# Work Plan-II

# Lake Pepin Watershed TMDL Project for Eutrophication & Turbidity Impairments

# Watershed Studies

**June 30, 2006**

## I: Introduction

This work plan builds on several preceding efforts, including the first Lake Pepin TMDL Work Plan (March 23, 2005), the first Request for Proposals for the Lake Pepin TMDL Monitoring Project (Nov. 12, 2005), and initial development of an ambient water quality model by Limno-Tech., Inc.(Jan. 3, 2006). Whereas the first work plan and RFP focused to a large extent on ambient water quality issues in the Mississippi River, Spring Lake, and Lake Pepin, the second work plan focuses on the need to provide input data for the model that is being developed by Limno-Tech, Inc., to evaluate water quality conditions in the Mississippi River from Lock & Dam 1 through Lake Pepin. This three-dimensional model, called ECOM/SED-RCA, combines hydrodynamic, sediment transport and water quality components into an integrated modeling system.

## II: Background & Problem

The Lake Pepin Watershed Total Maximum Daily Load (TMDL) project includes two hypereutrophic lakes – Lake Pepin and Spring Lake – and a chronically turbid segment of the Mississippi River, roughly from mid-Lake Pepin upstream to the confluence with the Minnesota River. In addition, the lower 22-mile impaired reach of the Minnesota River may be included in the Lake Pepin watershed project as a continuation of the Mississippi River turbidity impairment, which is basically a long Minnesota River sediment plume.

The Lake Pepin Watershed TMDL will establish Waste Load Allocations (for point sources) and Load Allocations (for nonpoint sources). Permitted wastewater treatment facilities will be assigned individual allocations. For other point sources and nonpoint sources, load allocations will be assigned at a fairly high level of aggregation for the following areas: Minnesota River Basin; Upper Mississippi River Basin upstream of Anoka; the St. Croix River Basin, the Twin Cities Metropolitan Area, and remaining

smaller tributaries. An attempt will be made to take into account the practical feasibility and cost of achieving alternative source load reductions for sediment and phosphorus. However, some of this work will be directed toward the completion of an implementation plan subsequent to the completion and approval of the TMDL Report. The Minnesota Pollution Control Agency (MPCA) requires that implementation plans be completed within a year of TMDL approval – U.S. EPA has no such requirement.

Lake Pepin is a natural lake on the Mississippi River. The lake formed about 10,000 years ago behind an alluvial fan of the Chippewa River, which dammed the Mississippi after outflow from Glacial Lake Agassiz was diverted northward and ceased to scour sediments deposited by the Mississippi's tributaries. (Wright et al.,1998). It has a surface area of about 40 square miles and a mean depth of 18 feet. Its watershed is about 48,634

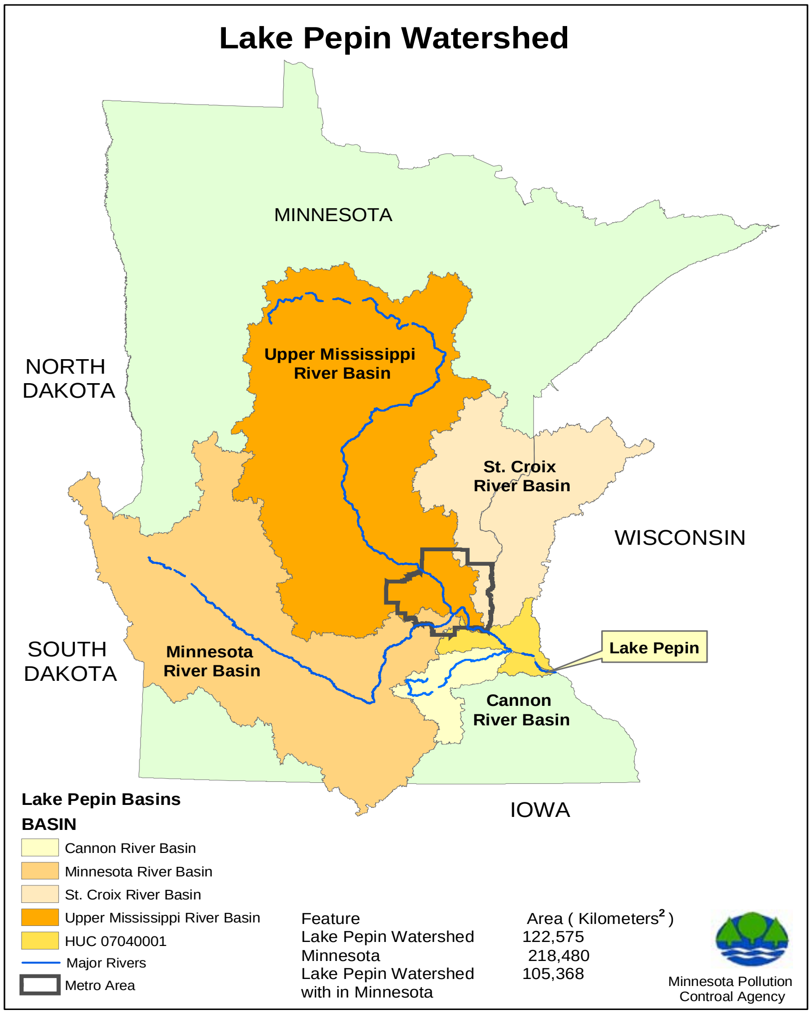
**Table 1: Lake Pepin Morphometric and Watershed Characteristics**

| Parameter | Value |
|---|---|
| Surface area ($mi^2$) | 39.7 |
| Mean depth (*ft*) | 17.7 |
| Maximum depth (*ft*) | 56 |
| Maximum width (*mi*) | 1-2 |
| Length (*mi*) | 20.8 |
| Volume (*acre-ft*) | 448,340 |
| Watershed Area ($mi^2$) | 48,634 |
| Mean Hydraulic Retention Time (*days*) | 16 |
| Range of Hydraulic Retention Time (*days*) | 6-47 |
| 1988 Hydraulic Retention Time (*days*) | 47 |
| Source: MPCA 1993 | |

square miles and includes the Upper Mississippi, St. Croix and Minnesota Rivers and drains about 48 percent of Minnesota and a portion of Wisconsin (Figure 1). This results in watershed-to-lake ratio of about 1,215:1. This large watershed area promotes short water residence times that range from 6 to 47 days, with an average of 16 days. As flows decrease, and Lake Pepin residence time lengthens, environmental stress from natural and anthropogenic sources increases.

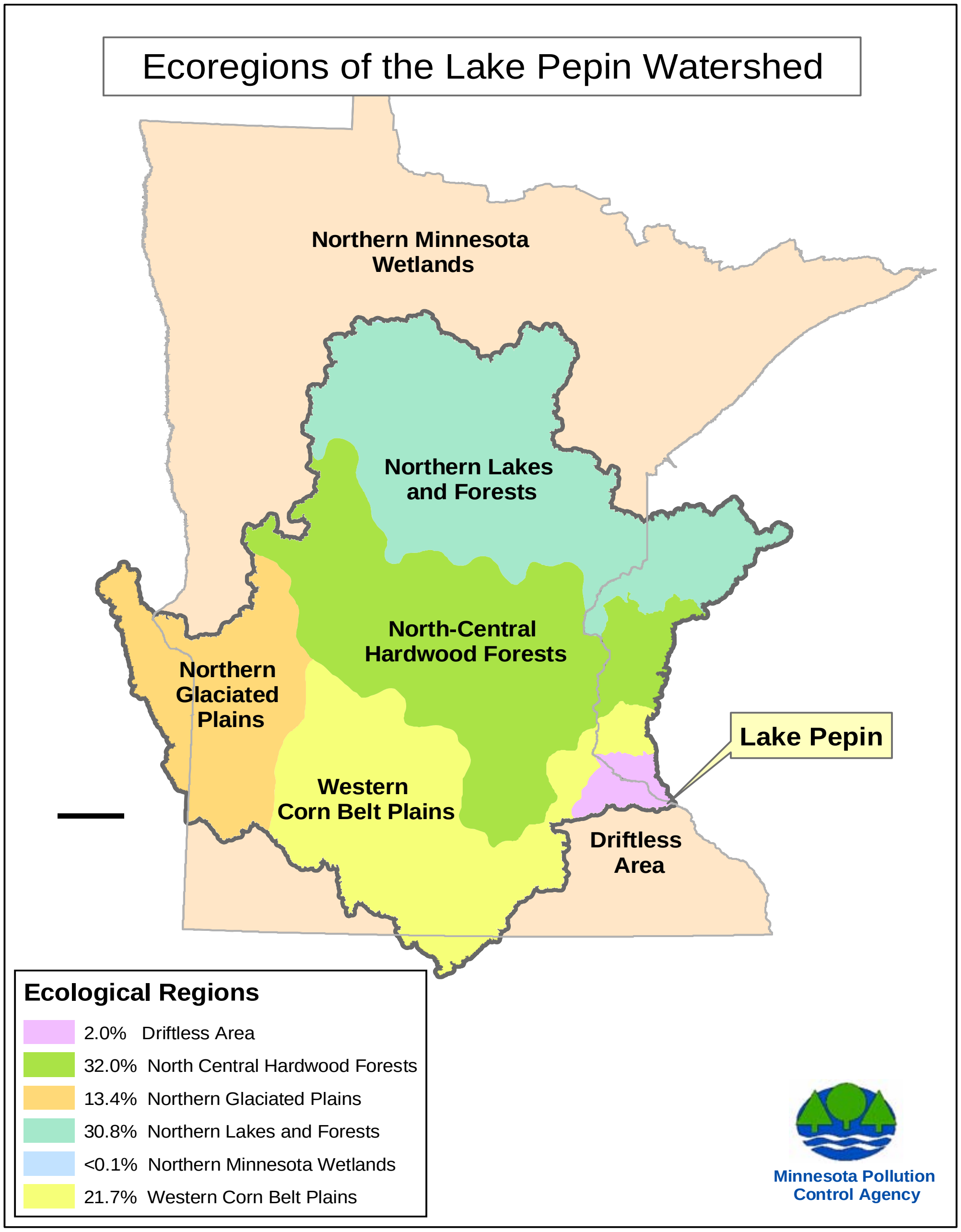
Spring Lake is a shallow floodplain lake on the west side of the pooled area behind Lock and Dam 2 near Hastings, Minnesota (see Figure 3). Before European settlement, the area was a floodplain forest and marsh separated from the main channel by a series of natural levee islands….In the mid-1800s, the lake was formed when a mill and dam were constructed on a creek draining the marsh. Since construction of Lock & Dam 2 in 1931, water levels in the lake have been stable, and the bordering islands have increased in size with dredged material from channel maintenance. Stump fields from the former floodplain forest are still evident in the lake. The median depth of Spring Lake is 1.3 meters, and the maximum depth is 4.6 meters. The surface area is roughly six square kilometers. (Metropolitan Council, 2002, pp 18-19).

## Figure 1: The Lake Pepin Watershed




Water quality in Lake Pepin and the Mississippi River immediately upstream is a reflection of the climate, soils, vegetation and land uses within its watershed. Considerable variation exists across the watershed, as shown in the ecoregion map (Figure 2) below. Land uses vary from heavily forested to the north and east, to mainly agricultural in the south and west, to highly urbanized in the metropolitan region immediately upstream of Lake Pepin.

## Figure 2: Ecoregions of the Lake Pepin Watershed




Lake Pepin was placed on the 2002 list of impaired waters (303(d)) for two types of water quality problems that will be dealt with in the present TMDL study (it is also listed for mercury and PCB impairments, which will be dealt with in other TMDL studies). As a lake, it is listed as impaired by nutrient enrichment, which causes algae blooms which are particularly severe during lower-flow periods. As part of the 48.36-mile Mississippi River reach that extends from the St. Croix River to the Chippewa River (AUID

07040001-531), Lake Pepin also is listed for turbidity. These problems are distinct but inter-related. Eutrophication at lower flows results from excessive growth of algae,

**Table 2: Lake Pepin Watershed Project Impairments**

| Reach | Assessment Unit ID | DNR Lake # | Affected use | Pollutant or stressor |
|---|---|---|---|---|
| Lake Pepin | | 25-0001 | Aquatic recreation | Excess nutrients |
| Spring Lake | | 19-0005-01 | Aquatic recreation | Excess nutrients |
| Minnesota River, RM 22 to Mississippi River | 07020012-505 | | Aquatic life | Turbidity |
| Mississippi River, Minnesota River to Metro WWTP (RM 844 – 835) | 07010206-505 | | Aquatic life | Turbidity |
| Mississippi River; Metro WWTP to Rock Island RR Bridge (RM 835 to 830) | 07010206-504 | | Aquatic life | Turbidity |
| Mississippi River; Rock Island RR Bridge to Lock & Dam #2 (RM 830 to 815.2) | 07010206-502 | | Aquatic life | Turbidity |
| Mississippi River; Lock & Dam #2 to St. Croix R (RM 815.2 to 811.3) | 07010206-501 | | Aquatic life | Turbidity |
| Mississippi River; St. Croix River through Lake Pepin to the Chippewa R (WI) | 07040001-531 | | Aquatic life | Turbidity |

which in turn results from the superabundance of phosphorus in the lake and upstream in its vast watershed. Much of the phosphorus is attached to sediment that is transported from the watershed through tributaries to Lake Pepin. While in suspension, sediment contributes to the problem of turbidity in the river reach that includes Lake Pepin, particularly at higher flows. Sediment that settles to the lake bed releases considerable quantities of phosphorus as dissolved oxygen levels in the upper layer of sediments decline to near zero. Sestonic algae produced from this and other sources of phosphorus in the watershed may contribute somewhat to the problem of turbidity. Because these problems are inter-related, they will be dealt with in a single TMDL report.

For a detailed discussion of eutrophication and turbidity technical issues in the Mississippi River from Lock & Dam 1 through Lake Pepin, see MPCA 2005a and MPCA 2005b) at http://www.pca.state.mn.us/water/tmdl/index.html#support

There are many impaired waters listed in the watershed upstream of the impairments being assessed in the present study. The following is a list of upstream TMDL projects that will need to be coordinated with the Lake Pepin Watershed TMDL:

1. Low Oxygen, Lower Minnesota River: Completed.
2. Low Oxygen in Crow River Watershed: Includes North Fork Crow River from Mill Creek to South Fork (AUID 07010204-503); and unnamed ditch to North Fork Crow River (AUID 07010204-527).
3. Turbidity: Mississippi River from Minnesota River to St. Croix River (River Mile 844 to 811.3, includes three listed impairments: AUID 07010206-505; AUID 07010206-504; and AUID 07010206-501).
4. Turbidity: Crow River, from the S Fk to Mississippi River (AUID 07010204-502); South Fork of Crow River from Buffalo Creek to the Crow River (AUID 07010205-508); and North Fork of the Crow River from Mill Creek to South Fork (AUID 07010204-503)
5. Eutrophication: Lake Byllesby on the Cannon River; Horseshoe Chain of Lakes, Sauk River.

| Upstream Related TMDLs Scheduled in the Lake Pepin Watershed | | | | |
|---|---|---|---|---|
| Waterbody/shed | Impairments | Status | Completion Date | comments |
| Lake Pepin Watershed | Turbidity & eutrophication | Underway | 2009 | |
| Lower Minn River | Dissolved $O_2$ | Complete | 2004 | WLA for TP; basin permit allows trading |
| Minn River Basin | Turbidity – 18 reaches | Underway | 2008 | |
| Crow River Watershed | Dissolved $O_2$ Turbidity | Starting | 2009 | Pending EPA approval of 319 work plan |
| Horshoe Chain of Lakes | Eutrophication | Underway | 2010 | Preceded by CWP projects |
| Lake Byllesby | Eutrophication | Underway | 2006 | |
| Lower Cannon River | Turbidity | Underway | 2006 | |

Following is a description of the main pollutant source regions that need to be included in source assessment and watershed modeling:

Minnesota River Basin. In recent years, the basin has accounted for 80 to 90 percent of the total sediment load to Lake Pepin. Near the mouth, TSS concentrations are extremely high, with an annual average of 141 mg/L at Jordan over the 1976-2002 period (Metropolitan Council 2004), and a median of 97 mg/L, far above concentrations in most of Lake Pepin of 10-20 mg/L. Mean and median concentrations of TP, at 0.28 and 0.23 mg/L, respectively, are somewhat higher than annual average concentrations in Lake Pepin. Chlorophyll-a concentrations of 63 µg/L (mean) and 35 µg/L (median) are well above the 1988-based target of 30 µg/L chlorophyll-a for Lake Pepin. Thus, on all counts, the Minnesota River appears to have a highly degrading effect on the water quality of the Mississippi River and Lake Pepin. This influence will be greater in years of normal or higher flows, when the Minnesota River comprises a relatively large part of Lake Pepin's water budget, compared to low flows, when its proportion is smaller. The highest loading watersheds in the basin for phosphorus and sediment are the Le Sueur River, Blue Earth River, and Lower Minnesota River watersheds. (Metropolitan Council, 2004)

Upper Mississippi River Basin (upstream of Anoka) Over the past 25 years, concentrations of TSS and TP have been relatively modest, but concentrations of chlorophyll-a have been comparable to concentrations found in Lake Pepin. The mean and median concentrations of TSS over the 1976-2002 period are 18 mg/L and 15 mg/L, respectively, close to average concentrations in Lake Pepin. TP concentrations at Anoka have been 0.12 mg/L (mean) and 0.09 mg/L (median), almost half the normal concentrations found in Lake Pepin. Long-term annual average chlorophyll-a concentrations are 0.028 mg/L (mean) and 0.022 mg/L (median), close to concentrations found in Lake Pepin, and just below the 30 µg/L chlorophyll-a goal established for 1988-like flow conditions. Thus, it appears that algal productivity in the Upper Mississippi River is sufficiently high to approach levels considered an impairment in Lake Pepin. The extent to which this algae actually contributes to the chlorophyll-a load of Lake Pepin needs to be evaluated in the TMDL study.

St. Croix River Basin St. Croix River water quality is relatively good, serving to dilute higher concentrations of pollutants from the Minnesota River and Upper Mississippi. At Stillwater, concentrations of TSS are extremely low at 8.5 mg/L (mean) and 8.0 mg/L (median). TP concentrations are 0.058 mg/L (mean) and 0.05 mg/L (median), about half the concentrations found in Lake Pepin. Likewise, chlorophyll-a concentrations are 14 µg/L (mean) and 9 µg/L (median), far below levels found in Lake Pepin.

Metro Area Basin There is no single measuring point for metropolitan area water quality. However, an extensive monitoring program by the Metropolitan Council provides detailed information on major rivers and minor streams within and immediately upstream of the Twin Cities Metropolitan Area (Metropolitan Council, January 2004). In addition to storm water runoff reflected in ambient water quality data, major point sources continuously discharge phosphorus into the Minnesota and Mississippi Rivers. Point source loads are being substantially reduced as phosphorus limitations are placed on more

of its wastewater treatment facilities, the most recent being the Metro Plant. Spring Lake in Navigation Pool 2 often is severely impaired by nutrient enrichment. Earlier studies have identified Lower Pool 2 as an important source of chlorophyll-a load to Lake Pepin, and as a significant sink of sediment.

Lake Pepin Area/Cannon River Watershed: Pollutant loads from hydrologic unit 07040001 and the Cannon River watershed upstream of Lake Byllesby were not well documented for previous Lake Pepin eutrophication studies. In aggregate these loads will be minor in comparison to those from larger watersheds. However, the highly erosive nature of the soils in the 532,000-acre Driftless Area portion of this area, combined with relatively high annual precipitation, produce the potential for severe runoff on a per-acre basis. Some of the highest soil erosion rates in Minnesota area experienced in this region. Because residents of this region live in close proximity to the Mississippi River, Spring Lake and Lake Pepin, they will be among the main beneficiaries of efforts to restore these water bodies. Thus, it is important that the contribution of this region to TMDL impairments be accurately assessed, and that methods of reducing the impacts of development pressure and changing agricultural land use be explored.

Internal, Shoreline and Channel Management-Related Sources: In addition to upstream sources of sediment, phosphorus and chlorophyll are a set of additional factors that affect the recycling or resuspension of sources within Lake Pepin or the upstream Mississippi River. These factors will need to be taken into account in the TMDL study. They include internal loading of phosphorus from lake sediments, shoreline erosion from recreational boat traffic, effects of commercial navigation and river level management. Internal loading of phosphorus has been discussed elsewhere. Shoreline erosion from all contributing influences, including recreational boating, has been identified by the Minnesota DNR as a potentially significant source of sediment, generating an estimated 82,600 cubic yards of sediment annually from Lock and Dam 3 to the head of Lake Pepin (Minnesota DNR, 2004). The impacts of commercial navigation on water quality and shoreline erosion on the Lower Minnesota River, Pool 2 and Pool 3 needs to be addressed, considering the use of methods from the Navigation Expansion Feasibility Study, which did not investigate impacts upstream of Lock and Dam 3. In addition, there may be ways of operating the 9-foot channel reservoirs that could tie up available phosphorus by restoring the historical abundance of aquatic macrophytes and reducing the residence time of Lake Pepin. Options to consider include returning to earlier authorized levels of allowable summer drawdown, and conducting planned drawdowns in Pools 2, 3 and 4. Finally, introducing structural changes such as islands in strategic locations in the Mississippi River could be used to reduce wind fetch and consequently suppress resuspension of sediments from wind and wave action. In many areas, historical island habitat can be restored and new islands created where, prior to lock and dam construction, emergent lands existed.

Pollutant Source Assessment Process: The Stakeholder Advisory Committee, Science Advisory Panel and Sediment Reduction Advisory Committee are helping the MPCA to assess current sediment and phosphorus loads from significant point and nonpoint sources, and to select source-reduction scenarios to project future loads under a range of

assumptions regarding land use and wastewater treatment technology. This information will be used to generate current and future estimates of pollutant loads, and to evaluate the feasibility of alternative source-reduction alternatives.

## III: Technical and Policy-Related Issues

The following technical and policy-related issues need to be considered in addressing eutrophication and turbidity impairments through the Lake Pepin Watershed TMDL process:

<u>Pollutant Source Assessment Issues</u>

1. Defining and estimating natural background water quality conditions, or conditions reflecting "best attainable" management of current land uses, modeling water quality associated with an historical reference point, and modeling a "best case scenario" such as grass cover on the entire river basin are needed to inform our discussion of the cost of attaining the turbidity standard – and ultimately the feasibility of bearing those costs.

2. Recent monitoring in the Minnesota River suggests that sediment sources responsible for turbidity can be targeted by weather, season, and topography:
   - i. <u>Weather</u>. Recent monitoring in the Minnesota River basin indicates that 2-4 storms/year often are responsible for most sediment. There is a need to estimate/model the effect of severe storms on sediment mobilization and transport, and evaluate land use changes and BMPs for high-intensity events of one inch or more.
   - ii. <u>Season</u>: Monitoring in the Minnesota River basin indicates that most sediment is mobilized and transported in the spring and early summer, up to the time of crop canopy closure around mid-June or early July. There is a need to evaluate land-use practices and BMPs for this time period, including row-spacing (drilled soybeans, 20-inch corn rows) which affect the date of canopy closure.
   - iii. <u>Topography</u>: Monitoring within watersheds of the eastern Minnesota River Basin where streams are highly incised near the confluence with the main stem indicates that the majority of sediment is mobilized and transported within a very small part of the landscape, i.e., steeper sloping areas such as ravines at field edges and steep valley walls. There is a need to evaluate alternative means of reducing sediment losses from such areas through perennial ground cover (trees, hay), and grade stabilization structures. Methods of estimating gully erosion, as distinct from sheet & rill erosion on the one hand, and stream channel erosion on the other hand, are needed.
   - iv. <u>Stream Bank and Bluff Erosion</u>: Estimates of the contribution of stream bank and bluff erosion to total suspended solids in Minnesota River mainstem and tributaries range widely. There is a need for better estimates of the sediment loads from banks and bluffs of the main stem

and tributaries, making distinctions between small and large hydrologic scales and different types of stream morphologies. In addition, it would be desirable to estimate on a small watershed scale how bed and bank erosion could be reduced through increased water storage on the landscape, perennial vegetation, drainage management and other methods, in a manner that could be extrapolated to larger areas.

3. To what extent can the floodplains of main stems and tributaries be used as a sediment sink during higher flows, and how can this contribute to reduced sediment load and turbidity?

4. To what extent does altered hydrology induced by artificial drainage affect time of concentration, stream flow, channel stability and streambank and bluff erosion? How could increased water storage ameliorate such effects?

5. Not all phosphorus discharged to a tributary will be transported to Lake Pepin. A way of estimating phosphorus sorption, sequestration in algae, bed sediments and other forms of natural assimilation is needed in order to develop distance-discount factors for phosphorus discharges at various distances from Lake Pepin.

6. There is a need to evaluate the effect of phosphorus reductions already planned or implemented upstream of Lake Pepin. This includes Metro Plant improvements, and the extent to which the Waste Load Allocation for point source phosphorus from the Minnesota River will suffice to meet phosphorus and chlorophyll a goals for Lake Pepin. The Lower Minnesota D.O. TMDL calls for a 50% reduction in point sources over a ten year period, or a 35% reduction by 2009, during low flow periods, through the implementation of effluent limits. http://www.pca.state.mn.us/water/tmdl/index.html#finaltmdl

7. Methods of estimating resuspension of sediment caused by wind and wave action, boat waves and turbulence, and high river flows are needed.

Ecological, Economic and Social Issues:

8. The ultimate environmental goal associated with reduced turbidity is enhanced aquatic life. Submersed aquatic vegetation (SAV), in particular, is a central response variable that needs to be estimated for the shallower parts of the study area. SAV provides good habitat for fish, wildlife and waterfowl populations. Thus, the response of these populations to improved SAV habitat needs to be estimated as well.

9. Estimates of biological response in (8) above can provide a basis for estimating the economic value associated with achievement of the water

quality standard for turbidity. This would include the economic value of enhanced fish, wildlife and waterfowl populations.

10. Other measures of economic value include: recreational benefits associated with achieving the water quality standard for eutrophication in Lake Pepin; ecological amenities associated with land-use changes introduced throughout the watershed to achieve water quality standards; reduced costs associated with sedimentation of drainage ditches, road ditches and river navigation channels; and benefits of improved water quality incidentally achieved upstream of the impaired reaches in the TMDL study.

11. The ultimate success of the TMDL depends on implementation of wastewater treatment and land use improvements by residents of the Lake Pepin watershed. Some understanding of the factors likely to influence adoption are needed to evaluate the degree of assurance that can be placed in the many source-reduction scenarios that will be evaluated as part of the TMDL study. Such knowledge also will prove useful in designing an implementation plan for the approved TMDL.

Modeling Issues:
Water quality modeling will be needed to develop estimates of key TMDL components – Wasteload Allocations and Load Allocations, in particular -- for sub-components of the Lake Pepin Watershed. Likely more than a single model will need to be used. This presents a need to select, calibrate and integrate models for use in the TMDL study. During the study, the models will be used to evaluate alternative means of meeting the TMDL targets, which will provide key information to support decisions regarding source allocations. Watershed modeling will be conducted at several scales, including river basin, major watershed, and small watershed. A modeling plan needs to ensure consistency of time periods, compatibility of data, and quality control of data sources concerning the set of watershed models used, and with respect to the water quality model for which they will provide input.

Following is a list of models that have been used in the Lake Pepin watershed, that are under consideration for further use in the TMDL process:

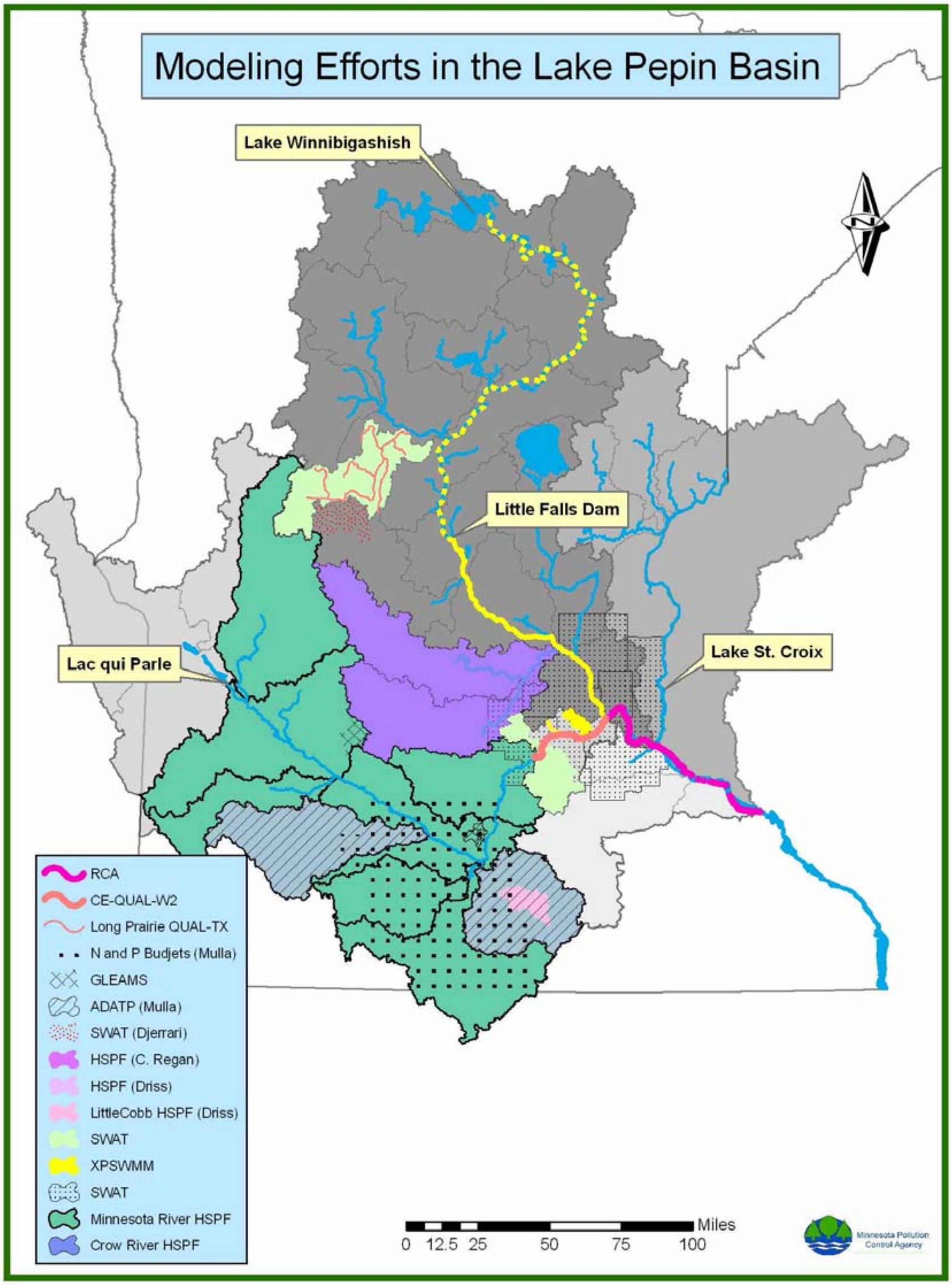
1. Lake Pepin Model – ECOM/SED-RCA model developed by HydroQual for Lake Pepin is being developed by Limno-Tech, Inc. for ambient water quality modeling from Lock & Dam 1 through Lake Pepin. Its boundaries, where basin inputs are needed, extend to the mouth of the Minnesota and St Croix Rivers, Lock and Dam 1 on the Upper Mississippi River, and minor tributaries. Limno-Tech, Inc., advises that model accuracy could be improved with the following additional data: a resampling of sediment cores in Lake Pepin, analyzed for sediment deposition rate and phosphorus concentration;

more detailed information on zooplankton and phytoplankton populations in Lake Pepin; and bathymetry data for Navigation Pools 2 and 3.

2. Minnesota River Basin: The HSPF model has been calibrated for the Minnesota River Low Oxygen TMDL, and will be adapted for use in the Lake Pepin TMDL and for a Minnesota River Turbidity TMDL. The model needs to be validated for agricultural tile flows, bank and bluff source contributions, bed load estimation, ultimate vs. 5-Day BOD. It needs to be supplemented with minor watershed modeling to obtain greater detail on specific land use practices.
    - ADAPT has been applied to a 44,445-acre subwatershed of the Chippewa River in the Minnesota Basin, and to Wells Creek watershed in the Lower Mississippi River Basin, to evaluate the effect on water quality of progressive degrees of land-use change. The Multiple Benefits of Agriculture study, conducted by the University of Minnesota for the Land Stewardship Project, estimated long-term-average annual edge-of-field reductions of 25 to 80 percent for sediment and 50 to 75 percent for phosphorus.
    - Modeling studies of other watersheds are being summarized.
    - The Metropolitan Council-Environmental Services is modeling the Lower Minnesota River using the CE-QUAL-W2 model. This project will evaluate dissolved oxygen, ammonia, nutrients and sediment under a variety of flows. It is scheduled to end in 2008.
    - There is a need to ensure that models used for the TMDL study work together, i.e., that output from a basin sub-model can be used as input by the main Lake Pepin water quality model.

3. St.Croix River Basin: A sediment core study of Lake St Croix was conducted to infer earlier levels of total phosphorus concentrations. The USGS built BATHTUB models for much of the St. Croix River. The nutrient subcommittee of the St. Croix Basin Water Resources Planning Team determined that a 20 percent reduction in total phosphorus loading to the basin would be needed to restore conditions to those prevailing in 1940, before major increases in nutrient loadings occurred during 1950-1960. The SWAT (Soil and Water Assessment Tool) model is being used to predict phosphorus loads from subwatersheds.

4. Metropolitan Area: The SWAT model has been applied to several watersheds in the Twin Cities region as a component of the Metropolitan Council's target pollutant load program. Modeling is complete or in progress for five watersheds in the Minnesota River basin: Bevens Creek, Bluff Creek, Carver Creek, Credit River, and Sand Creek. These models are dynamic, daily time-step simulations with a semi-lumped representation of spatial data. Modeling output variables focus on flow, total suspended solids, and nutrients. Model calibration is primarily based on comparison to long-term flow and water quality data collected near the mouths of these streams to the main stem river.




The models are being used to assess the ability of various management alternatives to help meet water quality goals.

5. Upper Mississippi River Basin: Water quality modeling has not been conducted on the basin as a whole. Limited modeling has been done on the

Crow River Watershed and the Sauk River Watershed, two of the highest-loading watersheds in the basins.

6. Crow River Watershed: Water quality goals for sediment and phosphorus were developed based on estimated loads from the FLUX model in combination with flows estimated using the USGS SWSTAT 4.1 software. A reduction of 25 percent in Total Suspended Solids and Total Phosphorus throughout the watershed is listed as an overall resource management goal by the Crow River Organization of Water. Subwatershed load and yield estimates have been developed for 2001 and 2002.

Scale and Sector Questions:

1. Watershed models and channel process models will be used to estimate phosphorus and sediment loads at the following locations in the greater Lake Pepin watershed:
   a. Lock & Dam 1, or Anoka Dam, to serve as endpoint for the Upper Mississippi River Basin;
   b. Mouth of the Minnesota River Basin
   c. Mouth of the St. Croix River Basin
   d. Lock and Dam #3, near the inlet to Lake Pepin;
   e. Smaller watersheds and direct tributaries.

2. A method of deriving a "metro-area" basin allocation needs to be developed, probably in conjunction with the Metropolitan Council's target pollutant load reduction program.

3. Within each basin, means of applying wasteload allocations to NPDES permits, and load allocations to nonpoint source programs, need to be developed in concert with stakeholder representatives from each basin. Technical and policy issues that must be resolved include: estimation of current point source discharges together with discount factors reflecting effective phosphorus delivery under different flow regimes to the locations described in 1 above; possible establishment of deminimus levels of pollutant discharge for individual NPDES permittees; and establishing geographical boundaries for watershed modeling which balance the desire for computational simplicity with the need for accurate and inclusive estimation of significant pollutant sources.

Policy-Related TMDL Issues: The following policy issues have been identified by the Stakeholder Advisory Committee as warranting attention during the TMDL process.

1. Reserve Capacity Management: After the TMDL is completed, a policy is needed to ensure that economic and population growth do not result in the waste load allocation for phosphorus being exceeded. A portion of the loading capacity for phosphorus

needs to be set aside as *reserve capacity,* and a policy developed to guide its allocation among wastewater treatment facilities and possibly other sources in the future.

2. Developing a framework for deciding on wasteload allocation (for point sources) and load allocations (for nonpoint sources).We need to decide in advance what process will be used. Will stakeholders be asked to vote on alternatives? How will the question of fairness be addressed?

3. Providing reasonable assurance that nonpoint source reductions will be achieved. According to 1991 USEPA guidance, a TMDL should (not must) provide reasonable assurances that the load allocation will be achieved through nonpoint source management measures. The need for reasonable assurance is greater in cases where nonpoint source reductions are being substituted for reductions that otherwise would be required of point sources. The relative effectiveness of technical assistance, economic incentives for BMP adoption, and regulation, alone and in combination, for various types of land use, needs to be evaluated. These questions are pertinent to stormwater runoff from smaller towns, noncompliant septic systems, and agricultural activities such as tillage, manure and fertilizer application, riparian corridor management for streams and drainage ditches.

4. Prioritization of nonpoint source control measures: How to prioritize and target vulnerable landscapes for implementation emphasis, given limited dollars and a vast watershed. This question applies to state and federal funding programs.

5. Evaluating trade-offs, and avoiding conflicts, in implementation:
    a. Eutrophication problems could be exacerbated if turbidity reductions occur ahead of reductions in phosphorus. The TMDL implementation plan should consider phasing pollutant reduction strategies, as feasible, to reduce the possibility of this occurring.
    b. Land use measures to reduce surface runoff of sediment and phosphorus may increase infiltration of water-soluble compounds such as nitrogen. Such possible trade-off should be taken into account in implementation planning.
    c. In this connection, we may consider adding nitrogen, related to the problem of Gulf of Mexico hypoxia, to the modeled outputs.

6. Addressing internal, shoreline and channel management-related sources of pollutants: If such factors as commercial and recreational boat traffic are identified as pollutant sources in the TMDL, policy avenues for addressing these sources will need to be evaluated. Surface water management of recreational boating is not under the authority of state agencies at this time. Changing nine-foot channel operations to accomplish TMDL-related goals would require unprecedented levels of cooperation with the federal government.

## V: Goals, Objectives & Tasks

**GOAL I: Estimate loads of sediment and phosphorus from the Lake Pepin watershed and its major sub-basins under a range of flow and climatic conditions. Collect data needed to improve the accuracy of the ECOM/SED-RCA model.**

<u>Objective A: Large Watershed Model Development</u>. Develop a set of watershed models to provide data input needed to assess current pollutant load contributions and to evaluate source-reduction scenarios from major river basins and watersheds using the ECOM/SED-RCA model.

Task A1: Define information needs of the ECOM/SED-RCA Model along with calibration and forecasting periods, so that additional models can provide the needed data in the appropriate form.

Task A2: Minnesota River HSPF Model Development

Task A3: Crow River Watershed Model Development

Task A4: Estimate sediment load from Cannon River and Driftless Area tributaries using data from the Cannon River, Wells Creek and the Rush River in Wisconsin.

Task A5: Collect and/or organize additional data needed to improve the accuracy of the ECOM/SED-RCA model, specifically: a) Collect shallow sediment core samples from Lake Pepin sites that were sampled by the Science Museum of Minnesota in the mid-1990s; b) Examine, interpret and organize Lake Pepin samples of zooplankton and phytoplankton taken by the Long-Term Resource Monitoring Program; c) Collect additional bathymetric data on Pools 2,3 and 4 to enable the model to predict where submersed aquatic vegetation may grow in response to reduced turbidity (see Objective H, all three tasks).

<u>Objective B: Small Watershed Model Development</u>. Develop a set of minor watershed models representative of significant pollutant loading areas, in order to allow the evaluation of alternative land uses suitable to specific hydro-geologic environments. Conduct the following tasks for both rural and urban components of the Lake Pepin watershed.

Task B1: Determine the purpose of the minor watershed models (e.g., estimating sediment yield, flow, impact of BMPs and other land-use changes)
Task B2: Identify existing models, if available, that meet these requirements.
Task B3: Define land-use scenarios that need to be modeled and geologically distinct, significantly contributing regions where these should be evaluated.
Task B4: Determine where current data are available to run watershed models.
Task B5: Select appropriate model to apply to the minor watersheds.
Task B6: Develop, calibrate and run models to evaluate land-use scenarios. Develop linkages to HSPF and ECOM/SED-RCA models.

Objective C: Stream Channel vs. Upland Erosion Estimation. Estimate the relative proportion of sediment originating from upland vs. stream channel sources.

Task C1: Review and summarize available data on precipitation patterns, tile drainage and current estimates of stream channel erosion in the project area.

Task C2: Develop an analytical framework that distinguishes streambank from upland sediment to characterize sediment sources across the main loading areas. Possible approaches include aerial imagery comparisons of streambank boundaries over time; geochemical fingerprinting techniques; and regression analysis of stream flow on TSS under contrasting flow/precipitation conditions.

Task C3: Apply the analytical framework to estimate streambank and upland sediment at basin, major watershed and small watershed scales that characterize the main sediment-producing ecoregions of the watershed.

Task C4: Provide results in a format that can be used as input for watershed models at the basin, major watershed and minor watershed scale.

Objective D: Gully Erosion Estimation. Estimate current loads and relative proportion of sediment and phosphorus from gully erosion in highly erosive portions of the watershed.

Task D1: Select an appropriate method of estimating sediment and phosphorus losses generated by channel erosion in a representative sample of significantly-contributing ecoregions/watersheds. The method should provide guidance for extrapolating from site-specific estimates of soil displacement from characteristic landscapes and land uses, to watersheds in proportion as they reflect such landscapes and land uses.

Task D2: Develop a means of extrapolating from site-specific estimates to a larger scale – watershed, ecoregion, or combination.

Task D3: Generate estimates of sediment and phosphorus loads under current conditions for a range of storm intensities, along with estimates of load reductions under two different degrees of land treatment ('improved' and 'best attainable')

Task D4: Integrate estimates of current loads and potential load reductions into watershed models.

Objective E: Hydrologic Remediation Analysis. Estimate the impact of practices that influence time of concentration, and therefore peak and channel-forming flows (e.g., 1.5 year recurrence interval). Use data from University of Minnesota's Research and Outreach Centers and other information where available.

Task E1: Develop methods to quantify various aspects of artificial drainage enhancement in agricultural areas. Include miles of drain tile installed, density, line spacing and depth

of tile, extent of surface intakes, extension of surface drainage ditches, conversion of subsurface main lines to surface drainage ditches, etc.

Task E2: Develop methods of estimating the effect of artificial drainage on watershed hydrology, and consequential effects on stream flow, channel stability and stream bank erosion.

Task E3: Use the methods developed in the tasks above to evaluate alternative ways of reducing the impact of artificial drainage on hydrology, stream channel stability and stream bank erosion. Among alternatives evaluated, include the substitution of increased tile drainage for surface tile intakes to minimize surface ponding; and different degrees of surface water storage.

Objective F: Channel Process Modeling. Model the fate and transport of phosphorus approximately from Bemidji to Anoka on the Mississippi River, with particular attention to rates of deposition, sequestration and re-entrainment at a wide range of river flows. Model should be capable of determining fate and transport of point source phosphorus from major dischargers.

Task F1: Problem Evaluation based on review of data on river flow, phosphorus concentration, algal productivity, etc.

Task F2: Formulate and select a modeling framework, CE-QUAL-W2 model or equivalent, from the public domain. Should be compatible with ECOMSED-RCA model under development by Limno-Tech, Inc. from Lock & Dam 1 through Lake Pepin.

Task F3: Determine the upper extent of the Mississippi River to include in the model domain and which major tributaries to include as input to the model.

Task F4: Develop, evaluate and modify the model as needed to reflect current conditions and to represent phosphorus transport at a range of river flows.

Task F5: Apply the model to develop estimates of phosphorus transport during a range of river flows. These estimates will be used to develop distance discount factors for point source phosphorus discharges to reflect phosphorus sequestration in the river channel.

**GOAL II: Estimate "non-watershed" impacts on loads of sediment and phosphorus within the ECOM/SED-RCA model domain (L&D 1 through Lake Pepin), including shoreland erosion, internal cycling of sediment and phosphorus, and activities and structures related to river management.**

Objective G: Attempt to quantify the following non-watershed sources of sediment and phosphorus loading of the Mississippi River through Lake Pepin: internal resuspension,

shoreline erosion, and activities related to river navigation, including maintenance of the lock & dam system and the nine-foot navigation channel.

Task G1: Develop ECOM/SED-RCA model to estimate internal re-entrainment of phosphorus from lake sediments under lower flow conditions. Compare with earlier estimates from USACE and HydroQual modeling in mid-1990s.

Task G2: Estimate potential sediment resuspension from wind, wave and boat activity, and how these would be affected by the re-establishment of aquatic vegetation in shallower areas, by structural changes (island-building), and river management methods such as pool drawdowns that help to consolidate sediments.

Task G3: Review Minnesota Department of Natural Resources estimates of river bank erosion in the narrow channels between Lake Pepin and Pool 2. Consider how this or another approach could be used to provide an estimate of stream channel erosion from the Mississippi River within the RCA model domain. Evaluate whether the results of such analysis are likely to be significant in relation to other known sources of sediment and phosphorus loads. Also consider ways of estimating streambank erosion in the lower Minnesota River segment. Recommend course of action.

Objective H: Use the ECOM/SED-RCA model to evaluate the potential effect of Mississippi River management methods on aquatic vegetation in Spring Lake and other shallow areas of the Mississippi, and on sediment and phosphorus loadings to Lake Pepin.

Task H1: Identify existing bathymetry data on the Mississippi River from the Minnesota River through Lake Pepin; collect data in shallow areas where it is missing. Ensure that Spring Lake data are accurate and current.

Task H2: Estimate the response of emergent and submersed aquatic vegetation to pool drawdowns under two scenarios: current turbidity levels, and achieving the water quality standard of 25 NTUs in the main channel.

Task H3: Estimate the response of fish, wildlife, waterfowl and bird populations to results obtained in Task H2.

**GOAL III: Estimate potential reductions in watershed and nonwatershed loads of sediment and phosphorus, and the degree and cost and difficulty associated with such reductions, using qualitative and quantitative measures of difficulty, as appropriate. Identify factors that will influence adoption of these practices.**

Objective I: Use small watershed models and other assessment methods developed in Task D to evaluate the aggregate effect of land-use changes on watershed runoff, stream hydrology and stream channel erosion.

Task I1: Use small watershed models to test alternative land-use scenarios.

Task I2: Evaluate alternatives for reducing loads from gully erosion in highly erosive parts of the Lake Pepin watershed.

Task I3: Develop spreadsheets and graphics displaying the quantity and percent reduction in sediment and phosphorus loads achieved by alternative land-use scenarios in representative watersheds.

Objective J: Estimate economic benefits and costs associated with attainment of water quality standards resulting from changes in land use and wastewater management in the Lake Pepin Watershed.

Task J1: Use hedonic price model to estimate the market price differential for agricultural cropland converted to restored wetlands, forests and prairies, compared to similar land that remains used for crop production. Identify the component of current market prices attributable to government transfer payments (commodity price supports), and which should be excluded from an estimate of net social benefits. Develop means of extrapolating results throughout the Lake Pepin watershed, to estimate the potential future benefits associated with additional conversion of cropland to wetlands and prairie uses as part of the TMDL implementation.

Task J2: Estimate the economic value of re-establishing aquatic vegetation in shallow areas of the Mississippi River from the Metro Area through Lake Pepin, including the value of the fish, waterfowl and wildlife populations that likely would be attracted to this type of habitat. Consider the use of US Fish & Wildlife Service and US Department of Agriculture estimates used to place dollar values on increased populations of fish, bird and wildlife species. Advise whether new surveys based on travel cost or contingent valuation methods of valuation are needed.

Task J3: Estimate the value of improved recreation resulting from less algae and turbidity in the Mississippi River through Lake Pepin. First estimate how improved water quality would be likely to affect recreational use. Next, review literature to determine if existing studies could be used, or if new studies are warranted, using contingent valuation surveys, travel cost estimates, etc. Take into account possible congestion costs at peak use periods (week-ends, holidays), as well as the potential for increased shoreland erosion if recreational boat traffic is increased without effective erosion-control policies.

Task J4: Estimate the value of improved environmental amenities on the Mississippi River, Spring Lake and Lake Pepin by comparing residential property values in impaired vs. unimpaired parts of the study area.

Task J5: Conduct cost-avoidance studies to estimate the benefits associated with projected reductions in sedimentation of drainage ditches in the Lake Pepin watershed, reduced dredging of the Mississippi River, infilling road ditches and box culverts, and reduced shoreline erosion of the Mississippi River.

Task J6: Estimate the economic benefit of decreased sediment loading on dredging to maintain a navigation channel on the Lower Minnesota River.

Objective K: Identify barriers to the adoption of best management practices and factors that need to be considered in promoting them, in order to develop more effective means of achieving needed changes in land use.

Task K1: Use appropriate survey techniques (focus group interviews, random surveys, etc.) to identify barriers to the attainment of management practices and other changes being considered to achieve TMDL load-reduction objectives. Consider the use of demand-revealing mechanisms to help design effective incentives.

Task K2: Based on this information, recommend changes to current methods of promoting adoption of best management practices, including information-education, technical and financial assistance, and regulation.

Task K3: Design pilot projects to test these ideas in a manner that facilitates timely evaluation and adjustment based on feedback information.

**GOAL IV: Determine the best possible combination of source reductions required to achieve water quality standards in Spring Lake, Lake Pepin and the Mississippi River with an adequate margin of safety and allowing for new and expanded future discharges.**

Objective L: In consultation with the SAC and SAP, select a preferred ranking of source-reduction scenarios to model for each of the upstream sub-basins or areas.

Task L1: Use models to generate a list of source-reduction scenarios and associated load reductions as a starting point for consideration of options.

Task L2: Generate recommendations on source-reduction scenarios from upstream basin organizations, based on small-watershed modeling and discussions among stakeholders.

Task L3: The MPCA and SAP develop a rank-order list of preferred source-reduction scenarios based on input from upstream basin organizations balanced with best professional judgment regarding the technical efficacy and likely success in implementing the individual scenarios.

Task L4: The SAC, through a formal decision process, is given the opportunity to review and re-order the priority ranking developed by the SAP/MPCA in L3.

Task L5: Watershed models are used to estimate the effect of implementing the recommended scenarios, with results provided as input for the ECOM/SED-RCA model.

Objective M: Use ECOM/SED-RCA model to evaluate which combination of source-reduction scenarios will meet water quality standards.

Task M1: Model the results of the watershed source reduction scenarios provided by the SAP, SAC and MPCA, as described in 4A above. Determine which combinations will meet water quality standards.

Task M2: Using the priority ranking provided, develop practicable combinations of source-reduction scenarios to consider for the draft TMDL. Engage the SAC in selecting one of these, or in creating a different combination.

Task M3: Rerun the model based on comments from the SAC and MPCA.

Objective N: Write Draft TMDL, conduct public review, modify as needed, and submit to USEPA for approval.

Task N1: Conduct public review of Draft TMDL. Gather comments, provide response, and revise the TMDL as appropriate. The SAC reviews and comments on the revised draft.

Task N2: Revised draft TMDL is routed for approval by the MPCA.

Task N3: Following revisions, Final Draft TMDL is submitted to USEPA for approval.

Task N4: USEPA either approves or requests changes based on review and comments.

## VI: References

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