LAKE ST. CROIX NUTRIENT TOTAL MAXIMUM DAILY LOAD

May 2012

Prepared in Partnership
by
Minnesota Pollution Control Agency
Wisconsin Department of Natural Resources

With
St. Croix Basin Water Resources Planning Team
Science Museum of Minnesota, St. Croix Watershed Research Station
Barr Engineering Company

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Cover photo courtesy of Randy Ferrin. This photo was taken on June 20, 2010, in a backwaters area of the St. Croix River near Log House Landing in Scandia, MN.

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List of Abbreviations:

ac	acre(s)
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CAFO	Concentrated Animal Feeding Operation
DATCP	Wisconsin Department of Agriculture, Trade, and Consumer Protection
ha	hectare(s)
ISTS	Individual Subsurface Treatment Systems
kg	kilogram(s)
lb	pound(s)
mg/L	milligram per liter (part per million)
mgd	million gallons per day
MDA	Minnesota Department of Agriculture
MDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MCES	Metropolitan Council Environmental Services
NCHF	North Central Hardwood Forest ecoregion
NLCD	National Land Cover Dataset
NLF	Northern Lakes and Forest ecoregion
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
ORVW	Outstanding Resource Value Water
RIBs	Rapid Infiltration Basins
SCWRS	St. Croix Watershed Research Station, Science Museum of Minnesota
SWAT	Soil and Water Assessment Tool watershed model
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	total phosphorus
UW	University of Wisconsin
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System
WQBELs	Water quality based effluent limits
yr	year(s)
µg/L	microgram per liter (part per billion)

TMDL SUMMARY TABLE	
Waterbody	Lake St. Croix MDNR Identification Code: 82-0001, WDNR Identification Code: 2601500
Location	Washington County, MN St. Croix and Pierce Counties, WI
303(d) Listing Information	Impaired Beneficial Use: Aquatic Recreation Impairment/TMDL Pollutant of Concern: Excessive Nutrients (Phosphorus)
Applicable Water Quality Standards/ Numeric Targets	<u>Minnesota Water Quality Standards</u> Deep Lake Eutrophication Standards (North Central Hardwood Forests): 40 µg/L Total Phosphorus 14 µg/L Chlorophyll a 1.4 m Secchi disc transparency <u>Wisconsin Water Quality Standards</u> 75 µg/L Total Phosphorus <u>St. Croix Basin Water Resources Planning Team</u> Numeric Targets, 2004. (May-September median): 40 µg/L Total Phosphorus 12 µg/L Chlorophyll a 1.5 m Secchi disc transparency
TMDL Goal (Total Loading Capacity)	2,172.8 lbs/day (360.000 metric tons/yr) of Total Phosphorus
TMDL Allocations	Wasteload Allocation: 240.9 lbs/day (39.924 metric tons/yr) Load Allocation: 1,790.3 lbs/day (296.604 metric tons/yr) Reserve Capacity: 29.0 lbs/day (4.816 metric tons/yr) Tribal Load: 4.0 lbs/day (0.656 metric tons/yr) Margin of Safety: 108.6 lbs/day (18.000 metric tons/yr)

1. Introduction and Summary

The St. Croix River and Lake St. Croix are highly valued resources that provide exceptional recreational opportunities and support a highly diverse ecology of aquatic and terrestrial species. However, over the years eutrophication, or nutrient enrichment, has occurred in Lake St. Croix due to excess phosphorus loading. This loading drives nuisance algae blooms which diminish the enjoyment and use of the lake. This report represents an important step in the improvement of Lake St. Croix by focusing on establishing the needed reduction in the loading of phosphorus from its contributing basin in order to achieve water quality standards.

The St. Croix River basin (Figure 1) represents a large area—approximately 7,760 square miles—with 44 percent of the basin land area (excluding water and wetlands) located within Minnesota and 56 percent within Wisconsin. It includes portions of the Northern Lakes and Forests (NLF), North Central Hardwood Forests (NCHF) and a small portion of the Western Corn Belt Plains (WCBP) ecoregions. The St. Croix River originates near Solon Springs, Wisconsin, and flows west and south more than 160 miles until it joins the Mississippi River at Prescott, Wisconsin. Lake St. Croix is a naturally impounded riverine lake in the lower 25 miles of the St. Croix River.

Worried that continued development and other urban stressors would put the natural resources of the St. Croix River watershed at risk, concerned citizens and legislators during the 1960s pushed for the St. Croix to be included in the original National Wild and Scenic Rivers Act. The St. Croix National Scenic Riverway, which includes the Namekagon River in Wisconsin and the upper portion of the St. Croix, was established as part of that original Act in 1968. The Lower St. Croix National Scenic Riverway was added in 1972.

In addition both Minnesota and Wisconsin have created further protective designations. Minnesota has designated the entire St. Croix and its Kettle River tributary as Outstanding Resource Value Waters (ORVW). Wisconsin has designated portions of the St. Croix as Exceptional Resource Water and the remainder as an Outstanding Resource Water. Wisconsin has also declared its tributary, the Namekagon River, an Outstanding Resource Water.

Under Minnesota Law ORVW designation means that no new or expanded discharge of any sewage, industrial waste, or other waste is allowed unless there is no prudent, feasible alternative to the discharge. If allowed, the discharge is restricted to the extent necessary, to preserve the existing high quality, or to preserve the wilderness, scientific, recreational, or other special characteristics that make the water an ORVW. Under Wisconsin Law, an Outstanding Resource Water designation requires water quality of any discharge to match the background quality of the river and an Exceptional Resource Water designation means the water quality of any discharge must match the background quality of the river, unless there are compelling environmental, public health, social, or economic reasons to meet lower standards for sustaining fish and aquatic life.

The federal Clean Water Act requires states to identify water bodies or stream segments that are not meeting state water quality standards and designated uses, and place them on the USEPA impaired waters list. Once listed, the State is required to quantify the amount of a specific pollutant that a listed water body can receive without violating applicable water quality standards and to apportion that allowable load among the sources of the designated pollutant. The maximum allowable pollutant quantity is referred to as the Total Maximum Daily Load (TMDL). A TMDL is the sum of the allowable loads of a single pollutant from all contributing sources. Lake St. Croix was first listed on both the Minnesota and the Wisconsin 2008 303(d) Impaired Waters List due to eutrophication (excess phosphorus).

This TMDL was a collaborative effort among the Minnesota Pollution Control Agency (MPCA), Wisconsin Department of Natural Resources (WDNR) and the St. Croix Basin Water Resources Planning Team (St. Croix Basin Team). The primary components of the TMDL were largely based on the results of past lake and nutrient loading studies. The key outcomes of these studies and this TMDL are as follows:

- Lake St. Croix's total annual loading capacity needed to meet an in-lake total phosphorus water quality standard of 40 µg/L is 360 metric tons/yr.
- The lake's "current" loading (using a 1990s baseline) is 460 metric tons/yr, meaning a 100 metric ton/yr reduction would be needed. However, this TMDL adopts a margin of safety and a reserve capacity which increases the needed load reduction to about 123 metric tons/yr. This equates to an overall needed phosphorus load reduction of 27 percent.

In order to meet this reduction goal and restore Lake St. Croix water quality, communities and landowners in the St. Croix Basin will need to reduce stormwater runoff from urban and agricultural land and limit wastewater treatment discharges. Restoration of water quality in Lake St. Croix depends upon local support as many phosphorus reduction activities will require voluntary efforts on privately owned land areas. Effective watershed management involves state and local government agencies, non-profit agencies and citizens all working together to sustainably manage local water resources.

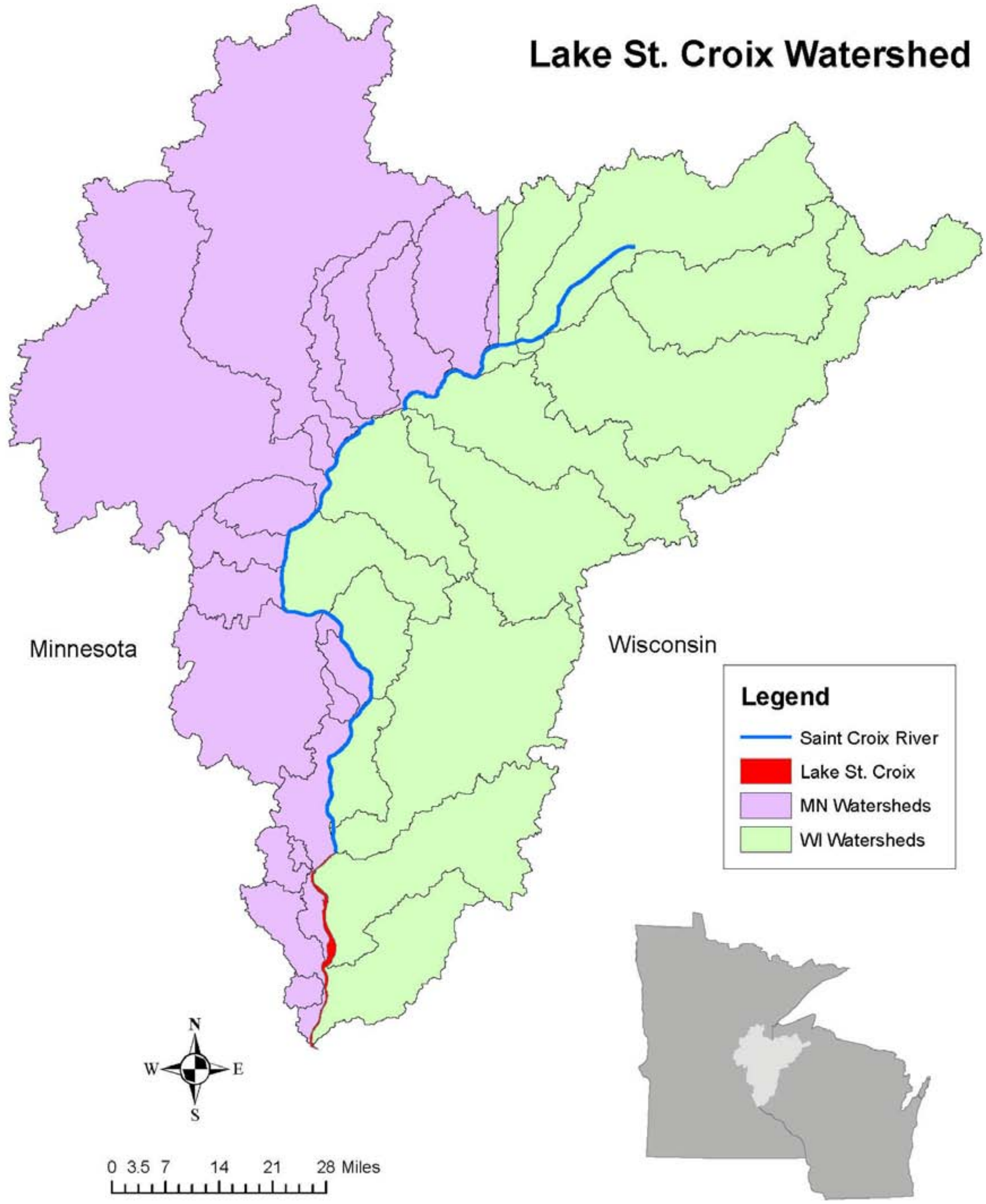


Figure 1. St. Croix Watershed and Location Map

2. Description of Lake St. Croix and St. Croix River Basin

2.1 Lake Morphometry

Lake St. Croix (MDNR Identification Code: 82-0001; WDNR Identification Code: 2601500) consists of a four pools downstream of Stillwater, Minnesota: Bayport, Troy Beach, Black Bass, and Kinnickinnic Pools (Figure 2). Morphometric data for each of the Lake St. Croix Pools are shown in Table 1.

Table 1. Morphometry of the Lake St. Croix pools based on average water level during May through September, 1999 (Robertson and Lenz, 2002)

Pool Name	Length (km)	Area (km^2)	Volume (m^3x10^6)	Mean Depth (m)
Bayport	9.7	11.3	77.1	6.8
Troy Beach	9.7	12.7	133.0	10.5
Black Bass	11.3	5.5	73.6	13.5
Kinnickinnic	8.1	5.8	57.1	9.8
Lake St. Croix (total)	**38.8**	**35.3**	**340.8**	**9.7**

Water residence times are on the order of 20 to 49 days for the whole lake, depending on season and precipitation (Table 2). Three large tributaries (the Apple, Kinnickinnic and Willow Rivers) enter the St. Croix River downstream of St. Croix Falls and increase the flow through the lake by approximately 11 percent.

Table 2. Water Residence Time (days) in the Lake St. Croix Pools Modified from (Robertson and Lenz, 2002)

Pool Name	Dry Year	Wet Year
Bayport	11	5
Troy Beach	19	8
Black Bass	11	4
Kinnickinnic	8	3
Lake St. Croix (total)	**49**	**20**

Runoff and precipitation frequency curves, developed for the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr 2004), showed that flows during the period of 1979-2002 were not significantly different than the long-term period of record for the St. Croix River Basin. In general, the rainfall and runoff volumes typically decrease from the eastern edge to the western edge of the St. Croix Basin (Barr 2004). The estimated water yield percentage (measured flow as a percentage of water year precipitation) in the St. Croix Basin ranges from approximately 24 percent, during dry conditions, to 38 percent under wet conditions (Barr 2004).

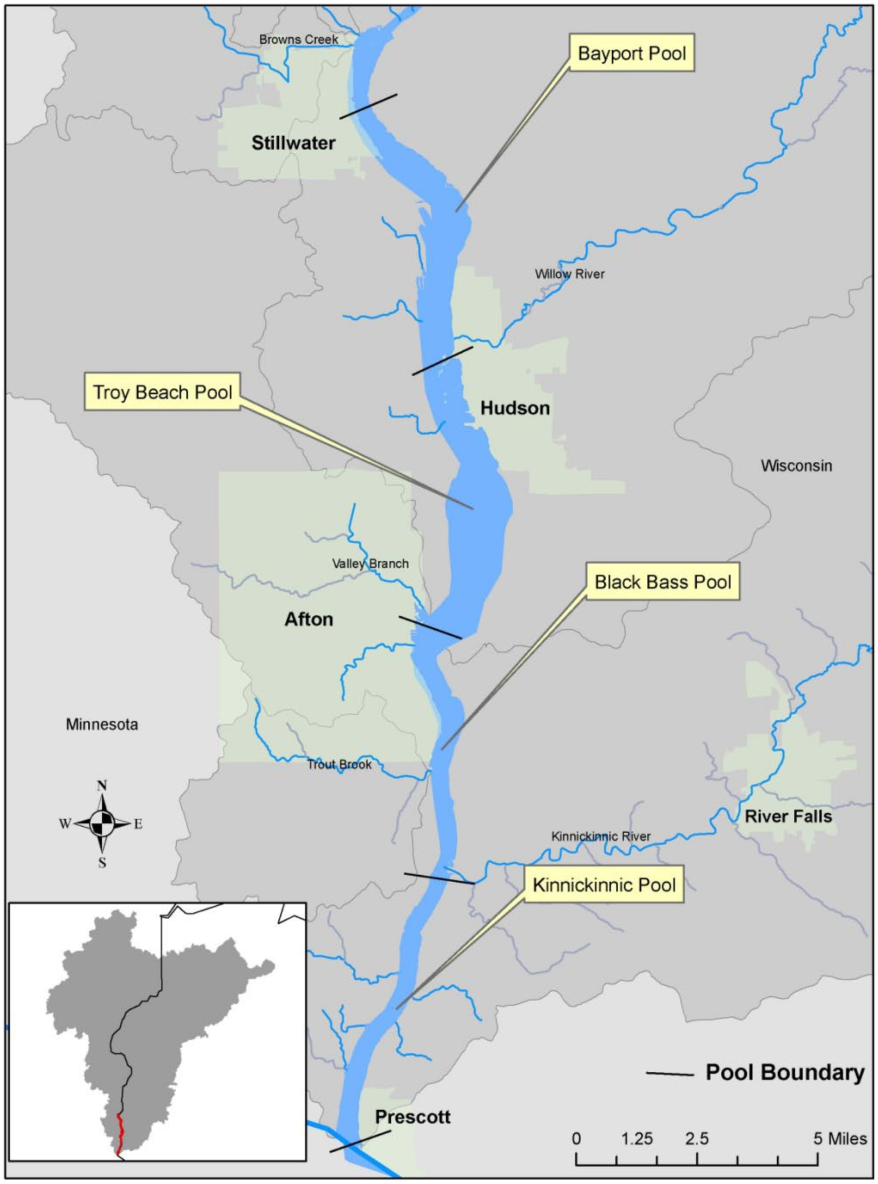


Figure 2. Lake St. Croix Location and Pools

2.2 Basin Hydrology

The St. Croix River is a sixth-order stream, draining an area of 20,098 square kilometers (7,760 square miles). The river is largely free-flowing with the exception of a four meter high dam at Gordon, WI which impounds 774 ha of water in the main-stem, and an 18 meter high hydroelectric dam at St. Croix Falls, WI and Taylor Falls, MN which impounds 314 ha. The final 26.4 km of the main-stem includes Lake St. Croix, a natural lake covering 1,889 ha. The lake formed after the formation of an eight kilometer land spur which narrows the river channel to 0.2 km. The water level in the lake is significantly influenced by the Mississippi River. Average annual mean discharge at St. Croix Falls from 1931 to 1982 was 120 cubic meters per second (m^3/sec), or 4,238 cubic feet per second (cfs). The permitted design flows of wastewater facilities in the basin total 38.6 million gallons per day (Appendix A). (This total excludes the very large cooling water discharge from the Xcel Alan S. King Power Plant since the cooling water is also withdrawn directly from the St. Croix.) The total wastewater flow is equal to 60 cfs, or less than 1.5% of the annual mean discharge. Groundwater contributions stabilize flows during periods of low precipitation. The basin drainage network is illustrated in Figure 3.

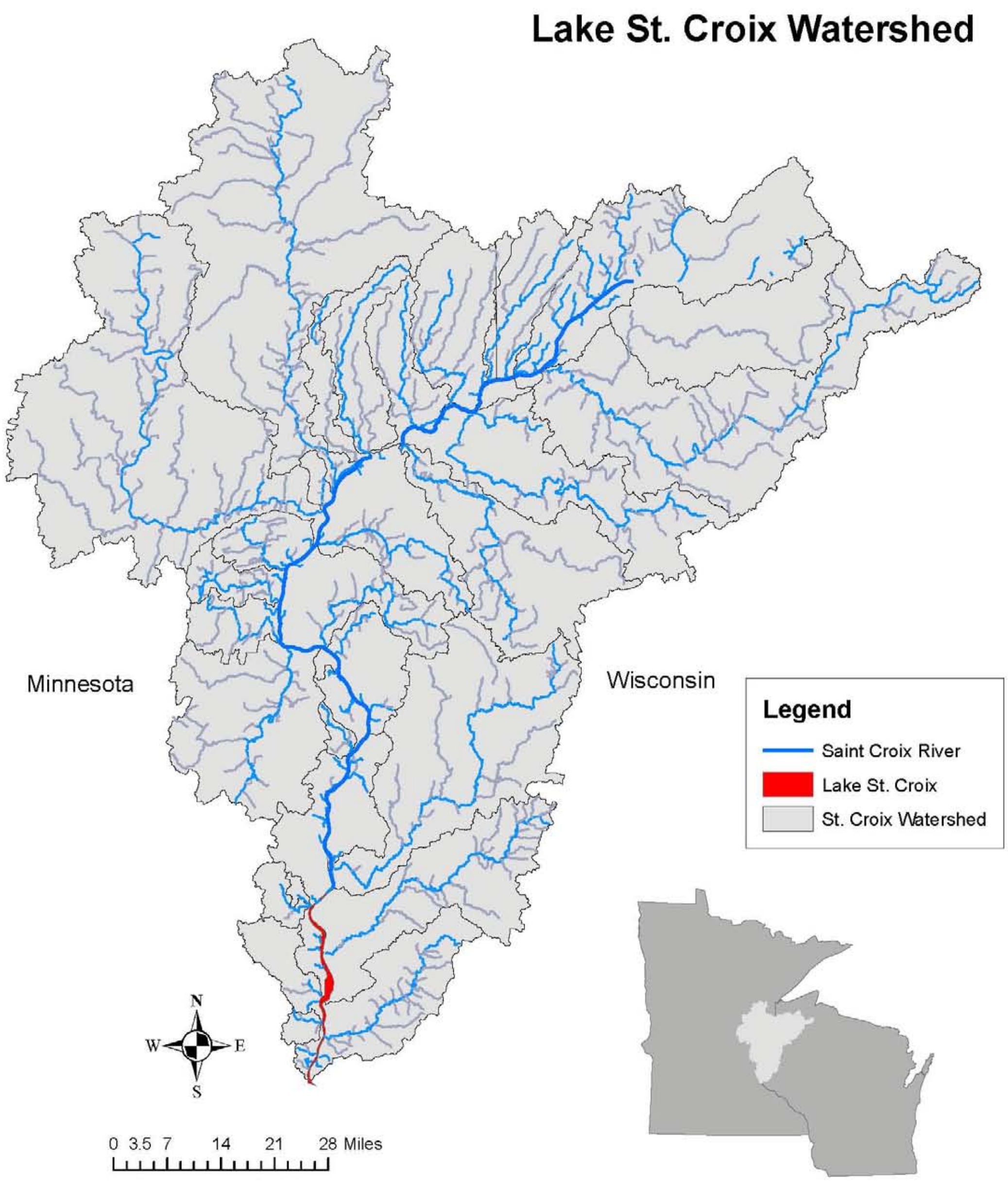


Figure 3. St. Croix Drainage Area

2.3 Basin Geology and Soils

Bedrock in the upper St. Croix includes Precambrian basalt and Precambrian granite and sandstone on the west and Cambrian sandstone and shale on the east. Large flows of glacial meltwater eroded the bedrock for 1400 to 1500 years. At Taylor Falls, erosion resistant basaltic rock forms the steep-sided St. Croix Dalles, a deep gorge cut by runoff from Glacial Lake Duluth into ancient bedrock (Harris et al. 1997). The St. Croix Basin is predominantly covered with medium to coarse, sandy glacial deposits.

2.4 Basin Land Use

Historical Land Use

Prior to European settlement, the northern two thirds of the upper basin were dominated by Great Lakes Pine Forest and peatlands. The southern third of the upper basin, including the Wood, Trade and southern Snake Basins, was dominated by northern hardwood forest and oak woodland.

The lower basin land was covered primarily with oak, but eastern Washington County, Minnesota, and large portions of Polk and St. Croix Counties, Wisconsin, were covered with upland prairies of blue stems, Indian grass, needle grass, grama grass, and a variety of composite forbs. Following the Treaty of 1837, the United States obtained the St. Croix delta from the Dakota and Ojibwe and proceeded to log that area heavily. From 1839 to 1914 more than 15 billion board feet of timber were removed.

Agriculture gradually replaced logging as the primary land use. Land productivity, however, was poor and significant portions of the basin reverted to forest (Harris et al. 1997). The forested land is primarily second growth aspen, birch, maple, basswood, lowland hardwood, and oak-hickory forest. One national forest, ten state forests, 11 state parks, six wildlife management areas and one state wild river property, located wholly or partly within the basin occupy much of the forested land.

Dairy farming and row-crop agriculture are an important component of the basin’s land use, particularly in the southern half of the Wisconsin portion of the basin.

Existing (1990s) Land Use / Land Cover

The 1992 National Land Cover Dataset (NLCD) was adopted as the base-line land use / land cover for this TMDL (Figure 4). The 1992 NLCD coverage is the only consistent basin-wide dataset representing the decade of the 1990s. Standard GIS methods were used to determine the areas in the 17 relevant 1992 NLCD land categories. For subsequent analysis, the 1992 NLCD coverage was condensed into six categories: agricultural, forest, grassland, shrubland, urban, and water (Table 4).

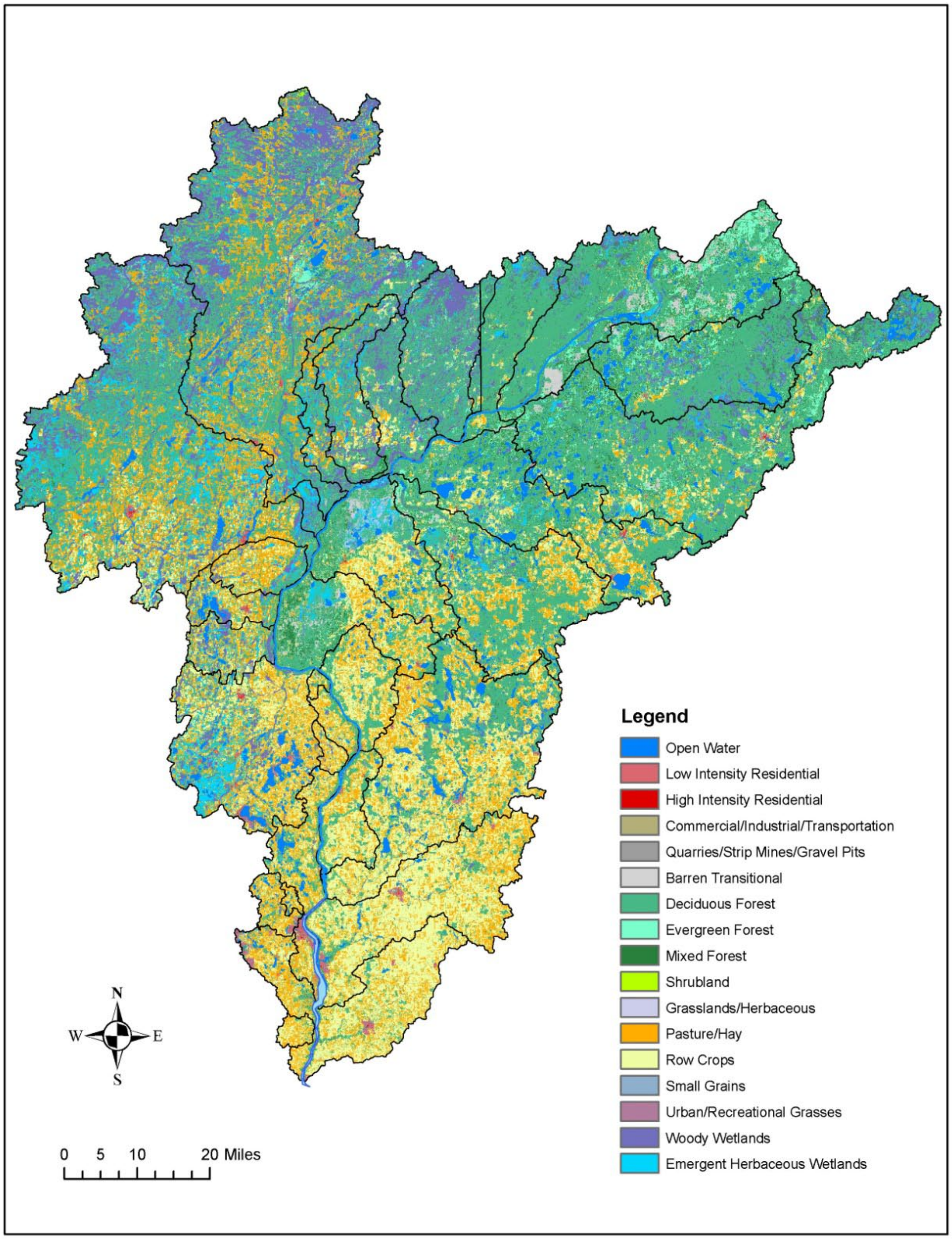


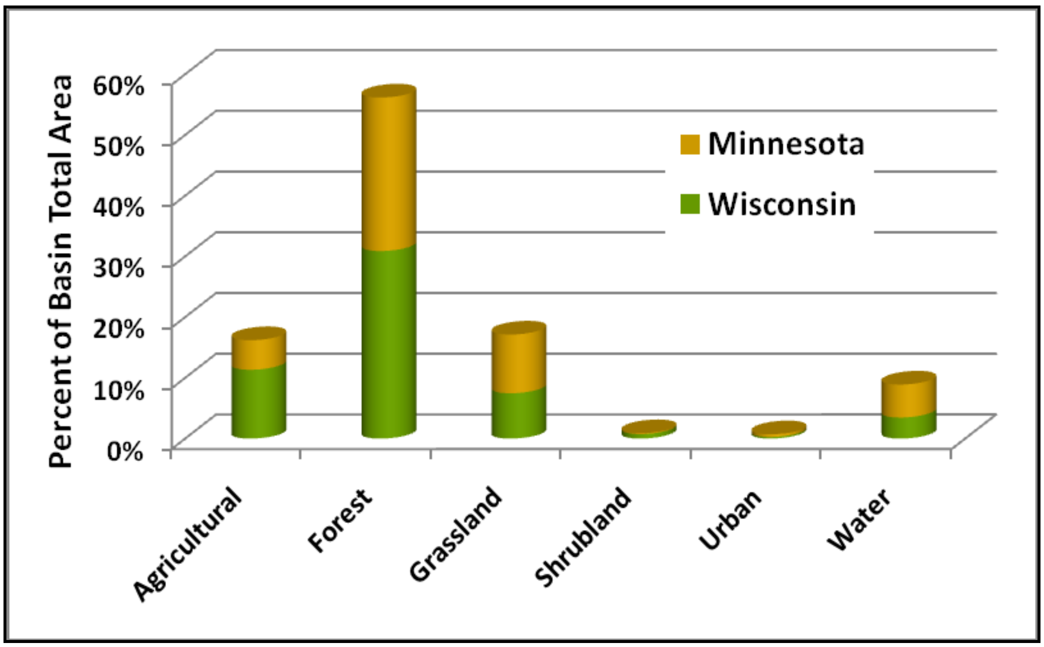
Figure 4. St. Croix Basin Land Use (1992 NLCD)

Table 3. Aggregation of NLCD 1992 Land Use/Land Cover Categories for TMDL

TMDL Category	1992 NLCD Categories
Agricultural	Row Crops + Small Grains
Forest	Deciduous Forest + Evergreen Forest + Mixed Forest + Woody Wetlands
Grassland	Grasslands/Herbaceous + Pasture/Hay + Urban / Recreational Grasses
Shrubland	Barren Transitional + Shrubland
Urban	Low Intensity Residential + High Intensity Residential + Commercial/Industrial/Transport + Quarries/Strip Mines/Gravel Pit
Water	Open Water + Emergent Herbaceous Wetlands

Under existing (1990s) conditions, forest is the main land use / land cover in the St. Croix Basin, representing 56.2% of the total area (Figure 5). The high proportion of forest cover is one of the primary reasons why water quality in the St. Croix is as good as it is. Forest is especially predominant in the uppermost watershed, where it comprises 80% to 90% of the Namekagon, Totagatic, Upper St. Croix, Upper and Lower Tamarack, and Crooked subwatersheds.

Figure 5. Land Use /Land Cover Summary



Grassland and agricultural land comprise another 33.3% of the Basin. (Pasture and hay make up nearly all – 97% – of the grassland in the Basin.) These areas of higher P export are concentrated in the southern third of the Basin. The percentage of agricultural-plus-grassland is in the 60% to 80% range in all of the tributary subwatersheds south of the Trade River on the Wisconsin side and the Sunrise on the Minnesota side. This area includes the Apple, Wolf, Willow, and Kinnickinnic subwatersheds in Wisconsin, and the easterly portion of the Twin Cities Metro area in Minnesota.

Thus, forest, agricultural, and grassland represent 89.5% of the St. Croix Basin. Most of the remaining area (8.9%) is water (including wetland). Shrubland (0.9%) and urban areas (0.7%) make up the remainder of the Basin.

Note that "urban" land use / land cover is *not* synonymous with "city" or "municipal" area. There are 25 regulated Municipal Separate Storm Sewer Systems (MS4s) in the Basin, but their areas are mostly non-urban (~90% non-urban on average). At the same time, most of the Basin's urban area is *not* in these 25 MS4s, but in other, smaller communities (which account for ~80% of the Basin's urban area).

Table 4 presents the same data as shown in Figure 5 but in area units (acres).

Table 4. Land Use/Land Cover Areas (NLCD 1992)

	Area in Land Use / Land Cover* (acres)						
Basin part	**Agricultural**	**Forest**	**Grassland**	**Shrubland**	**Urban**	**Water**	**Total**
Minnesota	239,253	1,241,595	474,935	6,698	22,023	266,687	2,251,192
Wisconsin	556,639	1,517,071	366,560	36,534	12,765	170,444	2,660,014
Basin	**795,892**	**2,758,665**	**841,496**	**43,233**	**34,789**	**437,131**	**4,911,206**

Appendices B, C, and D include tables of detailed land use/land cover data in units of hectares (Tables B-1, C-1, and D-1) and acres (Tables B-1, C-1, and D-1), as follows:

- Appendix B, Tables B-1 and B-2 – areas by tributary subwatersheds
- Appendix C, Tables C-1 and C-2 – areas for regulated MS4s
- Appendix D, Tables D-1 and D-2 – areas for tribal lands

2.5 Basin Water Quality

Water quality samples were collected from ten stations on the St. Croix and its tributaries between 1975 and 1983 at time scales ranging from annually to bimonthly by the United States Geological Survey (Harris et al. 1997). Mean total phosphorus concentrations were always less than 0.1 mg/L.

Available data indicate that water quality in the St. Croix River is generally good when compared to other large Midwestern rivers. Instantaneous loading rates calculated for events in 1997 and 1998 demonstrated that loading during storm events was a large portion of the annual loading of the St. Croix River tributaries, like the Willow River. During the study period, storm events affecting the southern tributary basins were few and small, resulting in loads and yields that were correspondingly small. In contrast, storm events affecting northern tributaries were more frequent and more intense, leading to higher loads and yields (Lenz et al. 2001).

Annual loads for 1999 in the southern St. Croix River Basin tributaries probably were lower than the long-term average loading rates. Trend analyses of loading rates in the St. Croix River Basin are not possible without long-term data. Loading during storm events appears to be a large portion of the nutrient and suspended-sediment loading from tributaries to the St. Croix River. In some cases, a single event contributed most of the annual load of a given tributary. Because of the importance of event loads in the St. Croix River Basin, a single year of data collection was not adequate to fully evaluate the variability among tributaries in annual tributary loading. Results from limited-length sampling depend highly on weather patterns and the amount and duration of runoff throughout the basin during the study period (Lenz et al. 2001).

The disparities in runoff caused by climatological factors throughout the basin may be more important to 1999 annual tributary loading than variability in land use and environmental characteristics. The 1999 water year annual loads and yields calculated in monitored tributaries to the St. Croix River had lower standard errors of prediction than the loads and yields calculated for unmonitored tributaries using relations between annual yields and environmental characteristics. Because of the climatological variability in the basin, relations between annual yields and environmental characteristics of the tributary basins were poorly defined resulting in large errors when predicting annual loads and yields in the unmonitored basins (Lenz et al. 2001).

The average in-lake water quality for Lake St. Croix over the period from 1998 to 2006 was 51 µg/L total phosphorus, 20.5 µg/L chlorophyll-a (a measure of algae) and 1.2 m Secchi disk (a measure of water clarity).

3. Water Quality Goals

In Minnesota, Lake St. Croix is classified as a Class 2B, 3C, 4A, 4B, 5, and 6 water. The most protective of these classes is Class 2B and is defined in Minn. Rules 7050.0222, Subp. 4 as follows:

> Class 2B waters. The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water.

In Wisconsin all surface waters shall be suitable for fish and aquatic life, recreational, public health and welfare, and wildlife uses (NR 102.04 pars. (3) to (8)). Waters identified as cold to warmwater fish communities outlined in NR 102.04 (3) pars. (a) to (c), shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community.

During the 2002-2008 303(d) assessment cycles, Minnesota's lakes were assessed for nutrient impairment (excess phosphorus) based on the narrative water quality standard and numeric translators as described in Minnesota Rules 7050.0150 and accompanying assessment guidance. To be listed as impaired, the monitoring data must show that the standards for both total phosphorus (the causal factor) and either chlorophyll-*a* or Secchi disc depth (response factors) are not met. Lake St. Croix was listed as impaired for aquatic recreation in 2008, based on the numeric translators for the North Central Hardwood Forests (NCHF) ecoregion. Since then, Minnesota's lake eutrophication standards were promulgated into rule (Ch. 7050) and are now the basis for assessing nutrient impairment and drafting TMDLs for impaired (listed) Minnesota lakes (Table 5).

At the time of Minnesota's 303(d) listing of Lake St. Croix, and throughout most of the TMDL process, the State of Wisconsin did not have lake eutrophication (nutrient) criteria. Wisconsin's numeric phosphorus standards took effect December 1, 2010, and are provided in Wisconsin Rules Chapter NR 102. The Wisconsin phosphorus standard for Lake St. Croix is 75 µg/L. Wisconsin lake standards apply to either reservoirs with a constructed outlet, or lakes or flowages that do not generally "exhibit unidirectional flow." Lake St. Croix, being a natural, riverine lake, does not meet these criteria, as there is no constructed outlet, and unidirectional flow is measured at Stillwater (the head end of the lake) and also at Prescott (the mouth of the lake). The standard in NR 102.06(3)b of 75 µg/L is applicable in this case, covering all waters not specifically listed by name in the code that "generally exhibit unidirectional flow." However, the St. Croix Basin Team has proposed that a standard of 40 µg/L total phosphorus, the same as Minnesota's standard, be used instead based on extensive study indicating that this level best represents the unimpaired state of the lake in the 1940s before phosphorus loading increased significantly. A combination of historical sediment loading (Triplett et al., 2009) and reconstructed in-lake phosphorus concentrations were used to determine the relationship between phosphorus loading and resultant in-lake water phosphorus concentrations in Lake St. Croix (Davis 2004). It is expected that by achieving 40 µg/L the lake will achieve very beneficial recreational and ecological outcomes, specifically: 1) it will limit the frequency of nuisance algae conditions and 2) it will switch the lake back from a planktic (free-floating) algal community to a more desirable benthic (bottom-dwelling) diatom algal community. (See Section 5.2 for more detailed discussion on the basis of the proposed phosphorus endpoint.) In addition to the Basin Team's recommendation of 40 µg/L, the USEPA requires that in situations where multiple states share a water body that the more stringent of the states' water quality standards apply for TMDLs.

Chlorophyll-a and Secchi disc depth targets are also established for this TMDL. Minnesota's applicable chlorophyll-a and Secchi disc standards are 14 µg/L and 1.4 m, respectively. The St. Croix Basin Team has set goals of 12 µg/L and 1.5 m, respectively. Minnesota uses a June-September mean, whereas the St. Croix Basin Team uses May-September median. (Wisconsin does not have chlorophyll-a and Secchi disc standards.) Table 5 provides applicable water quality standards and Basin Team goals. It is expected that by achieving the 40 µg/L TP endpoint that both Minnesota's and the St. Croix Basin Team's chlorophyll-a and Secchi disc targets will be met. However, for the purpose of this TMDL and USEPA approval Minnesota's standards will be used.

Table 5. Lake St. Croix Minnesota and Wisconsin Standards and Basin Team's Goals

Water Quality Parameter	Minnesota Standards (NCHF Ecoregion, deep lakes)	Wisconsin Standards	St. Croix Basin Team Goals
Averaging Period	June-September mean		May-September median
Total Phosphorus, µg/L	40	75	40
Chlorophyll-a, µg/L	14		12
Secchi disc transparency, m	1.4		1.5

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

4. Phosphorus Source Overview

The following provides a general overview of the phosphorus sources in the basin. More detailed information on loading from the various source categories and reductions needed is provided in Section 5. A full list of permitted point sources is provided in Appendix A.

4.1 Point Sources

Point sources in this TMDL are considered those entities that operate under the National Pollutant Discharge Elimination System (NPDES) Permit Program. They all fall within the wasteload category for the purposes of a TMDL. The point sources in the St. Croix Basin include: municipal and industrial wastewater, regulated stormwater, and concentrated animal feeding operations (CAFOs).

Municipal and Industrial Wastewater

There are 52 wastewater facilities, municipal and industrial, that discharge to surface waters located in Wisconsin, Minnesota and on St. Croix Chippewa Indians of Wisconsin land, as well as operations authorized by various categories of Wisconsin Pollutant Discharge Elimination System (WPDES) General Permits (See Appendix A). Both states have adopted comparable regulations which require that NPDES permitted facilities meet effluent phosphorus limitations based on the magnitude of the discharge. Both states established requirements for phosphorus treatment to a one mg/L effluent concentration if a permitted wastewater source discharges 1,800 lbs. or more of phosphorus per year.

Regulated Stormwater Discharges

There are 230 municipalities in the St. Croix Basin. Only one to two percent of the basin's land area is used for urban and commercial development. Most of the urban or developed land area is located in the lower portion of the basin. There are 21 municipalities (see Appendix A) in Minnesota and two in Wisconsin that are regulated by Municipal Separate Storm Sewer System (MS4) permits. Hudson and North Hudson, Wisconsin are also included in the regulated stormwater load and assigned a wasteload allocation in this TMDL because they will become permittees in the near future. See Figure 6.

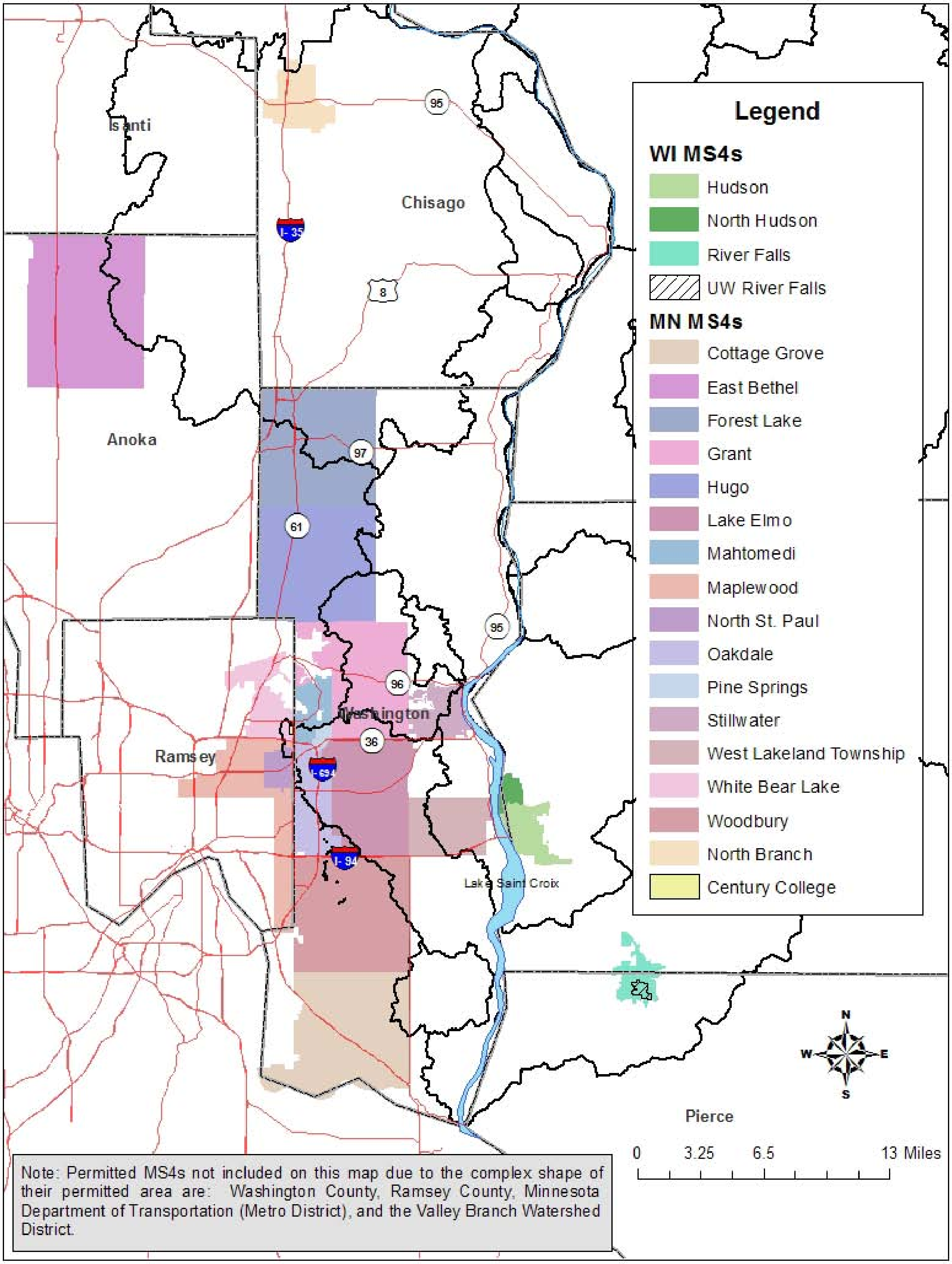


Figure 6. St. Croix Basin Regulated MS4s

CAFOs

There are ten CAFOs in the St. Croix Basin (see Appendix A). Although these facilities have the potential to contribute phosphorus from manure stored on site, they are not allowed to release any pollutant containing runoff from their production areas. However, one CAFO (Emerald Dairy in Wisconsin) does have a permitted discharge as part of its operation with a phosphorus limit.

4.2 Nonpoint Sources

Nonpoint sources of phosphorus include both anthropogenic and natural background sources. They fall within the load category for the purposes of a TMDL.

Anthropogenic Sources

Anthropogenic sources include agriculture, forestry, stormwater runoff from urban or other areas that are not subject to a NPDES permit, and stream channel and ravine erosion (due to land use management affecting hydrology). Agriculture is the most significant phosphorus contributor of these sources in the basin and the primary pathways for phosphorus transport are via stormwater runoff from cropland, pastureland and feedlots. Atmospheric deposition of windblown soil from exposed croplands can occur as well.

Natural background Sources

Natural background sources include surface runoff from the natural landscape, background stream channel erosion, groundwater discharge and atmospheric deposition of windblown particulate matter from the natural landscape.

Internal loading of phosphorus in Lake St. Croix is an additional nonpoint source, which can be of both anthropogenic and natural origin. This loading is primarily from release of phosphorus from lake sediments or aquatic plants.

Tribal Lands

Tribal land areas represent another land category in the St. Croix Basin. Tribal lands have been evaluated using GIS (computer mapping) data to establish an accurate account from all basin land area phosphorus loads. In order to balance the TMDL equation, phosphorus loading from these land areas will be identified, but no reductions are required due to their not being part of the states' jurisdiction.

Portions of land areas owned by the Mille Lacs Band of Ojibwe and the Fond du Lac Band of Chippewa are located on the Minnesota side of the St. Croix River Basin. The St. Croix Reservation in Wisconsin has many established communities. The five major communities are Sand Lake, Danbury, Round Lake, Maple Plain, and Gaslyn, on land in Barron, Burnett, Polk and Douglas Counties. The reservation size is 4,689 acres, with a population of 2,909. The St. Croix Band of the Chippewa operates a community wastewater treatment system to serve tribal homes and businesses in the Sand Lake Community (west of Hertel, Wisconsin).

5. Total Maximum Daily Load

5.1 Overview

A TMDL is the maximum amount of a pollutant that a water body can receive and still meet water quality standards. The "amount of a pollutant" is expressed more precisely as a *mass rate* of input. A pollutant's mass rate of input is also called a *pollutant load*, or *loading*, and the term *loading capacity* is synonymous with the TMDL. For Lake St. Croix, the TMDL for phosphorus is stated in units of *metric tons per year* (for consistency with previous scientific studies that led up to the TMDL) and *pounds per day*. Because the Clean Water Act emphasized wastewater discharges to rivers when it became law in 1972, all TMDLs are daily loading rates, at least nominally. But TMDLs for most lakes, including Lake St. Croix, are more meaningful as annual loading rates because lakes respond to loading changes slowly, not (as rivers do) instantaneously. The determination of Lake St. Croix's phosphorus loading capacity (phosphorus TMDL) is described in the next section.

After determining the Lake St. Croix's phosphorus loading capacity (phosphorus TMDL), the TMDL was divided among three categories of sources, plus two other components, as follows:

	Total Maximum Daily Phosphorus Load	=	Wasteload Allocations	+	Load Allocations*	+	Tribal Loads	+	Margin of Safety	+	Reserve Capacity
metric tons per year:	360.000	=	39.924	+	296.604	+	0.656	+	18.000	+	4.816
pounds per day:	2,172.8	=	240.9	+	1790.3	+	4.0	+	108.6	+	29.0

Load Allocations** include the **Natural Background Load.

The first source category, Wasteload Allocations (WLAs), comprises all sources that are regulated under the National Pollutant Discharge Elimination System (NPDES) program. This is a federal program and states are designated by USEPA as permitting authorities to issue NPDES permits. The NPDES program specifies appropriate (1) load limits / treatment requirements, as well as self-monitoring requirements, for municipal and industrial wastewater discharges, (2) urban runoff load reductions or surrogate measures for Municipal Separate Storm Sewer Systems (MS4s) that meet certain criteria based on their population and proximity to impaired waters, the so-called regulated MS4s, and (3) similar requirements for general permits, and both construction stormwater sites and industrial stormwater. The St. Croix Basin has 52 individual NPDES-permitted wastewater discharges and 25 regulated MS4s (including two that are not yet actually regulated but are expected to be in the near-future).

The second source category, *Load Allocations* (LAs), includes all sources that are *not* regulated under the NPDES, but with one exception (tribal loads, see below). The LAs encompass *internal loading* (phosphorus "recycled" from the lake's bottom sediments), *atmospheric loading* directly on the lake's surface (via precipitation and "dryfall"), and most importantly, runoff from all areas in the Basin (except tribal areas) outside the regulated MS4s. The latter runoff loading is divided between the *natural background runoff load* and the *watershed land use load*, which is the result of human alterations of the landscape, such as agriculture and urban development.

The third source category is *Tribal Loads*. In the St. Croix Basin, the Tribal Loads include one minor wastewater discharge and runoff from scattered land areas amounting to 0.17% of the Basin area.

The other two TMDL components are the Margin of Safety (MOS), a portion of the TMDL set aside to account for scientific uncertainties, and the reserve capacity (RC), which is a place-holder load for future pollutant sources or future expansion of existing sources.

The allocation methodology and results are presented in subsequent parts of this section.

5.2 Loading Capacity

Lake St. Croix's phosphorus loading capacity was determined by means of historical concentration and load reconstructions, rather than by use of a water quality model (as in the large majority of TMDLs). The historical reconstructions spanned the period 1800 to 2000 and were based primarily on sediment cores extracted from the lake and analyzed by scientists at the St. Croix Watershed Research Station (SCWRS). The May 2009 issue of the *Journal of Paleolimnology* is devoted to reports on these reconstructions and additional related studies for Lake St. Croix and Lake Pepin. In particular, Edlund, Engstrom, Triplett, Lafrancois, and Leavitt (2009) report on the in-lake total phosphorus (TP) concentration reconstruction. And Triplett, Engstrom, and Edlund (2009) report on the phosphorus (P) load reconstruction, which was also presented earlier in a SCWRS report (Triplett, Edlund, and Engstrom 2003) to the Metropolitan Council Environmental Services, the funding agency for that study.

For the Lake St. Croix historical reconstructions, three sediment cores were obtained across the lake at each of eight transects, approximately equally spaced along the lake's length and including two transects in each of the four pools. The primary core in each transect was dated by ^{210}Pb analysis in 18 to 25 samples per core. Additional dating was performed using ^{137}Cs and ^{14}C methods. The dating established a chronology for each core and enabled sediment accumulation rates to be determined. Core samples were analyzed for phosphorus, using fractionation procedures; loss-on-ignition; and, for a subset of cores, fossil pigments (carotenoids, chlorophylls, and derivatives) and biogenic silica.

The primary cores from the first (most downstream) transect in the lower Kinnickinnic Pool and the sixth transect in the upper Troy Beach Pool were analyzed for diatom micro-fossil remains at, respectively, 21 and 23 sections (i.e., depths) in each core. These sections span the time from the present at the sediment surface back to before 1800 at depths of 1 to 2 m into the sediment, depending on the coring site. Diatom "shells" (called *valves* or *tests*) are siliceous – essentially glass – and are thus well-preserved and, moreover, of such diversity of form that they allow species determinations. The valves in a known quantity of sediment from each section were recovered by first digesting away the organic material, then drying the remaining material on coverslips using settling chambers. Coverslips from each section were inspected microscopically to enable species identification and counting until a total of 500 diatoms was reached for each inspected coverslip. Based on the data so obtained, relative diatom abundances (the diatom assemblage) and diatom accumulation rates (the latter also relying sedimentation rates) were calculated for each of the levels in the cores. The procedures and results are documented in Edlund, Engstrom, Triplett, Lafrancois, and Leavitt (2009).

The history of water-column total phosphorus (TP) concentrations was also reconstructed with the above data. The TP reconstruction made use of a prior study of 55 Minnesota lakes, with TP ranging from 7.5 to 139 µg/L, in which diatom assemblages, TP, and additional environmental data were obtained and analyzed to yield a data "training set" (Ramstack et al. 2003). The purpose of the training set is to estimate TP histories in other lakes based on their historical diatom assemblages. The training set is well suited for application to Lake St. Croix because it has 33 diatom taxa (species or related-species groups) in common with, and includes (modern) species assemblages analogous to, Lake St. Croix's diatom micro-fossil record. Pertinent results (Edlund, Engstrom, Triplett, Lafrancois, and Leavitt 2009) are illustrated below.

Lake St. Croix's phosphorus load was reconstructed by summing the historical rates of (1) P sedimentation in the lake and (2) P outflow from the lake. P sedimentation rates over time were calculated as the product of total sediment accumulation rates and the measured P concentrations in sediment-core samples. The P outflow rates over time were calculated as the product of historical water-column TP concentrations at the downstream end of the lake (from the above study) and the lake's volumetric outflow rate.

The outflow history was derived primarily from the continuous 1892-2001 main-stem flow record at St. Croix Falls, some 30 miles upstream from the head of Lake S. Croix. Added to the flow at St. Croix Falls were measured and estimated flows for the three large downstream tributaries – the Apple (75-year flow record), Willow, and Kinnickinnic Rivers (the latter two with short records overlapping the Apple record) – which together add about 11% to the main-stem flow. For the period prior to 1892, flows were estimated on the basis of the 1892-2001 mean flow (four billion cubic meters per year) at St. Croix Falls. The procedures and results are documented in Triplett, Edlund, and Engstrom (2003) and Triplett, Engstrom, and Edlund (2009).

Table 6 below shows results from the load and concentration history reconstructions for the pre-1850 period, the 1940s, and the 1990s. (In addition, year 2020 projections are shown for the current urban growth trajectory with no restoration actions). The historical results revealed major shifts in Lake St. Croix beginning around 1950: large jumps in phosphorus loading and lake total phosphorus concentration, and a switch from benthic (bottom dwelling) to planktic (free floating) diatom community dominance (Figure 7). Thus, the St. Croix Basin Team recommended the 1940s-era conditions (bolded in Table 6) as load and water quality goals for Lake St. Croix. In terms of phosphorus, the 1940s-era conditions were 40 µg/L for TP concentration and 360 metric tons/yr for overall P load. Since these were historical conditions, the P load goal ties directly to the TP goal.

The Minnesota lake standards subsequently affirmed the Basin Team's 40-µg/L TP goal.

Table 6. Lake St. Croix Phosphorus Loads and Associated Water Quality for Selected Times[1]

Time	Phosphorus Load (metric tons/yr)	Total Phosphorus (µg/L)	Chlorophyll-*a*[2] (µg/L)	Secchi Depth[2] (m)
Est. 2020	540	56	15	1.4
1990s	460	50	14	1.4
1940s[3]	**360**	**40**	**12**	**1.5**
pre-1850	170	30	9	1.7

Notes:
[1] Table from Davis (2004). See text for explanation of historical reconstructions of phosphorus loads and in-lake total phosphorus concentrations.
[2] Lake chlorophyll-*a* concentration and Secchi depth estimated from lake total phosphorus concentrations via application of BATHTUB model (Robertson and Lenz 2002).
[3] The St. Croix Basin Team selected 1940s-era phosphorus load and water quality as goals for Lake St. Croix.

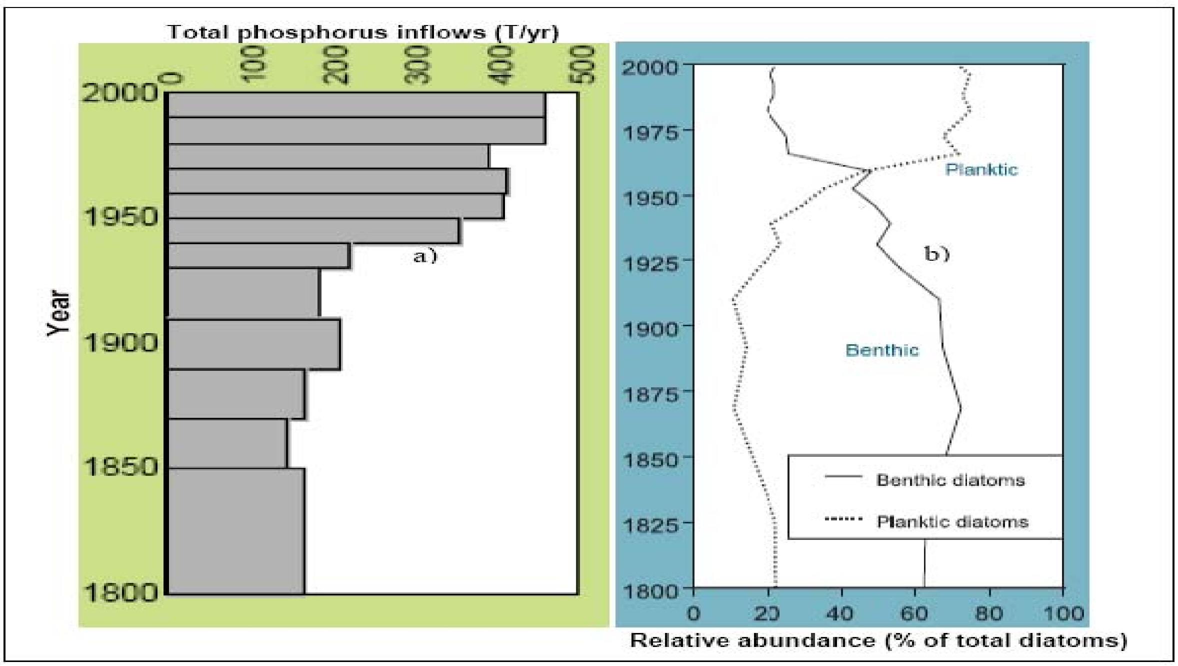


Figure 7. Historical reconstruction of a) total phosphorus loads of Lake St. Croix inflows and, b) diatom relative abundance (from Davis 2004)

The estimates of chlorophyll-*a* and Secchi depth in Table 6 were developed in a companion study (Robertson and Lenz 2002) through application of the BATHTUB model. Since the 1940s-era estimates for these two parameters (12 µg/L and 1.5 m, respectively) are better than the corresponding Minnesota standards (14 µg/L and 1.4 m), the 360-metric ton/yr load goal is expected to satisfy the Minnesota standards for both chlorophyll-*a* and Secchi depth, in addition to total phosphorus.

Therefore, the phosphorus loading capacity of Lake St. Croix is 360 metric tons/yr.

5.3 Existing (1990s) Phosphorus Load Articulation

TMDL Phosphorus Load Framework

In addition to the loading capacity, the studies described above also determined that:

- The baseline (1990s) overall phosphorus load to Lake St. Croix was 460 metric tons/yr
- The natural background phosphorus loading to the lake equaled 166 metric tons/yr

For the purposes of the TMDL, the above loading values were kept fixed and regarded as exact. The conditions represented by the decade of the 1990s were taken as the baseline ("existing") conditions for the Lake St. Croix TMDL because the scientific studies that quantified the TMDL and natural background load were completed in the early 2000s and were based on decadal-scale analyses.

The human-caused (anthropogenic) phosphorus load is simply the difference between the total load and the natural background load (Table 7).

Table 7. TMDL Phosphorus Load Framework

	Phosphorus Load (metric tons/yr)		
Component	**Existing (1990s)**	**TMDL**	**Reduction**
Total load	460	360	100
Natural Background load	166	166	0
Anthropogenic load (difference)	**294**	**194**	**100**

Since the background load remains unchanged, the anthropogenic load (and hence the total load) must be reduced by 100 metric tons/yr to meet the TMDL. (The adoption of a Margin of Safety and a Reserve Capacity, as discussed subsequently, increases the needed load reduction to about 123 metric tons/yr.)

Note that the *atmospheric load* – i.e., the phosphorus in precipitation and dust particles that fall directly onto the lake surface – was considered to be a part of the natural background load. Robertson and Lenz (2002) quantified the atmospheric load as 441 kg/yr. Accordingly, the natural background was divided into two components: (1) *natural background runoff load,* 165.559 metric tons/yr, and (2) atmospheric load, 0.441 metric tons/yr.

Existing (1990s) Anthropogenic Load Division into Runoff and Non-runoff Parts

The existing (1990s) anthropogenic load was divided among its components by first quantifying all *anthropogenic non-runoff loads,* then subtracting the sum of these from the existing total, giving the *anthropogenic runoff load*.

The anthropogenic non-runoff loads included various wastewater loads and, in addition, the lake's internal phosphorus load – quantified as 7.095 metric tons/yr by Robertson and Lenz

(2002). The sum of these existing loads was 60.313 metric tons/yr, which resulted in an existing *anthropogenic runoff load* of 233.687 metric tons/yr (Table 8). Portions of the anthropogenic runoff load will subsequently be designated for the regulated MS4s, tribal lands, and stormwater runoff loads from construction and industrial sites; the remainder will be termed the *watershed land use load*.

Table 8. Existing (1990s) Anthropogenic Load Division, Runoff - Non-Runoff

Component	Reference / Note	Phosphorus Load (metric tons/yr)
Existing total anthropogenic load	**Table 7**	**294.000**
	Existing anthropogenic non-runoff loads:	
Wastewater - municipal and industrial	Discharge records	51.914
Wastewater - WI General Permits	Estimate by WDNR	1.000
Tribal wastewater load	Discharge records	0.304
Lake internal load	Robertson and Lenz (2002)	7.095
Total existing anthropogenic non-runoff load		**60.313**
Existing anthropogenic runoff load (difference)		**233.687**

In this accounting, the phosphorus loadings from wastewater treatment facilities were assumed to arrive at Lake St. Croix undiminished by retention within the drainage network. The fact that the largest of such sources are in the southern portion of the basin, close to Lake St. Croix, justifies this assumption. The watershed land use load, on the other hand, being determined by difference, implicitly reflects basin-wide average retention / attenuation of upland loads.

The sum of the existing *anthropogenic runoff load* and the *natural background runoff load* is the Basin's existing *total runoff load*: 399.246 metric tons/yr. Dividing this load (expressed as 399,246 kg/yr) by the Basin's total area (1,987,494 hectares; Appendix B, Table B-1) gives the existing *average P export* (load per unit area): 0.20 kg/ha-yr.

Existing (1990s) Runoff Load Spatial Distribution

Natural background runoff load – The natural background runoff load (165.559 metric tons/yr) was apportioned uniformly over the Basin's *land area* – i.e., total area minus water and wetland area – which is 1,810,594 hectares (Appendix B, Table B-1). The Minnesota–Wisconsin load apportionment on this basis is approximately 44% – 56% (Table 9).

Table 9. Apportionment of Phosphorus Natural Background Runoff by State

Area or Load (units)	Minnesota	Wisconsin	Basin
Land area (hectares)	803,101	1,007,493	1,810,594
Land area (% of Basin land area)	44.356%	55.644%	100.000%
Natural background TP runoff load (metric tons/yr)	**73.435**	**92.124**	**165.559**

Consistent with the above, the *natural background P export* is 0.091439 kg/ha-yr (equivalent to 0.081580 lb/ac-yr).

<u>Existing anthropogenic runoff load</u> – The existing anthropogenic runoff load (233.687 metric tons/yr) was distributed over the Basin spatially using a calibrated set of P export coefficients for the land use / land cover categories in Table 10. The export coefficients were developed for these land categories to reflect differences known from widely used national, regional, and local studies. These studies have shown clear export-land use patterns despite large variability within land use categories. In this TMDL, export coefficients were used not as a means to estimate watershed loads that were initially unknown, but rather as a means only to estimate the spatial distribution of the Basin's known runoff P load. The P export coefficients for the land use / land cover categories were developed as follows (Table 9):

1. "First estimates" for the export coefficients were proposed by members of the St. Croix Basin Team's Implementation Subcommittee, based on the literature review in the P loading study (Magdalene 2009; see second appendix) and on professional judgment and experience. The first estimates for grassland and for water deserve comment. The grassland export value was intentionally estimated high because it represents pasture and hay land almost entirely. Water was given a non-zero export value because of widespread alteration of wetlands (58% of the Basin's "water" area) that have caused them to release P on average, rather than to retain it.
2. The natural background export was subtracted from the first estimates, giving new first estimates of what may be called the *anthropogenic P export* (or "excess P export") – i.e., export reflecting only the anthropogenic effects on the land. Water's excess phosphorus export was set equal to the forest and shrubland value (lowest value) in this step, rather than subtracting the natural background export, which would have given water a negative export value.
3. A trial calculation of the anthropogenic runoff load was made by multiplying the six land use / land cover category areas times their corresponding initial excess phosphorus export values and totaling the results. The trial calculation over-estimated the anthropogenic runoff load; the excess phosphorus export values were then adjusted uniformly by the ratio of the known anthropogenic runoff load to the trial estimate. *The results of this step were used to distribute the <u>existing anthropogenic runoff load</u> throughout the Basin spatially*.
4. Finally, the natural background export was added back to the adjusted excess P export values for land areas (Appendix B, Table B-3, entries immediately below land category headings). *The results of this step were used to distribute the <u>existing total runoff load</u> throughout the Basin spatially*.

Table 10. Existing (1990s) Phosphorus Export Coefficients for Land Use/Land Cover Categories

		Agriculture	Forest	Grassland	Shrubland	Urban	Water*
Step	Description	(kilograms per hectare per year)					
1	First estimates	0.75	0.10	0.25	0.10	0.75	0.05
2	Subtract natural backgrnd	0.658561	0.008561	0.158561	0.008561	0.658561	0.008561
3	Adjust to 1990s load	0.536970	0.006980	0.129286	0.006980	0.536970	0.006980
4	Add natural background	0.628409	0.098419	0.220725	0.098419	0.628409	0.006980

*In lieu of subtracting the natural background export (0.091439 kg/ha-yr) from water's first estimate, water's export was set equal to the forest and shrubland value in step 2.

Based on the P export values from step 3, the *existing anthropogenic runoff loads* for Minnesota and Wisconsin were calculated to be 85.905 and 147.782 metric tons/yr, respectively (see Appendix C, Table C-3, right-most column).

Existing watershed land use load – The *watershed land use load* in general designates the portion of the basin's runoff load that results from human alterations of the landscape, such as agriculture and urban development. However, in this TMDL, the watershed land use load is defined specifically to exclude regulated runoff loads and runoff loads from tribal lands. In other words, the watershed land use load equals the *anthropogenic runoff load* minus (1) the regulated MS4 loads, (2) the tribal runoff loads, and (in Minnesota only) (3) the *construction stormwater runoff* and *industrial stormwater runoff* loads (Table 10).

The existing loads from the regulated MS4s and tribal lands were found to be 8.743 and 0.352 metric tons/yr, respectively, Basin-wide (see Appendix C, Table C-3, right-most column; and Appendix D, Table D-3; next-to-right-most column).

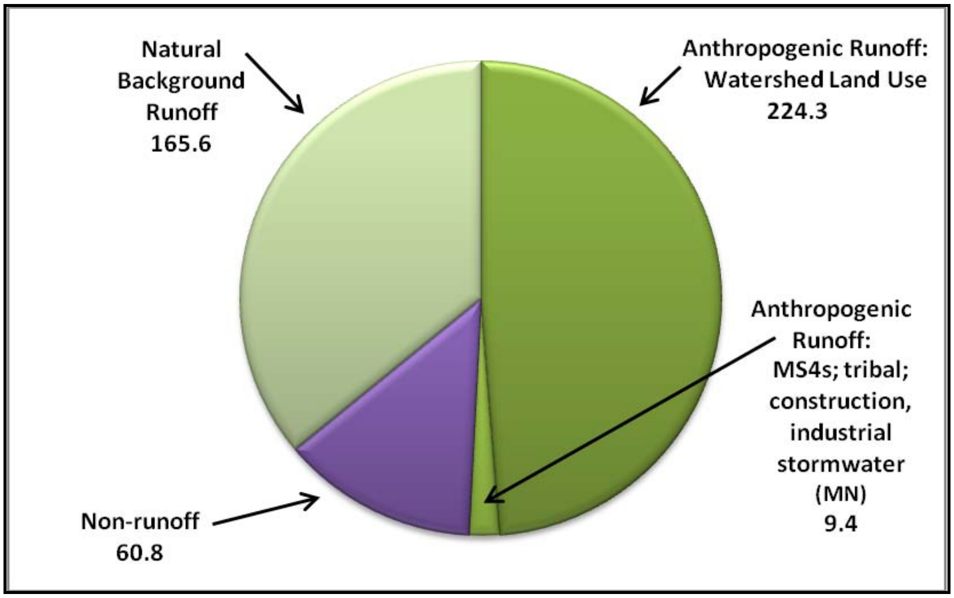
Minnesota requires separately estimated loads for *construction stormwater runoff* and *industrial stormwater runoff*. A common procedure in Minnesota TMDLs is to set aside for each of these two load categories, 0.001 times the total runoff load (see Approach for Regulated Stormwater Allocations, below). For consistency, the same procedure was followed to estimate the corresponding existing loads. Minnesota's portion of the existing total runoff load is 159.339 metric tons/yr. Hence, the existing load for each of these two stormwater runoff sources was estimated as 0.159 metric tons/yr.

Table 11. Existing (1990s) Anthropogenic Runoff Load Distribution

	Phosphorus Load (metric tons/yr)		
Load Component	**Minnesota**	**Wisconsin**	**Basin**
Anthropogenic runoff	**85.905**	**147.782**	**233.687**
MS4 permittees	7.446	1.297	8.743
Tribal runoff load	0.132	0.220	0.352
Construction runoff - MN	0.159	--	0.159
Industrial runoff - MN	0.159	--	0.159
Subtotal	7.896	1.517	9.413
Watershed land use	**78.008**	**146.266**	**224.274**

The existing Basin-wide *watershed land use load* was determined as 224.274 metric tons/yr, which is 96% of the existing anthropogenic runoff load (Figure 8).

Figure 8. Existing (1990s) Runoff and Non-runoff Loads (metric tons/yr)



The non-runoff load in Figure 8 is dominated by municipal and industrial wastewater but also includes atmospheric loading, as well as the other anthropogenic loads in Table 8 (Wisconsin General Permit wastewater, tribal wastewater, and lake internal load).

5.4 TMDL Allocation Methodology

The MPCA, WDNR, St. Croix Basin Team, local partners, and source sectors were consulted in developing the TMDL allocation. MPCA and WDNR staff worked together to develop the calculation methodology and submitted their approach to the Implementation Subcommittee of the St. Croix Basin Team for input and final approval.

Approach for Wastewater Treatment Facilities

The approach for setting phosphorus allocations among the various categories of wastewater treatment facilities was based on the associated magnitude of loading and facility size. In essence those contributing the most phosphorus are given more restrictive allocations, as it is more cost effective for larger facilities to remove phosphorus per unit of mass than it is for smaller facilities. Moreover, since most of the larger facilities are located in close proximity to Lake St. Croix, a greater proportion of their phosphorus is transported directly into the lake during the summer growing season.

The 51 state permitted facilities and operations in the St. Croix Basin have been sorted into categories based on facility type, permit type, facility size and existence of current effluent phosphorus limitation. As explained below, the facilities are also sorted into two more general groups: (1) those assigned individual WLAs and (2) those eligible for an aggregate load cap. Table 12 provides a summary; see Appendix A for details.

Table 12. Wastewater Phosphorus Wasteload Categories

Facility Type	Category	Number of Facilities	Effluent TP Assumption (mg/L)	Wasteload Allocation Subtotal Minnesota (kg/yr)	Wasteload Allocation Subtotal Wisconsin (kg/yr)	Wasteload Allocation Subtotal Basin Total (kg/yr)	% of Total (All) Wastewater WLA
Facilities Assigned Individual Wasteload Allocations							
Industrial - low concentration	I1	1	0.1	594	0	594	2%
Industrial - high concentration	I2	1	1.0	0	345	345	1%
Industrial - high volume cooling water	I3	1	*	1,300	0	1,300	4%
Municipal - design flow ≥ 1.0 mgd	LM	5	0.6	6,847	6,756	13,603	39%
Municipal - design flow ≥ 0.2 & < 1.0 mgd	MM	19	1.0	7,531	5,186	12,717	36%
Municipal with existing permit limit and design flow < 0.2 mgd**	SM3	5	1.0	811	0	811	2%
Total individual wastewater load		*32*		*17,083*	*12,287*	*29,370*	*84%*
Facilities Eligible for Aggregate Load Cap							
Fish hatchery	H	3	0.1	0	598	598	1.7%
Industrial - low concentration	I1	3	0.05 – 0.1	104	99	203	0.6%
Industrial - high concentration	I2	1	Load estimate	0	4	4	0.01%
Municipal controlled discharge and design flow < 0.2 mgd	SM1	9	2.0	1,369	563	1,932	6%
Municipal continuous discharge and design flow < 0.2 mgd	SM2	3	3.5	0	1,887	1,887	5%
Total aggregate wastewater load		*19*		*1,473*	*3,151*	*4,624*	*13%*
Total regular wastewater		**51**		**18,556**	**15,438**	**33,994**	**97%**
Wisconsin General Permits	WGP	varies	***	--	1,000	1,000	3%
Total all wastewater		**varies**		**18,556**	**16,438**	**34,994**	**100%**

* Estimated loading of phosphate-bearing additives.

** Wasteload allocations for these small municipal dischargers (SM3) are based on existing permit limits.

*** Estimated Wisconsin General Permit cumulative annual loading.

<u>Individual Wastewater Wasteload Allocations</u> – Individual WLAs were assigned to the municipal and industrial facilities in categories I3, LM, MM, SM3, and, in addition, one

discharger each from categories I1 and I2. The individual WLAs were calculated by combining category-based effluent concentration and/or loading assumptions with average wet weather design flow for domestic wastewater treatment facilities or maximum flow for industrial facilities. This group's total WLA is 29.370 metric tons/yr, or 84% of the TMDL's overall wastewater WLA (Table 12). Future NPDES permits for the existing dischargers in these categories will include phosphorus effluent limits and monitoring requirements that are consistent with the assumptions and requirements of the individual wasteload allocations and, where necessary, compliance schedules for achieving the limits.

<u>Aggregate Implementation of Selected Wastewater Wasteload Allocations</u> – In order to minimize the need for expensive and inefficient investments for the installation and operation of phosphorus removal technologies, the MPCA and the WDNR intend to implement the wasteload allocations for a select group of wastewater NPDES permits in each state as aggregate loading caps applicable to the entire group. Implementation procedures will be designed to ensure that the sum of the effluent wastewater loads from these dischargers remains below the sum of their individually calculated wasteload allocations.

Facilities subject to aggregate loading caps include those in categories H, SM1, SM2, and categories I1 and I2 (except as above). This group comprises 19 facilities: seven in Minnesota and 12 in Wisconsin. The group represents low-volume municipal and industrial wastewater dischargers, industrial dischargers of very low phosphorus effluent concentration, and other dischargers with low phosphorus loads. Phosphorus removal costs for these types of facilities are relatively high due to the small size of the facilities or the low concentration of the wastewater, and beneficial effects resulting from the implementation of phosphorus removal technologies at these facilities would be minimal because their effluent phosphorus loads represent a very small proportion of the watershed load. Aggregate loading caps were calculated as the sum of each facility's categorical effluent concentration assumption (Table 12) multiplied by its average wet weather design flow. The group's WLAs amount to 4.624 metric tons/yr, or 13% of the TMDL's overall wastewater WLA; the Minnesota and Wisconsin subtotals are 1.473 and 3.151 metric tons/yr, respectively (Table 12).

In addition to the above facilities, the aggregate loading cap also encompasses the 13 WPDES General Permits (WGPs). The WGPs cover specific wastewater discharge categories separate from all those above and from stormwater general permits. Most of the covered discharges are either non-contact cooling water with low flow and low phosphorus, intermittent or short-duration project discharges, or discharges that seep to groundwater. It is estimated that in any given year, WGPs authorize fewer than 25 operations within the St. Croix Basin that discharge directly to surface waters; and none of the facilities or projects covered under these permits contributes a significant phosphorus loading to surface waters. It is difficult to calculate loads or even potential loads from assumed operating parameters for the WGP dischargers. The total WGP load is estimated as 1.0 metric ton/yr, or 3% of the TMDL's overall wastewater WLA. Facilities operating under WGPs will be screened to determine whether additional requirements may be needed to insure that the permitted activity is consistent with TMDL goals. The requirements may include issuing individual permits or other measures.

All the dischargers subject to the aggregate loading caps will be deemed to be in compliance with their permit effluent limits, consistent with the assumptions and requirements of the wasteload allocation, as long as:

- the cumulative effluent loading from the seven dischargers in Minnesota remains under the aggregate loading cap of 1.473 metric tons/yr,
- the cumulative effluent loading from the 12 dischargers in Wisconsin remains under the aggregate loading cap of 3.151 metric tons/yr, and
- the operations authorized by the 13 Wisconsin General Permits remain under the aggregate loading cap of 1.0 metric ton/yr.

Future effluent phosphorus loads will be tracked through monitoring or modeling to ensure compliance with the aggregate allocations.

Some additional notes follow on particular wastewater facilities:

- A phosphorus load for the Hertel Tribal Wastewater Treatment Plant (WWTP) has been calculated but this TMDL does not establish a binding wasteload allocation for the facility because it is not subject to the jurisdiction of either state.
- The Xcel Energy Allen S. King Power Plant permit (MN0000825) authorizes the use of 331 million gallons per day of river water for cooling. Rather than attempting to calculate the facility’s WLA based on the difference between the phosphorus load withdrawn from the river and the phosphorus load discharged to the river, the WLA is based on the quantity of phosphate- bearing additives used at the facility.
- The Hammond WWTP (WPDES No. 0024171) and the Frederic WWTP (WPDES No. 0029254) currently operate as subsurface disposal systems. They have been assigned WLAs because their permits also authorize them to discharge to surface waters.
- One CAFO in Wisconsin (Emerald Dairy) will be given a portion of the WLA for a wastewater discharge treatment system. This discharge represents a very small load and is based on its current permit limit. Other CAFOs in the basin are not allowed to release any pollutant-containing runoff from their production areas and will not be assigned a WLA.

Appendix A provides further details for both the individual and the aggregate WLAs.

Runoff Load Methodology

<u>TMDL Anthropogenic Load Division into Runoff and Non-runoff Parts</u> – The anthropogenic load was divided among its components for the TMDL in the same manner as for the existing condition (Table 13). First, the *anthropogenic non-runoff loads* were quantified for the TMDL. These included two new components not considered in the analysis of existing loads: the Margin of Safety and the Reserve Capacity. These two loads are explained in separate sections below. The Wisconsin General Permit wastewater load, tribal wastewater load, and lake internal load are the same for the TMDL as for existing conditions. The TMDL *anthropogenic runoff load* is 128.791 metric tons/yr (Table 13), which requires a *runoff load reduction* of 104.896 metric tons/yr.

Table 13. TMDL Anthropogenic Load Division, Runoff - Non-runoff

Component	Reference / Note	Phosphorus Load (metric tons/yr)
TMDL anthropogenic load	**Table 7**	**194.000**
	TMDL anthropogenic non-runoff loads:	
Wastewater - municipal and industrial	Table 12 and text	33.994
Wastewater - WI General Permits	Table 12 and text	1.000
Tribal wastewater load	Discharge records	0.304
Lake internal load	Robertson and Lenz (2002)	7.095
Margin of Safety	See text	18.000
Reserve Capacity	See text	4.816
TMDL anthropogenic non-runoff load total		**65.209**
TMDL anthropogenic runoff load (difference)		**128.791**

Under the TMDL, the *total runoff load* (sum of the above anthropogenic runoff load and the natural background runoff load) is 294.791 metric tons/yr, and the Basin's average P export is 0.15 kg/ha-yr. The total runoff load and average P export are 25% smaller under the TMDL than under existing conditions.

TMDL anthropogenic runoff load distribution – The TMDL anthropogenic runoff load was distributed over the Basin spatially by appropriately reducing the P export coefficients calibrated to the existing load. The existing land use / land cover data were used for this purpose. It is of course recognized that future land use / land cover will differ from the existing conditions. However, the most substantial changes are expected to arise from increasing urban development that will occur by and large on land currently in agricultural use. Since P export from agricultural and urban land is similar (actually assumed to be identical in this TMDL), the existing land use / land cover serves as a reasonable and practical surrogate for future conditions.

Export reductions were assumed to occur only for three of the six land use / land cover categories: Agricultural, Grassland, and Urban. (Recall that grassland is considered to be quasi-agricultural because pasture and hay account for 97% of the Basin's grassland area.) This assumption recognizes that runoff load reductions will primarily occur on the most substantially altered landscapes. The assumption was made to facilitate calculation of the allowable load's spatial distribution. It does not preclude runoff load reductions on forested land or shrubland where appropriate.

Following the above assumption, the TMDL divides the anthropogenic runoff load as shown below (Table 14).

Table 14. Land-Category Division of TMDL Anthropogenic Runoff Load

	Phosphorus Load (metric tons/yr)		
Runoff Load Component	**Ag + Grass + Urban**	**Forest + Shrub + Water**	**Basin**
Existing anthropogenic	224.537	9.150	233.687
Reduction needed	104.896	0.000	104.896
TMDL anthropogenic runoff (difference)	**119.641**	**9.150**	**128.791**

To distribute the TMDL anthropogenic runoff load over the Basin spatially, the P export coefficients were adjusted as follows (Table 15):

1. The starting point was the set of previously developed *existing anthropogenic P export coefficients* (these are the step 3 results from Table 10).
2. The Agricultural, Grassland, and Urban P export values from step 1 were adjusted uniformly by the ratio of the TMDL anthropogenic runoff load to the existing anthropogenic runoff load (see again Table 14).
3. The Forest, Shrubland, and Water export values remained unchanged. The resulting TMDL *anthropogenic P export coefficients* were used to distribute the TMDL *anthropogenic runoff load* throughout the Basin spatially.
4. The natural background export was added to the export values from step 2, Water excluded. The results of this step were used to distribute the TMDL *total runoff load* throughout the Basin spatially (Appendices B and C).

Table 15. Phosphorus Export Coefficients Used for TMDL Calculations

		Agricultural	Forest	Grassland	Shrubland	Urban	Water*
Step	**Description**	(kilograms per hectare per year)					
1	Existing anthropogenic**	0.536970	0.006980	0.129286	0.006980	0.536970	0.006980
2	Adjust to TMDL load***	0.286116	0.006980	0.068888	0.006980	0.286116	0.006980
3	Add natural background	0.377555	0.098419	0.160327	0.098419	0.377555	0.006980

* Export for Water was not adjusted for the TMDL condition, and (since the natural background export was attributed to *land areas* only) remained the same in steps 2 and 3.

** Existing anthropogenic exports are the step 3 results from Table 10.

*** Adjustments to meet the TMDL load were made for Agricultural, Grassland, and Urban exports only (see text).

The major components of the TMDL *anthropogenic runoff load* are the *watershed land use* LAs (96% overall, with 34% in Minnesota and 62% in Wisconsin) and the regulated MS4 WLAs (3.6% overall, with 3.1% in Minnesota and 0.5% in Wisconsin) (Table 16). The *watershed land use* LAs and regulated MS4 WLAs were determined using the *anthropogenic P export coefficients* from step 2 above. The other anthropogenic runoff load components are the tribal runoff loads, which remain unchanged from existing conditions, and Minnesota's *construction* and *industrial stormwater runoff load* (see following section of this report).

Table 16. TMDL Anthropogenic Runoff Load Distribution

	Phosphorus Load (metric tons/yr)		
Load Component	**Minnesota**	**Wisconsin**	**Basin**
Anthropogenic runoff	**47.772**	**81.019**	**128.791**
MS4 permittees	3.995	0.693	4.688
Tribal runoff load	0.132	0.220	0.352
Construction runoff - MN	0.121	--	0.121
Industrial runoff - MN	0.121	--	0.121
Subtotal	4.369	0.913	5.282
Watershed land use	**43.403**	**80.106**	**123.509**

Approach for Regulated Stormwater Allocations

There are 21 regulated MS4 permittees in the Minnesota portion of the St. Croix Basin. In the Wisconsin portion, there are two existing regulated MS4 permittees, and two additional cities (Hudson and North Hudson) treated as a regulated MS4 permittees in the TMDL on the basis that they will become regulated MS4 permittees in the near future because of their size and anticipated growth. WLAs for regulated MS4 permittees were determined categorically for Minnesota, with the exception of the Minnesota Department of Transportation (Mn/DOT) which received an individual WLA at their request. WLAs for regulated MS4 permittees were determined individually for Wisconsin. The reason Minnesota is using a categorical approach is due to the large number of permittees and the difficulty associated with providing accurate individual allocations at the finer MS4-area scale. In particular, some jurisdictions have drainage areas within them that are landlocked, which are not accounted for in the methodology used in this TMDL to estimate loading.

The regulated MS4 permittees' WLAs calculations are described in the Runoff Load Methodology section above. In this TMDL the decade of the 1990s is considered to be the baseline in general; however, for the WLAs for regulated MS4 permittees, the baseline is specifically taken to be 1992, as 1992 is the year of NLCD land use / land cover data used to develop the MS4 WLAs.

As development occurs within the watershed, the Census Bureau-defined Urban Area may expand. Therefore, it may be necessary to transfer load in the future. This can occur in the following situations:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be given additional WLA to accommodate the growth. This will involve transferring LA to the WLA.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.

4. Expansion of an urban area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an Urban Area at the time the TMDL was completed, but are now inside a newly expanded Urban Area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting allocations in the TMDL, which depend on the 1992 land use / land cover data (see immediately preceding section). In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer. These transfers do not require the public notice of the TMDL.

For Minnesota municipalities in the eastern portion of the Twin Cities Metro Area – namely, all Minnesota municipalities apart from North Branch – the entire municipal area is the basis for the WLA. The assumption is that these MS4 systems could expand to their municipal boundaries. This approach obviates transfers from load allocation to wasteload allocation that would otherwise be frequently necessary in coming years. For areas within these municipalities not presently served by a drainage system owned or operated by the MS4, runoff loads will be treated as load allocations until MS4 facilities service the area. The WLA for North Branch was based on the city's 2029 Growth Area (2,065 hectares, after subtracting County, State, and Interstate highway rights-of-way), rather than its full municipal area (9,319 hectares). Runoff loads for existing and TMDL conditions were calculated for North Branch's Growth Area just as for other regulated MS4s.

In Minnesota, MPCA's Construction Stormwater Program tracks all NPDES-regulated (permitted) construction activities, including the size of each project. A WLA for construction stormwater can be developed by calculating the average annual cumulative fraction of the watershed under construction and multiplying this fraction by the overall TMDL, minus the non-watershed loads. This method assumes equal areal loading for all pollutant sources. This methodology has been applied to several Minnesota TMDLs. The resulting fraction for all TMDLs has ranged from about 0.0003 to 0.0015, regardless of location within the state. Consequently, in Minnesota it is appropriate to assign a construction stormwater WLA of 0.001 times the state's portion of the TMDL total runoff load of 121.207 metric tons/yr. The construction stormwater WLA is therefore 0.121 metric tons/yr.

Industrial stormwater is not well-quantified in either state. Because this load is relatively small, similar to construction stormwater, in Minnesota it is routinely assigned a WLA equal to the construction stormwater WLA. Thus, Minnesota's industrial stormwater WLA is estimated as an additional 0.121 metric tons/yr. For consistency, construction and industrial stormwater loads for Minnesota were estimated for existing conditions in the same manner, the result being loadings of 0.159 metric tons/yr for each. In Wisconsin, construction stormwater and industrial stormwater WLAs come under the state's General Permit. A very rough estimate of the facilities regulated by Wisconsin DNR is 400 per year for construction activities and 170 per year in the industrial categories. Of course, the numbers of projects covered under the construction site and industrial general permits vary from year to year. The Wisconsin Department of Commerce regulated construction site stormwater at commercial sites in past years; this is another important component of the phosphorus loading from construction activities.

Tribal Lands

Tribal watershed loadings in the Lake St. Croix basin are spread throughout eight tributary watersheds in Wisconsin and five in Minnesota. There is one tribal wastewater treatment facility (Hertel Tribal Plant) in Wisconsin. For this study, land use on tribal lands was used to estimate the existing watershed runoff loads (Appendix D). These totaled 0.352 metric tons/yr for the Basin. Monitoring records for the Hertel facility were used to derive a present P loading rate of 0.304 metric tons/yr (this load estimate is not a WLA). The Basin's total estimated tribal loading is thus 0.656 metric tons/yr. No reductions have been assumed for this existing source of phosphorus in developing the TMDL load allocations.

Margin of Safety

Under Section 303(d) of the Clean Water Act, a margin of safety (MOS) is required as part of a TMDL. The MOS is meant to help ensure achievement of the water quality goals in the face of inevitable scientific uncertainties. The Lake St. Croix TMDL has an extremely robust scientific basis that includes long-term monitoring of the lake's water quality by Basin Team partners; extensive tributary flow and load monitoring (including multiple years at many stations); paleolimnological analyses by the St. Croix Watershed Research Station (Science Museum of Minnesota) of two dozen sediment cores obtained throughout the lake, a lake water quality modeling study conducted by Basin Team partners of the U.S. Geological Survey; and many other studies. A special issue of the peer-reviewed *Journal of Paleolimnology* was devoted to reports on these studies (and related studies of Lake Pepin) in 2009. The outstanding body of scientific work that is the foundation for the Lake St. Croix TMDL serves to minimize the TMDL's uncertainties, supporting a strong argument for an implicit MOS.

However, the St. Croix's status as a Wild and Scenic River – indeed, one of the first eight rivers in the U.S. to be so designated – demands special care. Therefore, an explicit MOS of five percent was specified for Lake St. Croix. This amounts to 18 metric tons/yr, a substantial loading, and increases the required basin-wide load reduction from 100 to 118 metric tons/yr. With the Reserve Capacity, the load reduction requirement increases to more than 123 metric tons/yr.

In addition, the load allocations assume internal loading in Lake St. Croix will remain constant with future loading reductions even though Lafrancois et al. (2009) showed both the inflow and outflow monitoring sites to Lake St. Croix had improving trends of the exact same magnitude (0.2 μg/L/year) in response to external loading reductions since the 1990s. This indicates reductions in the total phosphorus load into Lake St. Croix are resulting in commensurate improvements to the in-lake water quality. As a result, it does not appear that internal load will preclude proportional in-lake water quality improvements following load reductions associated with TMDL implementation.

Reserve Capacity

In the St. Croix basin, reserve capacity (RC) is only available to establish wasteload allocations for the conversion of existing phosphorus loads; it is not intended to provide wasteload allocations for new and expanding industrial or municipal discharges. In Minnesota, RC is established for projects that address failing or nonconforming septic systems and “unsewered” communities and will be made available only to new WWTPs or existing WWTPs that provide service to existing populations with failing or nonconforming systems. In Wisconsin RC is established for projects that address conversion of existing rapid infiltration basins (RIBs) to surface water discharging systems due to elevated groundwater nitrate concerns and for projects that address failing or nonconforming septic systems and “unsewered” communities and will be made available only to new WWTPs or existing WWTPs for the conversion of existing RIBs or to provide service to existing populations with failing or nonconforming systems. The determination of these RC components is described below.

The reserve capacities for individual subsurface treatment systems (ISTSs) were estimated based on the following populations: 95,752 for Wisconsin, and 59,930 for Minnesota. MPCA staff experience indicates around 10 percent of all ISTS systems in a given area ultimately convert to surface discharge. Applying this to the above populations gives expected populations for conversion to surface discharge of 9,575 for Wisconsin, and 5,993 for Minnesota.

Based on the expected ISTS conversion populations, the estimated ISTS reserve capacities are 1,532 kg/yr for Wisconsin and 959 kg/yr for Minnesota; or in other words, 1.532 and 0.959 metric tons/yr, respectively. A per capita phosphorus rate of 0.16 kg phosphorus/cap-yr was applied to calculate these loads. This per capita rate was estimated by applying an assumed 80 percent reduction through wastewater treatment to an MPCA raw-wastewater loading guideline of 0.80 kg phosphorus/cap-yr (or 1.76 lb phosphorus/cap-yr).The allotting of reserve capacity for future ISTS conversions will be made on the basis of this 0.16-kg phosphorus/cap-yr rate.

For Wisconsin’s municipal wastewater systems currently discharging to groundwater (RIBs), the reserve capacity was estimated to be 1,929 kg/yr, or 1.929 metric tons/yr. This estimate represents the current phosphorus loading from 11 systems deemed to be candidates for future conversion to surface discharge. There are an additional seven systems that are not expected to convert.

One additional accepted RC use is for existing treatment plants that discharge to a surface water with contained drainage, and not tributary to a water reaching the St. Croix. Two such non-tributary facilities exist in Wisconsin, the Village of Roberts and the Village of Siren. These communities could access RC in the future for a WLA if their operations change so that either discharge reaches a St. Croix tributary, thereby contributing a mass of phosphorus to Lake St. Croix. A “non-tributary” load allowance of 0.396 metric tons/yr was in fact added to Wisconsin’s RC following this TMDL’s public comment period. This change was the result of a comment from the Village of Siren, which had been assigned a WLA of the above magnitude in the prior TMDL draft. Siren’s comment pointed out that its municipal treatment plant discharges to an extensive wetland within a contained drainage basin; a subsequent WDNR field investigation of the surrounding drainage confirmed this situation. The 0.396-metric ton/yr load was then removed from the wastewater WLA and added to Wisconsin's RC.

5.5 Seasonal Variation

Total phosphorus concentrations in the lake vary significantly during the growing season, generally peaking in August. The water quality standard requires compliance with the phosphorus criterion during the growing season (June through September), which represents the critical condition and the time of the year when the water quality criteria are not being met. As a result, the TMDL goal for total phosphorus is defined as the growing season mean concentration. Nonetheless, seasonal effluent limits are not considered for this TMDL because of the large watershed scale, residence time, and the need to set annual watershed loading rates for meeting the in-lake phosphorus goal.

5.6 TMDL Allocation Summary

Table 17, Table 18, and Table 19 summarize the Lake St. Croix TMDL allocations and existing phosphorus loads for the whole Basin, the Minnesota part of the Basin, and the Wisconsin part of the Basin, respectively.

The St. Croix Basin Team originally set a phosphorus load-reduction goal for Lake St. Croix of 100 metric tons/yr (Davis 2004). However, since the MOS (18 metric tons/yr) and RC (4.816 metric tons/yr) are additional loads that need to be accounted for in the TMDL, the actual load reductions total 122.816 metric tons/yr, or 27 percent of the baseline load. Specific loadings must be reduced by larger percentages than the overall average because the natural background load cannot be reduced.

In the TMDL allocation tables, *watershed land use* in general designates the portion of the basin's runoff phosphorus load that results from human alterations of the landscape, such as agriculture and urban development. However, in this TMDL, the watershed land use load is defined specifically to exclude regulated runoff loads and runoff loads from tribal lands. Therefore, the separately listed runoff loadings for regulated MS4s, tribal lands, and construction and industrial runoff are not included in this category. Watershed land use also specifically excludes the *watershed background load* (*natural background runoff load*) in these tables.

Table 17. Lake St. Croix TMDL Phosphorus Allocations - Basin-wide

Component	Existing (1990s)	TMDL	Existing (1990s)	TMDL
	(metric tons/yr)		(pounds/day)	
Non-Regulated Loads (LAs)	**397.369**	**296.604**	**2398.5**	**1790.3**
Watershed background	165.559	165.559	999.3	999.3
Watershed land use	224.274	123.509	1353.7	745.5
Internal	7.095	7.095	42.8	42.8
Atmospheric	0.441	0.441	2.7	2.7
Wasteloads (WLAs)	**61.975**	**39.924**	**374.1**	**240.9**
MS4 Permitees	8.743	4.688	52.8	28.3
Wastewater Facilities	51.914	33.994	313.3	205.2
General Permits - WI	1.000	1.000	6.0	6.0
Construction runoff - MN	0.159	0.121	1.0	0.7
Industrial runoff - MN	0.159	0.121	1.0	0.7
Reserve Capacity (RC)	**--**	**4.816**	**--**	**29.0**
RIB conversions - WI	--	1.929	--	11.6
Non-contributing - WI	--	0.396	--	2.4
ISTS conversions	--	2.491	--	15.0
Tribal Load (TL)	**0.656**	**0.656**	**4.0**	**4.0**
Watershed runoff	0.352	0.352	2.1	2.1
Wastewater	0.304	0.304	1.9	1.9
Margin of Safety (MOS)	**--**	**18.000**	**--**	**108.6**
Total Load	**460.000**	**360.000**	**2776.6**	**2172.8**

Table 18. Lake St. Croix TMDL Phosphorus Allocations - State of Minnesota

	Existing (1990s)	TMDL	Existing (1990s)	TMDL
Component	**(metric tons/yr)**		**(lbs/day)**	
Non-Regulated Loads (LA)	**155.212**	**120.606**	**936.8**	**727.9**
Watershed background	73.435	73.435	443.2	443.2
Watershed land use	78.009	43.403	470.9	262.0
Internal	3.548	3.548	21.4	21.4
Atmospheric	0.220	0.220	1.3	1.3
Wasteloads (WLA)	**34.260**	**22.793**	**206.9**	**137.5**
MS4s	7.446	3.995	45.0	24.1
Wastewater	26.496	18.556	159.9	112.0
General Permits - WI	--	--	--	--
Construction runoff - MN	0.159	0.121	1.0	0.7
Industrial runoff - MN	0.159	0.121	1.0	0.7
Reserve Capacity (RC)	**--**	**0.959**	**--**	**5.8**
RIB conversions - WI	--	--	--	--
Non-contributing - WI	--	--	--	--
ISTS conversions	--	0.959	--	5.8
Tribal Load (TL)	**0.132**	**0.132**	**0.8**	**0.8**
Watershed runoff	0.132	0.132	0.8	0.8
Wastewater	--	--	--	--
Margin of Safety (MOS)	**--**	**7.605**	**--**	**45.9**
Total Load	**189.604**	**152.095**	**1144.5**	**917.9**

Table 19. Lake St. Croix TMDL Phosphorus Allocations - State of Wisconsin

	Existing (1990s)	TMDL	Existing (1990s)	TMDL
Component	**(metric tons/yr)**		**(pounds/day)**	
Non-Regulated Loads (LA)	**242.157**	**175.998**	**1461.7**	**1062.4**
Watershed background	92.124	92.124	556.1	556.1
Watershed land use	146.265	80.106	882.8	483.5
Internal	3.547	3.547	21.4	21.4
Atmospheric	0.221	0.221	1.4	1.4
Wasteloads (WLA)	**27.715**	**17.131**	**167.2**	**103.4**
MS4 Permitees	1.297	0.693	7.8	4.2
Wastewater Facilities	25.418	15.438	153.4	93.2
General Permits - WI	1.000	1.000	6.0	6.0
Construction runoff - MN	--	--	--	--
Industrial runoff - MN	--	--	--	--
Reserve Capacity (RC)	**--**	**3.857**	**--**	**23.2**
RIB conversions - WI	--	1.929	--	11.6
Non-contributing - WI	--	0.396	--	2.4
ISTS conversions	--	1.532	--	9.2
Tribal Load (TL)	**0.524**	**0.524**	**3.2**	**3.2**
Watershed runoff	0.220	0.220	1.3	1.3
Wastewater	0.304	0.304	1.9	1.9
Margin of Safety (MOS)	**--**	**10.395**	**--**	**62.7**
Total Load	**270.396**	**207.905**	**1632.1**	**1254.9**

5.7 Load Reductions Under the TMDL

General Discussion

The phosphorus sources with required load reductions under the TMDL are listed along with their existing and allowable loads in Table 20 (Basin), Table 21 (Minnesota) and Table 22 (Wisconsin) below. Phosphorus load reductions under the Lake St. Croix TMDL total 122.816 metric tons/yr (Table 20). This load reduction accommodates the MOS (18 metric tons/yr) and the RC (4.816 metric tons/yr) in addition to the 100-metric ton/yr overall net reduction from 460 to 360 metric tons/yr. The Basin's overall load reduction is 27% of the existing load.

Most of the required load reduction (~100 metric tons/yr) is from the runoff load that is designated *watershed land use*. This is the portion of the Basin's runoff load that results from human alterations of the landscape, such as agriculture and urban development (but excluding regulated MS4s). It is a non-regulated source. The other load reductions are from wastewater facilities (~18 metric tons/yr), regulated MS4s (~4 metric tons/yr), and stormwater runoff from construction sites and industrial sites (~0.04 metric tons/yr from each).

Interesting but purely coincidental is the near-equality between (1) the watershed land use load reduction and the required overall net reduction (both ~100 metric tons/yr), (2) the wastewater reduction and the MOS (both ~18 metric tons/yr), and (3) the regulated MS4 reduction and the RC (both ~4 metric tons/yr).

In Table 20, Table 21, and Table 22 the runoff loads (watershed land use, regulated MS4s, and construction and industrial stormwater runoff) include their portions of the natural background runoff load in addition to the anthropogenic loads. The natural background load was included to follow usual convention and to show the percentage load reductions realistically. This contrasts with the preceding TMDL allocation tables, in which the natural background load was separated out. However, in mass loading terms, the reductions are the same in the TMDL allocation tables as in the tables below. For example, in Table 17 (above), Wisconsin's watershed land use phosphorus load is 146.265 metric tons/yr under existing conditions and 80.106 metric tons/yr under the TMDL; the difference is 66.159 metric tons/yr, and this is the same as the reduction shown for Wisconsin in Table 20 below.

Table 20. Lake St. Croix TMDL Phosphorus Load Reductions - Whole Basin

Component	Existing (1990s)	TMDL	Reduction	Percent Reduction
	(metric tons/yr)			
Non-Regulated Loads (LAs)				
Watershed Land Use*	386.916	286.152	100.764	26%
Wasteloads (WLAs)				
MS4 Permittees*	11.660	7.604	4.056	35%
Wastewater Facilities	51.914	33.994	17.920	35%
Construction Stormwater Runoff	0.159	0.121	0.038	24%
Industrial Stormwater Runoff	0.159	0.121	0.038	24%

* Runoff loads here include natural background portion.

The overall percentage reduction for *watershed land use* is 23% for Minnesota (Table 21) and 28% for Wisconsin (Table 22). Wisconsin needs a larger reduction because it has more agricultural land: ~225,000 ha, or 11% of the whole Basin, versus Minnesota's ~97,000 ha, or 5% of the Basin.

Table 21. Lake St. Croix TMDL Phosphorus Load Reductions - State of Minnesota

Component	Existing (1990s)	TMDL	Reduction	Percent Reduction
	(metric tons/yr)			
Non-Regulated Loads (LAs)				
Watershed Land Use†	148.876	114.271	34.605	23%
Wasteloads (WLAs)				
MS4 Permittees†	10.014	6.562	3.452	34%
Wastewater Facilities	26.496	18.556	7.940	30%
Construction Stormwater Runoff	0.159	0.121	0.038	24%
Industrial Stormwater Runoff	0.159	0.121	0.038	24%

† Runoff loads here include natural background portion.

The percentage reduction for *wastewater treatment facilities* is 30% for Minnesota and 39% for Wisconsin. The reduction for Wisconsin is not as onerous as it appears because Wisconsin's wastewater facilities (in aggregate) substantially reduced their P load since the 1990s. There have also been lesser but significant reductions in Minnesota. Basin-wide, wastewater facilities reduced their P load by 45% from the 1990s to the current decade (Magdalene 2009). So the TMDL actually allows for growth in many wastewater facilities at present. Of course, the P load reductions required and achieved are not uniform; some facilities still need load reductions, and the percentage reductions vary among facilities. See Appendix A for details on the individual wastewater sources.

Table 22. Lake St. Croix TMDL Phosphorus Load Reductions - State of Wisconsin

Component	Existing (1990s)	TMDL	Reduction	Percent Reduction
	(metric tons/yr)			
Non-Regulated Loads (LAs)				
Watershed Land Use‡	238.04	171.881	66.159	28%
Non-Regulated Loads (LAs)				
MS4 Permittees‡	1.646	1.042	0.604	37%
Wastewater Facilities	25.418	15.438	9.980	39%
Construction Stormwater Runoff‡‡	--	--	--	--
Industrial Stormwater Runoff‡‡	--	--	--	--

‡ Runoff loads here include natural background portion.

‡‡ Wisconsin includes these source categories in its General Permits.

The required load reductions for *MS4 permittees* average 34% for Minnesota (Table 21), which has most of the regulated MS4s in the Basin (>80% by number and by load), and 37% for

Wisconsin. Again, the MS4 load reductions are not uniform; the percentage reductions vary as a result of differences in the MS4s' baseline (1990s) land use. See Appendix C for details.

Reductions by Subwatershed

To achieve the goals of the TMDL, reduction efforts will need to target priority areas where the most significant reductions can be realized. One way to approach this targeting is to compare P load data for the subwatersheds (Figure 10; note that the subwatershed delineations in Figure 9 follow the 2004 National Park Service map, *St. Croix River Basin Subwatersheds*, except for excision of the drainage area of Colby and Wilmes lakes, Woodbury, MN [landlocked, but considered to be in the Mississippi direct drainage]). Two different factors influence priority ranking among subwatersheds: phosphorus loading and phosphorus export, or load per unit area.

Total loading primarily reflects the subwatershed area: the larger the subwatershed, the larger the volume of runoff and the larger the loading of phosphorus and other pollutants. For example, the 12 largest-loading subwatersheds (Figure 10) include 11 of the 12 subwatersheds with the largest areas (see Appendix B). These 12 subwatersheds account for 77% of the Basin area and an estimated 67% of the Basin P load. Their estimated average phosphorus export during the 1990s was 0.20 kg/ha-yr, the same as the Basin average.

Phosphorus export reflects the subwatersheds' land use and land cover, rather than area. Basin-wide, the average phosphorus export was 0.20 kg/ha-yr during the 1990s, but the average export for individual subwatersheds varied from 0.07 to 0.46 kg/ha-yr (Figure 11). There is a general correlation between P export and location, with the southerly part of the Basin having high export values. In fact, the 13 most southerly subwatersheds in the Basin are also the 13 highest-exporting subwatersheds. These 13 subwatersheds encompass 26% of the Basin area and are estimated to produce 39% of the existing Basin P load. Their estimated average phosphorus export during the 1990s was 0.34 kg/ha-yr, or 1.7 times the Basin average. The higher export in the southern portion of the Basin reflects more intensive agriculture and urbanization there.

Generally, subwatershed P export is more important than overall P load in ranking priority for load-reduction implementation.

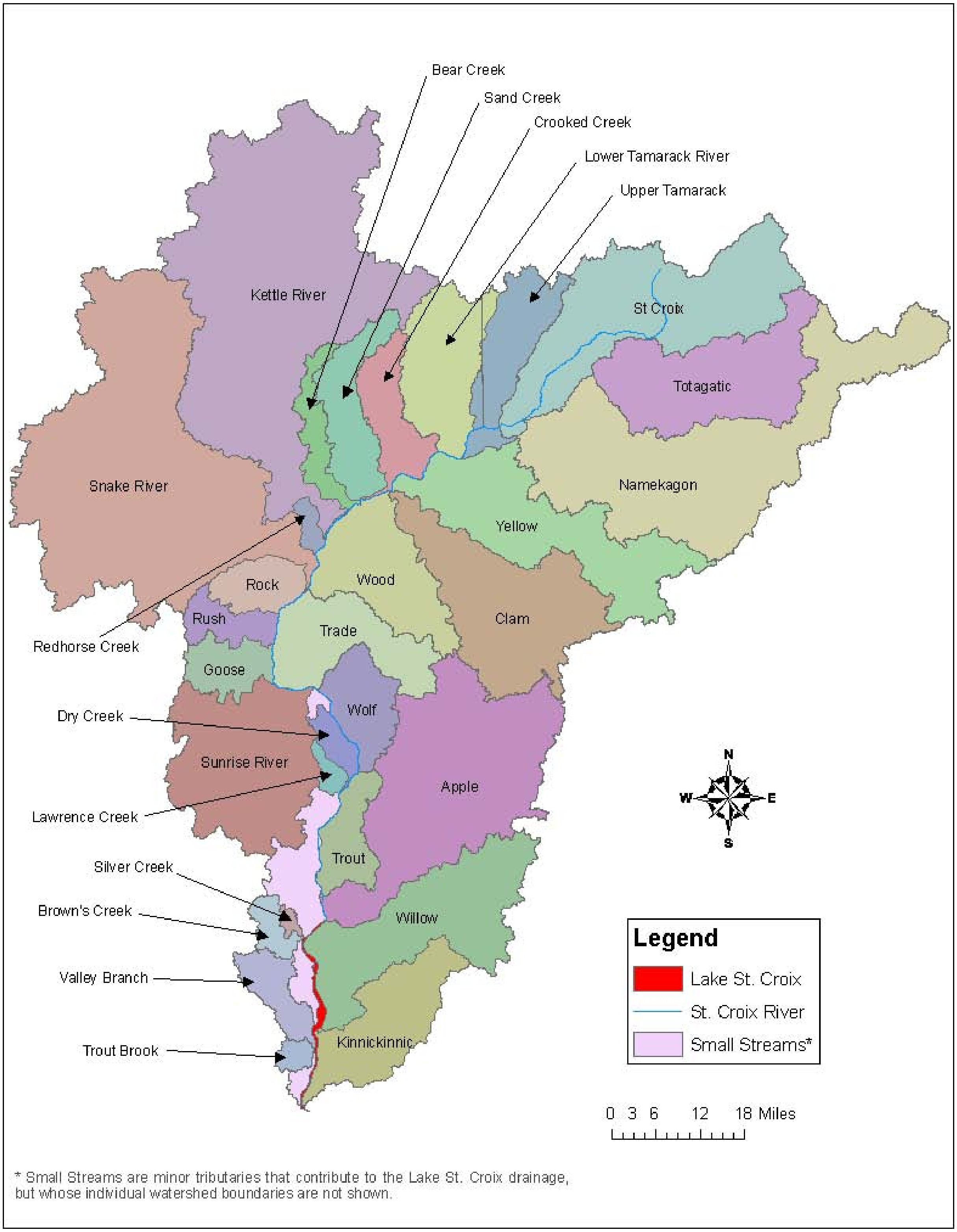


Figure 9. Sub-watersheds and their Locations in the St. Croix Basin*

*Some subwatersheds include adjacent, small tributaries not named (e.g., "Trout Brook (MN)" includes O'Conners Creek/Lake).

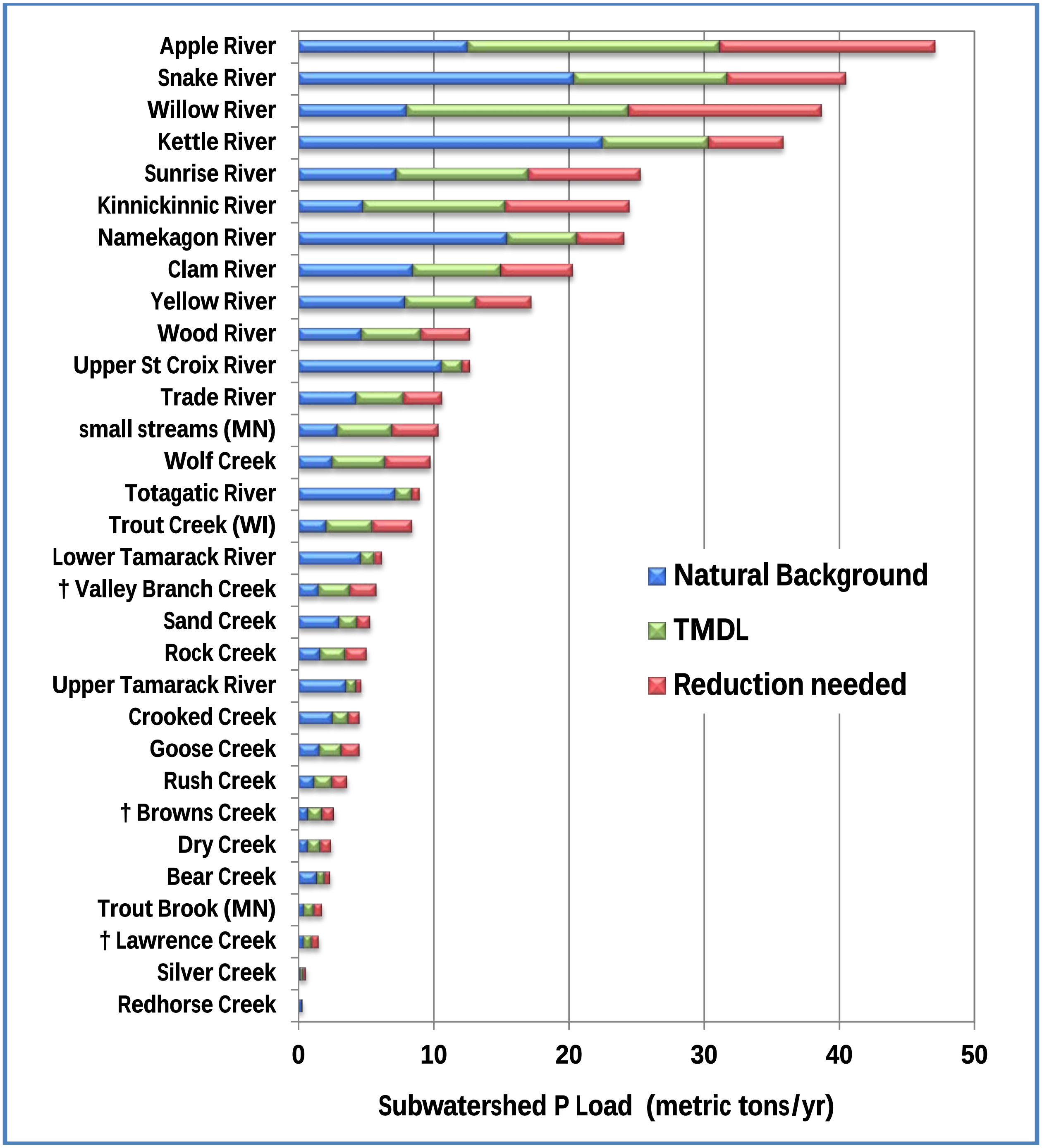


Figure 10. Lake St. Croix Subwatershed Phosphorus Loads (ranked in order of load)†

† Based on non-contributing area percentages, actual P loads are estimated to be smaller (by the percentages shown in parentheses) than those shown above for the following subwatersheds in Minnesota: Valley Branch (40%), Browns (76%), Lawrence (24%), and Silver (30%) creeks, as well as Trout Brook (50%) and small streams within the Carnelian-Marine-St. Croix Watershed District (43%).

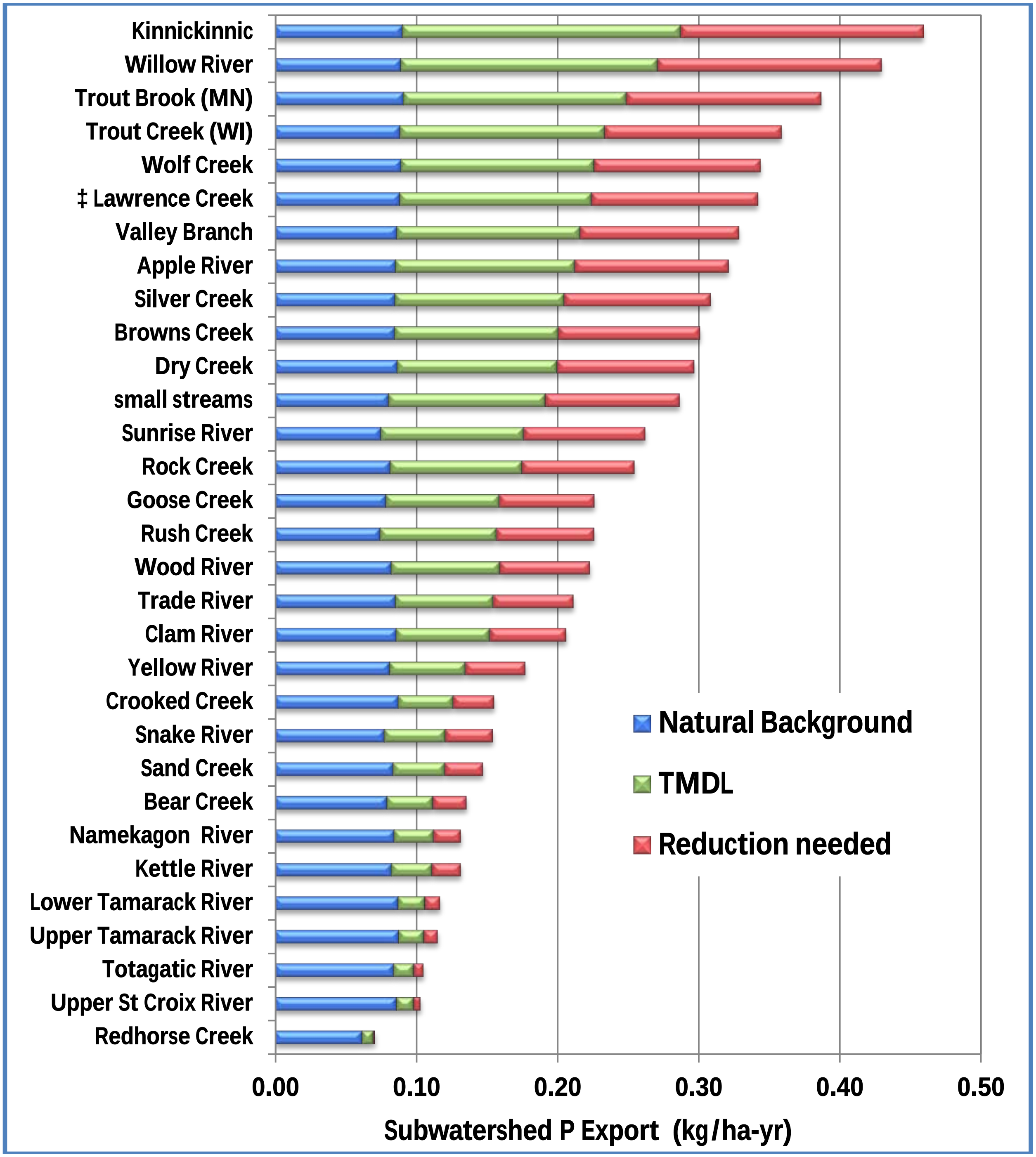


Figure 11. Lake St. Croix Sub-watershed Phosphorus Export [load per unit area] (ranked in order of export) ‡

‡ Lawrence and Silver creeks' actual P exports are believed to be substantially smaller than shown here.

6. Implementation Strategies

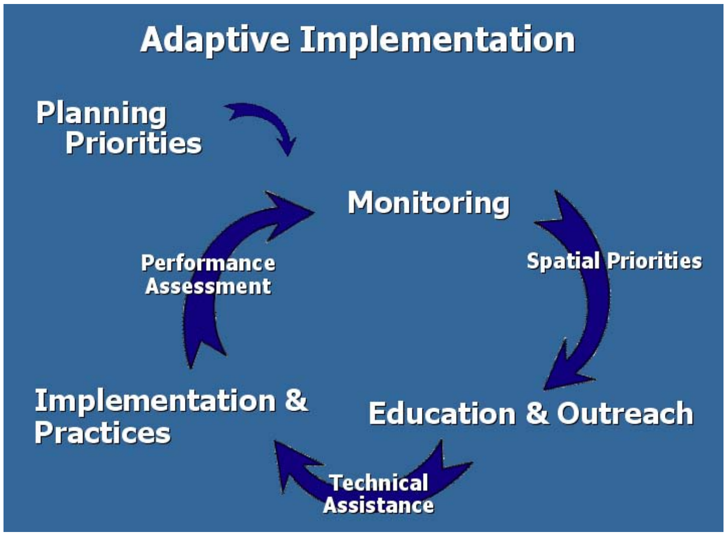
This section provides an overview of the considerations and potential implementation strategies to achieve the needed pollutant load reductions. A follow-up implementation plan will be drafted to provide more detail and specifics for carrying out the work.

Although the TMDL's individual wasteload allocations are expressed in terms of both daily and annual loads, for implementation purposes, water quality based effluent limits (WQBELs) developed for NPDES permits do not necessarily have to be expressed in terms of a daily limit (USEPA, 2006). WQBELs should be consistent with the time increment assumptions upon which the TMDL was established. Additional considerations for the development of permit limits include the type of facility, the nature and frequency of the discharge and compatibility with any other applicable effluent limits.

6.1 Adaptive Management Approach

An adaptive management approach will be considered by stakeholders during implementation planning. The adaptive approach to watershed management uses sound science to drive implementation. The planning priorities stem from the TMDL report, which outlines pollutant load reduction goals. With a focus on implementation and receiving water benefits, this cyclical process is referred to as Adaptive Implementation and the components are shown in Figure 12.

Figure 12. Adaptive Implementation Cycle



Another component of the Adaptive Management Approach is the use of watershed-wide BMP prioritization and subwatershed assessments. A variety of tools and techniques exist to identify and prioritize locations in the watershed to implement best management practices. Larger-scale prioritization is used to identify priority areas for more focused assessment efforts. Modeling, monitoring, and prioritization criteria are all viable techniques for the first stage of prioritization.

6.2 Public Education and Outreach

During the implementation phase, partners will work together to identify the most effective approach to design an innovative public education program that will promote community awareness and clearly identify the contribution that all basin citizens must make to reduce nutrient loading. Any new public education and outreach activities related to water quality issues will build on existing programs currently implemented by local partners. A successful education and community outreach program will also include:

- Continuation of the annual Protecting the St. Croix Conference; used to communicate progress toward meeting the basin goals and the TMDL implementation goals.
- Homeowner education about specific, targeted phosphorus reduction opportunities such as composting, rain gardens and rain barrels.
- Collaborative working relationships with organizations actively involved in environmental education such as Northland NEMO, Watershed Partners, and others.
- Collaborative work with citizen-led environmental organizations such as local lake associations.
- Continued outreach to the agricultural community through collaboration with producers, farm organizations, crop consultants, Land Conservation Departments, Soil and Water Conservation Districts, University Extension staff, Watershed Districts, producer-led councils, and other affiliated groups.

6.3 Wastewater Treatment

The States of Minnesota and Wisconsin must ensure that all citizens are served by wastewater treatment practices that safeguard human health and water quality. In addition to reflecting WLAs in NPDES permits issued to wastewater treatment facilities, various strategies may be considered to further reduce the total wastewater phosphorus load, including:

- Identify the number of communities in the basin that are using phosphorus-based strategies for corrosion control in water mains, estimate the amount of phosphorus lost to receiving waters, and examine alternatives to polyphosphates.
- Promote and facilitate regionalization of wastewater treatment systems through the development of comprehensive sewage management plans for areas of the basin where existing sewage treatment practices (such as septic fields and holding tanks) are releasing excessive nutrients.

For the group of facilities identified in Appendix A as being “eligible for the aggregate loading cap” compliance with the aggregated loading limit will be implemented by establishing a tracking system to evaluate the aggregate load. Fact sheets, facility descriptions, notices of coverage, public notice documents or other permit documentation appropriate for each type of facility would include:

- Language describing the facility's role as a minor small contributor of phosphorus, eligible to participate in an aggregate loading cap as established in the Lake St. Croix TMDL.

- The facility's individual share of the wasteload allocation.
- A description of the method that will be used to assess compliance with their share of the aggregate wasteload allocation.
- Future permitting actions that would result from effluent loading trends suggesting that the aggregate wasteload allocation will be exceeded.

Each state will design its own permitting process which will be implemented in accordance with the following general principles:

- Each discharger will monitor and report effluent phosphorus concentrations and loads on their discharge monitoring reports and calculate a 12 month average, allowing for evaluation of annual loading rates from the facility.
- Where monitoring is not deemed to be feasible the permittee or the state may estimate loadings on the basis of models or other accepted methodologies.
- Cumulative phosphorus loads from eligible dischargers will be evaluated for compliance with the aggregate loading caps.
- Trends indicating probability of future exceedance of the aggregate loading cap (i.e. aggregate load $\geq$ 85% of the aggregate WLA) will trigger a data evaluation process to identify the cause for the increasing phosphorus loading trend.
- Permits for the individual discharger (or dischargers) exceeding their individual share of the aggregate loading cap will be evaluated for development of water quality based effluent limits consistent with the individual wasteload allocations established by the TMDL.
- Any annual phosphorus loads incorporated into individual or general permits as WQBELs will be subtracted from the aggregate loading cap. The remaining dischargers will continue to share in the remaining portion of the aggregate loading cap.

Each state will design and implement its own tracking process for allocation of available reserve capacity.

6.4 Stormwater Treatment

Successful stormwater management includes implementation of local planning and zoning ordinances, codes, and policies, ideally including standards for treatment that:

- Incorporate low-impact development concepts into future land-use planning and stormwater treatment to reduce pollutant loading and maintain hydrologic integrity for all new development, redevelopment, industrial, and construction sites.
- Establish zoning regulations, such as minimum set-back distances from shorelines for new developments and redevelopment, to prevent significant disturbances which would result in increased erosion along lakes and waterways.
- Incorporate low-impact design principles into all plans for re-development or expansion and infrastructure or street replacement projects to treat existing sources of stormwater that are not subject to other permit programs.

- Where it is not feasible or cost-effective to improve the existing developed hydrology and pollutant loadings, other options for providing regional management of stormwater runoff should be explored.

In response to the growing need for stormwater BMP performance standards, in 2009 the Minnesota legislature allocated funds to develop performance standards, design standards or other tools to enable and promote the implementation of low impact development and other stormwater management techniques. The Minimal Impact Design Standards (MIDS) project represents the next generation in stormwater management and will develop tools to assist communities in meeting water quality goals. The three main elements of MIDS at this time are: a higher clean water performance goal, new modeling methods and calculations, and a credits system and ordinance package.

MS4 permittees in Wisconsin will be reducing total suspended solids (TSS) by 20 percent in established areas from the "no-control" scenario as required by the Wisconsin MS4 General Permit. Operations involving new construction (both inside and outside of MS4 areas) are required to reduce TSS by 80% (compared with no controls) under the Wisconsin Construction Site General Permit. Reduction of TSS will provide significant reduction of associated phosphorus.

To demonstrate compliance with their WLAs, MS4 permittees will have the option to select from a suite of Best Management Practices (BMPs), which will be developed collaboratively during implementation planning, and will be used as part of a performance-based compliance approach. Because this TMDL used the decade of the 1990s as a baseline for determining “current” loading there will be a need to determine load reductions that have occurred since that time in order to determine needed reductions to achieve allocations.

Construction stormwater activities in Minnesota are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

Industrial stormwater activities in Minnesota are considered in compliance with provisions of the TMDL if they obtain an industrial stormwater general permit or General Sand and Gravel general permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

6.5 Stormwater Practices for Smaller Communities

Many small communities, particularly in Wisconsin, are not part of a larger MS4 permitted area. Although these measures are not required by a permit, they can voluntarily be undertaken to reduce contaminated runoff to local water bodies:

- Develop a stormwater plan for future improvements to deal with the runoff using infiltration wherever possible (rather than piping it directly to surface water).
- Develop and enforce a stormwater ordinance to protect surface waters in your town and downstream.
- Monitor your success and provide adequate funding for your efforts.
- Continue regular street sweeping and stencil storm drains.
- Educate your community members about the sources of runoff and what they can do to help.

6.6 Integrated Watershed Management

Many St. Croix River Basin water resources span multiple jurisdictional boundaries and ultimately impact water quality in Lake St. Croix. Watershed Districts/Watershed Management Organizations, County Water Planning and Soil and Water Conservation Districts must work in unison to assist in the adoption of ordinances and implement effective pollutant mitigation and control technologies that protect local water quality. It is recommended that the St. Croix River Basin water planning organizations:

- Review all Local County Water Plans and Watershed Management Plans to ensure the Basin Team goals are identified in the plans and include implementation strategies designed to meet the TMDL and incorporate the strategies identified in the Lake St. Croix TMDL Study.
- Establish an integrated land and water resource planning process for development of consistent, basin-wide standards.
- Collaborate on effective education and public outreach efforts, designed to engage local communities in land use decisions and behavior change that will result in phosphorous loading reductions.
- Initiate watershed management planning with watersheds that contribute the highest amount of nutrient export per unit of land area.
- Work with other water planning organizations who share watersheds to develop combined watershed management plans.

6.7 Agricultural Activities

Water quality impacts and phosphorus loadings are dependent on animal manure handling, crop rotations, fertilizer application rates and practices (nutrient management), tillage practices, and precipitation frequency and intensity. Improvements will be needed in all of the farming practices listed above to lower the agricultural loading, especially in the watersheds with the highest loadings (the Apple, Kinnickinnic, Willow, Snake and Sunrise). Some other recommended reduction strategies include:

- Develop comprehensive nutrient management plans for all agricultural croplands in the basin.
- Directing drainage from confined livestock areas to retention basins, grassed buffer strips, constructed wetlands, or other effective nutrient-reduction practices.

- Use of holding areas and wintering areas for livestock, on a rotational basis, to prevent a build-up of nutrients in the soil. Remove manure accumulated in confined holding areas regularly and apply to crop or pasture lands at agronomic rates.
- Develop regional nutrient budgets to assist in siting intensive livestock operations and develop practical options for treating and exporting manure to nutrient-deficient areas.
- Consider new tile drainage systems, such as controlled drainage, to regulate the quantity of water removed at different times of the year.
- Work with all sectors of the agricultural community to implement new advances in agronomy, soil conservation, nutrient management, etc.

6.8 Silviculture

Implement silviculture operations, forest stewardship planning and BMPs that are appropriate for each site and process, based on the recommendations in Water Quality in Forest Management: Best Management Practices in Minnesota, Sustaining Minnesota Forest Resources Voluntary Site-Level Forest Management Guidelines and Wisconsin’s Forestry Best Management Practices for Water Quality or another state-approved forestry BMP guidebook.

6.9 Turf Farms and Golf Courses

Develop strategies that promote and support annual soil testing to provide land owners/operators with the tools necessary to make sound agronomic, economic, and/or environmental decisions. Create incentives for conducting soil fertility testing. Implement BMPs to minimize water usage and treat surface water discharge from each site.

6.10 Homeowners

Every citizen and visitor to the basin can make simple adjustments that will make a difference in the amount of phosphorus reaching our surface waters. Household wastes discharged through our home plumbing either reach an individual septic system or a community wastewater facility for further treatment and some level of phosphorus removal. Yard wastes and land use also affect sediment and nutrients in runoff carried to ditches, dry runs, small tributaries, wetlands, lakes, and rivers throughout the watershed. Here are some recommendations for everyone in the basin:

- Use phosphorus-free dish detergent and fabric softener.
- Compost food wastes and lawn clippings.
- Keep leaves and grass clippings out of the storm sewer drains.
- Dispose of pet waste properly.
- Use phosphorus-free lawn fertilizers (now required by law in both states).
- Let driveway and roof top runoff soak into the ground (use rain gardens, vegetative swales, etc.).
- Minimize hard surfaces like rooftops and driveways on your property.
- Properly maintain septic systems.
- Plant trees and shrubs in place of turf to help capture rainwater and minimize runoff.

6.11 Businesses, Churches, Schools, etc.

In addition to the recommendations above for homeowners, below are some general recommendations for these sectors:

- Use low or no-phosphorus products in manufacturing, cleaning and lawn care.
- Reduce runoff from roofs and parking areas through infiltrative practices.
- Implement water conservation measures.

6.12 Shorefront Property Owners

Shorefront property owners are another vital group to protecting water bodies from direct input of nutrients and sediment. Here are some recommendations for reducing phosphorus inputs from riparian lots and shorelines (in addition to those above for homeowners):

- Restore native vegetation and shorefront buffers to control runoff, minimize shoreline erosion and decrease grassed areas (in compliance with local zoning ordinances),
- Identify sources of runoff and find ways to intercept and infiltrate rainwater (rain barrels, rain gardens, infiltration pads, etc.),
- Use good erosion control practices around any ground-disturbing activities to prevent runoff and siltation,
- Leave water vegetation, fallen trees and woody habitat in place in the shallow water zone to provide valuable habitat and protect the shoreline from wave erosion.

7. Monitoring Plan to Track TMDL Effectiveness

The water quality in Lake St. Croix has been monitored for more than 30 years and will continue to be monitored for the foreseeable future. An extensive watershed program is also in place with different types of ongoing monitoring being conducted in different areas of the watershed. The St. Croix Basin Team will coordinate the ongoing monitoring efforts being conducted by the various agencies working throughout the watershed. The monitoring goals determined by the St. Croix Basin Team include:

- Determining nutrient and sediment concentration trends and loads for the main stem of the St. Croix River and Lake St. Croix.
- Determine nutrient and sediment loads for the selected tributaries used to track progress on tributary nutrient-management goals.
- Determine trends in biological indicators in Lake St. Croix, Lake Mallalieu, and at main-stem and tributary locations.
- Provide information used in the development and calibration of main stem and tributary nutrient models.

Monitoring is based on an ideal monitoring network, detailed in the Monitoring Plan for the St. Croix River: 2010 (VanderMeulen, D., 2010). The monitoring sites have been selected to achieve the goals stated above. The desired monitoring scheme and parameters, based on the four goals outlined above, are shown below:

Monitoring Objective 1: Mainstem and Lake St. Croix Water Quality

- A minimum of five monitoring sites from within the main stem of the St. Croix River and Lake St. Croix,
- Continuous flow gauging,
- Base-flow and storm-composite sample analysis for sediment and nutrient variables.

Monitoring Objective 2: Tributary Loads

- Up to 23 sites for individual tributaries will be monitored,
- Base-flow and storm-composite sample analysis for sediment and nutrient variables.

Monitoring Objective 3: Algal Response

- Seven monitoring sites within the pools of Lake St. Croix and Lake Mallalieu,
- Semi-monthly (May-September) sample collection and analysis for Secchi depth, dissolved organic, carbon, chlorophyll-a, and phytoplankton biomass and composition,
- Sediment sample collection and analysis every third year for diatom biomass and composition.

Monitoring Objective 4: Subwatershed Load Distribution

- One to four monitoring sites targeted for each sub-watershed,
- Continuous flow gauging,
- Base-flow and storm-composite sample analysis for a conservative tracer (chloride) and sediment, and nutrient variables.

The comparison between future monitoring data and the modeling results in this study can be conducted as follows:

- Using monitoring results (flow and water quality sampling data), calculate the annual load (or the load over some other time period) of phosphorus leaving the monitored basins,
- Run the in-lake models for same time period and calculate the load that the model predicts for pre-project conditions,
- Compare the two loads, and calculate the percent reduction that was achieved over the time period of interest.

A number of recommendations are made below to better detail phosphorus loading sources and track the effectiveness of BMP implementation within the Lake St. Croix watershed:

7.1 Monitoring of BMPs and other Water Quality Improvement Measures

It is important to assess the long-term effectiveness of water quality improvement projects. This may include site-specific monitoring designed to evaluate the effectiveness of selected BMPs or other implementation measures taken to reduce loading to Lake St. Croix.

7.2 Tributary Monitoring during Spring Runoff

Expand the monitoring program to include data collection during spring runoff in priority tributaries. As much as 50 percent of pollutant loading to Lake St. Croix may occur during spring runoff. Some monitoring data exist for spring runoff and snowmelt, but additional monitoring is recommended to estimate the proportion of the annual loads that enter the system during this period.

7.3 Sediment Fingerprinting Study

Conduct a sediment fingerprinting study to assess major watershed sediment (and phosphorus) loading sources to the St. Croix River and Lake St. Croix. Sediment fingerprinting will involve the comparison of sediments collected from potential source areas to those entering Lake St. Croix by using geochemical; mineralogic; lead, cesium, and beryllium-activity; or other methods.

7.4 Sediment Phosphorus Composition and Internal Phosphorus Loading Study

Internal sources of phosphorus loading have been addressed at a rudimentary level but additional work is needed to quantify the potential extent, variability, and magnitude of internal phosphorus loading in the different pools and their effect on phosphorus loading and eventual in-lake phosphorus reductions in Lake St. Croix. Phosphorus release rates were estimated previously by incubation of sediment collected from the Bayport and Troy Beach pools (USGS; Robertson and

Lenz, 2002). Release rates ranged from 0.2 to 0.7 mg/m2/d and 8.6 to 26.1 mg/m2/d under oxic or anoxic conditions, respectively.

To determine the amount of phosphorus available for internal loading in Lake St. Croix, sediment from the Bayport, Troy Beach, Black Bass, and Kinnickinnic pools should be collected and analyzed for phosphorus by depth in the sediment. Recent methods that separate the different pools of sediment phosphorus allow for the estimation of internal phosphorus loading rates using mobile phosphorus (mainly loosely sorbed and iron- and manganese-bound phosphorus). This method is less time consuming, costs less, and has been shown to be consistent in a wide variety of lakes in Minnesota (Pilgrim et al. 2007). This study will build on the previous work and can be expanded to unstudied areas of the system.

8. Reasonable Assurances

The Clean Water Act requires that states provide a "reasonable assurance" that the TMDL will be implemented. Reasonable assurance will be provided through a variety of voluntary and/or regulatory means in the Lake St. Croix TMDL. The TMDL will be implemented through enforcement of existing regulations, financial incentives and various local, state and federal water pollution control programs. Following are some activities, programs, requirements and institutional arrangements that will provide a reasonable assurance that the TMDL is implemented and the water quality goals will be achieved.

8.1 Minnesota and Wisconsin

- An implementation plan addressing both Minnesota and Wisconsin sources of phosphorus will be finalized within one year of USEPA approval of the TMDL, which will identify specific BMP opportunities sufficient to achieve the sector-specific load reduction and an associated adoption schedule. Individual SWPPPs may be modified accordingly following the recommendations of the implementation plan.
- Monitoring will be conducted to track progress and guide adjustments in the implementation approach.
- All significant development, redevelopment, industrial, and construction projects need to be designed to maintain or improve existing developed hydrology and pollutant loadings to fully comply with the local watershed and government authorities, NPDES, and anti-degradation requirements for ORVW in both states.
- Citizens of the St. Croix Basin are dedicated stewards willing to set a peer example and advocate for protection of the St. Croix River and its watersheds.

8.2 Minnesota

Point Sources

Point source dischargers in the Lake St. Croix watershed include municipal and industrial wastewater, stormwater, and concentrated animal feeding operations (CAFOs). The MPCA regulates point source discharges (municipal and industrial operations; MS4, industrial and construction stormwater; and CAFOs) through the National Pollutant Discharge Elimination System (NPDES) Permit Program. NPDES permits can be divided into two categories; individual and general permits. Individual permits are issued to more complex facilities and activities such as municipal and industrial wastewater discharges. General permits are issued to classes of municipal and industrial activities that are similar in nature such as small wastewater treatment facilities, nonmetallic mining, non-contact cooling water, and stormwater discharges.

Individual NPDES permits issued to municipal and industrial wastewater discharges to surface water will be issued with loads and limits consistent with the approved TMDL WLA providing the necessary reasonable assurance that the WLAs in the TMDL will be achieved. The MPCA may modify a permit to include WLA-derived limits or include WLA-derived limits when the permit is reissued. Water Quality Based Effluent Limitations must be consistent with the assumptions and requirements of any available USEPA approved wasteload allocations.

Facilities operating under general permits will be screened to determine whether additional requirements may be needed to insure that the permitted activity is consistent with TMDL WLAs, which may include issuing individual permits or other measures.

Nonpoint Sources

The MPCA administers two important financial assistance programs for watershed management of nonpoint source water pollution: the Clean Water Partnership (CWP) grant and loan program, and the Federal Clean Water Act Section 319 program. The MPCA administers both programs with the assistance of a project coordination team comprised of staff from state and local resource agencies. Also, The Clean Water Legacy Act (CWLA) of 2006 established the Board of Water and Soil Resources (BWSR) as the agency to lead nonpoint source pollution reduction activities. Most BWSR funds through CWLA provide grants to implement local conservation practices that clean up impaired waters and protect high-quality lakes, rivers, streams, and wetlands.

The CWP grant program was created in 1987 to address pollution associated with runoff from agricultural and urban areas. The program provides local governments with resources to protect and improve lakes, streams and ground water. CWP projects begin with a desire by a local unit of government to improve a water resource that has been polluted by land-use-related activities or to protect unpolluted water from pollution. Local leadership and expertise, combined with technical and financial resources from the state, create an effective program for controlling pollution and restoring water quality. The CWP loan program focuses on implementing BMPs that are targeted toward the restoration of specific water resources, such as lakes, streams or groundwater aquifers. CWP implementation activities include upgrading or replacing ISTSs and fostering beneficial agricultural practices. The local unit of government can use the funds to implement BMPs itself or it can re-lend the funds to private parties for other types of BMP activities.

The Clean Water Act Section 319 grant program offers funds for nonpoint source water pollution control implementation projects. The goal of this grant program is to protect and improve the quality of Minnesota's water resources by implementing nonpoint source pollution control measures that have been identified in the state Nonpoint Source Management Program Plan. The USEPA provides the grant funds for the program.

8.3 Wisconsin

The TMDL will be an amendment to the Area-wide Water Quality Management Plan for the St. Croix River Basin pursuant to chapter NR121, Wis. Adm. Code. A detailed discussion of management activities aimed at meeting the goals of the TMDL will be included in the Minnesota/Wisconsin Implementation Plan.

Point Sources

Point source dischargers in the Lake St. Croix watershed include municipal and industrial wastewater, storm water, and concentrated animal feeding operations (CAFOs). The DNR regulates point sources (municipal and industrial operations, MS4 permittees, and CAFOs discharging wastewater to surface water or groundwater through the WPDES Permit Program.

WPDES permits can be divided into two categories; specific and general permits. Specific permits are issued to more complex facilities and activities such as municipal and industrial wastewater discharges. General permits are issued to classes of industries or activities that are similar in nature, such as nonmetallic mining, non-contact cooling water, and storm water discharges.

Individual WPDES permits issued to municipal and industrial wastewater discharges to surface water will be issued with loads and limits consistent with the approved TMDL wasteload allocations providing the necessary reasonable assurance that the WLAs in the TMDL will be achieved. The WDNR may modify a permit to include WLA-derived limits or include WLA-derived limits when the permit is reissued. Once a TMDL has been state and federally approved the permit for a point source allocated wasteload by the TMDL may not be reissued without a WLA-derived limit (and if needed, a schedule of compliance for meeting the limit).

Wastewater facilities operating under general permits will be screened to determine whether additional requirements may be needed to insure that the permitted activity is consistent with TMDL goals, which may include issuing specific permits or other measures. Standard requirements in general permits for industrial wastewater (18 different kinds currently) and construction sites administered by DNR are considered adequate for attainment of the TMDL goal. If these facilities are meeting current general permit requirements, they are considered in compliance with the wasteload allocations defined in this TMDL.

Nonpoint Sources

To ensure the reduction goals of this TMDL are attained, management measures must be implemented and maintained to control nutrient and sediment loadings from nonpoint source pollution. Wisconsin's Nonpoint Source Pollution Abatement Program (NPS Program), described in the state's Section 319 Program Management Plan outlines a variety of financial, technical and educational programs, which support implementation of management measures to address nonpoint source pollution. The WDNR and the Department of Agriculture, Trade, and Consumer Protection (DATCP) coordinate statewide implementation of the NPS Program. The NPS Program includes core activities and programs, which, discussed below, are a high priority and the focus of WDNR and DATCP's efforts to address NPS pollution:

The WDNR is a leader in the development of regulatory authority to prevent and control nonpoint source pollution. Chapter NR 151, Wis. Adm. Code, establishes polluted runoff performance standards and prohibitions for agricultural and non-agricultural facilities and practices. DATCP has adopted specific farm conservation practices to implement the performance standards via Chapter ATCP 50, Wis. Adm. Code. All farms in Wisconsin are required to implement the performance standards if offered cost-sharing. These standards are intended to be minimum standards of performance necessary to achieve water quality standards. Implementing the performance standards and prohibitions on a statewide basis is a high priority for the NPS Program.

In particular, the implementation and enforcement of agricultural performance standards and manure management prohibitions, listed below, will be critical to achieving the necessary nonpoint source load reductions throughout the basin:

- Sheet, rill and wind erosion: All cropped fields shall meet the tolerable (T) soil erosion rate established for that soil.
- Manure storage facilities: All new, substantially altered, or abandoned manure storage facilities shall be constructed, maintained or abandoned in accordance with accepted standards. Failing and leaking existing facilities posing an imminent threat to public health or fish and aquatic life or violating groundwater standards shall be upgraded or replaced.
- Clean water diversions: Runoff from agricultural buildings and fields shall be diverted away from contacting feedlots, manure storage areas and barnyards located within water quality management areas (300 feet from a stream or 1,000 feet from a lake or areas susceptible to groundwater contamination).
- Nutrient management: Agricultural operations applying nutrients to agricultural fields shall do so according to a nutrient management plan.

Manure management prohibitions:

- No overflow of manure storage facilities
- No unconfined manure piles in a water quality management area
- No direct runoff from feedlots or stored manure into state waters
- No unlimited livestock access to waters of the state in locations where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover

In addition to the performance standards and prohibitions, the NPS Program supports NPS pollution abatement by administering and providing cost-sharing grants to fund best management practices (BMPs) through various WDNR grant programs, including, but not limited to:

- The Targeted Runoff Management (TRM) Grant Program,
- The Notice of Discharge (NOD) Grant Program,
- The Urban Nonpoint Source & Storm Water Management Grant Program, and
- The River Planning & Protection Grant Program.

DATCP administers the Farmland Preservation Program which requires participating farmers to meet the state performance standards to be eligible for tax credits, without cost-sharing. Currently, about 17,000 farms receive tax credits in Wisconsin. While participation rates vary from 6.5 percent to 22 percent in the counties within the St. Croix watershed, a significant acreage of farmland within the watershed will be required to meet state performance standards without additional incentives.

DATCP oversees and supports county conservation programs that implement the state performance standards, prohibitions and conservation practices. The DATCP's Soil and Water Resource Management Program requires counties to develop Land and Water Resource Management (LWRM) Plans to identify conservation needs. Counties must receive the DATCP approval of their plans to receive state cost-sharing grants for BMP installation. The DATCP is also responsible for providing local assistance grant (LAG) funding for county conservation staff implementing NPS control programs included in the LWRM plans. This includes local staff support for DATCP and WDNR programs.

County LWRM plans advance land and water conservation and prevent NPS pollution by:

- Inventorying water quality and soil erosion conditions in the county.
- Identifying relevant state and local regulations, and any inconsistencies between them.
- Setting water quality goals, in consultation with the WDNR.
- Identifying key water quality and soil erosion problems, and practices to address those problems.
- Identifying priority farm areas using a range of criteria (e.g., impaired waters, manure management, high nutrient applications).
- Identifying strategies to promote voluntary compliance with statewide performance standards and prohibitions, including information, cost-sharing, and technical assistance.
- Identifying enforcement procedures, including notice and appeal procedures.
- Including a multi-year work plan to achieve soil and water conservation objectives.

The WDNR, the DATCP, and County Land Conservation Departments (LCD) will work with landowners to implement agricultural and non-agricultural performance standards and manure management prohibitions to address sediment and nutrient loadings to Lake St. Croix. Many landowners voluntarily install BMPs to help improve water quality and comply with the performance standards. Cost sharing may be available for many of these BMPs. In most cases, farmers will not be required to comply with the agricultural performance standards and prohibitions unless they are offered at least 70 percent cost sharing funds. If cost-share money is offered, those in violation of the standards are obligated to comply with the rule.

The counties and other local units of government in the basin may apply for Targeted Runoff Management (TRM) grants through the WDNR. TRM grants are competitive financial awards to support small-scale, short-term projects (24 months) completed locally to reduce runoff pollution. Both urban and agricultural projects can be funded through TRM grants which require a local contribution to the project. Projects that correct violations of the performance standards and prohibitions and reduce runoff pollution to impaired waters are a high priority for this grant program.

Numerous federal programs are also being implemented in the basin and are expected to be an important source of funds for future projects designed to control phosphorus loadings to Lake St. Croix. A few of the federal programs include:

- The Environmental Quality Incentive Program (EQIP) is another option available to farmers. EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.

- The Conservation Reserve Program (CRP) is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, Farm Service Administration (FSA) provides participants with rental payments and cost-share assistance.
- The Conservation Reserve Enhancement Program (CREP) provides annual rental payments up to 15 years for taking cropland adjacent to surface water and sinkholes out of production. A strip of land adjacent to the stream must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs and/or grass species. Cost sharing incentives and technical assistance are provided for planting and maintenance of the vegetative strips. Landowners also receive an upfront, lump sum payment for enrolling in the program, with the amount of payment dependent on whether they enroll the program for 15 years or permanently.

9. Public Participation

In 1994, the St. Croix Basin Team was created by a Memorandum of Understanding which was signed by the MPCA, the WDNR, the Minnesota Department of Natural Resources and the National Park Service (NPS). For the past 16 years, these partners have met to establish water resource goals for the St. Croix River Basin and develop a plan to accomplish these goals. They have been joined by the following groups in this effort: the St. Croix River Association, the Metropolitan Council Environmental Services (MCES), the Minnesota Board of Water and Soil Resources (BWSR), the Minnesota Department of Agriculture (MDA), St. Croix County WI, Chisago County MN, the Science Museum of Minnesota--St. Croix Watershed Research Station, the United States Geological Survey (USGS), the University of Wisconsin Extension (UW), local Management Organizations, Soil and Water Conservation Districts and County Land Conservation Departments. Since 2001, the St. Croix Basin Team prepared biennial status reports to provide information to all St. Croix Basin partners and create a unified report between the states of Minnesota and Wisconsin. This collaborative team worked with local citizens and identified nutrient and sediment loading as the top threats to water quality in the St. Croix River. As a result of these discussions, the St. Croix Basin Team formed an Implementation Subcommittee, a Monitoring and Assessment Subcommittee, a Standards Subcommittee and a Funding Subcommittee.

At the April 16, 2009, conference “The Plan to Reduce Phosphorus by 100 Tons”, attendees heard about the phosphorus loading study, how the Basin Team got where it was at, and the TMDL process. In three breakout sessions (unregulated urban phosphorus sources, unregulated rural sources, and permitted sources) attendees had an opportunity to ask questions about the TMDL process and provide input on what needed to be done and who else needed to be involved. That input was then summarized in a general session for all attendees.

Prior to the spring 2009 conference, a stakeholder participation strategy was developed by MPCA with input from the WDNR and the Basin Team. It identified key stakeholders and provided a plan for reaching out to those stakeholders for local input. The intent of the strategy was to have an engaged and well-informed base of experts and citizens to provide input to the TMDL process. This was to be accomplished by providing all the necessary scientific information to interested parties so that they could submit relevant local information before final decisions were made. Local citizens’ knowledge of pollution sources and potential successful mitigation measures was sought throughout the process.

The first step in the strategy was to state the role of the stakeholder in the TMDL process, that is: to provide local data and relevant information; review and comment on proposed load allocation alternatives; and to review and comment on the draft TMDL Report during the 30-day public notice period. The second step was to identify stakeholders. This became a detailed list by sources of phosphorus and by categories of stakeholders affected by the impairment. The sources were: non-permitted urban runoff (both cities and townships); non-permitted rural runoff (row crops farms; feedlots operators; crop consultants; soil, land, and water conservation agencies); municipal, industrial and agricultural permit holders [wastewater treatment facilities, industrial permittees, confined animal feeding operations (CAFOs), MS4 permittees]. Groups that were potentially impacted by the impaired water body included lake associations, residents, recreational users, and downstream resources. The final component of the stakeholder list was comprised of local and county governments, environmental organizations, and state and federal agencies with an interest in protecting the St. Croix.

Next, a stakeholder engagement plan was implemented. News releases, letters of invitation, and conference brochures were sent out, inviting stakeholders to the annual conference (discussed above), two geographically targeted community meetings in each state, and three individual sector meetings.

After the annual conference, the first meetings that were held were the geographically targeted community meetings. These were held in June, 2009 in Hinckley and Forest Lake, Minnesota, and Frederic and Hudson, Wisconsin. The objective of those meetings was to help the public become aware of the complex issues involved in the restoration efforts for Lake St. Croix and how they may be impacted by the decisions that will be made during the TMDL process, to build an awareness at the community level, encourage support for the process, and provide for an informed citizenry.

There were two opportunities per meeting site to attend, one late afternoon, and the other early evening. As participants came into the meeting rooms, they were asked to show on a Basin map where they lived and where they recreated. There were a number of maps and informational handouts available at the registration table. The format of the meetings started with an introduction of the process and the intent of the meetings. This was followed by a roundtable introduction of the people present, and then an informal PowerPoint presentation on what's the basin, what's the problem, what's the solution, and how can citizens help. After the presentation, the participants were asked for input and encouraged to ask questions.

The next phase of the public participation process was to conduct the individual technical sector meetings in July and August 2009. The objective for these meetings was similar to the community meetings: to engage the permit-holders and the rural and agricultural community in discussions to increase awareness of the complex issues involved in the restoration efforts for Lake St. Croix and how they may be impacted by the decisions that will be made during the TMDL process, and to seek their input on possible allocation scenarios. The format for the meetings was very similar to the community meetings, except the TMDL presentation tailored to the individual sector group at each meeting, to highlight each sector's contribution to the problem and potential contribution to the restoration efforts. Again, at the end of the presentation, participants were encouraged to provide input and ask questions about the process.

As a result of the public participation process, land-use related export coefficients were rechecked and adjusted, individual sewage treatment system and unsewered communities were given a closer examination, stream channel and ravine erosion derived phosphorus was re-examined, all resulting in a refinement of source loads and recalculation of allocations for the draft TMDL report. Table 23 provides a summary of the 2009 TMDL public participation meetings.

Table 23. Lake St. Croix Public Participation, 2009

Date	Location	Target Group	Participants
4/16/09	River Falls, WI	Annual Conference	126
6/10/09	Hinckley, MN	Community	12
6/16/09	Forest Lake, MN	Community	17
6/23/09	Frederic, WI	Community	13
6/30/09	Hudson, WI	Community	26
7/17/09	Pine City, MN	Ag/rural	21
7/29/09	Stillwater, MN	MS4 Permittees	12
7/30/09	North Branch, MN	WWTP	11
8/04/09	St. Croix Falls, WI	WWTP	25
8/17/09	Balsam Lake, WI	Ag/rural	27

A preliminary draft of the TMDL was made available for public review in December 2010 and a public meeting to discuss this draft was held in Hudson, WI on January 11, 2011, with over 100 attendees. For submittal of comments on the final draft the MPCA and WDNR each followed their respective required administrative processes. The MPCA public noticed the final draft in the Minnesota State Register for a 30-day comment period from December 12, 2011, to January 11, 2012. WDNR provided a public notice from January 10 to February 10, 2012, and held public hearings on January 31, 2012, in Siren and Hudson, WI.

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12. Resources Available on the Internet

St. Croix River Basin: Interagency Water Resource Management Planning Effort:

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/basins-and-watersheds/st.-croix-river-basin/st.-croix-river-basin-interagency-water-resource-management-planning-effort.html

- St. Croix Basin Phosphorus-Based Water-Quality Goals
- Wisconsin Department of Natural Resources and Minnesota Pollution Control Agency Agreement on Nutrient and Sediment Reduction in the St. Croix River Basin
- St. Croix Basin Water Resources Planning Status Reports

St. Croix River Basin

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/basins-and-watersheds/st.-croix-river-basin/st.-croix-river-basin.html?menuid=&missing=0&redirect=1

Minnesota's Impaired Waters and TMDLs

Project: Lake St. Croix TMDL - Excess Nutrients: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/st.-croix-river-basin-tmdl-projects/project-lake-st.-croix-excess-nutrients.html

Wisconsin Department of Natural Resources

Natural Resources Board Agenda Item: http://dnr.wi.gov/org/nrboard/2010/June/06-10-3A4.pdf

Apple River (Wisconsin)

http://en.wikipedia.org/w/index.php?title=Apple_River_(Wisconsin)&oldid=234288408

Namekagon River (Wisconsin)

http://en.wikipedia.org/w/index.php?title=Namekagon_River&oldid=285239825

Willow River (Wisconsin)

http://en.wikipedia.org/w/index.php?title=Willow_River_(St._Croix_River)&oldid=285200245

Appendix A. National Pollution Discharge Elimination System Permittees

Title	Table
Minnesota Wastewater WLAs	A-1
Minnesota Wastewater Facilities Eligible for Aggregate NPDES Load Cap	A-2
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Wisconsin Wastewater Facilities Eligible for Aggregate WPDES Load Cap	A-4
Wisconsin General Permits Eligible for Aggregate WPDES Load Cap	A-5

Wastewater NPDES:

Table A.1. Minnesota Wastewater WLAs

Facility	Permit Number	Facility Category	Concentration Assumption (mg/L)	Design Flow (mgd)	WLA (kg/yr)	WLA (lb/day)
St. Croix Valley WWTP	MN0029998	LM	0.6	5.800	4,808	29.0
Chisago Lakes	MN0055808	LM	0.6	2.460	2,039	12.3
Xcel Alan S. King Power Plant	MN0000825	I3	Other	331.20	1,300	7.8
North Branch WWTP	MN0024350	MM	1.0	0.812	1,122	6.8
Mora WWTP	MN0021156	MM	1.0	0.800	1,105	6.7
Pine City WWTP	MN0021784	MM	1.0	0.750	1,036	6.3
Hinckley WWTP	MN0023701	MM	1.0	0.682	942	5.7
Moose Lake WWTP	MN0020699	MM	1.0	0.495	684	4.1
Aitkin Cromwell Agri-Peat	MN0055662	I1	0.1	4.300	594	3.6
Shafer WWTP	MN0030848	MM	1.0	0.400	553	3.3
Rush City WWTP	MN0021342	MM	1.0	0.400	552	3.3
Sandstone WWTP	MN0056910	MM	1.0	0.383	529	3.2
Finlayson WWTP	MN0023418	MM	1.0	0.300	414	2.5
Ogilvie WWTP	MN0021997	MM	1.0	0.230	318	1.9
Isle WWTP	MN0023809	MM	1.0	0.200	276	1.7
Linwood Terrace - Iacarella	MN0054372	SM3	1.0	0.167	231	1.4
Cimarron Park WWTF	MN0050636	SM3	1.0	0.120	166	1.0
Harris WWTP	MN0050130	SM3	Load Limit	0.121	164	1.0
Askov WWTP	MN0022616	SM3	Load Limit	0.050	128	0.8
Willow River WWTP	MNG580054	SM3	Load Limit	0.044	122	0.7
		Total		**349.714**	**17,083**	**103.1**

Table A.2. Minnesota Wastewater Facilities Eligible for Aggregate NPDES Load Cap

Facility	Permit Number	Facility Category	Concentration Assumption (mg/L)	Design Flow (mgd)	WLA (kg/yr)	WLA (lb/day)
Barnum WWTF	MNG580142	SM1	2.0	0.146	402	18.8*
Taylors Falls	MN0053309	SM1	2.0	0.141	390	19.0*
Wahkon WWTP	MNG580051	SM1	2.0	0.121	334	16.0*
Grasston WWTF	MNG580052	SM1	2.0	0.038	105	6.5*
Anderson Corp	MN0001724	I1	0.1	1.500	104	0.6
Kettle River WWTF	MNG580183	SM1	2.0	0.035	97	4.8*
Shorewood Park	MN0051390	SM1	2.0	0.015	41	3.3*
		Total		**1.996**	**1,473**	**8.8**

* Daily wasteload allocations for Minnesota facilities in the SM1 category are calculated from the 2 mg/L concentration assumption and the maximum permitted effluent flow rate of 6"/day over the area of the facility's discharging cell(s). These controlled discharge facilities are designed to store 180 days worth of influent flow and to discharge during spring and fall periods of relatively high stream flow and/or low receiving water temperature. Since these facilities discharge intermittently, their daily wasteload allocations do not represent their annual wasteload allocations divided by the days in a year. Rather they reflect the permitted daily effluent loads as described above. Based on these daily allocations, the median number of days per year these facilities may discharge (annual WLA ÷ daily WLA) is 45. For consistency with all other TMDL loads, however, the aggregate daily *subtotal* in the table simply equals the aggregate annual load subtotal divided by 365.25 days.

Table A.3. Wisconsin Wastewater WLAs

Facility	Permit Number	Facility Classification	Concentration Assumption (mg/L)	Design Flow (mgd)	WLA (kg/yr)	WLA (lb/day)
Hudson WWTF	24279	LM	0.6	3.250	2,694	16.3
River Falls WWTP	29394	LM	0.6	3.170	2,628	15.9
New Richmond WWTF	21245	LM	0.6	1.730	1,434	8.7
Osceola, Village of	25020	MM	1.0	0.750	1,036	6.3
Amery, City of	20125	MM	1.0	0.535	739	4.5
St. Croix Falls, City of	20796	MM	1.0	0.496	685	4.1
Hammond	24171	MM	1.0	0.450	622	3.8
Clear Lake, Village of	23639	MM	1.0	0.404	558	3.4
Grantsburg, Village of	60429	MM	1.0	0.380	525	3.2
Somerset WWTF	30252	MM	1.0	0.375	518	3.1
Luck, Village of	21482	MM	1.0	0.364	503	3.0
Burnett Dairy Cooperative	39039	I2	1.0	0.250	345	2.1
		Total		**12.154**	**12,287**	**74.4**

Table A.4. Wisconsin Wastewater Facilities Eligible for Aggregate WPDES Load Cap						
Facility	Permit Number	Facility Classification	Concentration Assumption (mg/L)	Design Flow (mgd)	WLA (kg/yr)	WLA (lb/day)
Frederic	29254	SM2	3.5	0.185	895	5.4
Star Prairie WWTF	60984	SM2	3.5	0.154	745	4.5
T. Thompson Hatchery	49191	H	0.1	2.208	305	1.8
Deer Park WWTF	25356	SM2	3.5	0.051	247	1.5
WI DNR Osceola Fish Hatchery	4197	H	0.1	1.770	245	1.5
Clayton, Village of	36706	SM1	2.0	0.087	240	8.7*
Webster, Village of	28843	SM1	2.0	0.085	235	8.5*
Amani Sanitary District	31861	SM1	2.0	0.032	88	3.2*
Advanced Food Products	39781	I1	0.1	0.401	55	0.3
W DNR St. Croix Falls Hatchery	4201	H	0.1	0.344	48	0.3
Lakeside Foods, INC.	2836	I1	0.1	0.316	44	0.3
Emerald Dairy	59315	I2	Load estimate		4	0.02
		Total		**5.633**	**3,151**	**18.9**

* Daily wasteload allocations for Wisconsin facilities in the SM1 category are calculated from the 2 mg/L concentration assumption and the maximum permitted effluent flow rate of 6 times the design flow. These controlled discharge facilities are designed to discharge the annual influent flow volume during 60 days of relatively high stream flow and/or low receiving water temperature in the spring and fall of the year. Since these facilities discharge intermittently, their daily wasteload allocations do not represent their annual wasteload allocations divided by the days in a year. Rather they reflect the permitted daily effluent loads as described above. Based on these daily allocations, the median number of days per year these facilities may discharge (annual WLA ÷ daily WLA) is 61. For consistency with all other TMDL loads, however, the aggregate daily *subtotal* in the table simply equals the aggregate annual load subtotal divided by 365.25 days.

Table A.5. Wisconsin General Permits Eligible for Aggregate WPDES Load Cap				
Facility	Permit Number	Facility Classification	WLA (kg/yr)	WLA (lb/day)
Wisconsin General Permits	various	WGP	1,000	6.0

Abbreviation Key	
Facility Classification	Abbreviation
Fish hatchery	H
Industrial - low concentration	I1
Industrial - high concentration	I2
Industrial - high volume cooling water	I3
Municipal - design flow ≥ 1.0 mgd	LM
Municipal - design flow ≥ 0.2 & < 1 mgd	MM
Municipal controlled discharge < 0.2 mgd	SM1
Municipal continuous discharge < 0.2 mgd	SM2
Municipal with existing permit limit < 0.2 mgd	SM3
Wisconsin General Permits	WGP

There are several WPDES general permits used to cover specific categories of wastewater discharges (separate from stormwater general permits). The bulk of the activities covered under general permits are discharges that seep to groundwater, are intermittent in operation, or low in loading. The permits that allow some type of direct discharge to inland surface waters include:

Carriage and Interstitial Water from Dredging Operations	WI-0046558-4
Concrete Products Operations	WI-0046507-5
Contaminated Groundwater from Remedial Action Operations	WI-0046566-5
Hydrostatic Test Water and Water Supply System Water	WI-0057681-4
Non-Contact Cooling Water, or Condensate and Boiler Blowdown	WI-0044938-5
Nonmetallic Mining Operations	WI-0046515-5
Petroleum Contaminated Water	WI-0046531-4
Pit/Trench Dewatering	WI-0049344-3
Potable Water Treatment and Conditioning	WI-0046540-5
Sanitary Sewer Overflows (SSO) from Sewage Collection Systems	WI-0047341-4
Short Duration Discharge	WI-0059137-3
Swimming Pool Facilities	WI-0046523-5
Wastewater from the Outside Washing of Vehicles, Equipment and Other Objects	WI-0059153-3

In the St. Croix Basin, it is estimated that there are less than 25 facilities that discharge to surface water in any given year. None of the facilities or projects covered under these permits contributes a significant loading to surface waters. The majority of the covered activities are non-contact cooling water with low flow and low phosphorus, projects that discharge intermittently or activities of short duration. It is very difficult to estimate a load or even potential loading from assumed operating parameters.

Stormwater NPDES:

Wisconsin has stormwater general permits for municipal MS4 permits, and construction and industrial activities, as follows:

Stormwater Construction Sites	WI-S067831
Stormwater Industrial Tier 1	WI-S067849
Stormwater Industrial Tier 2	WI-S067857
Municipal Separate Storm Sewer System	WI-S050075

<u>Wisconsin MS4 Permittees</u>
River Falls
University of Wisconsin, River Falls
Hudson (anticipated)
North Hudson (anticipated)

The numbers of projects covered under the construction site and industrial general permits vary from year to year. A very rough estimate of the facilities regulated by Wisconsin DNR is 400 per year for construction activities and 170 per year in the industrial categories. The Wisconsin Department of Commerce regulated construction site stormwater at commercial sites in past years; this is another important component of the phosphorus loading from construction activities (an estimate of the number of sites is not presently available).

Minnesota has stormwater general permits for municipal MS4 permits, and construction and industrial activities, as follows:

Construction stormwater	MNR100001
Industrial stormwater	MNR50000
Municipal Separate Storm Sewer System	MNR040000

Minnesota MS4 Permittees	MS4 ID #
Century College	MS400171
Cottage Grove	MS400082
East Bethel	MS400087
Forest Lake	MS400262
Grant	MS400091
Hugo	MS400094
Lake Elmo	MS400098
Mahtomedi	MS400031
Maplewood	MS400032
North Branch	MS400260
North Saint Paul	MS400041
Oakdale	MS400042
Pine Springs	MS400044
Stillwater	MS400259
Valley Branch Watershed District	MS400217
West Lakeland	MS400162
White Bear Lake	MS400060
Woodbury	MS400128
MNDOT Metro District	MS400170
Ramsey County	MS400191
Washington County	MS400160

CAFOs:

Minnesota	Permit #
Luoma Egg Ranch, Inc.	MN0056090

Wisconsin	Permit #
Arcand Poultry Farm, Inc.	0059366
Bomaz Farms	0064505
Emerald Dairy, LLC	0059315
Jennie-O Turkey Store	0062049
Legacy Farms, LLC	0063029
Minglewood, Inc.	0059358
Owens Farms Inc.	0063363
Schottler Dairy Inc.	0058289
Ulrich Farms Inc.	0058939

Appendix B. St. Croix Basin Subwatershed Areas and Land Use/Land Cover Areas (per NLCD 1992 coverage), P Loads and Load Reductions, and Average P Export Values

Title	Table	Units
St. Croix Basin Subwatershed Areas and Land Use / Land Cover Areas (per NLCD 1992 coverage)	B-1	hectares (ha)
	B-2	acres (ac)
St. Croix Basin Subwatershed P [phosphorus] Loads for Existing (1990s) Conditions	B-3	kilograms (kg) per year
	B-4	pounds (lb) per year
St. Croix Basin Subwatershed P Loads for TMDL Conditions	B-5	kg/yr
	B-6	lb/yr
St. Croix Basin Subwatershed P Load Reductions and P Export for Existing (1990s) and TMDL Conditions	B-7	kg/yr & kg/ha-yr lb/yr & lb/ac-yr

Table B-1. St. Croix Basin Subwatershed Areas and Land Use / Land Cover Areas in Hectares (per NLCD 1992 coverage)*

wsh _id	Name	Area in Land Use / Land Cover (hectares)						Area Totals
		Agricultural	Forest	Grassland	Shrubland	Urban	Water	(hectares)
0	small streams	1,037	521	1,215	0.09	0.03	357	3,130
1	Trout Brook	2,050	464	2,133	-	2.8	21	4,669
2	Valley Branch	5,153	2,662	8,037	0.8	855	998	17,707
3	small streams	7,989	7,475	10,629	0.7	1,115	3,878	31,085
4	Browns Creek	2,232	1,311	4,409	-	240	641	8,833
5	Silver Creek	569	251	1,014	-	3.7	136	1,974
6	Lawrence Creek	1,604	637	2,118	-	13	152	4,525
7	Sunrise River	24,765	25,303	27,686	7.3	1,669	17,142	96,572
8	Dry Creek	2,464	2,352	3,039	0.3	27	433	8,315
9	small streams	592	684	688	0.6	-	77	2,042
10	Goose Creek	3,999	7,963	5,179	2.0	143	2,813	20,099
11	Rush Creek	2,857	4,753	5,176	3.0	329	2,948	16,065
12	Rock Creek	4,160	5,171	8,341	13	182	2,131	19,998
13	Snake River	19,535	143,878	56,321	756	2,035	39,687	262,212
14	Kettle River	8,825	186,970	46,778	1,440	2,038	25,992	272,042
15	Redhorse Creek	9	3,196	54	24	1.2	1,577	4,861
16	Bear Creek	764	10,917	3,487	35	69	2,286	17,557
17	Sand Creek	3,012	26,099	3,718	313	18	3,052	36,212
18	Crooked Creek	2,967	23,464	1,514	82	62	1,283	29,373
19	Lower Tamarack	2,028	45,920	559	32	95	2,252	50,887
20	Upper Tamarack	213	2,465	102	0.8	16	70	2,867
	MN Totals	**96,822**	**502,456**	**192,200**	**2,711**	**8,913**	**107,924**	**911,025**
	% of MN Total	*10.6%*	*55.2%*	*21.1%*	*0.3%*	*1.0%*	*11.8%*	*100.0%*
23	Apple	54,460	45,955	36,113	8.6	511	9,551	146,599
24	Clam	16,872	57,883	17,043	565	260	5,829	98,451
25	Kinnickinnic	32,692	5,706	13,606	0.2	609	708	53,322
26	Namekagon	11,159	146,531	9,203	1,375	664	13,900	182,833
27	St Croix	1,586	104,562	1,873	7,605	360	7,050	123,034
28	Totagatic	1,656	74,242	1,884	534	233	6,892	85,441
29	Trade	9,250	26,661	8,396	2,717	143	3,266	50,433
30	Trout	10,112	6,567	5,943	0.5	215	722	23,559
31	Willow	50,030	11,914	24,968	2.4	883	2,268	90,065
32	Wolf	11,487	8,809	7,443	2.8	118	649	28,507
33	Wood	11,696	27,587	10,500	1,266	282	5,655	56,987
34	Yellow	13,138	61,441	10,421	626	845	10,760	97,231
35	Upper Tamarack	1,096	33,989	925	82	44	1,629	37,765
36	Lower Tamarack	30	2,091	23	1.7	0	98	2,243
	WI Totals	**225,264**	**613,937**	**148,342**	**14,785**	**5,166**	**68,976**	**1,076,469**
	% of WI Total	*20.9%*	*57.0%*	*13.8%*	*1.4%*	*0.5%*	*6.4%*	*100.0%*
	Basin Totals	**322,086**	**1,116,392**	**340,541**	**17,496**	**14,078**	**176,901**	**1,987,494**
	% of Basin Total	*16.2%*	*56.2%*	*17.1%*	*0.9%*	*0.7%*	*8.9%*	*100.0%*

*** Note:** 1 hectare = 10,000 square meters = 0.01 square kilometers. Also, 1 hectare = 2.471 acres.

*** Condensed classifications: Agricultural** = Row Crops (82) + Small Grains (83); **Forest** = Deciduous Forest (41) + Evergreen Forest (42) + Mixed Forest (43) + Woody wetlands (91); **Grassland** = Grasslands/Herbaceous (71) + Urban/Recreational Grasses (85) + Pasture/Hay (81); **Shrubland** = Barren Transitional (33) + Shrubland (51); **Urban** = Commercial/Industrial/Transport (23) + High Intensity Residential (22) + Low Intensity Residential (21) + Quarries/Strip Mines/Gravel Pit (32); **Water** = Emergent Herbaceous Wetlands (92) + Open Water (11).

Table B-2. St. Croix Basin Subwatershed Areas and Land Use / Land Cover Areas in Acres (per NLCD 1992 coverage)*								
wsh _id	**Name**	**Area in Land Use / Land Cover (acres)**						**Area Totals (acres)**
		Agricultural	**Forest**	**Grassland**	**Shrubland**	**Urban**	**Water**	
0	small streams	2,562	1,288	3,002	0.22	0.08	882	7,734
1	Trout Brook	5,064	1,147	5,270	-	7.0	51	11,539
2	Valley Branch	12,734	6,579	19,860	2.0	2,113	2,466	43,755
3	small streams	19,741	18,470	26,264	1.8	2,754	9,582	76,814
4	Browns Creek	5,514	3,241	10,895	-	594	1,583	21,826
5	Silver Creek	1,405	620	2,506	-	9.0	336	4,877
6	Lawrence Creek	3,964	1,575	5,234	-	33	374	11,181
7	Sunrise River	61,196	62,524	68,414	18.2	4,124	42,358	238,634
8	Dry Creek	6,088	5,812	7,510	0.7	66	1,070	20,548
9	small streams	1,463	1,689	1,701	1.4	-	190	5,045
10	Goose Creek	9,882	19,676	12,798	4.9	352	6,951	49,665
11	Rush Creek	7,061	11,744	12,789	7.5	813	7,283	39,698
12	Rock Creek	10,280	12,777	20,612	31	451	5,266	49,416
13	Snake River	48,271	355,530	139,173	1,869	5,028	98,069	647,941
14	Kettle River	21,806	462,013	115,591	3,558	5,035	64,227	672,230
15	Redhorse Creek	21.9	7,897	135	59	2.9	3,898	12,013
16	Bear Creek	1,888	26,976	8,616	85	171	5,649	43,385
17	Sand Creek	7,442	64,493	9,187	773	45	7,541	89,481
18	Crooked Creek	7,333	57,981	3,742	203	152	3,171	72,582
19	Lower Tamarack	5,010	113,472	1,382	80	234	5,565	125,744
20	Upper Tamarack	526	6,092	253	2.1	40	172	7,085
	MN Totals	**239,253**	**1,241,595**	**474,935**	**6,698**	**22,023**	**266,687**	**2,251,192**
	% of MN Total	*10.6%*	*55.2%*	*21.1%*	*0.3%*	*1.0%*	*11.8%*	*100.0%*
23	Apple	134,574	113,557	89,238	21.1	1,262	23,602	362,253
24	Clam	41,691	143,032	42,113	1,396	642	14,404	243,279
25	Kinnickinnic	80,783	14,101	33,622	0.5	1,505	1,749	131,761
26	Namekagon	27,575	362,087	22,742	3,397	1,641	34,348	451,790
27	St Croix	3,918	258,378	4,627	18,792	888	17,420	304,024
28	Totagatic	4,092	183,457	4,656	1,318	576	17,031	211,129
29	Trade	22,856	65,880	20,748	6,714	353	8,071	124,621
30	Trout	24,987	16,227	14,684	1.3	531	1,785	58,215
31	Willow	123,627	29,440	61,698	5.8	2,183	5,603	222,557
32	Wolf	28,385	21,766	18,391	6.8	291	1,603	70,443
33	Wood	28,903	68,168	25,946	3,128	698	13,974	140,817
34	Yellow	32,465	151,823	25,752	1,548	2,087	26,588	240,262
35	Upper Tamarack	2,708	83,988	2,287	201	110	4,025	93,319
36	Lower Tamarack	74	5,167	56	4.2	-	242	5,544
	WI Totals	**556,639**	**1,517,071**	**366,560**	**36,534**	**12,765**	**170,444**	**2,660,014**
	% of WI Total	*20.9%*	*57.0%*	*13.8%*	*1.4%*	*0.5%*	*6.4%*	*100.0%*
	Basin Totals	**795,892**	**2,758,665**	**841,496**	**43,233**	**34,789**	**437,131**	**4,911,206**
	% of Basin Total	*16.2%*	*56.2%*	*17.1%*	*0.9%*	*0.7%*	*8.9%*	*100.0%*

* **Condensed classifications:** **Agricultural** = Row Crops (82) + Small Grains (83); **Forest** = Deciduous Forest (41) + Evergreen Forest (42) + Mixed Forest (43) + Woody wetlands (91); **Grassland** = Grasslands/Herbaceous (71) + Urban/Recreational Grasses (85) + Pasture/Hay (81); **Shrubland** = Barren Transitional (33) + Shrubland (51); **Urban** = Commercial/Industrial/Transport (23) + High Intensity Residential (22) + Low Intensity Residential (21) + Quarries/Strip Mines/Gravel Pit (32); **Water** = Emergent Herbaceous Wetlands (92) + Open Water (11).

Table B-3. St. Croix Basin Subwatershed P Loads in Kilograms per Year for Existing (1990s) Conditions									
		Watershed P Load INCLUDING Natural Background (kg/yr)						Load Totals (kg/yr), with Natural Background:	
wsh	Name	Agricultural	Forest	Grassland	Shrubland	Urban	Water		
_id	*P export (kg/ha-yr)*	***0.628409***	***0.098419***	***0.220725***	***0.098419***	***0.628409***	***0.006980***	**INCLUDED**	**OMITTED**
0	small streams	651	51	268	0.009	0.021	2.5	974	720
1	Trout Brook†	1288	46	471	-	1.78	0.14	1,806	1,381
2	Valley Branch†	3238	262	1774	0.080	537	7.0	5,819	4,291
3	small streams	5020	736	2346	0.074	700	27	8,830	6,342
4	Browns Creek†	1,402	129	973	-	151	4.5	2,660	1,911
5	Silver Creek	357	25	224	-	2.3	0.95	609	441
6	Lawrence Creek†	1,008	63	468	-	8.3	1.1	1,548	1,148
7	Sunrise River	15,563	2,490	6,111	0.72	1,049	120	25,333	18,070
8	Dry Creek	1,548	231	671	0.03	17	3.0	2,471	1,750
9	small streams	372	67	152	0.05	-	0.54	592	412
10	Goose Creek	2,513	784	1,143	0.19	90	20	4,549	2,969
11	Rush Creek	1,796	468	1,142	0.30	207	21	3,633	2,434
12	Rock Creek	2,614	509	1,841	1.2	115	15	5,095	3,461
13	Snake River	12,276	14,160	12,432	74	1,279	277	40,498	20,150
14	Kettle River	5,545	18,401	10,325	142	1,281	181	35,876	13,377
15	Redhorse Creek	6	315	12	2.3	0.74	11	346	46
16	Bear Creek	480	1,074	770	3.4	43	16	2,387	991
17	Sand Creek	1,892	2,569	821	31	11	21	5,345	2,313
18	Crooked Creek	1,865	2,309	334	8.1	39	9.0	4,564	1,996
19	Lower Tamarack	1,274	4,519	123	3.2	60	16	5,996	1,548
20	Upper Tamarack	134	243	23	0.08	10.1	0.49	410	154
	MN Totals	**60,844**	**49,451**	**42,423**	**267**	**5,601**	**753**	**159,340**	**85,905**
	% of MN Total	*38.2%*	*31.0%*	*26.6%*	*0.2%*	*3.5%*	*0.5%*	*100.0%*	-
23	Apple	34,223	4,523	7,971	0.84	321	67	47,105	34,574
24	Clam	10,602	5,697	3,762	56	163	41	20,320	11,851
25	Kinnickinnic	20,544	562	3,003	0.02	383	4.9	24,496	19,685
26	Namekagon	7,013	14,422	2,031	135	417	97	24,115	8,668
27	St Croix	996	10,291	413	748	226	49	12,724	2,119
28	Totagatic	1,041	7,307	416	53	146	48	9,010	1,828
29	Trade	5,813	2,624	1,853	267	90	23	10,670	6,357
30	Trout	6,354	646	1,312	0.05	135	5.0	8,452	6,364
31	Willow	31,439	1,173	5,511	0.23	555	16	38,694	30,666
32	Wolf	7,218	867	1,643	0.27	74	4.5	9,807	7,260
33	Wood	7,350	2,715	2,318	125	177	39	12,724	8,031
34	Yellow	8,256	6,047	2,300	62	531	75	17,271	9,364
35	Upper Tamarack	689	3,345	204	8.0	28	11	4,285	981
36	Lower Tamarack	19	206	5.0	0.17	-	0.68	230	34
	WI Totals	**141,558**	**60,423**	**32,743**	**1,455**	**3,246**	**481**	**239,906**	**147,782**
	% of WI Total	*59.0%*	*25.2%*	*13.6%*	*0.6%*	*1.4%*	*0.2%*	*100.0%*	-
	Basin Totals	**202,402**	**109,875**	**75,166**	**1,722**	**8,847**	**1,235**	**399,246**	**233,687**
	% of Basin Total	*50.7%*	*27.5%*	*18.8%*	*0.4%*	*2.2%*	*0.3%*	*100.0%*	-

† Note: For Trout Brook and Browns, Lawrence, and Valley Branch creeks, areas that actually contribute to the St. Croix are smaller than their watershed totals in this table, reflecting substantial landlocked portions. Actual P loads are estimated to be smaller than those shown here by 52%, 76%, 24%, and 40%, respectively, based on non-contributing area percentages.

Table B-4. St. Croix Basin Subwatershed P Loads in Pounds per Year for Existing (1990s) Conditions

wsh_id	Name	Watershed P Load INCLUDING Natural Background (lb/yr): Agricultural	Forest	Grassland	Shrubland	Urban	Water	Load Totals (lb/yr), with Natural Background Load: INCLUDED	OMITTED
	P export (lb/ac-yr)	*0.560653*	*0.087808*	*0.196926*	*0.087808*	*0.560653*	*0.006228*		
0	small streams	1,436	113	591	0.02	0.05	5.5	2,147	1,587
1	Trout Brook††	2,839	101	1,038	-	3.9	0.32	3,982	3,045
2	Valley Branch††	7,140	578	3,911	0.18	1,185	15	12,828	9,460
3	small streams	11,068	1,622	5,172	0.16	1,544	60	19,466	13,981
4	Browns Creek††	3,092	285	2,146	-	333	10	5,864	4,213
5	Silver Creek	788	54	494	-	5.1	2.1	1,343	973
6	Lawrence Creek††	2,222	138	1,031	-	18	2.3	3,412	2,531
7	Sunrise River	34,310	5,490	13,473	1.6	2,312	264	55,850	39,838
8	Dry Creek	3,413	510	1,479	0.06	37	6.7	5,447	3,858
9	small streams	820	148	335	0.12	0	1.2	1,305	909
10	Goose Creek	5,540	1,728	2,520	0.43	197	43	10,030	6,545
11	Rush Creek	3,959	1,031	2,519	0.66	456	45	8,010	5,366
12	Rock Creek	5,763	1,122	4,059	2.7	253	33	11,232	7,631
13	Snake River	27,063	31,218	27,407	164	2,819	611	89,282	44,424
14	Kettle River	12,226	40,568	22,763	312	2,823	400	79,092	29,491
15	Redhorse Creek	12	693	27	5.2	1.6	24	763	101
16	Bear Creek	1,058	2,369	1,697	7.5	96	35	5,262	2,184
17	Sand Creek	4,172	5,663	1,809	68	25	47	11,784	5,100
18	Crooked Creek	4,111	5,091	737	18	85	20	10,062	4,400
19	Lower Tamarack	2,809	9,964	272	7.0	131	35	13,218	3,414
20	Upper Tamarack	295	535	50	0.18	22	1.1	903	339
	MN Totals	**134,138**	**109,022**	**93,527**	**588**	**12,347**	**1,661**	**351,285**	**189,387**
	% of MN Total	*38.2%*	*31.0%*	*26.6%*	*0.2%*	*3.5%*	*0.5%*	*100.0%*	-
23	Apple	75,449	9,971	17,573	1.9	707	147	103,850	76,223
24	Clam	23,374	12,559	8,293	123	360	90	44,799	26,127
25	Kinnickinnic	45,292	1,238	6,621	0.05	844	11	54,005	43,399
26	Namekagon	15,460	31,794	4,478	298	920	214	53,165	19,110
27	St Croix	2,197	22,688	911	1,650	498	108	28,052	4,671
28	Totagatic	2,294	16,109	917	116	323	106	19,865	4,030
29	Trade	12,814	5,785	4,086	590	198	50	23,523	14,015
30	Trout	14,009	1,425	2,892	0.11	298	11	18,634	14,031
31	Willow	69,312	2,585	12,150	0.51	1,224	35	85,306	67,607
32	Wolf	15,914	1,911	3,622	0.60	163	10	21,621	16,005
33	Wood	16,204	5,986	5,109	275	391	87	28,052	17,705
34	Yellow	18,201	13,331	5,071	136	1,170	166	38,076	20,644
35	Upper Tamarack	1,518	7,375	450	18	61	25	9,448	2,163
36	Lower Tamarack	42	454	11	0.37	-	1.5	507	76
	WI Totals	**312,081**	**133,211**	**72,185**	**3,208**	**7,157**	**1,061**	**528,902**	**325,804**
	% of WI Total	*59.0%*	*25.2%*	*13.6%*	*0.6%*	*1.4%*	*0.2%*	*100.0%*	-
	Basin Totals	**446,219**	**242,232**	**165,712**	**3,796**	**19,504**	**2,722**	**880,187**	**515,192**
	% of Basin Total	*50.7%*	*27.5%*	*18.8%*	*0.4%*	*2.2%*	*0.3%*	*100.0%*	-

†† Note: For Trout Brook and Browns, Lawrence, and Valley Branch creeks, areas that actually contribute to the St. Croix are smaller than their watershed totals in this table, reflecting substantial landlocked portions. Actual P loads are estimated to be smaller than those shown here by 52%, 76%, 24%, and 40%, respectively, based on non-contributing area percentages.

Table B-5. St. Croix Basin Subwatershed P Loads in Kilograms per Year for TMDL Conditions

wsh _id	Name	Watershed P Load INCLUDING Natural Background (kg/yr)						Load Totals (kg/yr), with Natural Background Load:	
		Agricultural	Forest	Grassland	Shrubland	Urban	Water	INCLUDED	OMITTED
	P export (kg/ha-yr)	*0.377555*	*0.098419*	*0.160327*	*0.098419*	*0.377555*	*0.006980*		
0	small streams	391	51	195	0.009	0.012	2.5	640	386
1	Trout Brook‡	774	46	342	-	1.1	0.14	1,163	737
2	Valley Branch‡	1,946	262	1,289	0.08	323	7.0	3,826	2,298
3	small streams	3,016	736	1,704	0.07	421	27	5,904	3,416
4	Browns Creek‡	843	129	707	-	91	4.5	1,774	1,025
5	Silver Creek	215	25	163	-	1.4	1.0	404	236
6	Lawrence Creek‡	606	63	340	-	5.0	1.1	1,014	614
7	Sunrise River	9,350	2,490	4,439	0.72	630	120	17,030	9,767
8	Dry Creek	930	231	487	0.03	10.1	3.0	1,662	941
9	small streams	224	67	110	0.05	-	0.54	402	222
10	Goose Creek	1,510	784	830	0.19	54	20	3,198	1,617
11	Rush Creek	1,079	468	830	0.30	124	21	2,521	1,322
12	Rock Creek	1,571	509	1,337	1.2	69	15	3,502	1,868
13	Snake River	7,375	14,160	9,030	74	768	277	31,685	11,338
14	Kettle River	3,332	18,401	7,500	142	769	181	30,326	7,827
15	Redhorse Creek	3.3	315	8.7	2.3	0.4	11	340	40
16	Bear Creek	288	1,074	559	3.4	26	16	1,967	571
17	Sand Creek	1,137	2,569	596	31	6.8	21	4,361	1,329
18	Crooked Creek	1,120	2,309	243	8.1	23	9.0	3,713	1,144
19	Lower Tamarack	766	4,519	90	3.2	36	16	5,429	982
20	Upper Tamarack	80	243	16	0.08	6.1	0.49	346	90
	MN Totals	**36,556**	**49,451**	**30,815**	**267**	**3,365**	**753**	**121,207**	**47,772**
	% of MN Total	*30.2%*	*40.8%*	*25.4%*	*0.2%*	*2.8%*	*0.6%*	*100.0%*	-
23	Apple	20,562	4,523	5,790	0.84	193	67	31,135	18,603
24	Clam	6,370	5,697	2,732	56	98	41	14,994	6,524
25	Kinnickinnic	12,343	562	2,181	0.02	230	4.9	15,321	10,510
26	Namekagon	4,213	14,422	1,476	135	251	97	20,593	5,146
27	St Croix	599	10,291	300	748	136	49	12,123	1,518
28	Totagatic	625	7,307	302	53	88	48	8,423	1,240
29	Trade	3,492	2,624	1,346	267	54	23	7,806	3,494
30	Trout	3,818	646	953	0.05	81	5.0	5,503	3,415
31	Willow	18,889	1,173	4,003	0.23	333	16	24,414	16,386
32	Wolf	4,337	867	1,193	0.27	44	4.5	6,446	3,899
33	Wood	4,416	2,715	1,683	125	107	39	9,085	4,392
34	Yellow	4,960	6,047	1,671	62	319	75	13,134	5,227
35	Upper Tamarack	414	3,345	148	8.0	17	11	3,943	639
36	Lower Tamarack	11	206	3.7	0.17	-	0.68	222	25
	WI Totals	**85,049**	**60,423**	**23,783**	**1,455**	**1,950**	**481**	**173,143**	**81,019**
	% of WI Total	*49.1%*	*34.9%*	*13.7%*	*0.8%*	*1.1%*	*0.3%*	*100.0%*	-
	Basin Totals	**121,605**	**109,875**	**54,598**	**1,722**	**5,315**	**1,235**	**294,350**	**128,791**
	% of Basin Total	*41.3%*	*37.3%*	*18.5%*	*0.6%*	*1.8%*	*0.4%*	*100.0%*	-

‡ **Note**: For Trout Brook and Browns, Lawrence, and Valley Branch creeks, areas that actually contribute to the St. Croix are smaller than their watershed totals in this table, reflecting substantial landlocked portions. Actual P loads are estimated to be smaller than those shown here by 52%, 76%, 24%, and 40%, respectively, based on non-contributing area percentages.

Table B-6. St. Croix Basin Subwatershed P Loads in Pounds per Year for TMDL Conditions

wsh	Name	Watershed P Load INCLUDING Natural Background (lb/yr)						Load Totals (lb/yr), with Natural Background Load:	
		Agricultural	Forest	Grassland	Shrubland	Urban	Water		
_id	*P export (lb/ac-yr)*	*0.336847*	*0.087808*	*0.143040*	*0.087808*	*0.336847*	*0.006228*	INCLUDED	OMITTED
0	small streams	863	113	429	0.020	0.027	5.5	1,411	852
1	Trout Brook‡‡	1,706	101	754	-	2.4	0.32	2,563	1,626
2	Valley Branch‡‡	4,289	578	2,841	0.18	712	15	8,435	5,067
3	small streams	6,650	1,622	3,757	0.16	928	60	13,016	7,531
4	Browns Creek‡‡	1,857	285	1,558	-	200	9.9	3,910	2,259
5	Silver Creek	473	54	359	-	3.0	2.1	891	521
6	Lawrence Creek‡‡	1,335	138	749	-	11.0	2.3	2,236	1,354
7	Sunrise River	20,614	5,490	9,786	1.59	1,389	264	37,544	21,532
8	Dry Creek	2,051	510	1,074	0.06	22	6.7	3,664	2,075
9	small streams	493	148	243	0.12	-	1.2	886	490
10	Goose Creek	3,329	1,728	1,831	0.43	119	43	7,050	3,565
11	Rush Creek	2,378	1,031	1,829	0.66	274	45	5,559	2,914
12	Rock Creek	3,463	1,122	2,948	2.7	152	33	7,720	4,118
13	Snake River	16,260	31,218	19,907	164	1,694	611	69,854	24,996
14	Kettle River	7,345	40,568	16,534	312	1,696	400	66,856	17,255
15	Redhorse Creek	7.4	693	19.3	5.173	1.0	24	750	88
16	Bear Creek	636	2,369	1,232	7.494	58	35	4,337	1,259
17	Sand Creek	2,507	5,663	1,314	68	15.1	47	9,614	2,929
18	Crooked Creek	2,470	5,091	535	18	51	20	8,185	2,523
19	Lower Tamarack	1,688	9,964	198	7.0	79	35	11,970	2,166
20	Upper Tamarack	177	535	36	0.18	13.4	1.1	763	199
	MN Totals	**80,592**	**109,022**	**67,935**	**588**	**7,418**	**1,661**	**267,216**	**105,320**
	% of MN Total	*30.2%*	*40.8%*	*25.4%*	*0.2%*	*2.8%*	*0.6%*	*100.0%*	-
23	Apple	45,331	9,971	12,765	1.86	425	147	68,640	41,013
24	Clam	14,044	12,559	6,024	123	216	90	33,055	14,384
25	Kinnickinnic	27,212	1,238	4,809	0.05	507	11	33,777	23,171
26	Namekagon	9,289	31,794	3,253	298	553	214	45,401	11,346
27	St Croix	1,320	22,688	662	1,650	299	108	26,727	3,346
28	Totagatic	1,378	16,109	666	116	194	106	18,569	2,734
29	Trade	7,699	5,785	2,968	590	119	50	17,210	7,702
30	Trout	8,417	1,425	2,100	0.11	179	11	12,132	7,529
31	Willow	41,643	2,585	8,825	0.51	735	35	53,824	36,125
32	Wolf	9,561	1,911	2,631	0.60	98	10	14,212	8,596
33	Wood	9,736	5,986	3,711	275	235	87	20,030	9,682
34	Yellow	10,936	13,331	3,684	136	703	166	28,955	11,523
35	Upper Tamarack	912	7,375	327	17.7	37	25	8,694	1,409
36	Lower Tamarack	25	454	8.1	0.37	-	1.5	489	56
	WI Totals	**187,502**	**133,211**	**52,433**	**3,208**	**4,300**	**1,061**	**381,715**	**178,616**
	% of WI Total	*49.1%*	*34.9%*	*13.7%*	*0.8%*	*1.1%*	*0.3%*	*100.0%*	-
	Basin Totals	**268,094**	**242,232**	**120,368**	**3,796**	**11,718**	**2,722**	**648,931**	**283,936**
	% of Basin Total	*41.3%*	*37.3%*	*18.5%*	*0.6%*	*1.8%*	*0.4%*	*100.0%*	-

‡‡ **Note**: For Trout Brook and Browns, Lawrence, and Valley Branch creeks, areas that actually contribute to the St. Croix are smaller than their watershed totals in this table, reflecting substantial landlocked portions. Actual P loads are estimated to be smaller than those shown here by 52%, 76%, 24%, and 40%, respectively, based on non-contributing area percentages.

Table B-7. St. Croix Basin Subwatershed P Load Reductions and P Export for Existing (1990s) and TMDL Conditions§

wsh _id	Name	P Load Reduction (kg/yr)	Average P Export (kg/ha-yr) Existing	Average P Export (kg/ha-yr) TMDL	P Load Reduction (lb/yr)	Average P Export (lb/ac-yr) Existing	Average P Export (lb/ac-yr) TMDL	Percentage Reduction (--)
0	small streams	334	0.31	0.20	736	0.28	0.18	34%
1	Trout Brook§§	644	0.39	0.25	1,419	0.35	0.22	36%
2	Valley Branch§§	1,993	0.33	0.22	4,393	0.29	0.19	34%
3	small streams	2,926	0.28	0.19	6,450	0.25	0.17	33%
4	Browns Creek§§	886	0.30	0.20	1,954	0.27	0.18	33%
5	Silver Creek	205	0.31	0.20	452	0.28	0.18	34%
6	Lawrence Creek§§	534	0.34	0.22	1,177	0.31	0.20	34%
7	Sunrise River	8,303	0.26	0.18	18,306	0.23	0.16	33%
8	Dry Creek	808	0.30	0.20	1,782	0.27	0.18	33%
9	small streams	190	0.29	0.20	419	0.26	0.18	32%
10	Goose Creek	1,352	0.23	0.16	2,980	0.20	0.14	30%
11	Rush Creek	1,112	0.23	0.16	2,451	0.20	0.14	31%
12	Rock Creek	1,593	0.25	0.18	3,512	0.23	0.16	31%
13	Snake River	8,812	0.15	0.12	19,428	0.14	0.11	22%
14	Kettle River	5,550	0.13	0.11	12,236	0.12	0.10	15%
15	Redhorse Creek	6	0.07	0.07	13	0.06	0.06	2%
16	Bear Creek	420	0.14	0.11	925	0.12	0.10	18%
17	Sand Creek	985	0.15	0.12	2,171	0.13	0.11	18%
18	Crooked Creek	851	0.16	0.13	1,877	0.14	0.11	19%
19	Lower Tamarack	566	0.12	0.11	1,248	0.11	0.10	9%
20	Upper Tamarack	64	0.14	0.12	140	0.13	0.11	16%
MN Totals		**38,133**			**84,069**			**24%**
MN Averages			**0.17**	**0.13**		**0.16**	**0.12**	
23	Apple	15,971	0.32	0.21	35,209	0.29	0.19	34%
24	Clam	5,327	0.21	0.15	11,744	0.18	0.14	26%
25	Kinnickinnic	9,175	0.46	0.29	20,228	0.41	0.26	37%
26	Namekagon	3,522	0.13	0.11	7,764	0.12	0.10	15%
27	St Croix	601	0.10	0.10	1,325	0.09	0.09	5%
28	Totagatic	588	0.11	0.10	1,296	0.09	0.09	7%
29	Trade	2,863	0.21	0.15	6,312	0.19	0.14	27%
30	Trout	2,949	0.36	0.23	6,502	0.32	0.21	35%
31	Willow	14,280	0.43	0.27	31,482	0.38	0.24	37%
32	Wolf	3,361	0.34	0.23	7,409	0.31	0.20	34%
33	Wood	3,639	0.22	0.16	8,023	0.20	0.14	29%
34	Yellow	4,137	0.18	0.14	9,121	0.16	0.12	24%
35	Upper Tamarack	342	0.11	0.10	754	0.10	0.09	8%
36	Lower Tamarack	8	0.10	0.10	18	0.09	0.09	4%
WI Totals		**66,763**			**147,187**			**28%**
WI Averages			**0.22**	**0.16**		**0.20**	**0.14**	
Basin Totals		**104,896**			**231,256**			**26%**
Basin Averages			**0.20**	**0.15**		**0.18**	**0.13**	

§ Note: P load reductions in kg/yr (or lb/yr) are same whether including or omitting natural background. P export values here include natural background contribution (0.091439 kg/ha-yr [0.081580 lb/ac-yr] on land areas). Percentage reductions are based on loads and exports that include natural background; they are the same for P loads as for P exports. Average exports are area-weighted.

§§ P load reductions: Trout Brook and Browns, Lawrence, and Valley Branch creeks' drainage areas are smaller than in Tables B-1 – B-2, reflecting substantial landlocked portions; this means that actual load reduction goals in some cases might be smaller than shown in Table B-7, possibly even zero.

Appendix C. St. Croix Basin MS4 Permittee Areas, Land Use/Land Cover Areas (per NLCD 1992 coverage), P Loads, P Wasteload Allocations, P Load Reductions, and Average P Export Values

Title	Table	Units
St. Croix Basin MS4 Permittee Areas and Land Use / Land Cover Areas (per NLCD 1992 coverage)	C-1	hectares (ha)
	C-2	acres (ac)
St. Croix Basin MS4 Permittee P [phosphorus] Loads for Existing (1990s) Conditions	C-3	kilograms (kg) per year
	C-4	pounds (lb) per year
St. Croix Basin MS4 Permittee P Loads (P Wasteload Allocations) for TMDL Conditions	C-5	kg/yr
	C-6	lb/yr
St. Croix Basin MS4 Permittee P Load Reductions and P Export for Existing (1990s) and TMDL Conditions	C-7	kg/yr & kg/ha-yr lb/yr & lb/ac-yr

Table C-1. St. Croix Basin MS4 Areas and Land Use / Land Cover Areas in Hectares (per NLCD 1992 coverage)*

Index	MS4	Area in Land Use / Land Cover (hectares)						Area Totals (hectares)
		Agricultural	Forest	Grassland	Shrubland	Urban	Water§	
1	Mn/DOT Metro Dist. †	59	11	73	-	90	2.6	236
2	Century College							
3	Cottage Grove							
4	East Bethel							
5	Forest Lake							
6	Grant City							
7	Hugo City							
8	Lake Elmo							
9	Mahtomedi							
10	Maplewood							
11	North St Paul	8,536	5,007	12,186	0.52	2,121	3,346	31,196
12	Oakdale							
13	Pine Springs							
14	Ramsey County							
15	Stillwater							
16	Valley Branch WD							
17	Washington County							
18	West Lakeland Twp.							
19	White Bear Lake							
20	Woodbury							
21	North Branch							
MN Totals		**8,595**	**5,017**	**12,260**	**0.52**	**2,211**	**3,349**	**31,432**
	% of MN Total	*27.3%*	*16.0%*	*39.0%*	*0.0%*	*7.0%*	*10.7%*	*100.0%*
1	Hudson	726	253	388	-	344	1.08	1,712
2	North Hudson	72	149	72	-	118	2.8	414
3	River Falls‡	491	188	542	-	321	6.8	1,548
4	UW River Falls‡	38	6.9	66	-	40	-	151
WI Totals		**1,327**	**597**	**1,068**	**-**	**823**	**10.6**	**3,826**
	% of WI Total	*34.7%*	*15.6%*	*27.9%*	*0.0%*	*21.5%*	*0.3%*	*100.0%*
Basin Totals		**9,921**	**5,614**	**13,328**	**0.52**	**3,034**	**3,360**	**35,258**
	% of Basin Total	*28.1%*	*15.9%*	*37.8%*	*0.0%*	*8.6%*	*9.5%*	*100.0%*

*** Note:** 1 hectare = 10,000 square meters = 0.01 square kilometers. Also, 1 hectare = 2.471 acres.

*** Condensed classifications: Agricultural** = Row Crops (82) + Small Grains (83); **Forest** = Deciduous Forest (41) + Evergreen Forest (42) + Mixed Forest (43) + Woody wetlands (91); **Grassland** = Grasslands/Herbaceous (71) + Urban/Recreational Grasses (85) + Pasture/Hay (81); **Shrubland** = Barren Transitional (33) + Shrubland (51); **Urban** = Commercial/Industrial/Transport (23) + High Intensity Residential (22) + Low Intensity Residential (21) + Quarries/Strip Mines/Gravel Pit (32); **Water** = Emergent Herbaceous Wetlands (92) + Open Water (11).

† Mn/DOT: Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

‡ River Falls: Areas for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

§ Lake St Croix and Lake Mallalieu areas: Water areas for Stillwater, Hudson, and North Hudson were decreased by those portions encompassing Lake St Croix and Lake Mallalieu.

Table C-2. St. Croix Basin MS4 Areas and Land Use / Land Cover Areas in Acres (per NLCD 1992 coverage)*

Index	MS4	Area in Land Use / Land Cover (acres)						Area Totals (acres)
		Agricultural	Forest	Grassland	Shrubland	Urban	Water§	
1	Mn/DOT Metro Dist. †	145	27	181	-	223	6.4	582
2	Century College	21,093	12,371	30,113	1.29	5,240	8,269	77,088
3	Cottage Grove							
4	East Bethel							
5	Forest Lake							
6	Grant City							
7	Hugo City							
8	Lake Elmo							
9	Mahtomedi							
10	Maplewood							
11	North St Paul							
12	Oakdale							
13	Pine Springs							
14	Ramsey County							
15	Stillwater							
16	Valley Branch WD							
17	Washington County							
18	West Lakeland Twp.							
19	White Bear Lake							
20	Woodbury							
21	North Branch							
MN Totals		**21,238**	**12,398**	**30,294**	**1.29**	**5,463**	**8,275**	**77,670**
	% of MN Total	*27.3%*	*16.0%*	*39.0%*	*0.0%*	*7.0%*	*10.7%*	*100.0%*
1	Hudson	1,793	626	958	-	850	2.67	4,230
2	North Hudson	179	369	178	-	291	6.9	1,024
3	River Falls‡	1,212	463	1,339	-	794	17	3,826
4	UW River Falls‡	94	17	163	-	99	-	374
WI Totals		**3,279**	**1,475**	**2,639**	**-**	**2,034**	**26**	**9,454**
	% of WI Total	*34.7%*	*15.6%*	*27.9%*	*0.0%*	*21.5%*	*0.3%*	*100.0%*
Basin Totals		**24,517**	**13,874**	**32,933**	**1.29**	**7,498**	**8,302**	**87,124**
	% of Basin Total	*28.1%*	*15.9%*	*37.8%*	*0.0%*	*8.6%*	*9.5%*	*100.0%*

The values 21,093; 12,371; 30,113; 1.29; 5,240; 8,269; 77,088 are printed once for rows 2–21 combined.

*** Condensed classifications: Agricultural** = Row Crops (82) + Small Grains (83); **Forest** = Deciduous Forest (41) + Evergreen Forest (42) + Mixed Forest (43) + Woody wetlands (91); **Grassland** = Grasslands/Herbaceous (71) + Urban/Recreational Grasses (85) + Pasture/Hay (81); **Shrubland** = Baren Transitional (33) + Shrubland (51); **Urban** = Commercial/Industrial/Transport (23) + High Intensity Residential (22) + Low Intensity Residential (21) + Quarries/Strip Mines/Gravel Pit (32); **Water** = Emergent Herbaceous Wetlands (92) + Open Water (11).

† Mn/DOT: Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

‡ River Falls: Areas for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

§ Lake St Croix and Lake Mallalieu areas: Water areas for Stillwater, Hudson, and North Hudson were decreased by those portions encompassing Lake St Croix and Lake Mallalieu.

Table C-3. St. Croix Basin MS4 P Loads in Kilograms per Year for Existing (1990s) Conditions

		Watershed P Load INCLUDING Natural Background (kg/yr)						Load Totals (kg/yr), with Natural Background Load:	
	MS4	**Agricultural**	**Forest**	**Grassland**	**Shrubland**	**Urban**	**Water**		
Index	***P export (kg/ha-yr)***	***0.628409***	***0.098419***	***0.220725***	***0.098419***	***0.628409***	***0.006980***	**INCLUDED**	**OMITTED**
1	Mn/DOT Metro Dist.*	37	1.07	16	-	57	0.02	111	90
2	Century College								
3	Cottage Grove								
4	East Bethel								
5	Forest Lake								
6	Grant City								
7	Hugo City								
8	Lake Elmo								
9	Mahtomedi								
10	Maplewood								
11	North St Paul	5,364	493	2,690	0.05	1,333	23	9,903	7,356
12	Oakdale								
13	Pine Springs								
14	Ramsey County								
15	Stillwater								
16	Valley Branch WD								
17	Washington County								
18	West Lakeland Twp.								
19	White Bear Lake								
20	Woodbury								
21	North Branch								
MN Totals		**5,401**	**494**	**2,706**	**0.05**	**1,389**	**23**	**10,014**	**7,446**
	% of MN Total	*53.9%*	*4.9%*	*27.0%*	*0.0%*	*13.9%*	*0.2%*	*100.0%*	-
1	Hudson	456	25	86	-	216	0.008	783	626
2	North Hudson	46	15	16	-	74	0.02	150	113
3	River Falls†	308	18	120	-	202	0.05	648	507
4	UW River Falls†	24	0.68	15	-	25	-	64	51
WI Totals		**834**	**59**	**236**	**-**	**517**	**0.1**	**1,646**	**1,297**
	% of WI Total	*50.7%*	*3.6%*	*14.3%*	*0.0%*	*31.4%*	*0.0%*	*100.0%*	-
Basin Totals		**6,235**	**553**	**2,942**	**0.05**	**1,907**	**23**	**11,660**	**8,743**
	% of Basin Total	*53.5%*	*4.7%*	*25.2%*	*0.0%*	*16.4%*	*0.2%*	*100.0%*	-

*** Mn/DOT:** Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

† River Falls: Loads for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

Table C-4. St. Croix Basin MS4 P Loads in Pounds per Year for Existing (1990s) Conditions									
		Watershed P Load INCLUDING Natural Background (lb/yr)						Load Totals (lb/yr), with Natural Background Load:	
	MS4	Agricultural	Forest	Grassland	Shrubland	Urban	Water		
Index	*P export (lb/ac-yr)*	***0.560653***	***0.087808***	***0.196926***	***0.087808***	***0.560653***	***0.006228***	INCLUDED	OMITTED
1	Mn/DOT Metro Dist.*	81	2.36	36	-	125	0.04	244	197
2	Century College	11,826	1,086	5,930	0.11	2,938	51	21,832	16,217
3	Cottage Grove								
4	East Bethel								
5	Forest Lake								
6	Grant City								
7	Hugo City								
8	Lake Elmo								
9	Mahtomedi								
10	Maplewood								
11	North St Paul								
12	Oakdale								
13	Pine Springs								
14	Ramsey County								
15	Stillwater								
16	Valley Branch WD								
17	Washington County								
18	West Lakeland Twp.								
19	White Bear Lake								
20	Woodbury								
21	North Branch								
	MN Totals	**11,907**	**1,089**	**5,966**	**0.11**	**3,063**	**52**	**22,076**	**16,415**
	% of MN Total	*53.9%*	*4.9%*	*27.0%*	*0.0%*	*13.9%*	*0.2%*	*100.0%*	-
1	Hudson	1,005	55	189	-	477	0.017	1,726	1,381
2	North Hudson	100	32	35	-	163	0.04	331	248
3	River Falls†	680	41	264	-	445	0.10	1,429	1,119
4	UW River Falls†	53	1.50	32	-	56	-	142	112
	WI Totals	**1,838**	**130**	**520**	**-**	**1,141**	**0.2**	**3,628**	**2,859**
	% of WI Total	*50.7%*	*3.6%*	*14.3%*	*0.0%*	*31.4%*	*0.0%*	*100.0%*	-
	Basin Totals	**13,745**	**1,218**	**6,485**	**0.11**	**4,204**	**52**	**25,704**	**19,274**
	% of Basin Total	*53.5%*	*4.7%*	*25.2%*	*0.0%*	*16.4%*	*0.2%*	*100.0%*	-

***Mn/DOT**: Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

† **River Falls**: Loads for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

Table C-5. St. Croix Basin MS4 P Loads in Kilograms per Year for TMDL Conditions

		Watershed P Load INCLUDING Natural Background (kg/yr)						Load Totals (kg/yr), with Natural Background Load:	
	Name	Agricultural	Forest	Grassland	Shrubland	Urban	Water		
Index	*P export (kg/ha-yr)*	*0.377555*	*0.098419*	*0.160327*	*0.098419*	*0.377555*	*0.006980*	INCLUDED	OMITTED
1	Mn/DOT Metro Dist.	22	1.07	12	-	34	0.02	69	48
2	Century College								
3	Cottage Grove								
4	East Bethel								
5	Forest Lake								
6	Grant City								
7	Hugo City								
8	Lake Elmo								
9	Mahtomedi								
10	Maplewood								
11	North St Paul	3,223	492.74	1,953.82	0.05	800.65	23.36	6,493	3,947
12	Oakdale								
13	Pine Springs								
14	Ramsey County								
15	Stillwater								
16	Valley Branch WD								
17	Washington County								
18	West Lakeland Twp.								
19	White Bear Lake								
20	Woodbury								
21	North Branch								
	MN Totals	**3,245**	**494**	**1,966**	**0.05**	**835**	**23**	**6,562**	**3,995**
	% of MN Total	*49.5%*	*7.5%*	*29.9%*	*0.0%*	*12.7%*	*0.4%*	*100.0%*	-
1	Hudson	274	25	62	-	130	0.008	491	335
2	North Hudson	27	15	12	-	44	0.02	98	60
3	River Falls‡	185	18	87	-	121	0.05	412	271
4	UW River Falls‡	14	0.68	11	-	15	-	41	27
	WI Totals	**501**	**59**	**171**	**-**	**311**	**0.07**	**1,042**	**693**
	% of WI Total	*48.1%*	*5.6%*	*16.4%*	*0.0%*	*29.8%*	*0.0%*	*100.0%*	-
	Basin Totals	**3,746**	**553**	**2,137**	**0.05**	**1,146**	**23**	**7,604**	**4,688**
	% of Basin Total	*49.3%*	*7.3%*	*28.1%*	*0.0%*	*15.1%*	*0.3%*	*100.0%*	-

‡ **Mn/DOT:** Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

‡ **River Falls:** Loads for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

Table C-6. St. Croix Basin MS4 P Loads in Pounds per Year for TMDL Conditions

Index	Name	Watershed P Load INCLUDING Natural Background (lb/yr)						Load Totals (lb/yr), with Natural Background Load:	
		Agricultural	Forest	Grassland	Shrubland	Urban	Water	INCLUDED	OMITTED
	P export (lb/ac-yr)	*0.336847*	*0.087808*	*0.143040*	*0.087808*	*0.336847*	*0.006228*		
1	Mn/DOT Metro Dist.	49	2.36	26	-	75	0.04	152	105
2	Century College	7,105	1,086	4,307	0.11	1,765	51	14,316	8,701
3	Cottage Grove								
4	East Bethel								
5	Forest Lake								
6	Grant City								
7	Hugo City								
8	Lake Elmo								
9	Mahtomedi								
10	Maplewood								
11	North St Paul								
12	Oakdale								
13	Pine Springs								
14	Ramsey County								
15	Stillwater								
16	Valley Branch WD								
17	Washington County								
18	West Lakeland Twp.								
19	White Bear Lake								
20	Woodbury								
21	North Branch								
	MN Totals	**7,154**	**1,089**	**4,333**	**0.11**	**1,840**	**52**	**14,468**	**8,807**
	% of MN Total	*49.5%*	*7.5%*	*29.9%*	*0.0%*	*12.7%*	*0.4%*	*100.0%*	-
1	Hudson	604	55	137	-	286	0.017	1,083	738
2	North Hudson	60	32	26	-	98	0.04	216	133
3	River Falls‡‡	408	41	192	-	267	0.10	908	597
4	UW River Falls‡‡	32	1.50	23	-	33	-	90	60
	WI Totals	**1,104**	**130**	**377**	**-**	**685**	**0.2**	**2,297**	**1,528**
	% of WI Total	*48.1%*	*5.6%*	*16.4%*	*0.0%*	*29.8%*	*0.0%*	*100.0%*	-
	Basin Totals	**8,258**	**1,218**	**4,711**	**0.11**	**2,526**	**52**	**16,765**	**10,334**
	% of Basin Total	*49.3%*	*7.3%*	*28.1%*	*0.0%*	*15.1%*	*0.3%*	*100.0%*	-

‡‡ **Mn/DOT:** Agricultural and Forest data for MN/DOT rights-of-way may be artifact of land use/land cover discretization or may reflect actual cropland infringement and/or temporary tree growth.

‡‡**River Falls:** Loads for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

Table C-7. St. Croix Basin MS4 P Load Reductions and P Export for Existing (1990s) and TMDL Conditions§								
		P Load	Average P Export		P Load	Average P Export		Percentage
		Reduction	Existing	TMDL	Reduction	Existing	TMDL	Reduction
Index	Name	(kg/yr)	(kg/ha-yr)		(lb/yr)	(lb/ac-yr)		(--)
1	Mn/DOT Metro Dist.	42	0.47	0.29	92	0.42	0.26	38%
2	Century College	3,409	0.32	0.21	7,516	0.28	0.19	34%
3	Cottage Grove							
4	East Bethel							
5	Forest Lake							
6	Grant City							
7	Hugo City							
8	Lake Elmo							
9	Mahtomedi							
10	Maplewood							
11	North St Paul							
12	Oakdale							
13	Pine Springs							
14	Ramsey County							
15	Stillwater							
16	Valley Branch WD							
17	Washington County							
18	West Lakeland Twp.							
19	White Bear Lake							
20	Woodbury							
21	North Branch							
MN Totals		**3,451**			**7,608**			**34%**
MN Averages			**0.32**	**0.21**		**0.28**	**0.19**	
1	Hudson	292	0.46	0.29	643	0.41	0.26	37%
2	North Hudson	52	0.36	0.24	115	0.32	0.21	35%
3	River Falls**§§**	236	0.42	0.27	521	0.37	0.24	36%
4	UW River Falls**§§**	24	0.43	0.27	52	0.38	0.24	37%
WI Totals		**604**			**1,331**			**37%**
WI Averages			**0.43**	**0.27**		**0.38**	**0.24**	
Basin Totals		**4,055**			**8,940**			**35%**
Basin Averages			**0.33**	**0.22**		**0.30**	**0.19**	

§ Note: P load reductions in kg/yr (or lb/yr) are same whether including or omitting natural background. P export values here include natural background contribution. Percentage reductions are based on loads and exports that include natural background; they are the same for P loads as for P exports. Average exports are area-weighted.

§§ River Falls: Load reductions and exports for the University of Wisconsin (UW) at River Falls are not included in the City of River Falls data.

Appendix D. St. Croix Basin Tribal Areas, Land Use / Land Cover Areas, Phosphorus Loads, and Average P Export

Title	Table	Units
St. Croix Basin Tribal Areas and Land Use / Land Cover Areas	D-1	hectares (ha)
	D-2	acres (ac)
St. Croix Basin Tribal Area P [phosphorus] Loads and P Exports	D-3	kg/yr & kg/ha-yr
	D-4	lb/yr & lb/ac-yr

Table D-1. St. Croix Basin Tribal Areas and Land Use / Land Cover Areas in Hectares*								
Subwatershed location		**Area in Land Use / Land Cover (hectares)**						**Area Totals**
wsh_id	**Name**	**Agricultural**	**Forest**	**Grassland**	**Shrubland**	**Urban**	**Water**	**(hectares)**
13	Snake River	-	1.21	-	-	0.12	0.04	1.38
14	Kettle River	0.40	417	4.0	33	17	123	594
15	Redhorse Creek	-	82	-	2.3	-	12	96
18	Crooked Creek	0.24	416	12	5.9	2.1	18	455
19	Lower Tamarack	-	174	13	4.4	0.49	22	214
MN Totals		**0.65**	**1,090**	**29**	**45**	**20**	**176**	**1,361**
% of MN Total		*0.0%*	*80.1%*	*2.1%*	*3.3%*	*1.5%*	*12.9%*	*100.0%*
23	Apple	20	399	11	2.8	1.7	20	454
24	Clam	14	367	56	15	5.5	80	539
26	Namekagon	-	244	-	1.01	0.16	15	260
27	St Croix	-	59	0.73	0.49	-	1.54	62
28	Totagatic	-	26	1.30	3.5	0.08	1.7	32
34	Yellow	0.69	451	19	17	15	44	546
35	Upper Tamarack	-	34	0.93	2.5	2.3	6.7	47
36	Lower Tamarack	-	15	-	0.08	-	-	15
WI Totals		**34.8**	**1,595**	**89**	**43**	**25**	**170**	**1,956**
% of WI Total		*1.8%*	*81.5%*	*4.6%*	*2.2%*	*1.3%*	*8.7%*	*100.0%*
Basin Totals		**35.5**	**2,685**	**119**	**88**	**45**	**346**	**3,317**
% of Basin Total		*1.1%*	*80.9%*	*3.6%*	*2.6%*	*1.3%*	*10.4%*	*100.0%*
*** Note:** 1 hectare = 10,000 square meters = 0.01 square kilometers. Also, 1 hectare = 2.471 acres.								
***Land use / land cover data:** from 2007 aerial coverage analyzed by M. Bauer et al., University of Minnesota. GIS analysis by Barr Eng.								

Table D-2. St. Croix Basin Tribal Areas and Land Use / Land Cover Areas in Acres*								
Subwatershed location		**Area in Land Use / Land Cover (acres)**						**Area Totals**
wsh_id	**Name**	**Agricultural**	**Forest**	**Grassland**	**Shrubland**	**Urban**	**Water**	**(acres)**
13	Snake River	-	3.0	-	-	0.30	0.10	3.4
14	Kettle River	1.00	1,030	10.0	80	43	304	1,468
15	Redhorse Creek	-	203	-	5.7	-	30	238
18	Crooked Creek	0.60	1,028	30	15	5.3	45	1,123
19	Lower Tamarack	-	430	32	10.9	1.20	55	530
MN Totals		**1.60**	**2,694**	**72**	**112**	**49**	**434**	**3,363**
% of MN Total		*0.0%*	*80.1%*	*2.1%*	*3.3%*	*1.5%*	*12.9%*	*100.0%*
23	Apple	49	985	27	6.9	4.3	49	1,121
24	Clam	36	908	139	38	13.5	199	1,333
26	Namekagon	-	603	-	2.50	0.40	38	643
27	St Croix	-	146	1.80	1.20	-	3.80	152
28	Totagatic	-	64	3.20	8.7	0.20	4.2	80
34	Yellow	1.70	1,113	47	42	37	109	1,350
35	Upper Tamarack	-	85	2.30	6.2	5.6	16.6	115
36	Lower Tamarack	-	38	-	0.20	-	-	38
WI Totals		**86**	**3,940**	**221**	**105**	**61**	**420**	**4,833**
% of WI Total		*1.8%*	*81.5%*	*4.6%*	*2.2%*	*1.3%*	*8.7%*	*100.0%*
Basin Totals		**88**	**6,635**	**293**	**217**	**110**	**854**	**8,196**
% of Basin Total		*1.1%*	*80.9%*	*3.6%*	*2.6%*	*1.3%*	*10.4%*	*100.0%*
***Land use / land cover data:** from 2007 aerial coverage analyzed by M. Bauer et al., University of Minnesota. GIS analysis by Barr Eng.								

Table D-3. St. Croix Basin Tribal Area P Loads in Kilograms per Year and P Exports in Kilograms per Hectare per Year†									
Subwatershed location		Watershed P Load INCLUDING Natural Background (kg/yr)						Load Totals (kg/yr)	Average P Export (kg/ha-yr)
wsh_id	Name	Agricultural	Forest	Grassland	Shrubland	Urban	Water		
	P export (kg/ha-yr)	*0.628409*	*0.098419*	*0.220725*	*0.098419*	*0.628409*	*0.006980*		
13	Snake River	-	0.12	-	-	0.08	0.0003	0.20	0.14
14	Kettle River	0.25	41	0.9	3.2	11	0.86	57	0.10
15	Redhorse Creek	-	8.1	-	0.23	-	0.09	8.4	0.09
18	Crooked Creek	0.15	41	2.7	0.58	1.35	0.13	46	0.10
19	Lower Tamarack	-	17	2.8	0.43	0.31	0.16	21	0.10
MN Totals		**0.4**	**107**	**6.4**	**4.4**	**13**	**1.2**	**132**	**0.10**
% of MN Total		*0.3%*	*81.1%*	*4.9%*	*3.4%*	*9.5%*	*0.9%*	*100.0%*	-
23	Apple	12	39	2.4	0.27	1.09	0.14	56	0.12
24	Clam	9.1	36	12	1.50	3.4	0.56	63	0.12
26	Namekagon	-	24	-	0.10	0.10	0.11	24	0.09
27	St Croix	-	5.8	0.16	0.05	-	0.011	6.0	0.10
28	Totagatic	-	2.5	0.29	0.35	0.05	0.012	3.2	0.10
34	Yellow	0.43	44	4.2	1.7	9.4	0.31	60	0.11
35	Upper Tamarack	-	3.4	0.21	0.25	1.42	0.05	5.3	0.11
36	Lower Tamarack	-	1.49	-	0.01	-	-	1.50	0.10
WI Totals		**22**	**157**	**20**	**4.2**	**15**	**1.2**	**220**	**0.11**
% of WI Total		*9.9%*	*71.3%*	*9.0%*	*1.9%*	*7.0%*	*0.5%*	*99.7%*	-
Basin Totals		**22**	**264**	**26**	**8.6**	**28**	**2.4**	**352**	**0.11**
% of Basin Total		*6.3%*	*75.0%*	*7.4%*	*2.4%*	*8.0%*	*0.7%*	*99.8%*	-
†**Notes**: P export values here include natural background contribution (0.091439 kg/ha-yr on land areas). Average exports are area-weighted.									

Table D-4. St. Croix Basin Tribal Area P Loads in Pounds per Year and P Exports in Pounds per Acre per Year†									
Subwatershed location		Watershed P Load INCLUDING Natural Background (lb/yr)						Load Totals (lb/yr)	Average P Export (lb/ac-yr)
wsh_id	Name	Agricultural	Forest	Grassland	Shrubland	Urban	Water		
	P export (lb/ac-yr)	*0.560653*	*0.087808*	*0.196926*	*0.087808*	*0.560653*	*0.006228*		
13	Snake River	-	0.26	-	-	0.17	0.0006	0.43	0.13
14	Kettle River	0.56	90	2.0	7.1	24	1.89	126	0.09
15	Redhorse Creek	-	17.8	-	0.50	-	0.19	18.5	0.08
18	Crooked Creek	0.34	90	6.0	1.27	2.97	0.28	101	0.09
19	Lower Tamarack	-	38	6.3	0.96	0.67	0.34	46	0.09
MN Totals		**0.9**	**237**	**14.2**	**9.8**	**28**	**2.7**	**292**	**0.09**
% of MN Total		*0.3%*	*81.1%*	*4.9%*	*3.4%*	*9.5%*	*0.9%*	*100.0%*	-
23	Apple	27	86	5.4	0.61	2.41	0.31	122	0.11
24	Clam	20.1	80	27	3.31	7.6	1.24	139	0.10
26	Namekagon	-	53	-	0.22	0.22	0.23	54	0.08
27	St Croix	-	12.8	0.35	0.11	-	0.024	13.3	0.09
28	Totagatic	-	5.6	0.63	0.76	0.11	0.03	7.1	0.09
34	Yellow	0.95	98	9.3	3.7	20.6	0.68	133	0.10
35	Upper Tamarack	-	7.4	0.45	0.54	3.14	0.10	11.7	0.10
36	Lower Tamarack	-	3.29	-	0.02	-	-	3.3	0.09
WI Totals		**48**	**346**	**44**	**9.2**	**34**	**2.6**	**484**	**0.10**
% of WI Total		*10.0%*	*71.5%*	*9.0%*	*1.9%*	*7.0%*	*0.5%*	*100.0%*	-
Basin Totals		**49**	**583**	**58**	**19.0**	**62**	**5.3**	**776**	**0.09**
% of Basin Total		*6.3%*	*75.1%*	*7.4%*	*2.5%*	*8.0%*	*0.7%*	*100.0%*	-
†**Notes**: P export values here include natural background contribution (or 0.081580 lb/ac-yr on land areas). Average exports are area-weighted.									