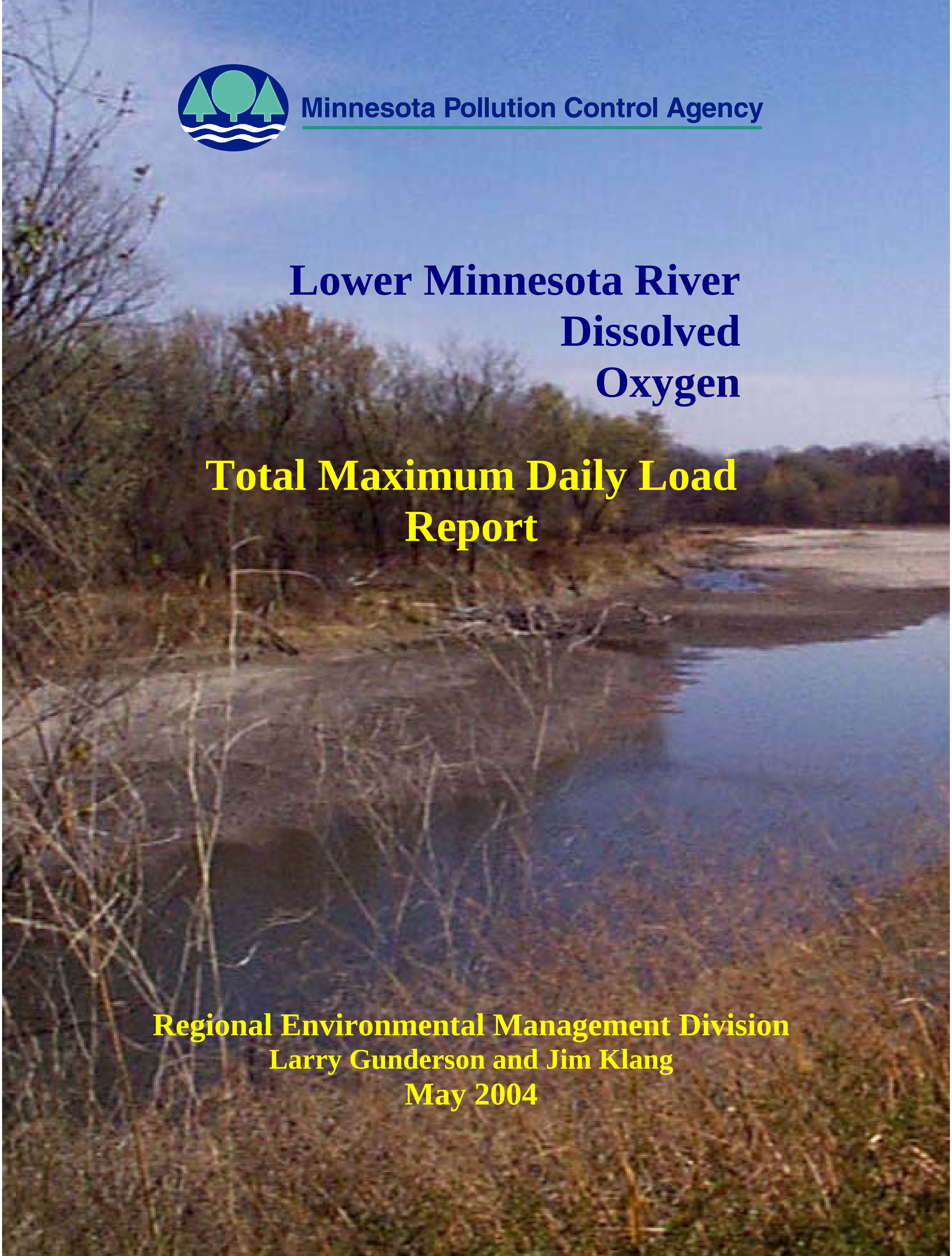

Minnesota Pollution Control Agency

Lower Minnesota River Dissolved Oxygen

Total Maximum Daily Load Report

Regional Environmental Management Division

Larry Gunderson and Jim Klang

May 2004

Acknowledgements

The Lower Minnesota River Dissolved Oxygen TMDL represents the work of many people, both inside and outside the Minnesota Pollution Control Agency (MCPA). The TMDL advisory committee, representing cities, industry, agriculture, environmental groups, and others spent many meetings developing the solutions presented in this document. Their names are listed in the appendix. Additionally, the MPCA staff played an important role in development of the document and a commitment to changing MPCA programs to solve the dissolved oxygen problem in the lower Minnesota River.

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Executive Summary

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations require states to develop Total Maximum Daily Loads (TMDLs) for water bodies not meeting water quality standards. The TMDL process establishes the allowable loading of pollutants for a waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The development of a TMDL Report provides states a basis for determining the pollutant reductions necessary from point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL Report is to identify the allowable levels of phosphorus that will result in the attainment of the dissolved oxygen standard in the lower 22 miles of the Minnesota River during low flow conditions. The low dissolved oxygen problem occurs during low flow conditions in this stretch of the Minnesota River.

As a first step in solving the problem, a 1985 Waste Load Allocation Study (WLA Study) established wastewater treatment plant biochemical oxygen demand (BOD) discharge limits for those facilities in the lower 22 miles of the Minnesota River. The WLA Study also established a 40 percent BOD reduction goal for the Minnesota River upstream of Shakopee. In the WLA Study, the upstream area was treated as one unit (i.e. not separated by major watershed or BOD source). The completion of the 1985 WLA Study was Phase I of the TMDL development.

This TMDL Report addresses Phase II. Phase II focuses on achieving the 40 percent BOD reduction goal by reducing the high phosphorus loading upstream of the metropolitan area. Phosphorus is targeted because the nutrient causes excessive algal growth, which in turn produces BOD as a result of algal decomposition. High BOD leads to the low dissolved oxygen.

A model was used to determine the major phosphorus sources and to simulate changes in land use (i.e. effluent limits, stormwater BMPs, agricultural BMPs). A 45-member advisory committee met to discuss the modeling results and to offer input on the allocation. The advisory committee was composed of people representing cities and their consulting groups, industry, agriculture, commodity groups, counties, watershed projects, and environmental groups. The recommended land use changes proposed by the group were run through the model.

Components of a TMDL Report include a waste load allocation for point sources, a load allocation for nonpoint sources, a margin of safety, which was included in the modeling assumptions, and reserve capacity to allow for growth. The modeling process used an implicit margin of safety by using conservative assumptions. A small amount of reserve capacity exists but is not presented in the formula below.

The TMDL, in pounds of phosphorus per day during critical low flow condition, is represented by the following formula:

TMDL = Waste Load Allocation + Load Allocation

Or, in numeric terms, 752 = 416 + 336

Under current land use practices, approximately 1,240 pounds per day of phosphorus is projected to be generated in the Basin during critical low flow conditions. This TMDL Report reduces the amount to 752 pounds per day during low flow conditions. Strategies to solve the problem involve decreasing the amount of phosphorus that reaches the river and increasing the amount of flow so low flow periods occur less frequently for shorter periods of time.

The emphasis of this low flow TMDL Report is on wastewater treatment facilities, although agriculture, noncompliant ISTS and stormwater each play a role in the reduction efforts. A watershed permit dealing exclusively with phosphorus will be drafted for the Minnesota River Basin. As a part of the permit, all communities will evaluate the feasibility of 30 and 50 percent phosphorus reductions and implement the reductions where feasible. Two approaches are being considered for wastewater treatment facilities discharging over 1,800 pounds of phosphorus per year: 1) a 1 mg/l effluent limit (seasonal average or flow triggered) to achieve a 51 percent reduction in ten years; and 2) point-point trading to achieve a 35 percent reduction by the end of the first phase of the watershed permit (five years). The first watershed permit will be followed by a second watershed permit requiring a 1 mg/l effluent limit or equivalent pollutant trading offsets by the end of the second phase of the permit (ten years). The method will be selected during the development of the watershed permit and the TMDL implementation plan. Additional information from other studies (e.g. updating the 1985 Waste Load Allocation Study) may update this TMDL Report and change the allocations or effluent limits.

Communities will reduce phosphorus in stormwater by stormwater prevention planning and using BMPs. Communities with and without Municipal Separate Storm Sewer permits will be involved.

Noncompliant ISTS that discharge to surface water are also a source of phosphorus. Ninety percent of these systems that discharge to surface water will be moved to compliance.

The methods cited above involve phosphorus reductions. Flow is also a consideration. Because the dissolved oxygen problem occurs during low flow periods, agricultural runoff contributes less phosphorus due to lack of runoff during low flow conditions.

The agricultural sector can, however, implement BMPs to increase ground water recharge such as crop residue and protection of surface tile intakes (or equivalent BMPs). The benefits of these practices will be exhibited during low flow periods when the previously stored water flows into the river via springs, thereby maintaining the flow.

As a result of these proposed solutions, phosphorus, and consequently BOD, can be reduced enough to meet the dissolved oxygen water quality standard during low flow conditions.

1.0 Introduction

Minnesota's namesake river marks the state map like a backward checkmark. From its source at Big Stone Lake on the South Dakota border, the Minnesota River flows 335 miles southeast to Mankato and then northeast to join the Mississippi River at Fort Snelling.

Minnesotans expect and depend on safe and clean water for drinking, swimming, industrial and agricultural uses, and the support of aquatic life. The Minnesota River fails to meet these expectations. The Basin's waters are contaminated by several pollutants. As a result, many streams throughout the Basin have been designated as impaired.

People have made cleanup a priority. In 1992, former Governor Arne Carlson called for a fishable and swimmable Minnesota River by 2002. This proclamation 1) established the Minnesota River as a priority Basin; 2) prompted conservation efforts in the Minnesota River Basin such as the Conservation Reserve Enhancement Program (CREP) creating 100,000 acres of wetlands and native grasslands in critical locations; and 3) helped people to understand the need to consider water quality in their daily activities. In addition, the Minnesota River Citizens' Advisory Committee issued 10 recommendations for river cleanup in 1994.

The lower 22 miles of the Minnesota River is impaired for dissolved oxygen, fecal coliform bacteria, turbidity, PCBs, and mercury. The Minnesota River is a major source of phosphorus and sediment in the Mississippi River, especially Lake Pepin.

This TMDL Report is the first in a series that will progressively define a broader set of pollutant reduction goals for the Minnesota River. Ultimately, a comprehensive set of quantitative goals will be developed to manage the Basin's water quality. While TMDL reports represent individual stream reaches, the implementation activities will be connected during implementation since most of the problems are related to excessive nutrients, sediment, oxygen demanding materials, and bacteria. Connections will be made via implementation activities.

This TMDL Report addresses violations of the dissolved oxygen standard in the Minnesota River from river mile 22 to the mouth of the Minnesota River. The dissolved oxygen problem is manifested during summer low flow periods. In this TMDL Report, summer low flow is defined as a 7-day average of the 10-year return frequency dry-weather condition. Upstream loading of Biochemical Oxygen Demand (BOD) is caused by excessive phosphorus levels that generate algae blooms. During the low flow conditions, dead algae produced by upstream nutrient sources accumulate in the lower reach due to its dredged channel and slow-moving current.

Most of the BOD is caused by bacterial decomposition of the algae. BOD discharged by wastewater treatment facilities upstream of Jordan is a small portion of the BOD causing the low flow dissolved oxygen problem. The problem was first identified in 1985 and received the impaired waters designation on Minnesota's first impaired waters list in 1992.

Reducing phosphorus at this large basin scale will occur in three phases described below. The phases feature a management process that uses current and new information as it becomes available. Phase I began at the large basin scale and set a BOD reduction goal at Shakopee. Subsequent phases move toward the smaller scale, which establishes goals by sector and watershed.

Phase I: A 1985 Waste Load Allocation Study established the basis for wastewater treatment facility BOD discharge limits that are currently for those facilities in the lower 22 miles of the Minnesota River and recognized the need for a 40 percent BOD reduction upstream of Shakopee (MPCA, 1985). In this phase, the upstream area was treated as one unit (i.e. not separated by watershed or BOD source). The EPA approved the 1985 Waste Load Allocation (Phase I). The approved allocation became the basis for further study of the Minnesota River.

Phase II (the topic of this Report): The Phase I portion of this project did not (and was not intended to) provide information on the sources of BOD in the upstream part of the Minnesota River Basin. Phase II provides: 1) an understanding of how the nutrient phosphorus creates BOD in this large river system; 2) a more comprehensive understanding of the loading contributions from upstream dischargers and area-wide nonpoint pollution sources; and 3) an understanding of how the loading and eutrophication cycles travel downstream to Shakopee. Phase II concludes with an implementation strategy that involves effluent limits for significantly contributing wastewater treatment facilities and development of more detailed phosphorus reduction strategies for nonpoint sources at the major watershed level.

Phase III: This phase has two main objectives. The first is to develop a finer scale assessment at the major and minor watershed level. This finer scale assessment will allow a more tailored best management practice (BMP) targeting strategy within the major watersheds. The second is to create a feedback loop as continued efforts to understand the river system provide new information. The new information gathered during other impairment studies on the Minnesota River turbidity problem and the downstream Lake Pepin excess nutrient problem may add to the implementation strategies in this TMDL Report, since this project targets low flow conditions. Additionally, mass allocations for phosphorus will eventually be set for most wastewater dischargers once a holistic understanding of phosphorus related impacts is developed. By that time, additional monitoring will be completed to further validate or adjust the assumptions used in the modeling. Future monitoring will determine the effect of ongoing phosphorus reduction efforts.

Adaptive management underlies the three-phase approach to reduce phosphorus. The objective is to meet the dissolved oxygen standard and is present in each phase. Under this adaptive approach, the solutions are improved as each step is identified corresponding to the information available. As each phase is employed, further information is obtained to improve implementation activities. This allows a flexible, iterative approach for future refinements.

For the present phase of the TMDL (Phase II), the MPCA organized an advisory committee to provide input on allocation and implementation options. This TMDL Report demonstrates a commitment to meeting the dissolved oxygen standard while using stakeholder input to help determine how to accomplish the goal.

2.0 Description of Water Body, Pollutants of Concern, Pollutant Sources, and Priority Ranking

The Minnesota River Basin covers nearly 17,000 square miles, or 9.5 million acres, approximately 20 percent of the state of Minnesota. According to the 2000 census, 486,000 people reside in the portion of the Basin above the metropolitan area. Population projections show a 2.5 percent increase over the next 10-year period. Growth trends indicate that larger communities are experiencing growth, medium sized communities are remaining stable, and smaller rural communities are declining in population. The agricultural sector uses 7.5 million acres and, as such, is the largest sector of the Basin. Other land uses include forest, pasture, urban, rural, transportation roads (including rail) and water.[1]

The Minnesota River has a dissolved oxygen impairment from river mile 22 to the mouth of the Minnesota River. The dissolved oxygen-impaired reaches include:

1. 07020012-501
2. 07020012-505
3. 07020012-506
4. 07020012-532

The impairment results from high BOD caused by excess phosphorus during low flow conditions. The lower 22 miles of the Minnesota River is dredged to maintain a nine-foot navigation channel. Under low flow conditions it becomes quiescent, a combined result of reduced flow and stage of the Minnesota River and damming of the Mississippi River at Lock and Dam 2 to maintain the navigation channel. This creates a condition similar to a lake. The slow-moving water provides sufficient residence time for algal death and decay such that oxygen demand is greater than oxygen production, resulting in reduced dissolved oxygen concentrations. The BOD is caused by phosphorus from direct discharges of wastewater treatment facilities and diffuse nonpoint sources. Phosphorus produces much of the algae and BOD upstream of the lower Minnesota River itself. Thus, BOD and phosphorus are the pollutants of concern.

There are approximately 280 municipal and industrial dischargers in the Minnesota River Basin (MPCA Basin Information Document, 1997). Many of the largest outside of the metropolitan area are in the eastern part of the Basin. These include Mankato, St. Peter, New Ulm, Waseca, Fairmont, St. James, and Madelia. Larger facilities in the west include Montevideo, Willmar, Marshall and Archer Daniels Midland, Marshall. The MPCA's phosphorus strategy establishes a de minimus level of 1,800 pounds of phosphorus per year as a general guideline for consideration of limits or management plans. Forty-two facilities are over this threshold, five of which are industrial dischargers.

[1] MPCA, Minnesota River Basin Information Document, 1997.

In addition to wastewater treatment discharges, stormwater runoff can also be a source of phosphorus. Water flowing over impervious surfaces efficiently transports materials such as grass clippings, lawn fertilizers, and leaves to the river.

Agriculture is the dominant land use in the Basin. In 2002, Renville County was Minnesota's leading producer of corn for grain, soybeans, green peas, and sweet corn. Martin and Redwood Counties ranked second and third in corn and soybean production. Martin, Blue Earth, Brown, Nicollet, and Renville were the state's top five hog producing counties (MDA, 2003).

Agricultural sources of phosphorus include commercial fertilizers and manure. The nutrient is transported to the river via runoff or through tile lines. The amount that reaches the river depends on antecedent moisture conditions and slope, among other factors. At the Basin scale, nutrients from manure tend to come from row-cropped land. Production lot runoff can be detrimental to a small watershed but does not have much influence at the basin scale (Mulla, 2001). Runoff is limited during low flow periods, but can still occur with storms even during drought conditions.

Untreated waste is also a source of phosphorus and BOD. Untreated waste flowing to surface water can be a potential Imminent Threat to Public Health and Safety (ITPHS). According to the 2002 county ISTS reports, the MPCA estimates there are approximately 155,000 septic systems in counties that are in or part of the Minnesota River Basin. Of those, nearly 20,000 are in the potential ITPHS category. Improperly treated discharges from noncompliant ISTS can range from 10 to 30 mg/l total phosphorus.

3.0 Background

The 1985 Waste Load Allocation study (WLA Study) projected that water quality in the lower reach of the Minnesota River would continue to degrade unless the Blue Lake and Seneca Wastewater Treatment Facilities increased controls to offset future expansion of their discharges. Without additional controls, a water quality model projected that future loadings of BOD from Blue Lake and Seneca could cause 55 percent of the total shortage of dissolved oxygen expected under summer low flow conditions. The WLA Study became the basis to set discharge permit limitations for BOD and ammonia, requiring that the Blue Lake and Seneca facilities be upgraded to provide advanced secondary treatment of their effluent. Effluent limitations for point source discharges are designed to prevent water quality degradation that could be harmful or fatal to aquatic life down to the "7Q10" river flow. The 7Q10-design river flow is the lowest consecutive seven-day flow that a river experiences on average at least once every 10 years.

The modeling analyses predicted that additional point source controls alone at the Blue Lake and Seneca facilities were inadequate to maintain the dissolved oxygen standard under critical summer low flow conditions. When BOD in the Minnesota River (upstream of Shakopee) was combined with the discharges from the Blue Lake and Seneca under low flow conditions, the resulting oxygen demands overwhelmed the river's ability to maintain water quality. The WLA Study indicated that in order to meet the dissolved oxygen water quality standard, a 40 percent reduction in BOD concentration from upstream of Shakopee would be needed, in addition to upgrading the Blue Lake and Seneca facilities to provide advanced secondary wastewater treatment. Table 3.1 shows the allocations and relative percentages of each source category of oxygen demands in the lower Minnesota River.

Table 3.1 Results of the 1985 Waste Load Allocation Study (MPCA, 1988)

Source	Ultimate CBOD pounds/day	
Blue Lake WWTP	14,600*	27.3 %
Seneca WWTP	15,100*	28.3 %
Headwater	13,600	25.5 %
Tributaries	1,200	2.2 %
Sediment Oxygen Demand	6,700	12.6 %
Nitrogenous Oxygen Demand	2,200	4.1 %
Total TMDL	53,400	100 %

*NPDES permitted loading expressed as $CBOD_U$.

Permitted industrial discharges from Midland Glass (cooling water), Cargill (cooling water), Kraemer (quarry wash water), and the International Airport (cooling water and stormwater) were not included in Table 3.1 because their aggregated $CBOD_U$ load at less than 0.8 percent was not considered significant to the total oxygen demand. The Blue Lake and Seneca facilities were each assigned $CBOD_5$ permit limitations corresponding to their allocated Ultimate CBOD ($CBOD_U$) load. The headwater allocation of 13,600 pounds per day of $CBOD_U$ incorporated the recommended 40 percent reduction at Shakopee.

Subsequent to the WLA Study, the MPCA further determined that the BOD in the lower Minnesota River is predominantly related to algae. Excessive phosphorus leads to the over-production of algae that dies and decays causing most of the BOD loading (Technical Memorandum, Phosphorus Reduction Goals for the Minnesota River at Jordan, 1997). This problem occurs during summer low flow conditions when algae flourish. During low flow periods, the major phosphorus sources are the continuously-discharging Wastewater Treatment Facilities. Noncompliant individual sewage treatment systems, stormwater, and agricultural runoff also contribute phosphorus during low flow periods. Stormwater and agricultural runoff are included because, even during dry periods, storm systems move through the large Minnesota River Basin causing localized runoff. Also, phosphorus from these sources enters the river prior to low flow conditions and remains there, manifesting itself during low flow conditions.

4.0 Description of applicable water quality standards and numerical water quality target

This TMDL Report addresses violations of the state standard for dissolved oxygen in the Minnesota River from river mile 22 to the mouth of the Minnesota River.

A discussion of water quality standards, in general, and the dissolved oxygen standard, in particular, is needed to clearly define the regulatory context and environmental endpoint of the TMDL. All waters of Minnesota are assigned classes, based on their suitability for the following beneficial uses:

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

All surface waters of the state are protected for multiple uses. This reach of the Minnesota River is specifically classified as 2C, 3B, 3C, 4A, 4B, 5, and 6 in Minn. R. 7050.0410 and 7050.0470, subp. 5. The designated beneficial use for these classes with rule citations for applicable water quality standards are as follows:

Class 2C: Aquatic life support and recreation includes boating and other forms of recreation for which the water may be suitable (i.e., swimming). Class 2C waters may also support indigenous aquatic life, but not necessarily sport or commercial fish [7050.0222, subp. 5];

Class 3B: General industrial purposes, except for food processing, with only a moderate degree of treatment [7050.0223, subp. 3];

Class 3C: Industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions [7050.0223, subp. 4];

Class 4A: Irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area, including truck garden crops [7050.0224, subp. 2];

Class 4B: Livestock and wildlife without injurious effects [7050.0224, subp. 3];

Class 5: Aesthetic enjoyment of scenery and should not interfere with navigation or cause damage to property [7050.0225]; and

Class 6: Other possible beneficial uses not specifically listed [7050.0226].

The dissolved oxygen standard for Class 2C waters is 5 mg/L as a daily *minimum*, except for a portion of the Mississippi River in St. Paul and the Minnesota River from river mile 21 to its mouth. This TMDL Report addresses the portion of the Minnesota River with a dissolved oxygen standard of 5 mg/L as a daily *average* applied year-round. Compliance with a dissolved oxygen standard is required 50 percent of the days at which the flow of the receiving water is equal to the lowest weekly flow with a once in 10-year recurrence interval (7Q10).

The 1985 Waste Load Allocation Study projected that, without changes in the Minnesota River Basin, the BOD concentration at Shakopee would average 6.1 mg/l during summer low flow conditions. To meet dissolved oxygen standards, the WLA Study established a 40 percent BOD reduction target for the Minnesota River upstream of Shakopee. Therefore, BOD target for this TMDL is 3.7 mg/l. The model projected a 0.131 mg/l phosphorus concentration would be needed to reach the 3.7 mg/l BOD target (Table 4.1). The 0.131 mg/l phosphorus concentration is supported by research from Heiskary and Walker (1995) for Lake Pepin. The Heiskary/Walker study indicated that an inflow goal for Lake Pepin of 0.130 mg/l of total phosphorus would be necessary in order to achieve an in-lake concentration of 0.070 under 1988 flow conditions.

Table 4.1 Water quality targets for TMDL

Pollutants of Concern	Phosphorus and BOD
Phosphorus concentration goal	0.131 mg/l
Five-year phosphorus reduction goal (35 percent reduction from point sources during low flow conditions)	58,400 pounds of phosphorus (will vary depending on flow)
Overall phosphorus water quality goal (during low flow conditions)	46,871 pounds of phosphorus (will vary depending on flow)
BOD concentration goal (during low flow conditions)	3.7 mg/l
Numeric water quality target for dissolved oxygen	5 mg/l, as a daily average

5.0 Source Assessment and Reduction Options

In response to the 40 percent reduction goal, the MPCA and other agencies began the Minnesota River Assessment Project (MRAP) to identify upstream sources of BOD (MRAP, 1986-1994). The MRAP study examined water quality across the Minnesota River Basin. The MRAP study linked the BOD to algae and ultimately to phosphorus.

Building on the algae-phosphorus relationship, a basin scale computer modeling project using the Hydrologic Simulation Program - FORTRAN (HSPF) model was started. The HSPF model is used nationally for completing watershed TMDL Reports. It simulates changes in water quality based on watershed hydrology and modifications of land use, amount of phosphorus and BOD discharged from point sources, etc. The HSPF model setup involved a collaborative contracting effort between MPCA staff and Aqua Terra Consultants. Early progress on the model was peer reviewed by the United States Geological Survey (USGS). The peer review provided several recommended model improvements prior to full completion of the model. The final contract with Tetra Tech, Inc. was set in 2000 to finish modeling 9 of the major watersheds in the Minnesota River Basin and included the adjustments suggested by the USGS. The tables in this TMDL Report are based on modeling results and not water quality monitoring results.

5.1 Model Development

The upstream boundary for the HSPF model is Lac Qui Parle Lake near Montevideo. The lake has a dampening effect on flow and parameter concentrations. Due to the dampening effect, the Upper Minnesota River and tributaries above Lac Qui Parle Lake (Pomme de Terre and Lac Qui Parle) are treated as a whole, while the downstream area is divided into watershed segments. Nearby monitoring stations (e.g. USGS and MRAP stations) provide additional data.

The lower boundary is a USGS flow monitoring station at Jordan and its associated water quality monitoring stations from MRAP and Metropolitan Council. The WLA Study established a boundary for upstream loading near Shakopee. However, Jordan was selected as the modeling endpoint because it has more data for calibrating the model than the Shakopee monitoring station. There is not significant variability between the two data sets with regard to instream concentrations of the key parameters. Therefore, the more robust data set at Jordan was used to check the performance of the model under various conditions. See Figure 5.1 for the modeled area and Figure 5.2 for model segments.

Figure 5.1 Minnesota River model subwatersheds

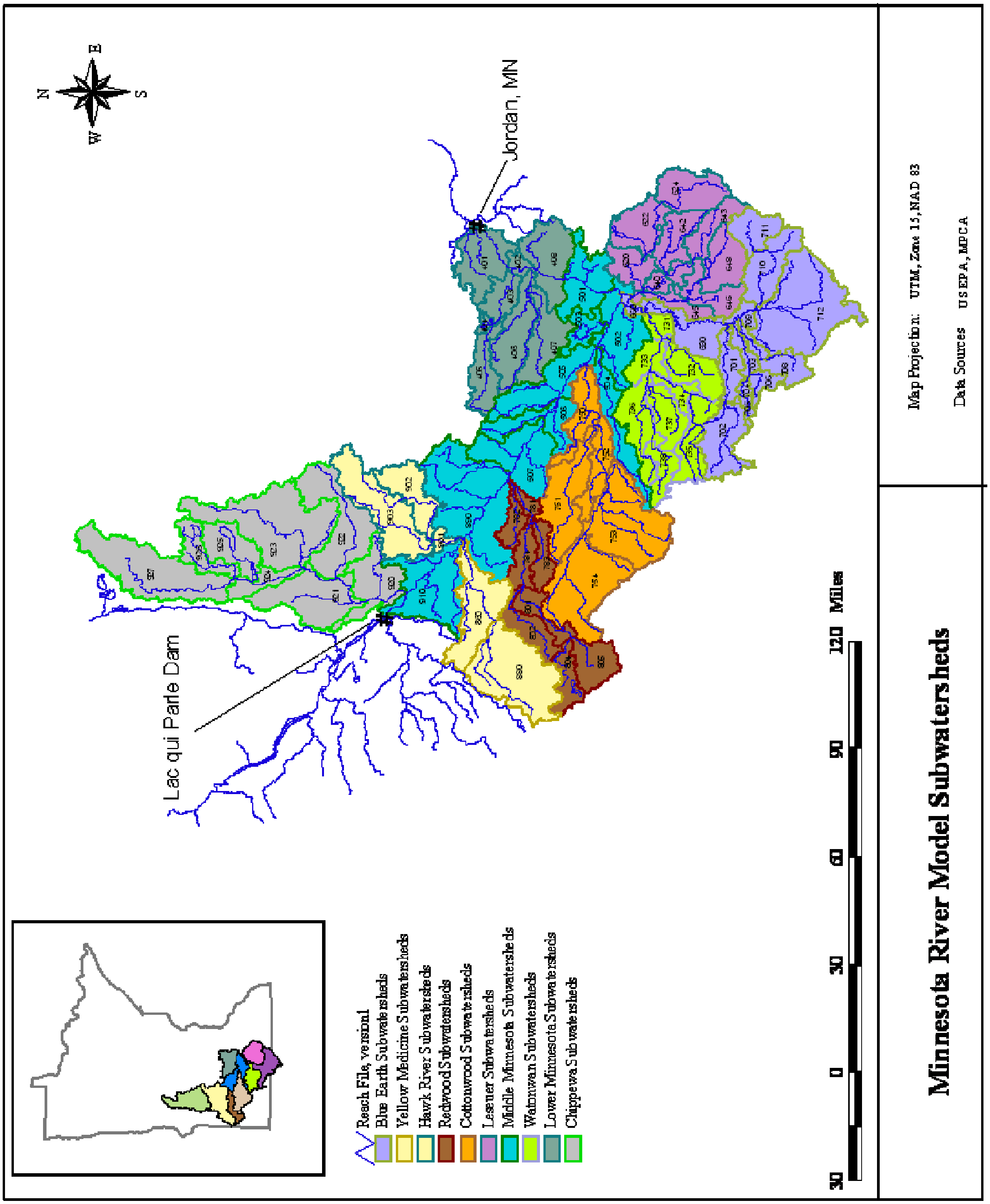
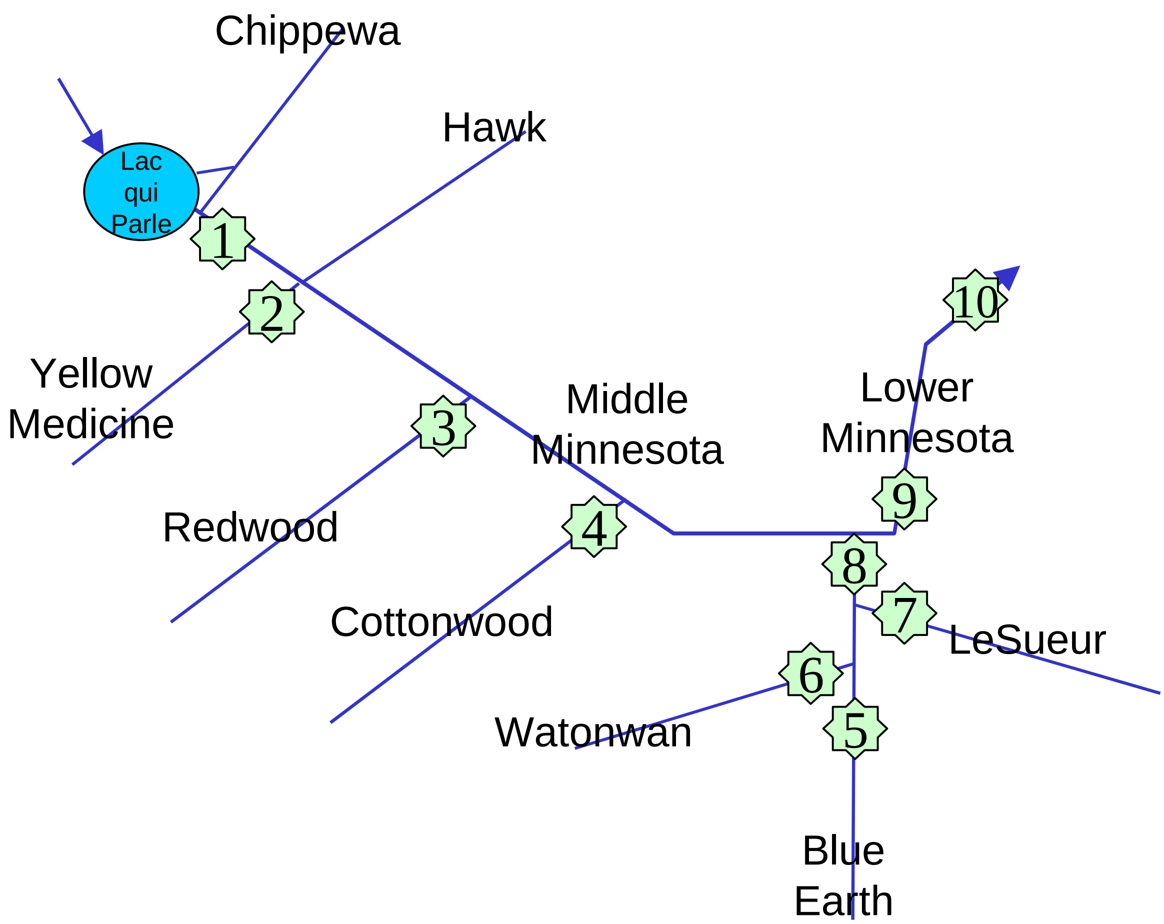


Figure 5.2 HSPF model segments as applied to the Minnesota River



The modeled area is approximately 12,200 square miles of the 17,000-square-mile Minnesota River Basin. Most of nine major watershed tributaries were modeled. They include Yellow Medicine River, Hawk Creek, Redwood River, Cottonwood River, Middle Minnesota, Blue Earth River, Le Sueur River, Watonwan River, and part of the Lower Minnesota River Watershed. The portion of the Lower Minnesota River Watershed below Jordan is not included in this modeling effort.

5.2 Data Used in the Model

The HSPF model was calibrated with data from the 1986-1992 MRAP, including flow, weather conditions, and water chemistry, along with land use and point source phosphorus loading from that time period. This timeframe included the last low flow period of 1988 as well as average and high flow years.

The broad data set, along with the variety of flow conditions, were valuable to calibrate the model across a range of flow regimes and to simulate low flow land use change.

Hydrological data from 1986-1992 provides the basis for all scenarios. Land use change and discharge data were updated using data from 1999 or 2000. Modifications included:

1. Livestock numbers;
2. NPDES discharge records for flow increases, new phosphorus limits, and BOD, nitrogen, and TSS limits;
3. Conservation Reserve Program, Reinvest In Minnesota , and signed Conservation Reserve Enhancement Program contracts for wetlands and native grass plantings in the modeled area;
4. Current information on communities with untreated sewage discharges; and
5. Current information on noncompliant ISTS.

The calibration of the HSPF model was validated using data sets from 1981 through 1985.

The contribution from bank and bluff erosion is a large and visible source in higher flow regimes in certain parts of the Basin. Estimates from bank and river bluff contributions are included in the modeling study across all flow regimes. The model does this by regenerating the bedload material to reflect the large deposit of material that a bluff collapse would provide. Subsequent flows then remove the material from the reach. However, this source is not actively contributing a significant load during low flow conditions. During low flow, sediment is temporarily redeposited onto the channel bed until higher flows re-entrain the material.

5.3 Selection of the Low Flow Critical Period

The dissolved oxygen standard applies to flow conditions down to the current seven-day ten-year summer low flow (7Q10). At Jordan, the Minnesota River's 7Q10 flow is 272 cubic feet per second (cfs) using June through September flow data from 1936 through 2001. The last 7Q10 flow occurred in 1988. In this TMDL Report, low flow means the 7Q10 flow.

The HSPF model, like any other, more accurately estimates longer term (week or month) water quality rather than daily concentrations. Therefore, a two-month critical low flow period of August and September 1988 was selected to represent the meteorological conditions and hydrologic response for this TMDL.

5.4 Sources of Oxygen Demand

There are several potential sources of oxygen demand in a river system: 1) nitrogen oxygen demands derived by the nitrogen cycle (i.e. when ammonia is converted into nitrate/nitrate chemically binding the oxygen); 2) sediment oxygen demand combining diffusion gradients with organic and/or chemical and mineral oxygen demands (i.e. when oxidized iron reenters an aerated water column it uses up oxygen as it reforms ferric compounds; 3) bacterial uptake of dissolved oxygen in ground water; 4) organic sources directly discharged to the water (e.g. BOD); and 5) BOD from eutrophication caused by high levels of nutrients producing excess algae. When the algae dies and decays, it exerts an oxygen demand leading to low dissolved oxygen. These last two sources exert most of the BOD during low flow conditions in the lower Minnesota River and deserve further discussion.

Direct discharges of organic materials from wastewater treatment plants or nonpoint runoff are typically a source of BOD. These processes are responsible for less than 30 percent of the BOD at Jordan during low flow conditions. This direct loading is more of a concern near a wastewater discharge. Nonpoint runoff with high organic matter also causes BOD. However, at the Basin scale, secondary treatment limits for BOD at wastewater treatment facilities and the diffuse nature of the BOD loading from nonpoint sources make neither source problematic for the lower Minnesota River. The WLA Study did require BOD limits for wastewater treatment facilities in the impaired reach by requiring effluent limits for Blue Lake (12 mg/l of $CBOD_5$) and Seneca (15 mg/l of $CBOD_5$ and 16 mg/l of dissolved oxygen. Wastewater treatment regulatory requirements for BOD in Minnesota are based on a five-day carbonaceous biochemical oxygen demand laboratory test. The laboratory test is used to monitor the BOD discharge). Usually, $CBOD_5$ limits are 25 mg/l. $CBOD_5$ discharges in close proximity to the impaired reach will be evaluated during permit reviews, but are not specifically addressed in this larger scale effort.

Algal growth and decay caused by excess phosphorus is responsible for approximately 70 percent of the BOD in the lower Minnesota River during low flow conditions. Algae provide a net addition of dissolved oxygen to the water body on an average daily basis; yet, respiration can cause low dissolved oxygen levels at night that can affect the survival of less tolerant fish species and macroinvertebrates. Decay of excessive levels of algae can cause severe oxygen depressions (EPA, 1983). Algae are produced by excess phosphorus upstream. Low velocity in the channelized reach allows algae to settle out exerting even more of an oxygen demand. The algae-BOD linkage was suggested in a Technical Memorandum (MPCA, 1997).

5.5 Current Loading

The first model scenario involved the estimation of phosphorus loads during future low flow conditions, assuming no changes in land use or wastewater treatment discharge. This provided a baseline to compare the results of other scenarios. Table 5.1 shows the phosphorus that is released by sector.

Continuously discharging point sources contribute the most phosphorus during low flow periods. For estimates of phosphorus released by sector by watershed, refer to Appendix D.

Table 5.1 "Current day" total phosphorus loading generated by source category, in pounds (August-September 1988 hydrology)*

	Scenario 1	Percent
Agriculture	10,907	14.4
Noncompliant ISTS	2,436	3.2
Under-treated Communities	593	0.8
Point Sources	49,222	65.1
Stormwater	12,294	16.3
Natural and background sources	168	0.2
TOTAL	75,620	100.0

*The data provided in this table and others referring to model results are based on model output provided by Tetra Tech. However, the data is sorted into different categories than the formal reports provided by Tetra Tech.

Although more than 75,000 pounds of phosphorus is predicted to be delivered to a stream or river system in the Basin, approximately 19,000 pounds is predicted to reach Jordan (Table 5.2). The difference between the two tables reflects phosphorus losses within the watersheds.

Table 5.2 Current day projection of total phosphorus loadings (pounds) for critical low flow period (August – September 1988 Hydrology)

	"Current Day" Projections (Pounds)	Total Phosphorus (average) (mg/l)	Chlorophyll-a (average) (mg/l)	BOD-5 (average) (mg/l)
Hawk	4,764	Parameters by watershed not available at this time		
Yellow Medicine	159			
Redwood	14,239			
Cottonwood	430			
Watonwan	1,042			
Le Sueur	2,814			
Blue Earth	2,174			
at Mankato	30,001			
at Jordan	19,105	0.393	0.121	5.68

Losses occur during runoff events in fields where sediment (and its attached phosphorus) is dropped out in a buffer, for example. Because phosphorus has a high affinity for sediment, the river processes temporarily sequester phosphorus until sufficient energy returns to the system (during higher flow events) to resuspend the deposited materials. Natural riverine processes at all flows also assimilate and/or temporarily sequester the nutrient (such as in root emergent plants, riparian wetlands and floodplains). Typically, smaller steams have higher assimilation capabilities than larger river channels.

Transport of algae downstream is another factor that reduces the export of phosphorus. Many algal cells travel at a slower rate than the water current itself because they are temporarily trapped in pools, riparian backwaters, or river shores. The thalweg, pools, riffles also influence water velocities.

5.6 Initial Scenarios

Once the phosphorus load during a future low flow period was estimated, additional scenarios (2 through 5) were intended to determine how sensitive the river was to changes in various source categories (e.g. wastewater treatment facilities and agriculture) or geographic locations. Additional information is available on the results of the scenarios in three reports (Tetra Tech.EM Inc, 2003a, b and c).

Scenario 1 – (explained above as "current day") evaluated the impact of phosphorus loading from land use and wastewater treatment facility discharges using data from the 1999-2000 period. No future changes in land use were assumed in this scenario.

Scenario 2 – evaluated the impact of high rates of nonpoint source BMP adoption while holding point source contributions constant.

Scenario 3 – evaluated the impact of point source controls while holding nonpoint source loading (Scenario 1) constant.

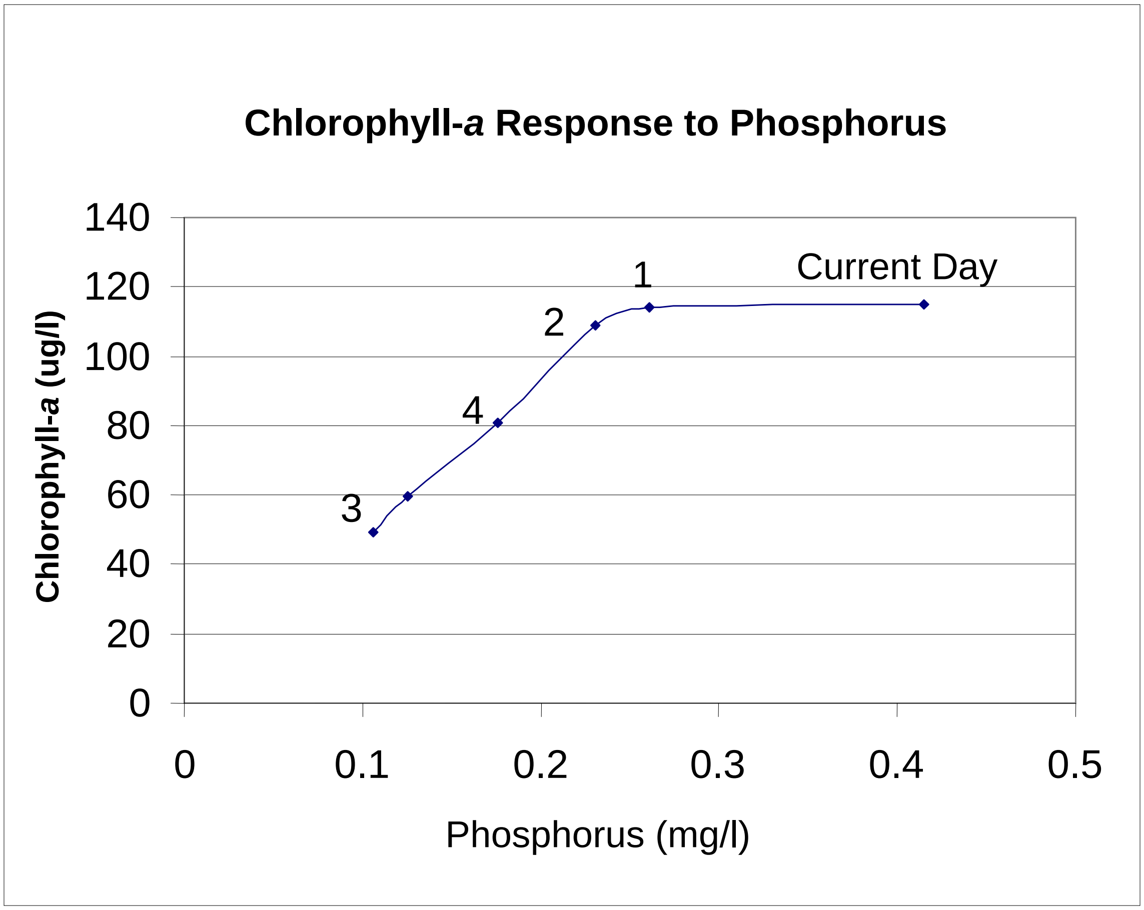
Scenario 4 – evaluated the load difference between actual discharge records and the current permitted flows with larger facilities required to meet a phosphorus effluent of 1 milligram per liter.

Scenario 5 – determined how much BOD loading was actually experienced on the Minnesota River at Jordan when compared to the nutrient release at various upstream locations (e.g. the impact of the Marshall-area phosphorus loading to the impact of the Waseca area phosphorus loading).

Although the scenarios for this TMDL Report considered low flow conditions, Appendix A contains results from long-term average flows.

Figure 5.3 below is an asymptotic curve of the HSPF model's predicted relationship between chlorophyll-a and phosphorus as the river passes by Jordan. Points 1-4 correspond to scenarios 1-4 above.

Figure 5.3 Model scenario outputs comparing phosphorus and chlorophyll-*a* relationships



By comparing the "current day" results with the "calibration" period results shown above, one can determine that the river is currently in a phosphorus saturated regime. The relatively flat line between the calibration data (1990) and the current day condition (1999-2000) indicates little response in chlorophyll-a to significant changes in phosphorus concentrations. Excessive levels of phosphorus are available, but algae growth is limited by some other attribute (such as light shading). Sensitivity scenarios 2-5 indicated a response in chlorophyll-a concentration related to decreases in phosphorus loads; although, some were more effective than others. This indicates that, during low flow periods, the river will once again become phosphorus limited and the implementation of phosphorus reduction measures for decreasing the production of algae communities will reduce BOD.

5.7 Initial Scenario to Balance the Allocation (Scenario 6)

Upon completion of the sensitivity runs in scenarios 1-5, it was evident that point source discharges dominated the loading during the low flow critical period. In addition to point sources, agriculture, noncompliant ISTS, and stormwater discharges contribute phosphorus in varying degrees during low flow conditions.

Key assumptions included in Scenario 6 are:

Point sources - 1 mg/l phosphorus effluent limit year round for sites above 1,800 pounds of phosphorus per year at Average Wet Weather Design Flows (approximately 0.2 MGD for municipalities).

Agriculture

1. 75 percent of acres adopting 30 percent residue use or equivalent BMPs.
2. Nutrient management of manure at N agronomic rates and 90 percent of non-manured land adopting nutrient management of commercial fertilizer.

Stormwater

1. Future MS4 communities reduce impermeable surface phosphorus loading by 30 percent.
2. Non-MS4 communities reduce impermeable surface phosphorus loading by 20 percent.

Noncompliant ISTS - 90 percent compliance with MN Rules 7080.

With the land-use changes and current point source discharge loads provided in Scenario 6 (“Example of a Balance Allocation”), the model predicted 3.44 mg/l BOD at Jordan. Under the changes in this scenario, the goal of 3.7 mg/l of BOD at Jordan was attained and the phosphorus load was projected to decrease by approximately 29,000 pounds. Table 5.3 shows the results of this scenario while Table 5.1 shows the original amount of phosphorus load generated in the Basin. Concentration predictions from these assumptions are provided in Table 5.4.

Table 5.3 Phosphorus load generated in Scenario 6 (example of future land use practices and critical period hydrology from August-September 1988)

	Scenario 6	Percent
Agriculture	11,631	24.8
Noncompliant ISTS	370	0.8
Under-treated Communities	593	1.3
Point Sources	23,397	50.0
Stormwater	10,496	22.4
Natural and background sources	325	0.7
TOTAL	46,812	100.0

Table 5.4 Critical period (August-September, 1988) average concentration results for Scenario 6, Minnesota River at Jordan

	Scenario 6
Total P (mg/L)	0.125
Total N (mg/L)	3.29
Total BOD (mg/L)	3.44
Chlorophyll-*a* (µg/L)	53

Phosphorus from the agriculture sector was projected to increase in spite of a large adoption of high residue usage and nutrient management in the system. For row cropped land, a high residue adoption goal was set at 75 percent, and a nutrient management adoption goal was set at 90 percent. Dr. Jon Butcher of Tetra Tech, Inc. indicates this increase in phosphorus from agriculture is not an increase in loading directly from field runoff. Rather, it is a product of the increased flow generated during base flow conditions from ground water seepage. Higher infiltration rates associated with residue usage during wet periods increased the flow during dry periods. The resulting increase in river flow would increase the phosphorus load even if the phosphorus concentration remains constant or slightly decreased. Algal communities are sensitive to the instream concentration of phosphorus and not the downstream loading of phosphorus. Therefore, even with more load due to flow, lower phosphorus concentrations lead to less algae growth.

5.8 Reduction Scenario Development

The MPCA formed a 45-member advisory committee to consider this question. Further information on the advisory committee is available in Section 9. Developing the reduction scenarios followed this process:

1. MPCA generated a scenario that would meet the 3.7 mg/l BOD target known as the Initial Scenario to Balance the Allocation (Scenario 6).

2. MPCA shared the scenarios and results with the advisory committee and asked the advisory committee to adjust the scenarios. The advisory committee considered factors such as the effectiveness of reducing phosphorus in point source discharges, increasing nonpoint source BMPs, and the cumulative impact of noncompliant ISTS being brought into compliance.

3. The advisory committee developed a suggested scenario run which was entered into the HSPF model and is titled the Second Scenario to Balance the Allocation (Scenario 7). The suggested land use changes were then used to arrive at the final allocation.

5.9 Guiding Themes from the Advisory Committee

The Initial Scenario to Balance the Allocation (Scenario 6) did meet the BOD goal. The advisory committee considered the assumptions used and made several changes, keeping the goal of 3.7 mg/l BOD concentration in the Minnesota River at Jordan, but providing input on the acceptability of certain changes (i.e. cost, timelines, and perceptions of fairness). The committee considered the results of the scenarios and provided these guiding themes that the majority of the committee agreed upon:

1. The conditions and health of the whole Basin should be considered, not just this low flow event in the lower portion of the river;

2. Each sector contributes something to the problem, and therefore, should contribute something to the solution;

3. There is a large concern for timing, planning, and cost of solutions;

4. The goal for failing ISTS compliance should be at least 90 percent, with the majority of the group suggesting a 100 percent goal since raw sewage poses problems for public health in addition to phosphorus; and

5. The focus often went to desired flexibility at an individual level rather than blanket requirements across the entire list of parties in a source category.

Detailed assumptions, discussion, and results are presented in Appendix C.

5.10 Second Scenario to Balance the Allocation (Scenario 7)

Using the guiding themes and verbal and written comments provided by the advisory committee, changes to initial scenario were as follows:

Wastewater Treatment Plants: Continuously discharging wastewater treatment facilities discharging more than 1,800 pounds of phosphorus per year (based on Average Wet Weather Design Flow and current phosphorus effluent levels) were assigned a 1 mg/l phosphorus limit using two treatment alternatives:

1. **Biological phosphorus treatment** or “Bio-P” with a seasonal average of 1 mg/l P from May – October. Bio-P capability is less costly in the long run because of reduced chemical costs and decreased biosolids production. Not all communities may be able to use this method, especially small communities with activated sludge systems, trickling filters, or rotating biological contact filters.

2. **Chemical addition during low flow periods**. A flow trigger at Jordan will be developed and used to determine when facilities using chemical treatment must engage the systems. The flow trigger will be set higher than the 7Q10 flow for further protection of the water body.

Point source loading inputs were updated with expansions that occurred prior to August, 2003.

Urban Stormwater: Communities and higher density developments in the Basin that are subject to MS4 requirements were assigned a 30 percent phosphorus reduction goal. Communities not subject to MS4 requirements were assigned a 20 percent phosphorus reduction goal.

Noncompliant ISTS: Noncompliant ISTS continue to discharge to surface waters via subsurface tile drainage pipes or ditches. The model assessed noncompliant ISTS and small communities and other developments that discharge into surface waters. A 100 percent correction goal was given to this noncompliant ISTS category. While this source was not a significant contributor to the loading issues, it is recognized to be a significant human health impact. Additionally, noncompliant ISTS due to failing systems or surface discharges along with direct discharges to surface waters will be a source considered in 22 reaches that are listed as impaired for fecal coliform bacteria on the 2002 impaired waters list.

Agriculture: The phosphorus released to the environment occurs as both sediment-attached phosphorus in eroded soils and soluble phosphorus. To address both forms of phosphorus, soil erosion control and nutrient management BMPs included:

1. 75 percent of row cropped land with 2 percent or greater slopes adopting 30 percent residue use or equivalent BMPs;
2. 50 percent of surface tile intakes protected on row crops with 2 percent or less slope. Protective practices for surface tile intakes include buffer strips and tile risers, among others;
3. 25 percent adoption of nutrient management for all row cropped acres for all was selected (nitrogen agronomic rates for manure applications and phosphorus agronomic rates for commercial fertilizer phosphorus applications on non-manured land or manured land receiving commercial fertilizer).

The combination of conservation tillage and surface tile intake protection allow treatment of flat and sloping lands. The distinction of slope was not considered in the previous scenario. The adjustment was made because certain studies indicate that on flat fields with heavy soils (with slopes ranging from 0 to 3 percent), high residue use may decrease crop yield.

Equivalent BMPs allow the reduction goal to be addressed using the Revised Universal Soil Loss Equation (RUSLE), a tool available in the soil conservation field. By selecting alternative crops (c factor adjustment), cultural BMPs such as residue (c factor adjustment), structural BMPs like terraces or surface tile intake protection (p factor adjustment), changes in field scale implementation can readily be selected as equal to or better than the suggested 30 percent crop residue use or surface tile intake protection.

5.11 Scenario 7 Results

The Second Scenario to Balance the Allocation (Scenario 7) met the 3.7 mg/l goal of BOD at Jordan set for meeting the dissolved oxygen standard. According to this scenario, the average low flow period BOD concentration is estimated to be 3.61 mg/l on the Minnesota River at Jordan. The loads generated in the Basin under these assumptions projected 45,095 pounds of phosphorus. This is an estimated 30,500 pound reduction when compared to the 75,620 pounds in Scenario 1 (Table 5.5).

Table 5.5 Scenario 7 sources of phosphorus loading (pounds) for the August-September 1988 critical period compared to current day loading

	Scenario 7	Percent reduction		Scenario 1	Percent reduction
Agriculture	9,669	21.4		10,907	14.4
Noncompliant ISTS	0	0.0		2,436	3.2
Under-treated Communities	593	1.3		593	0.8
Point Sources	24,018	53.3		49,222	65.1
Stormwater	10,496	23.3		12,294	16.3
Natural and background sources	319	0.7		168	0.2
TOTAL	45,095	100.0		75,620	100.0

Table 5.6 compares the concentration results of the three scenarios. Table 5.7 compares the remaining load at the mouth of the model segments. It shows, for example, that during a current low flow period just over 19,000 pounds of phosphorus was predicted to be delivered to Jordan. Land use changes as explained in scenarios 6 and 7 are predicted to deliver approximately 1,700 and 1,000 pounds, respectively. This reduction in loading reflects the reduced river flow associated with fewer acres of conservation tillage in Scenario 7.

These two tables demonstrate the premise that the concentration of BOD responds to the concentration of chlorophyll-a, and phosphorus rather than loading of phosphorus passing by Jordan.

Table 5.6 Critical period (August-September, 1988) average concentration results for Scenario 7, Minnesota River at Jordan

	"Current Day" (Scenario 1)	Initial Scenario to Balance the Allocation (Scenario 6)	Second Scenario to Balance the Allocation (Scenario 7)
Total P (mg/L)	0.393	0.125	0.131
Total BOD-5 (mg/L)	5.68	3.44	3.61
Chlorophyll *a* (µg/L)	121	53	56.3

Table 5.7 Scenario 7 phosphorus loading summary (pounds) for critical period (August-September, 1988)

	"Current Day" (Scenario 1)	Initial Scenario to Balance the Allocation (Scenario 6)	Second Scenario to Balance the Allocation (Scenario 7)
Hawk	4,764	1,812	1,603
Yellow Medicine	159	117	113
Redwood	14,239	1,208	1,137
Cottonwood	430	358	325
Watonwan	1,042	421	346
Le Sueur	2,814	1,524	2,003
total Blue Earth	2,174	1,063	1,063
at Mankato	30,001	4,812	4,693
at Jordan	19,105	1,757	1,002

The upstream boundary loading and Chippewa River contributions are not provided in the tables above. As previously stated, the upstream boundary loading is complicated by a flow diversion on the Chippewa River near the City of Watson. This flow diversion splits the river flow so that some of the flow continues downstream in the Chippewa River towards the City of Montevideo, while some of the flow is directed to Lake Lac Qui Parle. The management measures and BMP adoption goals for the discussed watersheds also apply to the Chippewa River. The upstream loading is projected to be reduced from current day phosphorus loading of 5,961 pounds over the 61 days down to approximately 1,770 pounds. Likewise, the Chippewa River loading has a similar reduction proposed, ranging from 3,714 pounds currently projected for the watershed down to 1,637 pounds of phosphorus. (The upstream loading includes the delivered loads from Chippewa River Watershed).

6.0 Loading Capacity and Selected Allocations

The TMDL requires the components of the following equation to balance in order reduce phosphorus enough to meet the dissolved oxygen standard during low flow conditions: TMDL = WLA + LA + MOS + Reserve Capacity. The allocation for this TMDL is provided in two ways. First, for the 61 day critical flow period, and second, in pounds per day. The TMDL must be in pounds per day because future low periods will be shorter or longer than 61 days. The allocation is different than the Second Scenario to Balance the Allocation (Scenario 7) because the advisory committee made the minor adjustments explained Section 6.3. Achieving the TMDL of 45,869 pounds of phosphorus over the 61 day period (or 752 pounds per day), the 40 percent BOD reduction can be achieved to meet the dissolved oxygen standard during low flow conditions.

<u>TMDL over 61 day period (pounds of phosphorus)</u>

TMDL	=	WLA	+	LA
45,869	=	25,389	+	20,480

<u>TMDL in pounds per day</u>:

TMDL	=	WLA	+	LA
752	=	416	+	336

TMDL = The total maximum daily load in the watershed.
WLA = The waste load allocation to NPDES discharges.
LA = The load allocation to nonpoint sources.
MOS = Margin of safety which is provided by conservative assumptions in the model. The margin of safety is explained in Section 6.7.
Reserve Capacity = Load set aside for future allocations from growth or changes. Reserve capacity is explained in Section 6.6.

The next sections provide a description of how the allocations were generated.

6.1 Summary of the Waste Load Allocation

The Waste Load Allocation is 25,389 pounds over 61 days or 416.2 pounds per day and includes:

1. Includes the NPDES sources of phosphorus loading in the modeled portion of the Basin (Lac qui Parle to Jordan). These sources include permitted direct discharges (and those that may become permitted). Some of the land uses have previously been considered nonpoint source runoff.

2. Wastewater Treatment Plant Discharges: 23,258 lbs of allocated phosphorus discharge over the critical low flow two months studied or an average value of 381.3 pounds of phosphorus per day.

3. Permitted Stormwater Sites: Municipal Separate Storm Sewer Systems (MS4), Construction Stormwater Sites, Industrial Stormwater Sites: 1,863 pounds of phosphorus over the two critical low flow months studied or 30.5 pounds of phosphorus per day.

4. Concentrated Animal Feeding Operations (CAFOs): Zero pounds of phosphorus allocated. Permitted NPDES facilities (CAFOs) are not allowed a discharge from the animal production area. If the manure is applied according to the NPDES Permit, runoff is considered agricultural stormwater.

5. Communities without proper sewage treatment: When covered by a NPDES permit, the future loading allocated is 268.4 pounds of phosphorus over the two critical months studied or an average daily loading of 4.4 pounds of phosphorus per day.

6.2 Summary of the Load Allocation

The Load Allocation is 20,480 pounds over 61 days or 335.2 pounds per day and includes:

1. The load allocation represents nonpoint sources (excluding permitted sources). Load allocations must include a natural or background loading representing forested areas, wetlands, grasslands, atmospheric deposition and contributions from stream bank and bluff erosion.

2. Agricultural land uses: 10,907 pounds of phosphorus over the two low-flow critical months studied or an average daily load of 178.8 pounds of phosphorus allocated. Both Scenarios 6 and 7 reduced the concentration of phosphorus. Phosphorus concentration is what determines the overall growth of algae. Loading results from Scenario 6 projected higher agricultural loads due to increased baseflow when compared to Scenario 1. Scenario 7 did not increase baseflow as significantly as Scenario 6, so a conservative interpretation was to use Scenario 1 agricultural loading on Scenario 7 hydrology.

3. Non-permitted stormwater cities: 8,999 pounds of phosphorus over the two month low flow critical period or an average daily load of 147.5 pounds of phosphorus per day allocated.

4. Other natural and background sources: 233 pounds of phosphorus over the low flow critical two months studied or an average daily load of 3.8 pounds of phosphorus per day allocated.

5. Noncompliant ISTS: 341 pounds of phosphorus loaded over the low flow critical periods or an average daily load of 5.6 pounds per day of phosphorus allocated.

Under present conditions with no land use change, the amount of phosphorus generated in the Basin in a future 61-day low flow period is 75,620 pounds (Table 5.1). This TMDL Report calls for a loading limit of 45,869 pounds of phosphorus over the 61-day period to meet the dissolved oxygen water quality standard during low flow conditions.

6.3 Changes to Scenario 7 that Resulted in the Selected Allocation

The advisory committee discussed both scenarios and generally supported the following:

1. Continuously discharging wastewater treatment facilities discharging more than 1,800 pounds of phosphorus per year (that are not new or expanding) participate in a watershed permit requiring seasonal effluent limits in 10 years, while using Phosphorus Management Plans and the MPCA Phosphorus Strategy in the interim period.

2. Stormwater goals were generally accepted.

3. ISTS goals were reduced from 100 percent correction of noncompliant ISTS to a 90 percent correction, as presented in the initial balanced allocation scenario (Scenario 6). The reasoning was that the 100 percent goal would be too high in a 10-year timeframe considering the number of noncompliant systems in the Basin.

4. The majority of the advisory committee favored agriculture participating in the solution *because the BMPs increase flow*. Some members were concerned that by setting BMP adoption goals with the absence of a statistically significant reduction in phosphorus loading; there may be a public perception that agriculture is the cause of the problem. However, agriculture's contribution to the correction of this problem comes from the approximately eight percent increase in flow during the critical period. *If flow is increased during drought periods, a low flow event will likely occur for a shorter time and less frequently.*

   Phosphorus load reductions will be required by wastewater treatment facilities, stormwater, and noncompliant ISTS. Many wastewater treatment facilities will receive phosphorus limits. For this particular TMDL, agriculture will not face additional phosphorus reductions in the allocation. The agricultural sector has the opportunity to partner in improving water quality. Rather, the agriculture sector should get credit for taking the initiative on being part of the solution to clean up the Minnesota River by assisting with the management of flow regimes.

5. Combining the straight piped noncompliant ISTS reduction goal of 90 percent back into the final allocation without rerunning the model introduced a minor error. This error is acceptable and of a very small margin that will be discussed further in the Margin of Safety section of this Report.

Based on the minor adjustments above, the allocation table was adjusted (Table 6.1 below). This same information is simplified to represent a daily average condition as provided in Table 6.2 below. The daily average would be calculated across the river's low flow critical period as determined by the watershed permit's triggered flow conditions.

Table 6.1 Total phosphorus allocation table by major watershed for the Minnesota River summer low flow critical period (August and September 1988 Hydrology)

	Ag	Non-compliant ISTS	Under-treated Commu-nities	Point Sources	NPDES Storm-water	Other Storm-water	Other Natural and Back-ground Sources	Total
Blue Earth	1,320	68	17	2,456	248	1,025	16	5,150
Cottonwood	1,027	15	33	755	138	1,195	34	3,197
Hawk	292	6	69	2,698	163	538	11	3,777
Le Sueur	1,017	64	0	2,265	122	1,033	15	4,516
Lower Minnesota	3,334	45	0	1,928	130	909	32	6,378
Middle Minnesota	1,980	91	53	8,236	622	2,574	50	13,606
Redwood	1,038	7	14	3,040	257	526	51	4,933
Watonwan	688	38	73	1,826	122	779	13	3,539
Yellow Medicine	212	7	9	54	61	420	11	774
TOTAL	10,907	341	268	23,258	1863	8,999	233	45,869
	23.8 %	0.7 %	0.6 %	50.7 %	4.1 %	19.6 %	0.5 %	

Table 6.2 Total average daily phosphorus allocation by major watershed for the Minnesota River summer low flow critical period (generated loading)

	Ag	Non–compliant ISTS	Under-treated Comm-unities	Point Sources	NPDES Storm-water	Other Storm-water	Other Natural and Back-ground Sources	Total
Blue Earth	21.6	1.1	0.3	40.3	4.1	16.8	0.3	84.4
Cottonwood	16.8	0.2	0.5	12.4	2.3	19.6	0.6	52.4
Hawk	4.8	0.1	1.1	44.2	2.7	8.8	0.2	61.9
Le Sueur	16.7	1.0	0.0	37.1	2.0	16.9	0.2	74.0
Lower Minnesota	54.6	0.7	0.0	31.6	2.1	14.9	0.5	104.6
Middle Minnesota	32.5	1.5	0.9	135.0	10.2	42.2	0.8	223.0
Redwood	17.0	0.1	0.2	49.8	4.2	8.6	0.8	80.9
Watonwan	11.3	0.6	1.2	29.9	2.0	12.8	0.2	58.0
Yellow Medicine	3.5	0.1	0.1	0.9	1.0	6.9	0.2	12.7
Total	178.8	5.6	4.4	381.3	30.5	147.5	3.8	752.0
	23.8 %	0.7 %	0.6 %	50.7 %	4.1 %	19.6 %	0.5 %	

The estimated river load at the end points of the major watersheds and Jordan are provided in Table 6.3 below. Local attainment of goals in the system will be tracked based on this table. When used in conjunction with measured discharges from nonpoint source goals, assessments can be made on the success of nonpoint source reductions.

Table 6.3 Total Average daily phosphorus load predicted in stream by major watershed for the Minnesota River summer low flow critical period

Station	Phosphorus (average pounds per day)
Hawk	26
Yellow Medicine	2
Redwood	12
Cottonwood	5
Watonwan	5
Le Sueur	26
Total Greater Blue Earth Watershed	18
at Mankato	78
at Jordan	29

6.4 Load Allocation Details

Load allocations for TMDLs include the loading from nonpoint sources such as agricultural runoff (non-permitted), natural background sources such as wetlands, forest, grasslands and atmospheric deposition as well as non-permitted stormwater, noncompliant ISTS, and river bank, bed, and bluff contributions. The nonpoint source load allocation table is provided major tributary (Tables 6.4 and 6.5).

Table 6.4 Generated load allocation by major tributary watershed (based on August and September 1988 hydrology)

	Agriculture	Non - compliant ISTS	Storm-water	Other Natural and Background Sources	Total
Blue Earth	1,320	68	1,025	16	2,429
Cottonwood	1,027	15	1,195	34	2,271
Hawk	292	6	538	11	847
Le Sueur	1,017	64	1,033	15	2,129
Lower Minnesota	3,334	45	909	32	4,320
Middle Minnesota	1,980	91	2,574	50	4,695
Redwood	1,038	7	526	51	1,622
Watonwan	688	38	779	13	1,518
Yellow Medicine	212	7	420	11	650
Total	10,907	341	8,999	233	20,480

Table 6.5 Average daily generated load allocation by major watershed

Watershed	Phosphorus (pounds)
Blue Earth	39.8
Cottonwood	37.2
Hawk	13.9
Le Sueur	34.9
Lower Minnesota	70.8
Middle Minnesota	77.0
Redwood	26.6
Watonwan	24.9
Yellow Medicine	10.7
Total load allocation	335.7

6.5 Waste Load Allocation Details

The EPA guidelines for a waste load allocation include:

1. Continuously discharging municipal wastewater treatment facilities;
2. Industrial wastewater treatment facilities;
3. Permitted stormwater sites; and
4. NPDES concentrated animal feeding operations.

Three of these categories currently have unpermitted sources that the regulatory programs intend to include in the near future. These are:

1. Sewered communities without proper treatment facilities that will be regulated under NPDES or SDS permits;
2. Communities included in the MS4 general permits (listed below); and
3. Concentrated animal feedlot operations that have yet to be identified by the registration system required by MN Rule Chp. 7020 and the NPDES program.

Point Sources: The communities required to be in compliance with a 1 mg/l phosphorus effluent limit are assigned a load allocation based on 70 percent of their permitted wet weather design flow or 5 percent higher than the permitted average dry weather design flow, whichever is greater. The complete list of facilities is provided in Table 6.6. The daily individual loads are based on a seven-year average since reduction methods will vary. Facilities using biological phosphorus control will use a six month seasonal average while facilities that opt for chemical treatment will treat at a certain flow that is protective of the river.

Table 6.6 Wastewater treatment facility individual allocated loads for the Minnesota River summer low flow dissolved oxygen TMDL

	Minnesota River Basin Modeled Watershed Facilities With a 1 mg/l Phosphorus Effluent Limit			
	Name	Permit Number	Allocated Load Pounds/Day	Major Watershed Name
1	Blue Earth WWTP	MN0020532	5.7	Blue Earth River
2	Darling International	MN0002313	1.3	Blue Earth River
3	Fairmont WWTP	MN0030112	22.8	Blue Earth River
4	Trimont WWTP	MN0022071	2.0	Blue Earth River
5	Welcome WWTP	MN0021296	1.5	Blue Earth River
6	Winnebago WWTP	MN0025267	9.9	Blue Earth River
7	Benson WWTP	MN0020036	5.7	Chippewa River
8	Montevideo WWTP	MN0020133	17.5	Chippewa River
9	Starbuck WWTP	MN0021415	1.6	Chippewa River
10	Del Monte Corp.	MN0001171	6.4	Cottonwood River
11	Springfield WWTP	MN0024953	4.6	Cottonwood River
12	Walnut Grove WWTP	MN0021776	1.2	Cottonwood River
13	Clara City WWTP	MN0023035	2.7	Hawk Creek
14	Willmar WWTP	MN0025259	30.6	Hawk Creek
15	Amboy WWTP	MN0022624	1.6	Le Sueur River
16	New Richland WWTP	MN0021032	3.5	Le Sueur River
17	St Clair WWTP	MN0024716	1.2	Le Sueur River
18	Waseca WWTP	MN0020796	20.4	Le Sueur River
19	Granite Falls WWTP	MN0021211	5.4	Minnesota River (Granite Falls)
20	Olivia WWTP	MN0020907	3.2	Minnesota River (Granite Falls)
21	Redwood Falls WWTP	MN0020401	7.7	Minnesota River (Granite Falls)
22	Renville WWTP	MN0020737	5.3	Minnesota River (Granite Falls)
23	Sacred Heart WWTP	MN0024708	1.1	Minnesota River (Granite Falls)
24	Lake Crystal WWTP	MN0055981	3.4	Minnesota River (Mankato)
25	Mankato WWTP*	MN0030171	54.2	Minnesota River (Mankato)
26	New Ulm WWTP*	MN0030066	21.7	Minnesota River (Mankato)
27	St Peter WWTP*	MN0022535	16.7	Minnesota River (Mankato)
28	Arlington WWTP	MN0020834	3.9	Minnesota River (Shakopee)
29	Cologne WWTP	MN0023108	1.9	Minnesota River (Shakopee)
30	Henderson WWTP**	MN0023621	2.1	Minnesota River (Shakopee)
31	Le Center WWTP	MN0023931	4.9	Minnesota River (Shakopee)
32	Le Sueur Cheese WWTP	MN0066494	4.6	Minnesota River (Shakopee)
33	LeSueur WWTP	MN0022152	5.2	Minnesota River (Shakopee)
34	Milton G Waldbaum Co.	MN0060798	3.3	Minnesota River (Shakopee)
35	Norwood Young America WWTP	MN0024392	3.0	Minnesota River (Shakopee)
36	Archer Daniels Midland - Marshall***	MN0057037	40.0	Redwood River
37	Marshall WWTP**	MN0022179	29.0	Redwood River
38	Madelia WWTP	MN0024040	7.6	Watonwan River
39	St James WWTP	MN0024759	17.3	Watonwan River
40	Truman WWTP	MN0021652	4.6	Watonwan River

*The cities of New Ulm, Mankato, and St. Peter are assigned loading based on DMR records during low stage river events plus an estimated 20-year growth projection of the community.

**The cities of Henderson and Marshall are assigned loading based on Average Dry Weather Design Flows plus 5 percent.

***Minnesota Corn Processors is now known as Archer Daniels Midland – Marshall.

Communities without proper sewage treatment are a public health and water quality problem. Flows from household septic tanks without a drainfield average 20 mg/l of phosphorus with flows of 50 gallons per person per day. New wastewater treatment plant design often assumes 100 gallons per person per day and averages 6-8 mg/l of phosphorus. A system with proper secondary treatment discharges less than 4 mg/l of phosphorus. Connecting these systems to a cluster mound treatment system would eliminate the surface water discharge entirely. In the original model data, there were 38 communities considered having untreated sewage. That number has now dropped to 20 because communities have fixed the problem and now have proper treatment (Table 6.7). Five of the 20 are in the process of construction. The goal is for these communities to achieve secondary treatment. Table 6.8 shows the major watershed allocations for communities with untreated sewage once they get adequate treatment. The Minnesota River Basin Plan calls for communities without proper sewage treatment to be in compliance by 2010. The loading discharged from these communities is left in the final allocation as a margin of safety.

Effluent from communities without proper sewage treatment also poses a health threat due to pathogens and bacteria. Efforts to provide treatment through connections with other municipal treatment systems, adding adequate facilities, or upgrading noncompliant ISTS are underway.

Table 6.7 Communities without proper wastewater treatment as of 2000 (this list is not comprehensive of all communities lacking proper treatment)

Communities without proper wastewater treatment		Communities in compliance since 2000	
Barry	Long Beach	Bingham Lake	Farwell
Blomkest	Louisburg	Boyd	Frost
Clontarf*	Odin	Correll	Green Isle
Cobden	Ormsby	Courtland	Lewisville
Delhi*	Prinsburg*	Darfur	North Redwood
Florence	Seaforth	De Graff	Pemberton
Forada	Skyline	Delavan	Pennock
Garvin*	Urbank	Evan	Sunburg
Heidelberg	Walters	Hazel Run	Nassau
La Salle	Revere*		

*Communities in the process of constructing wastewater treatment facilities.

Table 6.8 Allocated loads for communities previously without proper sewage treatment coming into compliance

Sewered but Under-treated Developed Communities by Watershed	61 day load	Pounds/day
Blue Earth	17	0.3
Cottonwood	33	0.5
Hawk	69	1.1
Le Sueur	0	0.0
Lower Minnesota	0	0.0
Middle Minnesota	53	0.9
Redwood	14	0.2
Watonwan	73	1.2
Yellow Medicine	9	0.2

Urban stormwater: Allocations for this sector were developed using the model predictions for urban land use runoff in each watershed. Phosphorus loading from MS4 communities was calculated by watershed to arrive at a cumulative loading average across the critical flow period. The allocation is a function of size of the urban area, the amount of phosphorus predicted from stormwater in each watershed, and whether the community is a potential MS4 versus a non-MS4. Storm sewer, industrial and construction categories were grouped together. The three categories will require BMPs to reduce phosphorus. Industrial and construction erosion stormwater sites are included in this allocation with the future MS4 communities for the watersheds listed in Table 6.9. Watersheds not in table were given a 1 to 2 pound per day cumulative load in other watersheds. The phosphorus reductions for permitted MS4 communities, permitted construction stormwater sites, and permitted industrial stormwater sites are 30 percent and for non-permitted communities, 20 percent.

Table 6.9 Permitted stormwater system allocated loads by major watershed for the Minnesota River summer low flow dissolved oxygen TMDL

Watershed	Stormwater WLA Across 61 days	Average Daily Stormwater WLA
Blue Earth	248	4.1
Cottonwood	138	2.3
Hawk	163	2.7
LeSueur	122	2
Lower Minnesota	130	2.1
Middle Minnesota	622	10.2
Redwood	257	4.2
Watonwan	122	2
Yellow Medicine	61	1
Total	1,863	30.5

MS4 general stormwater permits have been issued in Minnesota. Communities outside of the metro area were not permitted because they did not meet the population or population density requirements. The Agency may require these communities to meet the MS4 regulations. As a result, many were notified of an intent to permit within the next 18 months. These communities are:

1. Fairmont
2. Mankato
3. Marshall
4. New Ulm
5. North Mankato
6. Willmar

Existing NPDES Concentrated Animal Feedlot Operations (CAFOs) have a zero discharge requirement from the production lot of these facilities. The permit requirements for manure application establishes under federal law that the nutrient runoff is considered agricultural stormwater. The agricultural stormwater allocation is included in the nonpoint source load allocation portion of the TMDL Report.

6.6 Reserve Capacity

The long term provision for economic and population growth in the Minnesota River Basin must be provided for. Reserve capacity has not yet been estimated. This is due to the variability in allowable discharged phosphorus considering the distance of dischargers from the impaired reach and physical land and channel characteristics as partially explained by Scenario 5 (Impact Coefficient) in Appendix D.

Information from the Minnesota State Demographic Center indicates that the population of the area in the Minnesota River Basin above Shakopee increased from 467,000 in 1990 to 486,000 in 2000; a 4 percent increase over the decade. However, their prediction for the same area's population for the 2000 to 2010 period is only an average of 2.5 percent and that growth rate will continue for the immediate future. These population trends will likely continue because rural areas and small cities will likely maintain their population decline, medium-size cities will remain stable, and larger cities will continue slow growth. This could be interpreted to mean that the municipal population in the cities that discharge to the Minnesota River Basin will increase at a slightly higher rate than the overall population of the whole area, which was earlier stated to be about four percent over a 10-year period.

In looking specifically at the projected growth rates of medium-size cities in the Minnesota River Basin, the average growth rate of a total of 24 cities is projected to be about 5.5 percent for the next 10 years. This percentage is also similar to the past growth rates for a sampling of those cities. New Ulm and Mankato are only predicting a population increase of about 3 to 5 percent in the next 10 years.

The population projections can be a fairly accurate prediction of the growth of the dry weather flows from a municipality, except where there is a new or expanding wet industry located in those cities. However, in a polling of the city officials of some of the cities in the Minnesota River Basin, only in a few cases did the cities predict an industrial expansion that would cause a significant increase in the wastewater flows from the city. Therefore, no larger than normal expansion of industrial wastewater flows to the Basin is being considered at this time. It, therefore, is assumed that the growth in the dry weather flows from municipal sources over the next 10 to 20 years will be in the range of five to ten percent.

Reserve capacity is built into the TMDL assessment in the following ways:

1. The allocation for the proposed phosphorus reductions in the Basin is projected to achieve an average concentration of 5-day BOD of 3.68 mg/l at Jordan. The goal is an average concentration of 5-day BOD of 3.7 mg/l, a difference of 0.02 mg/l. Because of distance and time, point source loads farther upstream in the Basin are more thoroughly assimilated by the time they reach Jordan than are loads discharged in close proximity to Jordan. Therefore, this relatively small margin can be substantial for facilities farther from the Lower Minnesota River.

2. The larger dischargers of New Ulm, Mankato and St. Peter are located on the main stem closer to Jordan. These cities already have a projected 20-year reserve capacity built into their allocations and are from the growth trend group that would expect the higher gains in population.

3. Daily discharges were increased in the HSPF model for the municipalities listed in Table 6.6. The increases reflect a uniform shift in the entire

discharge record such that the peak storm events in the critical dry weather period were raised to be at least 70 percent of Average Wet Weather Design Flow conditions (flows from St. Peter, Mankato, and New Ulm were individually estimated). This is conservative because, during times of extended drought conditions, many communities will have less than 70 percent of the Average Wet Weather Design Flow, even during intense localized storms. *Therefore, the increased loading assuming a higher discharge from thunderstorms and dry weather flows across the 61 days from all of the larger wastewater treatment plants is a conservative factor.* Reserve capacity will reflect the conservative flow increase existing in each facility excluding the portion used for margin of safety as explained in Section 6.7.

4. The development of a pilot project focusing on watershed pollutant trading is being considered for the Minnesota River Basin. The TMDL includes provisions for MPCA-approved pollutant trading to be available to offset one entity's allocation exceedance with a reduction by another entity that has followed an approved and reviewed offset trading program for phosphorus. This program is not currently in place.

5. In the long term implementation of this TMDL, increases in growth-related flow for existing facilities can be offset by tighter concentration effluent limits to maintain the current waste load allocation.

6.7 Margin of Safety

The margin of safety was provided implicitly in the model assumptions. It is estimated to be at least 10 percent of the allocation or 76 pounds of phosphorus per day. The error associated with any large scale modeling effort can be significant. However, using the calibration and validation process and comparing results of input assumptions across the nine major tributary model segments minimized the errors associated with erroneous assumptions. While the implementation and effectiveness monitoring for this TMDL Report allows for adaptive management, the following list of conservative factors combine to provide an adequate margin of safety not addressed by the use of modeling protocols described above. The margin of safety includes:

1. Daily discharges were increased in the HSPF model for the municipalities listed in Table 6.6. The increases reflect a uniform shift in the entire discharge record such that the peak storm events in the critical dry weather period were raised to be at least 70 percent of Average Wet Weather Design Flow conditions (flows from St. Peter, Mankato, and New Ulm were individually estimated). This is conservative because, during times of extended drought conditions, many communities will have less than 70 percent of the Average Wet Weather Design Flow, even during intense localized storms. *Therefore, the increased loading assuming a higher discharge from thunderstorms and dry weather flows across the 61 days from all of the larger wastewater treatment plants is a conservative factor.* To

assess the magnitude of the margin of safety, the MPCA used 2003 individual flows from 40 wastewater treatment facilities in the waste load allocation and estimated the load discharges when all facilities met a 1 mg/l phosphorus effluent limit. The estimated load was only 64 percent of the modeled allocation, leaving 36 percent, or 129 pounds of phosphorus per day. Using a conservative 50 percent as a margin of safety allows 64 pounds per day for the 40 facilities in the waste load allocation.

2. Communities are allocated discharges for maximum permitted BOD effluent limit concentrations. Since the endpoint of the model is Jordan, most of the BOD discharged from facilities in close proximity will not be fully assimilated by the time it reaches Jordan. The river actually has an additional 17 miles between Jordan (river mile 39) and Shakopee (river mile 22) to assimilate BOD prior to reaching river mile 22.

3. The model includes small communities with inadequate wastewater treatment. The allocation for these communities is 4.4 pounds of phosphorus per day. Because not all of the communities will discharge to surface water as part of the treatment process, a conservative estimate of 50 percent can be applied. This leaves 2 pounds of phosphorus per day as the margin of safety. Of the 38 that were known to exist at the beginning of the modeling effort, 18 have been corrected and five are building wastewater treatment facilities.

4. The Basin contains many smaller permitted facilities that would not receive a phosphorus effluent limit either due to size or type of facility (e.g. waste stabilization ponds). These facilities are required to develop Phosphorus Management Plans (PMP) as part of the watershed permit process. First, the communities are required to evaluate the feasibility of achieving a reduction goal of 30 and 50 percent. The reduction that is determined feasible by a PMP process will be required to be implemented under the watershed permit. As the PMP feasibility evaluations have not yet been undertaken, and the site specific reductions are unknown, no reduction in phosphorus for these smaller facilities is credited in the allocation.

5. The agricultural allocation includes adoption goals for residue use, surface tile intake protection, and nutrient management. Although the outcome of the stakeholder process and the TMDL Report involved no reduction in the allocation for agriculture, the model indicated a reduction of 20 pounds of phosphorus per day. Assuming there will be 50 percent of the predicted reduction (20 pounds) leaves 10 pounds of phosphorus per day as a margin of safety for the agriculture sector.

   The model demonstrates that the impact of certain BMPs is to increase the base flow during the critical low flow period by recharging ground water during wetter periods, thereby increasing ground water seeps during dry periods. By increasing base flow, the frequency and duration of future low flow periods is minimized. Additionally, algal production responds to concentrations of phosphorus present in the local water column and not the downstream loading of phosphorus over time. Therefore, an improved condition occurs due to changes in flow and not loading, which is what the allocation is based on.

In summary, three areas contribute to the margin of safety. These include the 40 wastewater treatment facilities in the waste load allocation (64 pound per day), communities with inadequate wastewater treatment (2 pounds per day), and agriculture (10 pounds per day). These add up to a total of 76 pounds of phosphorus per day. Since the allocation is 752 pounds of phosphorus per day, the margin of safety is at least 10 percent. Other factors described will also contribute the margin of safety but they are difficult to measure.

6.8 Seasonal Variation

This TMDL Report specifically addresses the summer low flow critical period and the seasonal variation of loading does not apply.

6.9 Reasonable Assurances

The Minnesota River Dissolved Oxygen TMDL Report relies both on the NPDES permit program and voluntary reductions from the nonpoint sources to reduce phosphorus enough to meet the allocations. Since this TMDL Report involves point and nonpoint sources, reasonable assurance of the stated implementation measures must be provided. This section provides justification that phosphorus reductions will occur in the non-permitted source areas.

1. Ten of the 13 major watersheds in the Minnesota River Basin are working on projects to improve river water quality in their areas. Many receive funding from Minnesota's Clean Water Partnership Program or Clean Water Act Section 319 funding for nonpoint source demonstration projects (319 funding). In 2002, 319 funding was awarded to the Redwood River and Chippewa River Watershed Projects, and other 319 funding was awarded to projects in the Hawk Creek and High Island Creek Watersheds. The Hawk Creek Watershed Project plans to install 212 blind tile intakes in the next three years. For cost sharing on agricultural waste facilities, plans require nutrient applications based on phosphorus agronomic rates in addition to plans received when construction permits are required for facilities below the NPDES threshold. Since 2001, phosphorus reductions are estimated to be just over 9,000 pounds annually (or nearly 185,000 pounds over 20 years which is the effective life of the project). See the following web site for more detail: http://www.pca.state.mn.us/publications/reports/wq-cwp8-03.pdf.

2. Several projects have identified priority areas and set phosphorus and sediment reduction goals. Since nutrients and sediment plague the Minnesota River, many watershed projects are focusing on nutrient management, tile intake protection, filter strips, livestock waste management, and noncompliant ISTS, among other strategies. The Redwood-Cottonwood Rivers Control Area estimates a 6,170-ton sediment reduction and a 69,528-pound

phosphorus reduction (Redwood River Clean Water Project, 2001). In addition to watershed goals, the Minnesota River Basin Plan (2001) has also set Basin-wide goals to reduce phosphorus and sediment.

3. In 2002, the Greater Blue Earth River Watershed received funding via the EPA Watershed Initiative to restore wetlands, organize crop insurance for farmers, cost-share with landowners for installation of at least 300 acres of riparian buffers, organize educational awareness projects, and promote existing agricultural conservation programs. This includes the Blue Earth, Le Sueur and Watonwan River Watersheds.

4. Individual Sewage Treatment Systems (ISTS) with proper drainfields provide virtually complete removal of phosphorus from surface water. Acceptable designs are described in Minn. R. Ch. 7080. Fifteen of 37 Minnesota River counties have maintenance and pumping programs and 24 counties require point of sale inspections. This past session, the Legislature required the MPCA to prepare a plan to have 100 percent of systems in compliance in ten years. This will increase the rate at which noncompliant systems reach compliance. To view the plan, visit http://www.pca.state.mn.us/publications/reports/lrwq-wwists-1sy04.pdf.

5. One-hundred thousand acres of riparian land has been enrolled into the Conservation Reserve Enhancement Program (CREP) program. This program combines the CRP and RIM programs. Most of the acres are under permanent easements.

6. Minnesota's feedlot rules (Minn. R. Ch. 7020) require:
   1. Manure application recordkeeping and manure management planning; manure applied at nitrogen agronomic rates; reduced manure application frequency where soil phosphorus is elevated, especially near sensitive waters.

   2. In cases where feedlot facilities exceed 300 animal units and where soil test phosphorus levels are extremely high, a manure management plan is required that describes how phosphorus will be managed to prevent pollution resulting from phosphorus transport. By January 1, 2005, manure from facilities with more than 300 animal units must be land applied by a certified animal waste technician.

   3. Long-term build-up of soil phosphorus must be prevented within 300 feet of surface waters. Long-term is considered over any six-year period. Phosphorus build-up restrictions are not required if a vegetative buffer (50 or 100 feet) is established along the water. Manure must be incorporated if applied within 300 feet of surface waters.

7.0 Monitoring Plan to Track TMDL Effectiveness

Effectiveness Monitoring will consist of three aspects:

1. BMP and treatment measure adoption rates;
2. BMP treatment effectiveness; and
3. Major tributary and mainstem river water quality attainment

Additional details on BMPs will be available in the implementation plan for this TMDL.

Appendix D – Watershed Detailed Estimates will assist in explaining how a monitoring network of these three elements can be used both for final assessment and delisting as well as setting interim goals for progress.

8.0 Overview of Implementation Activities

This section provides an overview of implementation activities. A more detailed implementation plan will be developed within one year of EPA approval of the TMDL Report.

8.1 Point Sources

The emphasis of this low flow TMDL Report is on wastewater treatment facilities, although agriculture, noncompliant ISTS and stormwater are also considered. The MPCA is proposing a basin-wide watershed permit for phosphorus along with a parallel process to incorporate other information as it becomes available via the updated 1985 Waste Load Allocation, Minnesota River turbidity TMDLs, and the Lake Pepin TMDL. The process will include:

1. Watershed permit (Phase I) - 2004-2009 – wastewater treatment facilities develop phosphorus management plans (PMPs). Through the PMPs, wastewater treatment facilities will conduct feasibility studies evaluating 30 percent and 50 percent phosphorus reductions.

2. The waste load allocation in this TMDL Report involves continuously discharging wastewater treatment facilities permitted to discharge over 1,800 pounds of phosphorus per year. The specific requirements for the communities will be determined as a part of the watershed permit and the TMDL implementation plan. The overall approaches being considered include: 1) a 1 mg/l effluent limit (seasonal average or flow triggered) to achieve a 51 percent reduction ten years; and 2) point-point trading to achieve a 35 percent reduction by the end of the first phase of the watershed permit (five years). The first watershed permit will be followed by a second watershed permit requiring a 1 mg/l effluent limit or equivalent pollutant trading offsets by the end of the second phase permit (ten years). In both options, the 10-year goal may be adjusted by new information as explained below in items 3 through 7.

3. If the 1 mg/l effluent limit is selected, the first watershed permit will involve a goal to achieve the effluent limit. In the second watershed permit, communities comply with the effluent limits by the end of the permit (estimated to be 2014); or

4. If point-point trading is selected, trade agreements established via trade associations will be incorporated into the watershed permit and will provide flexibility to achieve the five-year interim goal of a 35 percent reduction (upstream Basin point source loading of 32,000 pounds of phosphorus). NPDES continuously discharging facilities electing not to participate in trading would individually achieve a 35 percent reduction in phosphorus concentration in five years. A point source permittee electing to participate will operate under a five-year trade association agreement with a group of participating permitted facilities. Trade agreements will consider the

geographic transport factors as well as actual discharged loadings. The terms of the loading goals for the trade association will be defined in the trade association's agreement, will be referenced in the watershed permit, and may be reconfigured every five years.

5. New information will be available from the Lower Minnesota River Model project, which the Metropolitan Council plans to complete in 2007 depending on funding and other resources (prior to end of first watershed permit).

6. The 1985 Waste Load Allocation will be revised by the MPCA with the completion of the Metropolitan Council's Lower Minnesota River model. The river loading information from early adoption of point source reduction goals from the point-point trading process will also be used in the update of the allocation.

7. The TMDL Report is updated, if necessary, using data from the updated waste load allocation and the revised BOD reduction goal. The current 10-year load reduction goal is a 51 percent reduction in phosphorus (a final loading of 24,018 pounds of phosphorus) from Minnesota River Basin point sources upstream of the metropolitan area.

8. Data is available from other TMDL Reports (i.e. Minnesota River turbidity and Lake Pepin) prior to 2009.

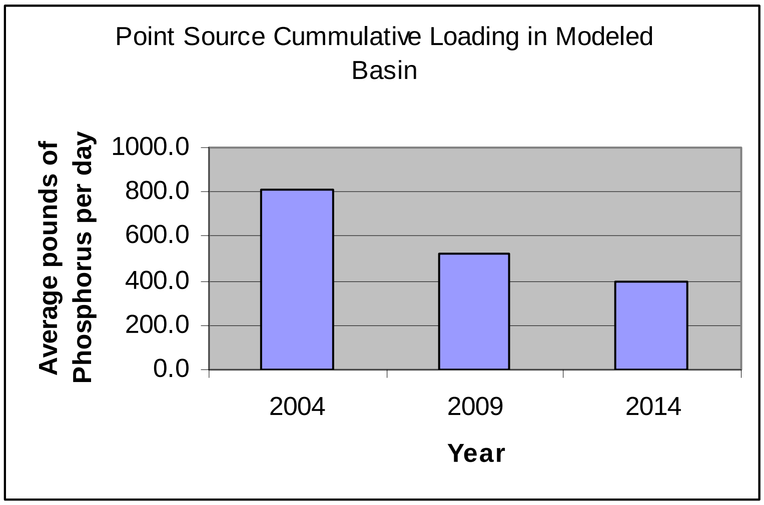
9. Watershed permit (Phase II) - 2009-2014 – targeted wastewater treatment facilities meet seasonal effluent limits for biological phosphorus control and flow triggered effluent limits for wastewater facilities electing to use chemical addition or point-point trading; all facilities will comply with the phosphorus planning and feasibility study results from the previous permit period. The targeted facilities and loading goals may change based on new data and revisions to the 1985 Waste Load Allocation and other TMDL Reports.

For both options (with or without point-point trading), an overall 10-year implementation timeline was selected to allow new information to adjust the allocation as indicated in the seven-step process above.

Point-point trading allows flexibility in offsetting phosphorus loads between wastewater treatment facilities. Point-point trading also provides a cost-effective alternative to treating phosphorus on an individual wastewater facility basis because it involves using available reserve capacity and economy of scale factors that may already exist in individual facilities in the Basin.

Current phosphorus loading from point sources in the Basin is projected to be 49,222 pounds over 61 days or an average daily load of 807 pounds of phosphorus. An interim reduction of 35 percent would reduce this loading to 32,000 pounds over the 61 day critical low flow period or an average daily cumulative load of 525 pounds of phosphorus. The current 51 percent reduction goal is 24,018 pounds over the 61 day critical low flow period or an average daily loading of 394 pounds of phosphorus (see Figure 8.1). These accelerated phosphorus reductions would occur prior to the update of the 1985 Waste Load Allocation, the Minnesota River turbidity, and the Lake Pepin TMDL Reports. Therefore, monitoring data will reflect the phosphorus reductions and be considered in adjustments to this TMDL Report around 2008. Often, for point-point trades a ratio of 1.1 to 1 is used. This ratio means that if a facility sells 11 pounds of phosphorus, 10 pounds are used in the trade and one is retired, which benefits the river and provides a margin of safety.

Figure 8.1 Cumulative point source phosphorus reduction targets with initial allocation (2009) and ten-year (2014) timelines



Phosphorus reductions from point sources are necessary, but the TMDL implementation allows flexibility. The longer time window for the watershed permit 1) allows new data to adjust this TMDL Report prior to the wastewater treatment facilities upgrades and 2) prevents facilities from having to upgrade multiple times (once based on this TMDL Report and again based on the turbidity or Lake Pepin TMDL Reports). For example, a particular facility would get a summer low flow triggered 1 mg/l limit in this TMDL Report. Based on the Lake Pepin TMDL Report, the effluent limit may need to be year round. In this example, two upgrades would be required. As structured, this TMDL Report prevents this situation from arising by phasing the permit limits in over time and allowing other TMDL Reports to further evaluate the need for phosphorus limits.

The first watershed permit cycle will require every NPDES wastewater discharger in the modeled watershed to develop a Phosphorus Management Plan (PMP) in the first three years. The PMP will set effluent target goals of 1mg/l phosphorus for all facilities currently without limits and discharging above 1,800 pounds of phosphorus a year. In addition, all facilities will evaluate the feasibility of a 30 percent and a 50 percent removal of phosphorus, and consequently adopt a feasible level of protection (Table 8.1).

New or expanding facilities will use reserve capacity or participate in pollutant trading. Outside of this low flow TMDL Report and related watershed permit, new or expanding facilities will continue to receive a 1 mg/l annual average phosphorus effluent limit according to the MPCA's Phosphorus Strategy.

Table 8.1 Wastewater treatment facility criteria for phosphorus effluent limits

	Phosphorus Load Less Than 1,800 Pounds per Year	**Phosphorus Load Equal to or Greater than 1,800 Pounds per Year**
Continuous Discharge	Phosphorus Management Plans and Phosphorus Strategy – 30 and 50 percent reduction feasibility study.	1 mg/l as a seasonal average goal through the Phosphorus Management Plan, 30 and 50 percent reduction feasibility study, and a 1 mg/l limit in ten years.
Controlled Discharge Stabilization Ponds	Phosphorus Management Plans and Phosphorus Strategy - 30 and 50 percent reduction feasibility study.	Phosphorus Management Plan and Phosphorus Strategy - 30 and 50 percent reduction feasibility study.

8.2 ISTS

Identify barriers to adoption of compliant ISTS. Develop strategy accordingly. Follow MPCA plan to move systems into compliance in 10 years.

8.3 Urban Stormwater

Stormwater permits for MS4 communities require a Stormwater Pollution Prevention Plan (SWPPP) that will be based on EPA requirements and the phosphorus allocation in this TMDL Report. To facilitate adapting the SWPPP with the allocation requirement in this TMDL Report, a list of guidelines will be developed in the implementation plan within a year of EPA approval of this TMDL Report. Possible guidelines may include:

1. MS4 communities will evaluate stormwater system BMP coverage and BMP treatment effectiveness.

2. Permitted construction stormwater sites will be required to evaluate the soil phosphorus content and potential soil erosion on the site and develop a BMP plan that is effective for the potential risk involve by the is the site. Effective BMPs for dry weather applications will take into account not only erosion controls but will also encourage infiltration of rainfall events, site plans limiting or reversing soil compaction, mulching, and wet detention ponds

needed for post site requirements instituted as early in the construction period as possible. In addition, BMP phosphorus treatment removal efficiencies will be used in the evaluation of the sites.

Permitted industrial stormwater sites will need to evaluate the phosphorus content and sources on their permitted site and examine reduction methods to reduce runoff and erosion, soil content of phosphorus, sources of phosphorus exposed to precipitation. Twenty years will be provided for retrofitting permitted urban stormwater areas.

8.4 Agriculture

Implementation of agricultural practices will be promoted by a variety of organizations. Implementation strategies will build on current practices.

1. Crop residue (or equivalent BMPs) on cropland land with slopes greater than three percent – crop residue (30 percent on a corn-soybean as a rotation average) holds soil in place and reduces overland runoff. Equivalent BMPs include terraces, alternative crops, etc.

2. Surface tile intakes – On cropland with slopes less than three percent, protection of surface tile intakes will reduce the direct path that sediment and phosphorus have to the river. Removal of surface tile intakes can also be effective on land with slopes greater than three percent. Protection methods for surface tile intakes include:
    a. Pattern tiling – a high density of subsurface tile in the proximity of the depressional area in loose soil textures can dewater as effectively as a surface tile intake.

    b. Installing perforated risers – a perforated riser slows the water at the intake and encourages ponding and settling of sediment prior to dewatering the field.

    c. Fall moldboard plowing without further implement passes in the fall. On flat fields the coarse clod texture left by a mold board plow creates a significant number of local ponding sites that are enhanced by the uncompacted soil creating the right environment for infiltration of precipitation versus surface runoff.

    d. Rock inlets – the inlets slow water at the intake allowing for settling of sediment.

    e. Grass buffers – protection of the intake with a sufficient width of a grass filter strip or buffer to slow water and settle and trap sediment is another option.

3. Fertilizer – According to the feedlot rule, on land with land application of manure, maximum application rates will be done at nitrogen agronomic rates for manure crediting; and manure application frequency will be reduced where soil phosphorus is elevated, especially near waters.

4. On land where commercial fertilizer is applied, 25 percent of the acres will use phosphorus agronomic rates, after manure crediting for phosphorus. Phosphorus agronomic applications are those determined by the University of Minnesota.

5. Native grasses or wetlands – An increase of native grass or wetland restorations will be pursued at a yet to be determined scale.

9.0 Public Participation

Public participation occurred on a variety of levels. Prior to approaching the public with the model results, the MPCA invited a group of model and land use experts to review the model inputs and results in June and July 2002. They included USGS, Metropolitan Council, University of Minnesota, and Minnesota Department of Agriculture. Tetra Tech EMI adjusted the model based on their comments.

Two public meetings were held to discuss the TMDL in 2003, with approximately 70 people attending. Following the public meetings an advisory committee was formed. More than 60 nominations were received and 45 people were selected. The committee is composed of people representing cities and their consulting groups, industry, agriculture, commodity groups, counties, watershed projects, and environmental groups. This 45-member committee worked hard to define the problem and shape solutions for the TMDL Report. Meetings occurred over a 6-month period (Table 9.1). A list of committee members appears in Appendix E.

The advisory committee provided these guiding themes that the majority of members agreed upon:

1. The conditions and health of the whole Basin should be considered, not just this low flow event in the lower portion of the river;

2. Each sector contributes something to the problem, and therefore, should contribute something to the solution;

3. There is a large concern for timing, planning, and cost of solutions;

4. The goal for failing ISTS compliance should be at least 90 percent, with the majority of the group suggesting a 100 percent goal since raw sewage poses problems for public health in addition to phosphorus; and

5. The focus often went to desired flexibility at an individual level rather than blanket requirements across the entire list of parties in a source category.

The MPCA presented the initial model results along with the Initial Scenario to Balance the Allocation (Scenario 6) to the committee. The advisory committee's suggestions were used to generate the Second Scenario to Balance the Allocation (Scenario 7). A comparison of these two scenarios based on advisory committee input is shown in Table 9.2. The advisory committee also suggested implementation options and timelines for each sector as suggested in section 8.

The draft TMDL Report was public notice from February 2 through March 18, 2004. Two public meetings were held on February 9 and 10 to provide an overview of the report and to allow people to ask questions. Additionally, representatives of wastewater treatment facilities met on February 27.

Eleven people commented on the draft report representing five cities, Metropolitan Council, Minnesota Department of Transportation, Minnesota Department of Natural Resources and the Minnesota Department of Environmental Advocacy.

The comments generally supported the direction of the TMDL Report. Many of the comments indicated concern about the requirements in the TMDL Report. However, the concerns were satisfied given the 10-year implementation timeline and the provision for new information to verify the current understanding and adjust the TMDL Report, if necessary. The themes included:

1. Requests more detail on specific reduction strategies;
2. Support from the cities for point-point phosphorus trading between wastewater treatment facilities;
3. Wastewater treatment facility limits - comments ranged from requests to issue effluent limits immediately to statements that there is no need for the effluent limits at this time;
4. Verifying modeling assumptions used in the study; and
5. Requesting more reasonable assurance showing that phosphorus reductions from non-point sources will actually be achieved.

Table 9.1 Meetings on Lower Minnesota River dissolved oxygen TMDL

Date		Location
May 28, 2003	Public Meeting	Redwood Falls
June 2, 2003	Public Meeting	Mankato
June 2, 2003	Advisory Committee Meeting	Redwood Falls
July 9, 2003	Advisory Committee Meeting	Redwood Falls
August 28, 2003	Advisory Committee Meeting	Redwood Falls
October 14, 2003	Advisory Committee Meeting	Redwood Falls
November 21, 2003	Advisory Committee Meeting	St. Paul
February 9, 2004	Public Meeting	Redwood Falls
February 10, 2004	Public Meeting	Mankato
February 27, 2004	Wastewater treatment operator Meeting	Mankato

Table 9.2 Changes to modeling scenario based on advisory committee input

Scenario 6	Scenario 7
WWTPs 1 mg/l P effluent limit **year round** for sites above 0.2 MGD (about 1800 lbs of P discharged per year).	**Options:** • 1 mg/l P seasonal effluent limit (6 month average, May to October) for Bio – P treatment systems • Flow triggered 1 mg/l P effluent limit for WWTPs selecting chemical addition treatment technology
Agriculture • 75 percent of acres adopting 30 percent residue use or equivalent BMPs • Nutrient Management of Manure at N agronomic rates and 90 percent of non-manured land adopting Nutrient Management of Commercial Fertilizer	• 75 percent of row cropped land with 2 percent or greater slopes adopting 30 percent residue use or equivalent BMPs • 50 percent of surface tile intakes protected on row crops with 2 percent or less slope • Nutrient management of manured land at N agronomic rates; 25 percent of non-manured land adopting phosphorus nutrient management of commercial fertilizer
Stormwater • Future MS4 cities reduce impermeable surface phosphorus loading by 30 percent • Non MS4 cities reduce impermeable surface phosphorus loading by 20 percent	**(No Changes)** • Future MS4 cities reduce impermeable surface phosphorus loading by 30 percent • Non MS4 cities reduce impermeable surface phosphorus loading by 20 percent
ISTS • 90 percent compliance with MN Rules 7080	• 100 percent compliance with MN Rules 7080

10.0 References

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Appendices

Appendix A – Preliminary Phosphorus Loading Across all Flow Regimes

7-year loading (includes low, average, and high flow periods)

(Note: comments received during a peer review by other modelers, the USGS and the University of Minnesota requested validation of the assumptions used at higher flow regimes so the reader should consider the following estimates as preliminary.)

Although this TMDL Report targets low flow conditions, the model was calibrated across all flow regimes to provide assurance that the system was being explained adequately. Consequently, estimates are also available during average flow conditions.

Review of the 7-year average annual loading (as opposed to the two-month critical period used previously) from the 1986-1992 weather period with current day loadings shows that the total loading of phosphorus is 14,370 tons, or an average of 11,240 pounds per day. The loading during the 61-day critical low flow period is 46,789 pounds, or an average of 767 pounds per day (Figure A.1). Also, the source load percentages are nearly inverted, with the loading for point sources being 9 percent of the total Basin loading across a 7-year average, as compared to 65 percent during the critical summer low flow period. Figures A.2 and A.3 compare phosphorus sources during low flow and high flow periods.

The average flow information presented does not pertain to allocations in this particular TMDL, but provides some insight as to the sources of other impairments such as turbidity in the Minnesota River.

During periods of long term average or higher flow, river bank and bluff erosion can also be a source of phosphorus. Phosphorus attaches to sediment. If soil from river banks or bluffs contain phosphorus and erosion takes place, this phosphorus also makes it to water, especially in areas of steep gradients.

Figure A.1 Percent contribution of total phosphorus by sector for the critical low flow period

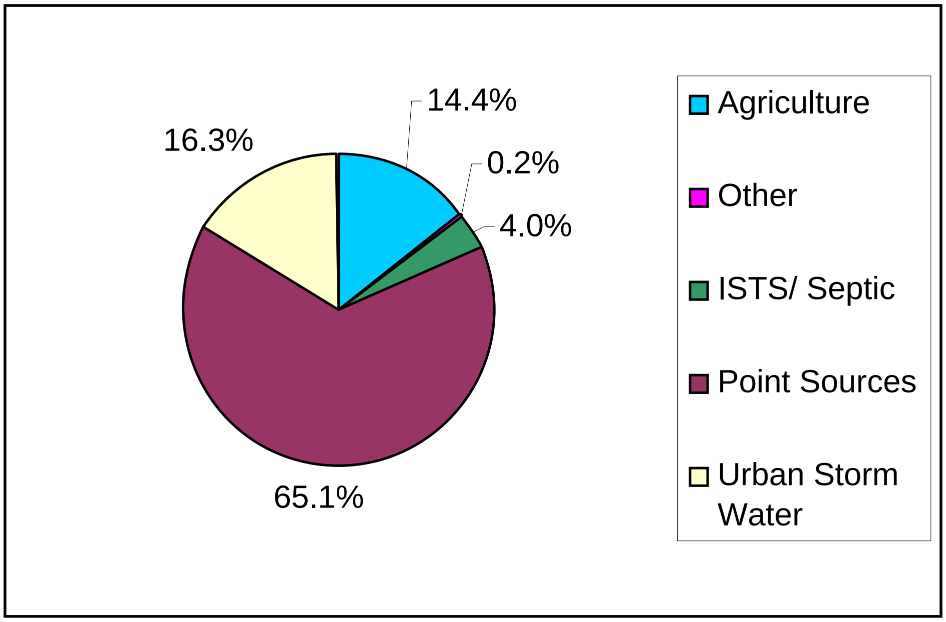


Figure A.2 Percent contribution of total phosphorus by sector over the seven year simulation period

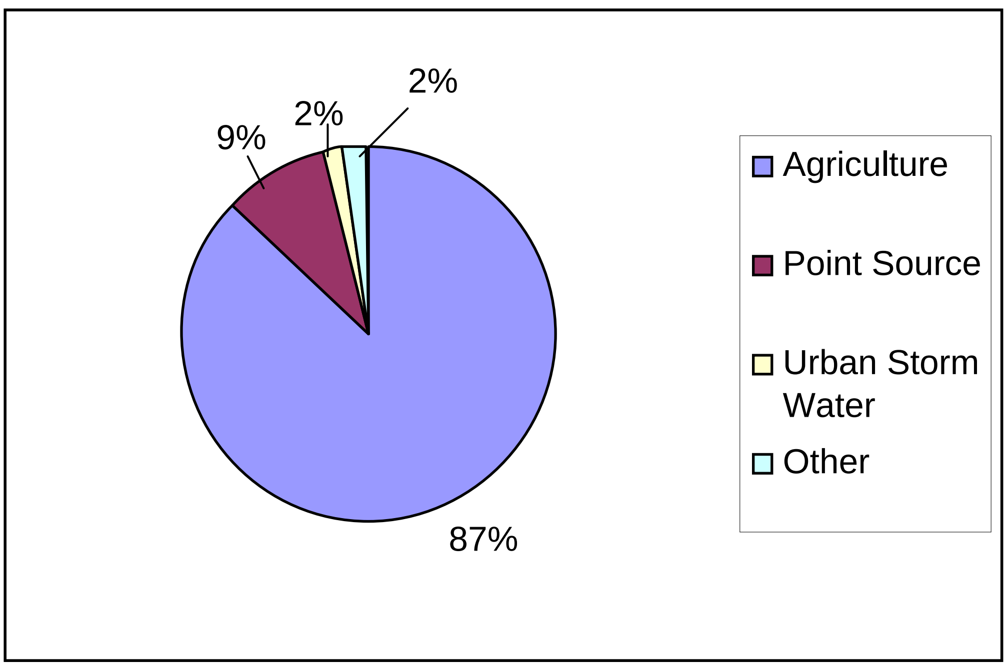
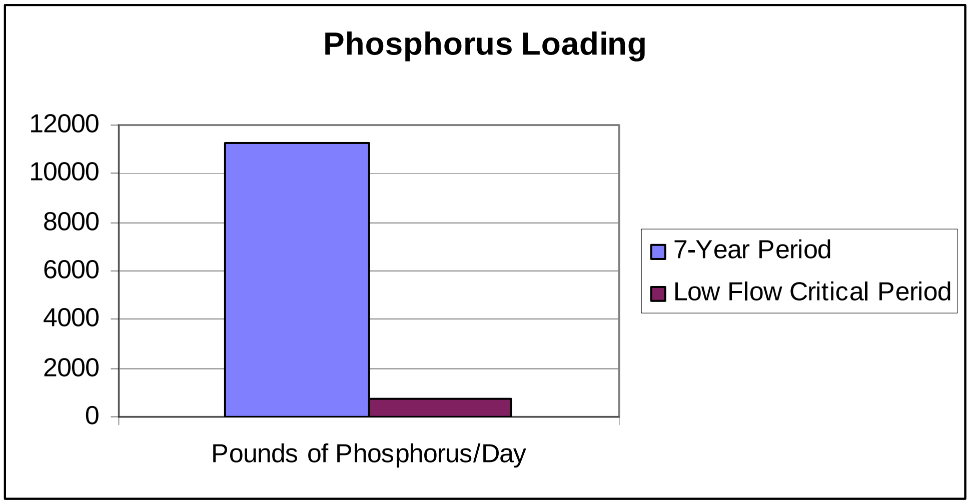


Figure A.3 Comparison of phosphorus loading for the seven-year modeled period and the critical low flow period at Jordan (average daily value)



Appendix B – Impact Coefficient (Scenario 5)

Do point and nonpoint of phosphorus or BOD farther away from Jordan affect the lower Minnesota River? Should phosphorus sources in the Yellow Medicine or Hawk Creek Watersheds do less than sources in the Blue Earth area because they are farther away from the impaired reach? Scenario 5 answered these questions by determining the impact of BOD and phosphorus considering proximity to Jordan and the relative magnitude from each sector.

There are two types of BOD that affect the lower Minnesota River. Most (70 percent) is a function of algae production by excess phosphorus. Second, actual BOD discharges from wastewater treatment facilities and nonpoint runoff containing organic material (30 percent). Table B.1 shows that nearly all BOD at Jordan is more than 100 percent of what is produced at each location.

Table B.1 Impact coefficients for remaining BOD load at Jordan

Map Station See Fig 5.2	Site Name	Impact of BOD at Jordan Compared to BOD at Local Location
1	Upstream Boundary Condition at Montevideo	66 percent
2	Yellow Medicine and Hawk Creek	104 percent
3	Redwood River	129 percent
4	Cottonwood River	309 percent
8	Greater Blue Earth River Basin	330 percent
5	Upper Blue Earth River	197 percent
6	Lower Watonwan River	197 percent
7	Lower Le Sueur River	345 percent
	Upper Le Sueur River (below Waseca)	331 percent
	Upper Redwood River (below Marshall)	102 percent
	Rush River and High Island Creek	262 percent
	Upper Cottonwood River (below Sleepy Eye)	154 percent

*Total BOD Impact represents BOD from point and nonpoint sources plus nutrient related BOD.

The percentages in the right column are a combination of the two sources of BOD (i.e. phosphorus producing algae and BOD discharges). The percentages indicate that excess nutrients are generating enough algae to produce more BOD loading at Jordan than exists upstream in the form of BOD in all watersheds, except the Lake Lac Qui Parle watershed (upstream boundary). If only BOD discharge was considered, the percentages would be much less. However, much of the BOD is caused by the phosphorus-algae cycle. For example, the BOD load measured at the mouth of the Redwood River is fully assimilated prior to reaching Jordan. However, nutrient loading from the Redwood River causes a BOD load at Jordan related to eutrophication that is 29 percent greater than the original load at Redwood Falls. For a closer river such as Rush River, only a portion of the original BOD loading is assimilated prior to passing by Jordan. Hence, the discharged and runoff produced BOD would be added to the BOD produced by phosphorus - a total of 162 percent greater than the original BOD in the Rush River.

This table is critical for confirming that: 1) modeled sources in the 12,200-square-mile study are sources of BOD loading at Jordan and 2) the nutrient related impacts outweigh actual BOD loading from each watershed. This is significant because the phosphorus produces algae and the algae dies, decomposes, and producing BOD and releasing phosphorus that was in the algae. The cycle continues, making it a persistent problem.

Appendix C – Initial Scenario to Balance the Allocation (Scenario 6)

The discussion below is more detailed than that provided in the TMDL. This scenario was developed to demonstrate a potential solution to begin discussions with stakeholders.

Assumptions

Point Sources: 1 mg/l phosphorus effluent limit year round for sites above 1,800 pounds of phosphorus per year at Average Wet Weather Design Flows (approximately 0.2 MGD). The phosphorus load for this trigger is set by consideration of Average Wet Weather Design Flow and Current Concentrations of Phosphorus Effluent.

In the proposed waste load allocation for this scenario (Scenario 6), it was determined to base the allocated load on 75 percent of the Permitted Average Monthly Wet Weather Design flow and the effluent limit of 1 mg/l concentration of phosphorus for these communities.

Agricultural sources: The current day loading from this sector represents about 14 percent of the total origination loading. The agricultural area represents over 70 percent of the land use in the 12,200-mile area modeled.

Assumptions for manure: Manure related nutrient loadings to the river system are handled from field losses and not animal production lot losses. This is necessary from a modeling perspective as the temporal and spatial variability of individual illicit discharges on the Basin scale are difficult, if not impossible, to predict with any accuracy. Two considerations that make this a safe assumption:

1. The Basin scale nutrient loading from animal manure is significantly dominated by row crop releases of phosphorus in runoff. Production lot runoff does not have much of an impact on the Basin scale. In a small watershed, a production lot release of manure can be overwhelmingly detrimental to water quality, but at the Basin scale the nutrient loading from production lots are a small percentage of the overall phosphorus budget (Mulla, 2001). Furthermore, this is a low flow critical period and lack of frequent precipitation events make production lot manure releases even more unlikely as runoff volumes from production lots should reflect the dryer weather patterns.

2. The implementation plan will rely on the new feedlot rules. The MPCA has adopted MN Rules Chapter 7020, Animal Feedlots (Minnesota Rules 2000). The revised rules include more manure management planning to provide adequate protection against manure releases from feedlots. Additionally, these rules require recordkeeping and stronger nutrient management efforts for fields receiving manure via land application. Due to the modifications of the feedlot rules, manure related land use will be compliant with the animal feedlot provisions provided in MN Rules Chapter 7020.

Assumptions for row cropping: The phosphorus released to the environment occurs as both sediment-attached phosphorus in eroded soils and soluble erosion. Two methods of control for phosphorus release were recommended in this scenario: 1) soil erosion control and 2) nutrient management BMPs. To decrease soil erosion, the model included an adoption goal of 75 percent of row-cropped land area to implement conservation tillage (30 percent residue use) or equal BMPs.

Stormwater: Communities and higher density developments in the Basin that are not subject to the requirements for the MS4 general permits were assigned a goal to reduce phosphorus concentrations from impervious surfaces by 20 percent. The goal for MS4 communities is a 30 percent reduction of phosphorus concentrations from impervious surfaces. Because these areas have both pervious and impervious surfaces, an overall goal of 15 percent phosphorus reduction from both pervious and impervious surfaces would be equivalent.

Noncompliant ISTS: Noncompliant individual sewage treatment systems continue to discharge to surface waters via subsurface tile drainage pipes or ditches. The model also assessed small communities and high density lakeshore developments that have septic tanks discharging into surface waters. A 90 percent correction goal was given to the noncompliant ISTS category.

Table C.1 shows the results of this scenario by watershed and sector.

Table C.1 Phosphorus load generated in Scenario 6

	Ag	Non-compliant ISTS	Under-treated Communities	Point Sources	Storm-water	Other Natural and Background	Total
Blue Earth	1,368	68	37	2,519	1,265	16	5,273
Cottonwood	1,125	15	73	658	1,327	35	3,233
Hawk	354	6	154	2,682	699	11	3,906
LeSueur	1,074	93	0	2,121	1,028	35	4,351
Lower Minnesota	3,513	45	0	1,308	1,037	100	6,002
Middle Minnesota	2,088	91	119	8,366	3,174	52	13,890
Redwood	1,033	7	30	3,737	775	52	5,634
Watonwan	850	38	161	1,952	773	8	3,782
Yellow Medicine	227	7	19	54	418	16	741
TOTAL	11,631	370	593	23,397	10,496	325	46,812
	24.8 %	0.8 %	1.3 %	50.0 %	22.4 %	0.7 %	

Appendix D – Watershed Detail

Watershed scale information will be used when developing the detailed implementation plans and effectiveness monitoring plans for individual watersheds or the Minnesota River Basin. This scale can be used as a benchmark to set resource monitoring goals in the effectiveness monitoring plan and as a check to see if the implementation activities are working in a particular area. Data from monitoring stations, BMP adoption tracking, and other changes in management can be used together to track progress toward achieving water quality attainment within the 10 to 20 year implementation window. The HSPF model, which is actually 10 separate models connected, can give watershed managers loading and concentration goals for each of the nine models higher in the Basin system. The modeled area in Figure 5.2 illustrates the level and regional zones in which milestone goals can be provided from the model. The level of effort assessed by using various BMPs in the current model scenarios include the term “or equal” when discussing BMPs. This allows implementation activities to be adapted to local conditions since the BMPs mentioned in the TMDL Report may not be effective in all situations.

Tables D.1 and D.2 can be used by a manager in a watershed to evaluate the progress a particular effort would have on reductions inside a specific source sector. The river concentrations given in Table D.3 can be used with load estimates from local monitoring stations to identify progress on efforts by each isolated major tributary. River concentrations will also be developed for checks on progress and are more useful than loading due to variability in flow across different events or years.

Table D.1 “Current day” total phosphorus loading generated (pounds) by sector (August-September 1988 Hydrology)

	Ag	Non-compliant ISTS	Under-treated Communities	Point Sources	Storm-water	Other Natural and Background Sources	Total
Blue Earth	1,320	511	37	2,808	1,578	-2	6,252
Cottonwood	1,027	113	73	847	1,413	34	3,507
Hawk	292	42	154	5,369	875	11	6,743
LeSueur	1,017	353	0	3,420	1,254	34	6,078
Lower Minnesota	3,334	340	0	3,880	1,278	63	8,894
Middle Minnesota	1,980	679	119	14,908	3,467	-4	21,149
Redwood	1,038	57	30	15,572	975	25	17,697
Watonwan	688	287	161	2,381	943	-9	4451
Yellow Medicine	212	54	19	37	511	16	849
Total	10,907	2,436	593	49,222	12,294	168	75,620
	14.4 %	3.2 %	0.8 %	65.1 %	16.3 %	0.2 %	100 %

Table D.2 Scenario 7 sources of phosphorus loading for the August-September 1988 critical period (pounds)

	Ag	Non-compliant ISTS	Undertreated Communities	Point Sources	Storm-water	Other Natural and Background Sources	Total
Blue Earth	1,136	0	37	2,329	1,265	14	4,781
Cottonwood	858	0	73	629	1,327	35	2,922
Hawk	90	0	154	2,698	699	11	3,652
Le Sueur	806	0	0	2,655	1,028	33	4,522
Lower Minnesota	3,483	0	0	1,789	1,037	99	6,407
Middle Minnesota	1,667	0	119	8,231	3,174	52	13,243
Redwood	855	0	30	3,807	775	52	5,519
Watonwan	591	0	161	1,826	773	7	3,358
Yellow Medicine	184	0	19	54	418	16	691
TOTAL	9,669	0	593	24,018	10,496	319	45,095
Percent	21.3 %	0.0 %	1.3 %	53.3 %	23.3 %	0.7 %	100.0 %

Table D.3. Scenario 7 phosphorus loading at confluence or main stem river locations (pounds) for critical period (August-September, 1988)

	"Current Day" (Scenario 1)	Second Scenario to Balance the Allocation (Scenario 7)	Projected Daily Average Loading pounds/day
Chippewa	3,714	1,637	26.8
Hawk	4,764	1,603	26.3
Yellow Medicine	159	113	1.9
Redwood	14,239	1,137	18.6
Cottonwood	430	325	5.3
Watonwan	1,042	346	5.7
Le Sueur	2,814	2,003	32.8
total Blue Earth	2,174	1,063	17.4
at Mankato	30,001	4,693	76.9
at Jordan	19,105	1,002	16.4

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