP scenarios with the watershed-wide model
      ii) Identify/refine BMP locations to promote stakeholder collaboration and cost sharing
      iii) Account for previously/concurrently implemented BMP and identify water quality improvements likely associated with management efforts
      iv) Project time to recovery for impaired waters
      v) Design future monitoring programs to assess the long-term efficacy of management efforts
   Task Cost: $18,000

38) Task 5.4 – Finalize Stakeholder Process
   a) Approach:
      i) Host stakeholder meetings to identify areas of geographic, ecological and political overlap and the potential for collaborative implementation of BMP projects
   Task Cost: $12,000

Total Objective Cost: $70,300

Deliverables: Watershed-wide TMDL and Implementation Plan
This phase consists of completing a draft and final TMDL report and implementation plan based on EPA and MPCA guidelines; and MPCA, EPA, WMO, and stakeholder reviews. The draft and final TMDL will at a minimum include:

1. Description of water body, pollutant of concern, pollutant sources, and priority ranking
2. Description of the applicable water quality standards and numeric water quality target
3. Loading capacity
4. Load Allocations (LAs)
5. Wasteload Allocations (WLAs)
6. Margin of Safety (MOS)
7. Critical Conditions

8. Monitoring Plan
9. Implementation Plan
10. Reasonable Assurance
11. Public Outreach Activities

The TMDL report and implementation plan will be submitted to the MPCA for submittal to EPA. All reports, documents, data files, modeling information, public information summary and outreach materials, fact sheets which were developed during the project will also be submitted to the MPCA.

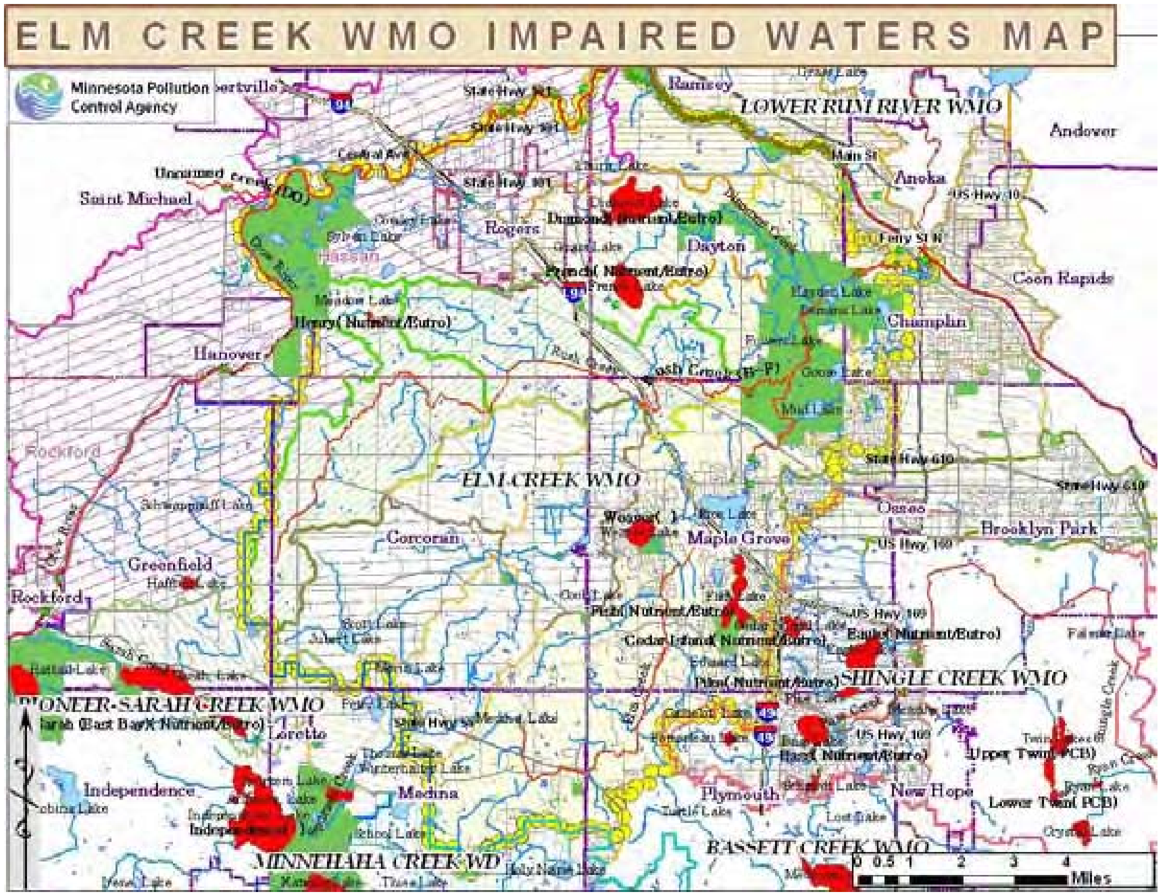

Figure 1 Outlines the Elm Creek watershed boundaries and highlights the current water quality impairments.

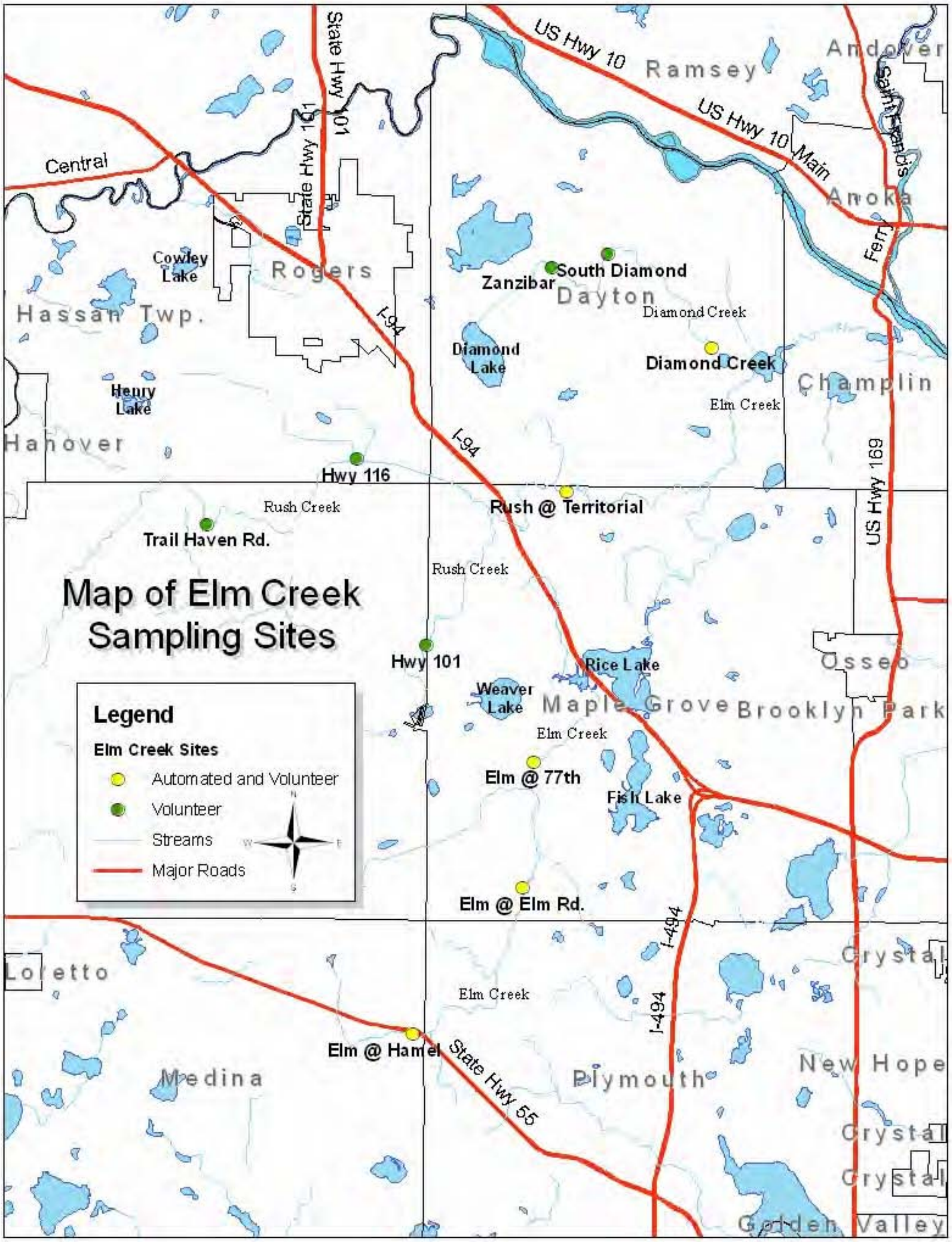

Figure 2 Elm Creek watershed automated and volunteer monitoring sites.

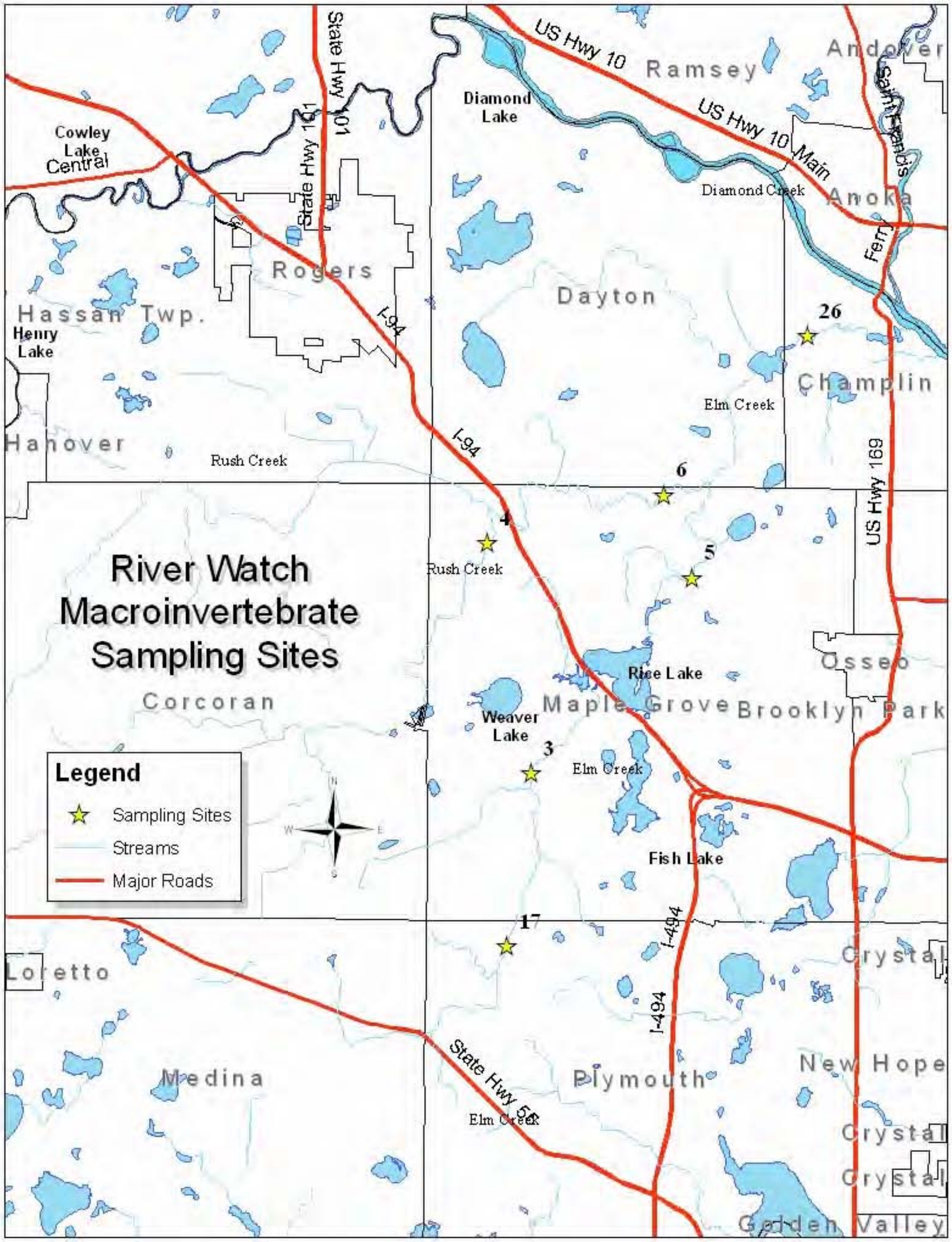

Figure 3 Hennepin County River Watch Macroinvertebrate Sampling Sites in Elm Creek Watershed.

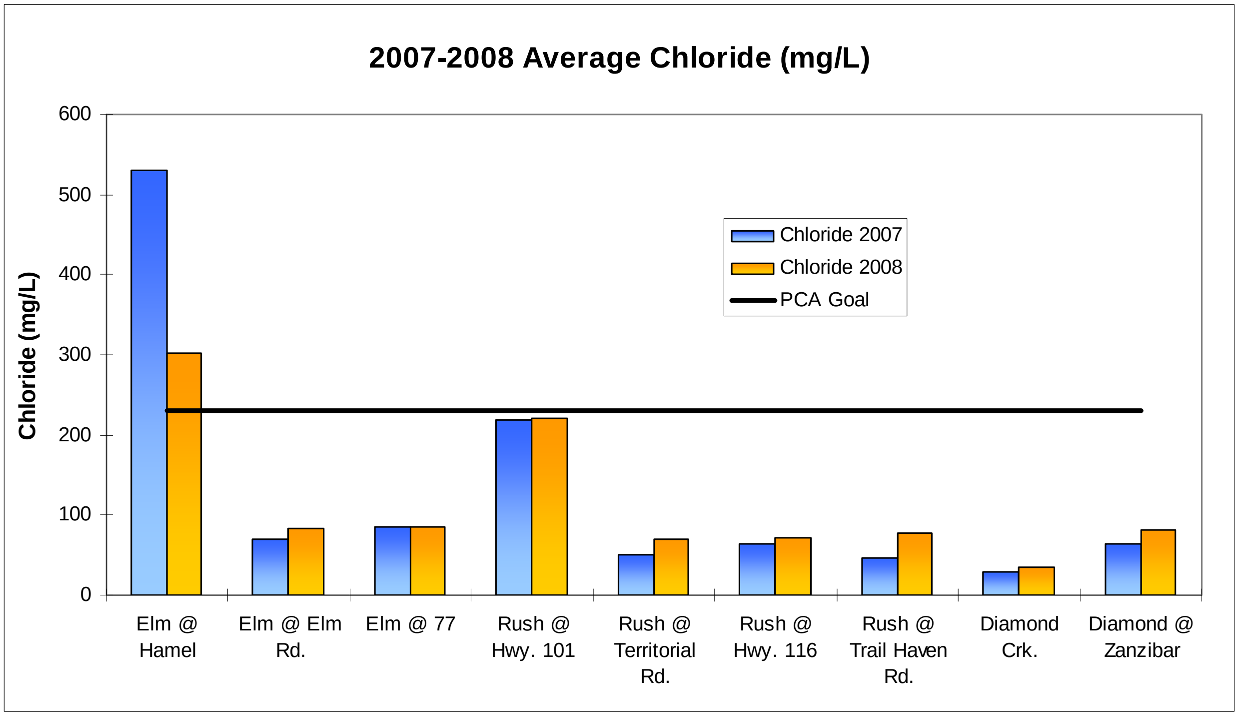

Figure 4 Average chloride (mg/L) for July-November 2007 and April-November 2008.

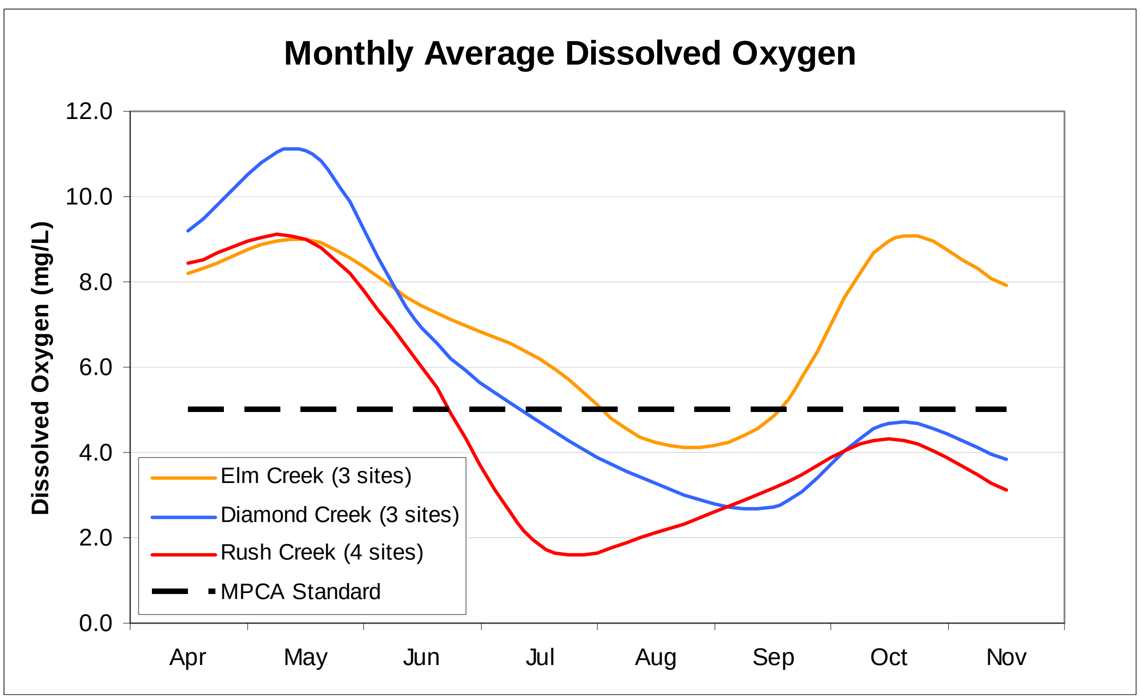

Figure 5 Average monthly dissolved oxygen readings for 2008. The 10 sites were grouped according to creek.

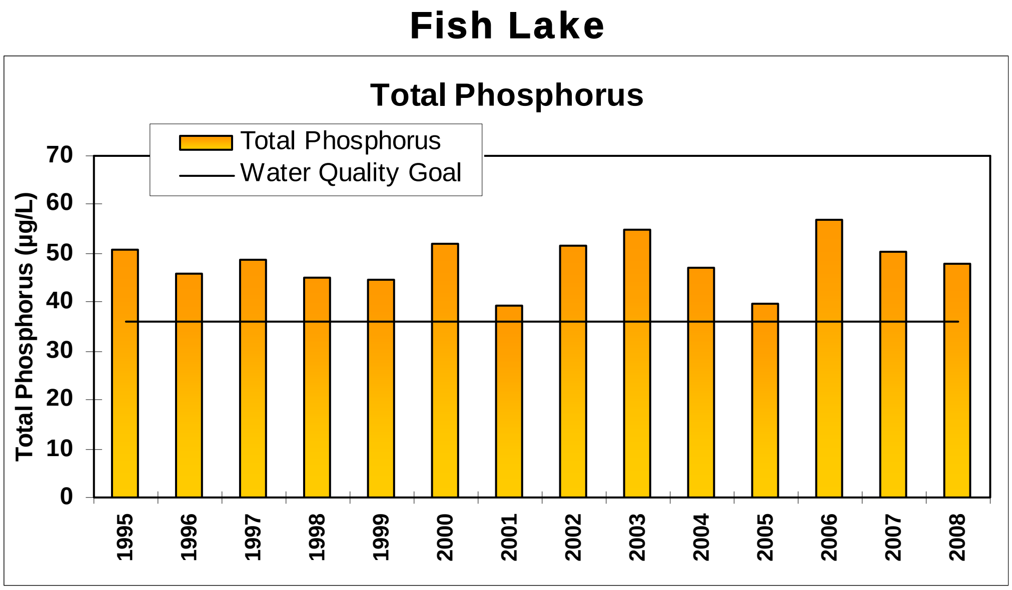

Figure 6 Fish Lake annual changes in total phosphorus data for 1995-2008. Values are the growing season average from May through September.

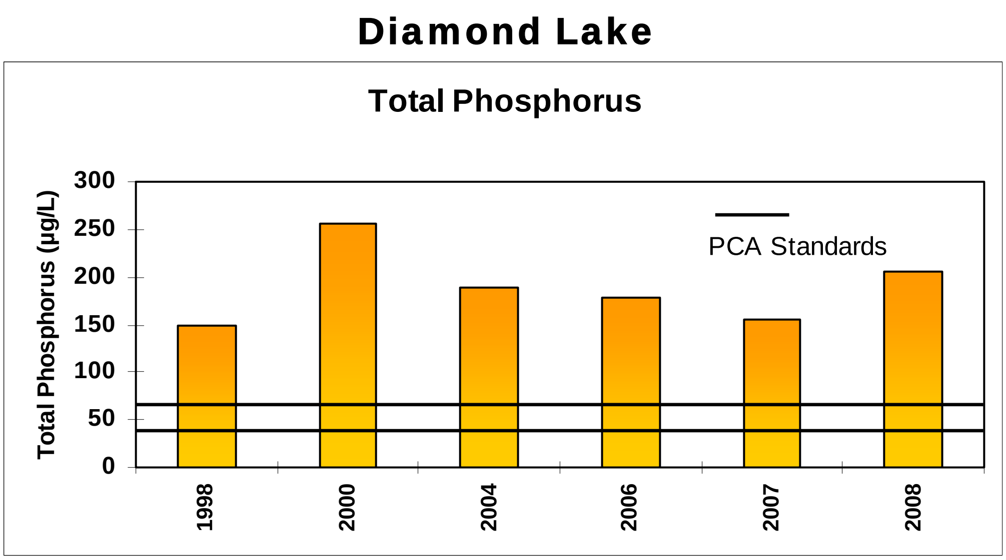

Figure 7 Diamond Lake annual changes in total phosphorus data. Values are the growing season average from May through September.

Weaver Lake

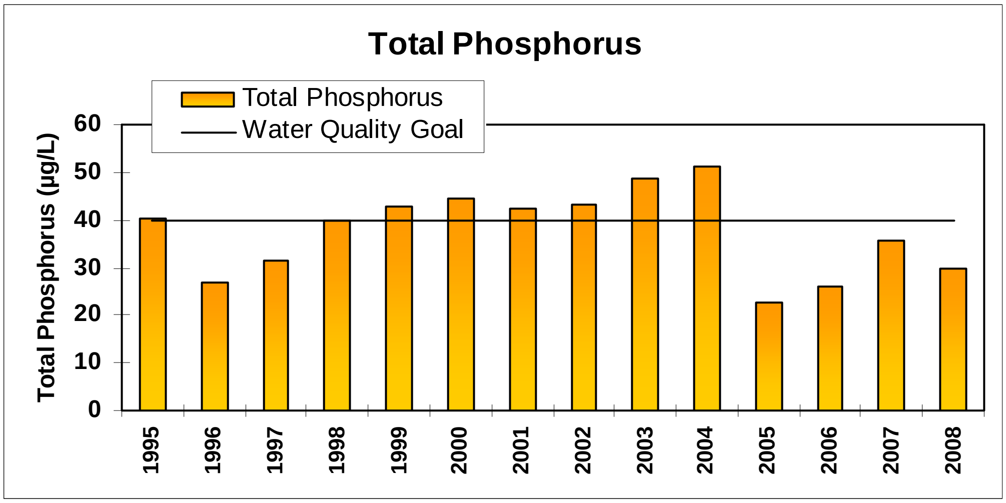

Figure 8 Weaver Lake annual changes in total phosphorus data for 1995-2008. Values are the growing season average from May through September.

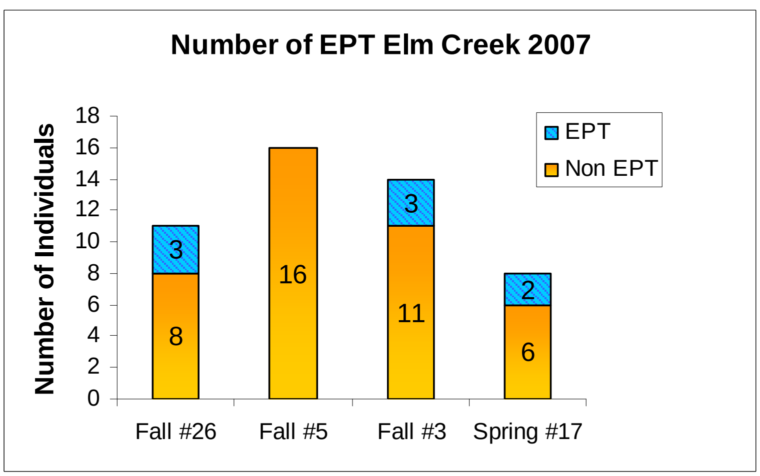

Figure 9 Taxa richness and number of pollution sensitive organisms (EPT) found at the four sampling sites on Elm Creek.

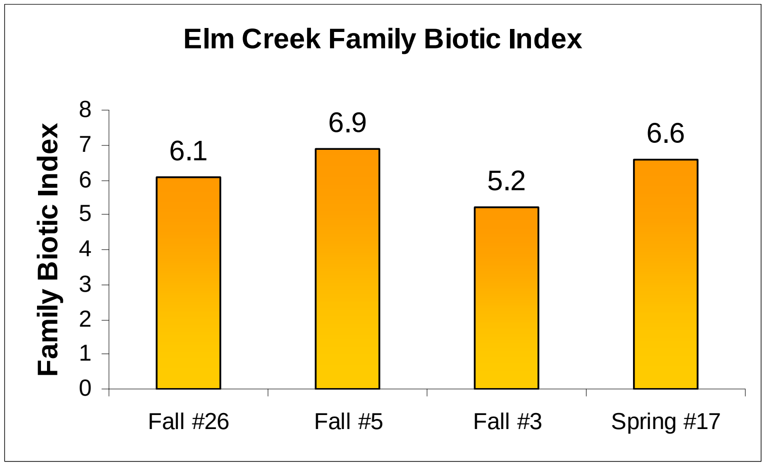

Figure 10 Family Biotic Index ratings for the four sites on Elm Creek in 2007.

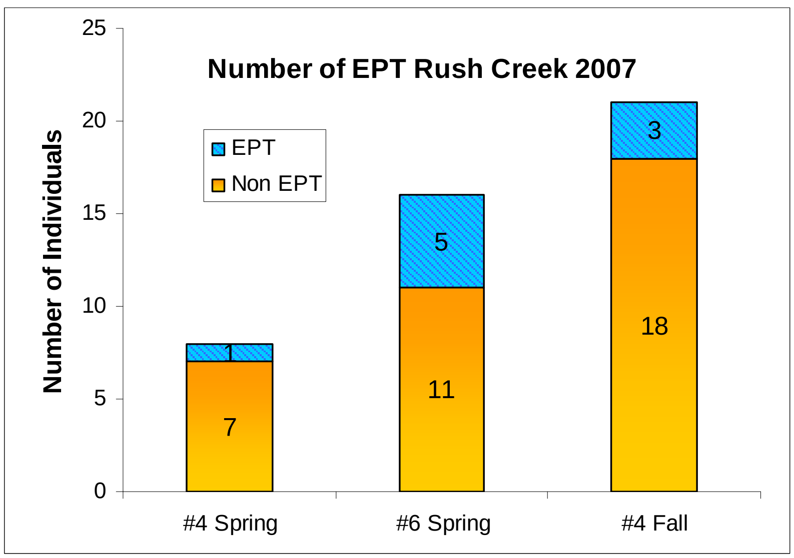

Figure 11 Taxa richness and number of pollution sensitive organisms (EPT) found at the two sampling sites on Rush Creek.

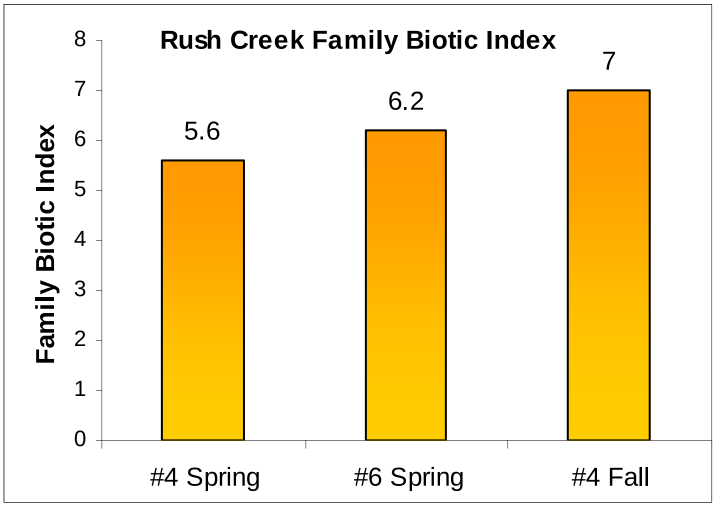

Figure 12 Family Biotic Index ratings for the two sites on Rush Creek in 2007.

Parameter	Method	Reference
Ammonia	4500-NH3 D	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Nitrate	4500-NO3 B	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Soluble Reactive Phosphorus	4500P E (Ascorbic Acid)	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Total Nitrogen	4500-N C	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Total Phosphorus	4500P B&E (Persulfate digestion and Ascorbic Acid)	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Total Suspended Solids	2450D	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Total Chloride	4500-Cl B (Argentometric Method)	Std. Meth. Anal. Water and Wastewater (21st Ed.)
E Coli and Total Coliform	9223B	Std. Meth. Anal. Water and Wastewater (21st Ed.)
Biochemical Oxygen Demand	5210 B (5-Day BOD)	Std. Meth. Anal. Water and Wastewater (21st Ed.)

Table 1 Summary of standard methods for surface water analysis at Three Rivers Park District laboratory.

Site	Annual Nutrient Loading (lbs/yr) and Flow Volume (m3)				
	Total Phosphorus	Soluble Reactive Phosphorus	Total Nitrogen	Total Suspended Solids	Flow
Elm @ Hamel	374.26	190.52	3539.14	159636.66	1030228.39
Elm @ Elm Rd.	916.50	468.38	6590.54	130483.38	1819567.85
Elm @ 77	2516.45	1008.79	13766.34	473186.76	4251790.37
Rush @ Territorial	3287.59	2045.84	19101.14	230678.15	4940202.81
Diamond Creek	539.85	754.37	4101.36	59106.11	1107111.15
Total	7260.39	4277.38	43559.39	893454.41	12118672.19

Table 2 Elm Creek watershed monitoring for nutrient loading (pounds/year) and flow volume (m^3).

Month	E. coli Average Monthly Geometric Mean 2008						
	May	June	July	August	September	October	November
Diamond @ Zanzibar Rd.	37	38	74	323	537	138	119
Diamond @ S. Diamond Rd.	6	30	45	289	1472	553	197
Diamond Creek	21	37	96	247	275	74	29
Rush @ Territorial Rd.	12	41	102	67	24	49	10
Rush @ Hwy. 116	25	73	130	87	49	31	6
Rush @ Trail Haven Rd.	11	38	107	Dry	Dry	Dry	Dry
Rush @ Hwy. 101	26	55	65	90	475	524	103
Elm @77	18	60	229	537	361	263	103
Elm @Elm Rd.	42	139	220	267	485	590	110
Elm @ Hamel	49	174	238	104	20	71	23

Table 3 Average monthly geometric mean of *E.coli* Most Probable Number from samples taken from weeks April 20th through November 18th, 2008.