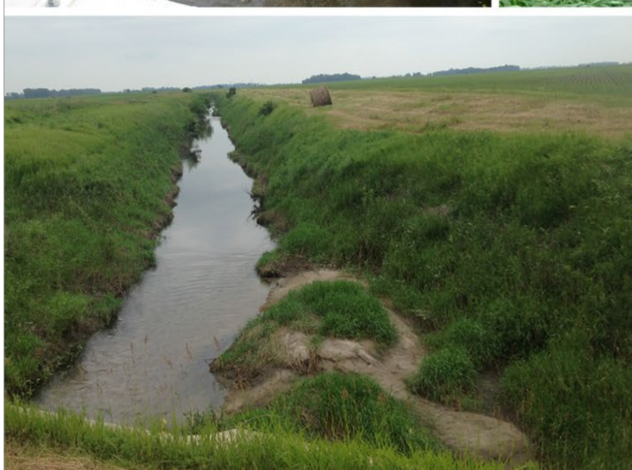
Draft Chippewa River Watershed Total Maximum Daily Load

A Total Maximum Daily Flow Report compiled by the Minnesota Pollution Control Agency



Minnesota Pollution Control Agency

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303(d) Listing Information	There are impairments for 13 stream reaches, 12* listings for *E. coli* bacteria, 1* listings for Total Suspended Solids (TSS), 2* listings for DO, 2* listings for macroinvertebrates IBI, and 1* listing for fish IBI. 25 lake impairments are listed for nutrient eutrophication; see Table 1.1 *Numbers are not cumulative	12
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Seasonal Variation	*E. coli:* Load duration curve methodology accounts for seasonal variation and the standard is developed for critical conditions; *See Section 4.6.1* TSS: Load duration curve methodology accounts for seasonal variation and the standard is developed for critical conditions; *See Section 4.6.2* Dissolved Oxygen: HSPF model accounts for seasonal variation Nutrient eutrophication: Standard is developed for critical conditions; *See Section 4.6.3*	65
Reasonable Assurance	Changes in the landscape and hydrology will need to occur if pollutant levels are going to decrease. The source reduction strategies detailed in the implementation section have been shown to be effective in improving water quality. Many of the goals outlined in this TMDL report run parallel to objectives outlined in the local water plans. Various programs and funding sources are currently being utilized in the watershed and will also be used in the future. Additionally, Minnesota voters have approved an	79

	amendment to increase the state sales tax to fund water quality improvements. *See Section 6*	
Monitoring	Intensive watershed monitoring will occur on a 10-year schedule. Long term load monitoring at the watershed outlet is currently occurring. *See Section 7*	80
Implementation	A summary of potential management measures is included with a rough approximation of the overall implementation cost to achieve the TMDL**.** *See Section 8*	81
Public Participation	Public participation in the Chippewa River Watershed has been ongoing for the past two years. With respect to this specific TMDL: A public comment period was open from ______ with a formal public meeting on ______. There were _____ comment letters received and responded to as a result of the public comment period. *See Section 9*	84

Acronyms

ARM	Agricultural Runoff Model
µg/L	Micrograms per Liter
ac-ft/yr	acre feet per year
AUID	Assessment Unit ID
AWQCP	Agricultural Water Quality Certification Program
BMP	Best Management Practice
CAC	Citizens Advisory Committee
CAFO	Concentrated Animal Feeding Operation
cfs	cubic feet per second
cfu	colony-forming unit
Chl-*a*	Chlorophyll-*a*
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
EPA	U. S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
FWMC	Flow Weighted Mean Concentration
GW	Groundwater
HSPF	Hydrologic Simulation Program – FORTRAN
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
in/yr	Inches per Year
kg/ha	Kilograms per Hectare
km^2	Square Kilometer
LA	Load Allocation
lb(s)	Pound(s)
lbs/yr	Pounds per Year
lbs/day	Pounds per Day
LC	Loading Capacity
m	Meter
MDA	Minnesota Department of Agriculture
mg	Milligrams
mg/L	Milligrams per Liter
mg/m^2-day	Milligrams per Square Meter per Day
mgd	Million Gallons per Day
mL	Milliliters
MLCCS	Minnesota Land Cover Classification System
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System

MSU-WRC	Minnesota State University, Mankato – Water Resources Center
NCHF	North Central Hardwood Forests
NGP	Northern Glaciated Plains
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NTU	Nephelometric TSS Unit
org	Organisms
SDS	State Disposal System
SOD	Sediment Oxygen Demand
SONAR	Statement of Need and Reasonableness
SRO	Surface Runoff
SSTS	Subsurface Sewage Treatment System
SWPPP	Stormwater Pollution Prevention Plan
TDLC	Total Daily Loading Capacity
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solid
USGS	United States Geological Survey
WCBP	Western Corn Belt Plains
WLA	Wasteload Allocations
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater Treatment Facility
μg/L	Microgram per Liter

Executive Summary

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or designated uses. The TMDL establishes the maximum amount of a pollutant a waterbody can receive on a daily basis and still meet water quality standards. The TMDL is divided into wasteload allocations (WLA) for point or permitted sources, load allocations (LA) for nonpoint sources and natural background plus a margin of safety (MOS).

This TMDL report addresses impairments for 13 stream reaches consisting of 12 bacteria impairments, 1 total suspended solid (TSS) impairment, 2 dissolved oxygen (DO) impairments, 2 macroinvertebrate Index of Biological Integrity (IBI) impairments, 1 fish IBI impairment, and 25 lakes for nutrient eutrophication impairments in the Chippewa River Watershed. Addressing multiple impairments in one TMDL report is consistent with Minnesota's Water Quality Framework that seeks to develop watershed wide protection and restoration strategies rather than focus on individual reach impairments.

The Chippewa River Watershed covers more than 1.3 million acres in the Western Corn Belt Plains (WCBP), Northern Glaciated Plains (NGP), and the North Central Hardwood Forests (NCHF) ecoregions and drains portions of nine counties (Chippewa, Douglas, Grant, Kandiyohi, Meeker, Otter Tail, Pope, Stevens, and Swift) in the Minnesota River Basin.

This TMDL report used a variety of methods to evaluate current loading contributions by the various pollutant sources as well as the allowable pollutant loading capacity (LC) of the impaired water bodies. These methods include the Hydrologic Simulation Program – FORTRAN (HSPF) model, the load duration curve approach, and the BATHTUB lake eutrophication model.

A general strategy and cost estimate for implementation to address the impairments are included. Non-point sources (NPS) will be the focus of implementation efforts. NPS contributions are not regulated and will need to proceed on a voluntary basis. Permitted point sources will be addressed through the Minnesota Pollution Control Agency's (MPCA) National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit) programs.

1. Project Overview

1.1 Purpose

The CWA Section 303(d) requires that states publish a list of surface waters that do not meet water quality standards and therefore, do not support their designated use(s). These waters are then classified as impaired and placed on the impaired waters list, which dictates that a TMDL report must be completed. The TMDL report calculates the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive "watershed approach" that integrates water resource management efforts, local governments, and stakeholders to develop watershed-scale TMDLs, restoration and protection strategies, and plans for each of Minnesota's 80 major watersheds. The information gained and strategies developed in the watershed approach are presented in major watershed-scale Watershed Restoration and Protection Strategy (WRAPS) Reports, which should help restore and protect streams, lakes, and wetlands across the watershed, including those for which TMDL calculations are not made.

The watershed approach started in the Chippewa River Watershed in 2009 with intensive watershed monitoring (MPCA 2012a) and subsequent assessment which resulted in 13 stream reaches and 25 lakes being listed as impaired for one or more water quality parameters (Figure 1.1).

This document addresses Chippewa River Watershed impairments identified in the 2009 monitoring and assessment cycle that have not been addressed in prior TMDLs, have an approved water quality standard, and have sufficient data for assessment. The findings of this report are similar to previous TMDLs that were done in the study area. Refer to these TMDL report webpages for more details: *Pope Lakes TMDL* (MPCA 2011b), the *TSS TMDL for Chippewa River Watershed* (Wenck 2014), and the *Chippewa River Fecal Coliform TMDL Report* (MPCA 2006). Slight differences are attributed to the change in standards (from fecal coliform to *E. coli* and Turbidity to Total Suspended Solids) that occurred between TMDL reports. Several biological impairments and the stressors identified with those impairments were identified within the watershed; however, due to lack of supporting data some of these impairments were deferred until sufficient data can be collected.

1.2 Identification of Waterbodies

This TMDL report applies to 43

separate impairment listings for 13 stream reaches and 25 lakes in the Chippewa River Watershed (Table 1.1). Supporting documentation for the proposed listing of the impairments can be found in:

Chippewa River Watershed Monitoring and Assessment Report (MPCA 2012b)

Chippewa River Watershed Stressor Identification Report (MPCA 2012d)

Table 1.1: Chippewa River Watershed 303(d) impairments addressed in this TMDL report grouped by HUC10 watersheds

HUC10 Subwatershed	Stream Reach or Lake Name Stream Reach Description	Stream Use Class or Lake Ecoregion & Type	Assessment Unit ID or DNR Lake #	Affected Designated Use	Year Listed	Impairment
Chippewa River	**Chippewa River** Shakopee Cr to Cottonwood Cr	2B	07020005-507	Aquatic Life	2012	Macro Invertebrate IBI
				Aquatic Life/ Recreation	2012	Turbidity
	Tributary to Chippewa River Unnamed cr to Chippewa R	2B	07020005-584	Aquatic Recreation	2014	*Escherichia coli*
				Aquatic Life	2012	Dissolved Oxygen
County Ditch No. 3 - Chippewa River	**Chippewa River** E Br Chippewa R to Shakopee Cr	2B	07020005-506	Aquatic Recreation	2012	*Escherichia coli*
	County Ditch No. 3 CD 7 to Chippewa R	2B	07020005-579	Aquatic Recreation	2014	*Escherichia coli*
	Long Lake	NGP	75-0024-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Cottonwood Creek	**Cottonwood Creek** T120 R41W S21, west line to Chippewa R	2B	07020005-511	Aquatic Recreation	2014	*Escherichia coli*
East Branch Chippewa River	**East Branch Chippewa River** Headwaters (Amelia Lk 61-0064-00) to Mud Cr	2B	07020005-515	Aquatic Recreation	2012	*Escherichia coli*
	Swenoda	NCHF	61-0051-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Hanson	NCHF	61-0080-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication

HUC10 Subwatershed	**Stream Reach or Lake Name** Stream Reach Description	Stream Use Class or Lake Ecoregion & Type	Assessment Unit ID or DNR Lake #	Affected Designated Use	Year Listed	Impairment
	Rasmuson	NGP	61-0086-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Mary	NCHF	61-0099-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Edwards	NCHF	61-0106-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Hassel	NGP	76-0086-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Judicial Ditch No. 19	**South Mud Creek** T121 R39W S2, south line to E Br Chippewa R	2B	07020005-518	Aquatic Recreation	2014	*Escherichia coli*
	Hollerberg	WCBP	76-0057-00	Aquatic Life/ Recreation	2010	Nutrient Eutrophication
Lake Minnewaska	**Outlet Creek** Lk Minnewaska to Lk Emily	2B	07020005-523	Aquatic Life	2012	Macro Invertebrate IBI
				Aquatic Life	2012	Fish IBI
				Aquatic Recreation	2012	*Escherichia coli*
	Trappers Run Creek Strandness Lk to Pelican Lk	2B	07020005-628	Aquatic Recreation	2014	*Escherichia coli*
	John	NCHF	61-0123-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Mud Creek	**North Mud Creek** CD 15 to E Br Chippewa R	2B	07020005-554	Aquatic Recreation	2014	*Escherichia coli*
				Aquatic Life	2012	Dissolved Oxygen

HUC10 Subwatershed	**Stream Reach or Lake Name** Stream Reach Description	Stream Use Class or Lake Ecoregion & Type	Assessment Unit ID or DNR Lake #	Affected Designated Use	Year Listed	Impairment
	Johanna	NCHF	61-0006-00	Aquatic Life/ Recreation	2010	Nutrient Eutrophication
	Simon	NCHF	61-0034-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Monson	NCHF	76-0033-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Shakopee Creek	**Shakopee Creek** Swan Lk to Shakopee Lk	2C	07020005-557	Aquatic Recreation	2012	*Escherichia coli*
	Huse Creek Headwater to Norway Lk	2B	07020005-917	Aquatic Recreation	2010	*Escherichia coli*
	Norway	NCHF Lake	34-0251-02	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	West Norway	NCHF Shallow Lake	34-0251-01	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Little Chippewa River	**Little Chippewa River** Unnamed cr to CD 2	2B	07020005-713	Aquatic Recreation	2010	*Escherichia coli*
	Jorgenson	NCHF	61-0164-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	McIver	NGP	61-0199-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Irgens	NCHF	61-0211-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
Headwaters Chippewa River	**Gilbert**	NCHF	21-0189-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication

HUC10 Subwatershed	**Stream Reach or Lake Name** Stream Reach Description	**Stream Use Class or Lake Ecoregion & Type**	**Assessment Unit ID or DNR Lake #**	**Affected Designated Use**	**Year Listed**	**Impairment**
	Red Rock	NGP	21-0291-00	Aquatic Life/ Recreation	2008	Nutrient Eutrophication
	Jennie	NGP	21-0323-00	Aquatic Life/ Recreation	2008	Nutrient Eutrophication
	Long	NCHF	21-0343-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Thompson	NGP	26-0020-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Block	NCHF	56-0079-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Wicklund	NGP	61-0204-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication
	Danielson Slough	NGP	61-0194-00	Aquatic Life/ Recreation	2012	Nutrient Eutrophication

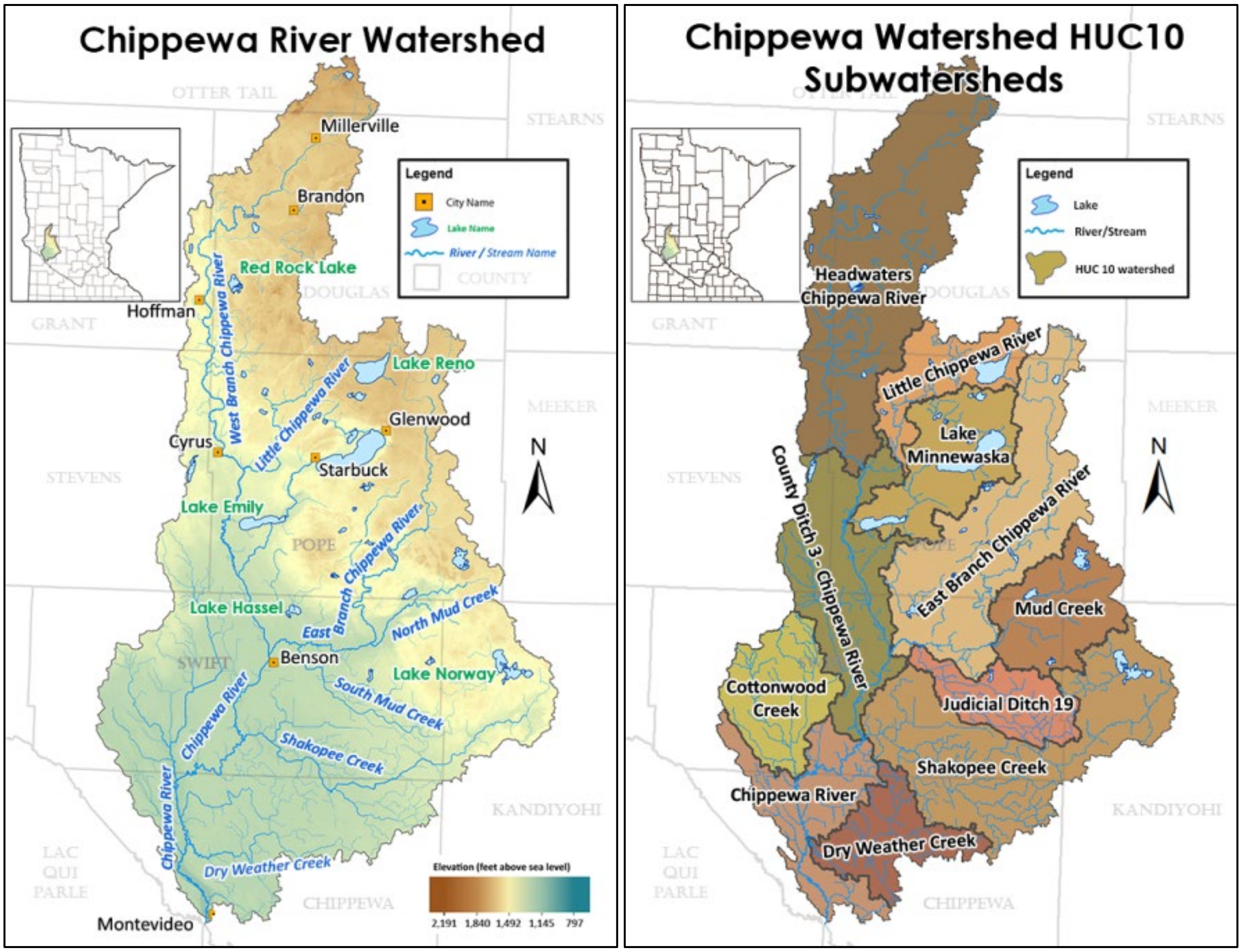

Figure 1.1 Overview map of the Chippewa River Watershed and map of subwatershed areas

1.3 Priority Ranking

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. Every 10 years Minnesota's 80 major watersheds are on a schedule to be monitored and assessed. 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.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

The criteria used to determine stream and lake impairments are outlined in the MPCA's document *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List* (MPCA 2014a). Minn. R. ch. 7050.0470 lists waterbody classifications and Minn. R. ch. 7050.2222 lists applicable water quality standards. The impaired waters covered in this TMDL are classified as Class 2B or 2C, 3B, 3C, 4A, 5, 6 and 7. Relative to aquatic life and recreation, the designated beneficial uses for the most stringent classifications, 2B and 2C waters, are:

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.

Class 2C waters – The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.

The water quality standards shown in Table 2.1 and Table 2.2 are the numeric water quality target for each parameter shown. For more detailed information refer to the *MPCA TMDL Policies and Guidance* (MPCA 2014b).

Table 2.1: Surface water quality standards for Chippewa River Watershed stream reaches addressed in this TMDL report

Parameter	Water Quality Standard	Units	Criteria	Period of Time Standard Applies
***Escherichia coli*; Class 2 waters**	Not to exceed 126	**org/100 mL**	Monthly geo mean of at least 5 samples within one calendar month	**April 1 – October 31**
	Not to exceed 1,260	**org/100 mL**	Monthly upper 10^{th} percentile	
TSS; Class 2 waters	Not to Exceed 65	**mg/L**	> 10% of total samples cannot exceed 65 mg/L	**April - September**
Dissolved Oxygen	Daily Minimum 5.0	**mg/L**	100% of days above 7Q10 flow; 50% of days at 7Q10 flow	**Year Round**
Fish Class	**2 - Southern Streams**			
Fish Bio Assessment Threshold Scores	Not Below 54			
Invert Class	**2 – Prairie Forest Rivers**		**7 - Prairie Streams Glide Pool**	
Macro-invertebrate Bio Assessment Threshold Scores	Not Below 41.5		Not Below 51.9	

The class 2B turbidity standard (Minn. R. ch. 7050.0222) that was in place at the time of the impairment assessment for reaches in the Chippewa River Watershed was 25 nephelometric turbidity units (NTUs). Impairment listings occur when greater than 10% of data points collected within the previous 10-year period exceed the 25 NTU standards (or equivalent values for TSS or the transparency tube).

The aforementioned 25 NTU turbidity standard had several weaknesses, including its application statewide and, since turbidity is a measure of light scatter and absorption, it is not a mass unit measurement and therefore not amenable to TMDLs and other load-based studies. Although previously recognized, these weaknesses became a significant problem when the U.S. Environmental Protection Agency (EPA) and the MPCA's TMDL program became fully realized in the early 2000s.

As a result, a committee of MPCA staff across several divisions met for over a year to develop TSS criteria to replace the turbidity standards. These TSS criteria are regional in scope and based on a combination of both biotic sensitivity to the TSS concentrations and reference streams/least impacts streams as data allow. The results of the TSS criteria development were published by the MPCA in 2011 and proposed a 65 mg/L TSS standard for Class 2B waters in the southern region of the state of Minnesota that may not be exceeded more than 10% of the time over a multiyear data window. The assessment season is identified as April through September. The new TSS standards were approved by EPA in January of 2015. For the purpose of this TMDL report, the newly adopted 65 mg/L standard for

Class 2B waters will be used to address the turbidity impairment listings in the Chippewa River Watershed.

Table 2.2: Lake water quality standards for lakes within the Chippewa River Watershed

Ecoregion & Lake Type	Total Phosphorus Standard (µg/L)	Chlorophyll –a Standard (µg/L)	Secchi Depth (m)	Criteria	Period of Time Standard Applies
NGP Shallow Lake	Not to exceed 90	Not to exceed 30	Not below 0.7	Summer average of all samples	June 1 – September 30
WCBP Shallow Lake	Not to exceed 90	Not to exceed 30	Not below 0.7	Summer average of all samples	June 1 – September 30
NCHF Shallow Lake	Not to exceed 60	Not to exceed 20	Not below 0.7	Summer average of all samples	June 1 – September 30
NCHF Lake	Not to exceed 40	Not to exceed 14	Not below 1.4	Summer average of all samples	June 1 – September 30

In addition to meeting phosphorus limits, chlorophyll-a (Chl-a) and Secchi transparency standards must also be met. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor total phosphorus (TP) and the response variables Chl-a and Secchi transparency. Based on these relationships it is expected that by meeting the phosphorus target in each lake, the Chl-a and Secchi standards will likewise be met.

3. Watershed and Waterbody Characterization

Located in West Central Minnesota, the Chippewa River Watershed covers more than 1.3 million acres in the Western Cornbelt Plains (WCBP), Northern Glaciated Plains (NGP), and North Central Hardwood Forest (NCHF) ecoregions and drains portions of nine counties (Otter Tail, Douglas, Grant, Stevens, Pope, Meeker, Swift, Kandiyohi, Chippewa). Benson and Glenwood are the largest towns in this largely rural watershed. Land use statistics of the Chippewa River Watershed are shown in Table 3.3 within Section 3.4. For more information on the Chippewa River Watershed, refer to the *Chippewa River Watershed Monitoring and Assessment Report* (MPCA 2012b).

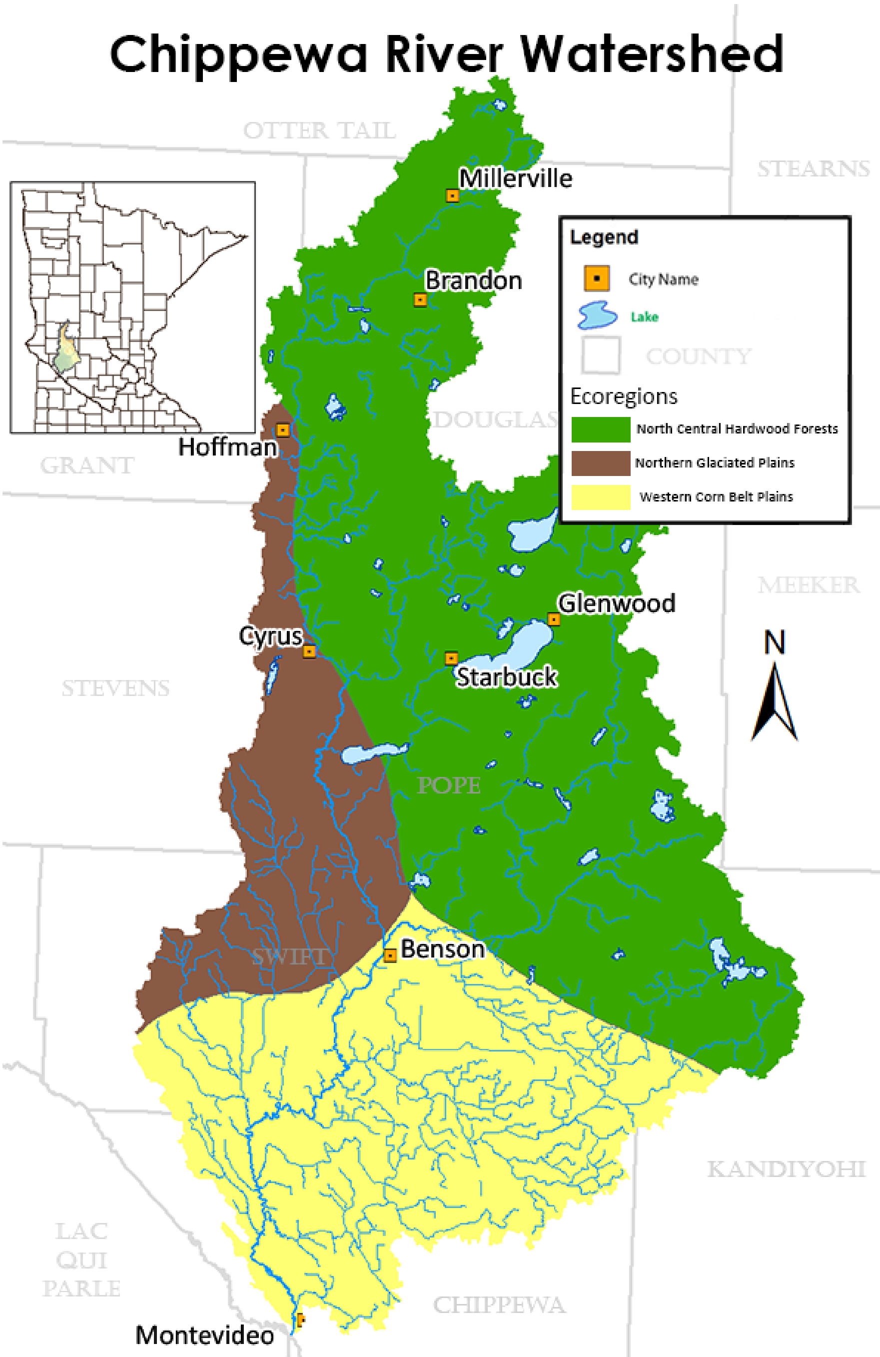

Figure 3.1: Ecoregions within the Chippewa River Watershed

3.1 Lakes

Chippewa River Watershed lake and morphometry data are listed in Table 3.1.

Table 3.1: Morphometry and watershed area of lakes addressed in this TMDL report

HUC 10 Subwatershed	Lake Name	DNR Lake #	Surface Area (acres)	Average Depth (feet)	Max Depth (feet)	Lakeshed Area (acres)	Lakeshed Area : Surface Area Ratio	Littoral Area (%)
County Ditch 3	Long Lake	75-0024-00	620	4.9	9.5	3,481	5.6 : 1	100
	Danielson Slough	61-0194-00	142	3.3	4.9	6,029	42.5 : 1	100
East Branch Chippewa River	Mary	61-0099-00	100	3.3	16.1	1,359	13.6 : 1	100
	Swenoda	61-0051-00	388	3.3	5.9	2,048	5.3 : 1	100
	Edwards	61-0106-00	165	3.3	8.5	4,317	26.2 : 1	100
	Hanson	61-0080-00	601	3.3	5.9	31,519	52.4 : 1	100
	Hassel	76-0086-00	706	2	5	22,230	31.5 : 1	100
	Rasmuson	61-0086-00	130	3.3	16.1	1,055	8.1 : 1	100
Headwaters Chippewa River	Block	56-0079-00	301	12.8	23	2,128	7.1 : 1	50
	Jennie	21-0323-00	316	6.9	2	2,336	7.4 : 1	100
	Long	21-0343-00	205	5.9	18	91,284	445.3 : 1	100
	Gilbert	21-0189-00	265	5.9	18	1,794	6.7 : 1	100
	Red Rock	21-0291-00	781	11.5	22	5,762	7.4 : 1	56

HUC 10 Subwatershed	Lake Name	DNR Lake #	Surface Area (acres)	Average Depth (feet)	Max Depth (feet)	Lakeshed Area (acres)	Lakeshed Area : Surface Area Ratio	Littoral Area (%)
	Thompson	26-0020-00	149	13.5	22	975	6.5 : 1	47
	Wicklund	61-0204-00	148	3.3	4.9	6,213	41.9 : 1	100
Judicial Ditch 19	Hollerberg	76-0057-00	260	3.3	5	2,713	10.4 : 1	100
Little Chippewa River	Jorgenson	61-0164-00	119	3.3	16.1	1,062	8.9 : 1	92
	Irgens	61-0211-00	198	3.3	5.6	13,119	66.3 : 1	100
	McIver	61-0199-00	156	3.3	16.1	2,345	15 : 1	100
Minnnewaska	John	61-0123-00	119	3.9	6.9	6,297	52.9 : 1	100
Mud Creek	Johanna	61-0006-00	1,204	3.3	9.8	7,316	6.1 : 1	100
	Simon	61-0034-00	569	3.3	8.9	3,384	5.9 : 1	100
	Monson	76-0033-00	143	6.6	16.1	957	6.7 : 1	90
Shakopee Creek	Norway	34-0251-02	1,197	9	33.1	24,893	21 : 1	78
	West Norway	34-0251-01	1,147	5.4	10	21,044	18.3:1	100

3.2 Streams

Estimated watershed drainage areas of impaired stream reaches addressed in this TMDL report are listed in Table 3.2. These areas consist of all of the land that drains into the respective reach.

Table 3.2: Approximate watershed areas of impaired stream reaches

HUC 10 Subwatershed	**Stream Name –** Reach Location Description	Assessment Unit ID #	Area (acres)
Chippewa River	**Chippewa River –** Shakopee Creek to Cottonwood Creek	07020005-507	1,115,206
	Tributary to Chippewa River – Unnamed creek to Chippewa River	07020005-584	19,410
Cottonwood Creek	**Cottonwood Creek –** T120 R41W S21, west line to Chippewa River	07020005-511	79,357
County Ditch No. 3	**Chippewa River – County Ditch No. 3 –** County Ditch 7 to Chippewa River	07020005-579	59,537
County Ditch No. 3 - Chippewa River	**Chippewa River –** East Branch Chippewa River to Shakopee Creek	07020005-506	887,386
East Branch Chippewa River	**East Branch Chippewa River –** Headwaters (Amelia Lk 61-0064-00) to Mud Cr	07020005-515	133,820
Judicial Ditch No. 19	**South Mud Creek –** T121 R39W S2, south line to East Branch Chippewa River	07020005-518	56,716
Lake Minnewaska	**Outlet Creek –** Lake Minnewaska to Lake Emily	07020005-523	144,595
	Trapper Run Creek – Strandness Lake to Pelican Lake	07020005-628	24,404
Little Chippewa River	**Little Chippewa River –** Unnamed creek to County Ditch 2	07020005-713	63,853
Mud Creek	**North Mud Creek –** CD 15 to East Branch Chippewa River	07020005-554	82,806
Shakopee Creek	**Shakopee Creek –** Swan Lake to Shakopee Lake	07020005-557	124,142
	Judicial Ditch 29 – Headwaters to CD 29	07020005-566	1,631
	County Ditch 29 – Headwaters to unnamed ditch	07020005-567	4,276
	County Ditch 27 – unnamed ditch to unnamed ditch	07020005-570	8,209
	Huse Creek – Headwater to Norway Lake	07020005-917	2,273

3.3 Subwatersheds

The Chippewa River Watershed (07020005) is located in west central Minnesota. The watershed falls in three different Ecoregions. The NCHF Ecoregion covers the eastern two-thirds of the watershed, the NGP Ecoregion covers the west central part of the watershed, and the WCBP Ecoregion covers the southern part of the watershed. Much of the landscape of this watershed was modified by the early settlers in the area. Draining wetlands and modifying stream channels were done to gain land for agriculture. Now approximately 79% of the watershed is used for agricultural production. Area within the watershed has been grouped together by HUC 10 subwatershed areas. This was done in order to group together land area that drains into the individual streams and tributaries that flow into the Chippewa River. The Headwaters HUC 10 in the northern part of the watershed marks the beginning of the watershed. As the river flows south it is joined by the Little Chippewa River and Outlet Creek from Lake Minnewaska. Downstream several small tributaries drain into the river, including the East Branch Chippewa River, Shakopee Creek, and Cottonwood Creek. Dry Weather Creek joins the Chippewa just before the confluence with the Minnesota River (See Figure 1.1).

3.4 Land Use

The land use for the entire watershed and HUC10 subwatersheds is summarized in Table 3.3 and shown in Figure 3.1 with the majority of the land being used for agricultural purposes.

Table 3.3: Approximate land use % breakdowns of Chippewa River Watershed HUC10 subwatersheds (MRLC 2011)

HUC-10 Subwatershed	Open Water	Developed	Barren/ Mining	Forest/ Shrub	Pasture/ Hay/ Grassland	Cropland	Wetland
Entire Chippewa River Watershed	6.1	5.0	0.1	4.3	10.7	68.5	5.3
County Ditch No. 3 - Chippewa River	2.0	5.8	0.4	1.2	6.5	73.9	10.2
Cottonwood Creek	0.2	6.3	0.1	0.5	2.4	82.8	7.7
East Branch Chippewa River	5.9	4.1	0	4.8	15.8	61.7	7.7
Judicial Ditch No. 19	1.1	5.0	0	1.4	5.0	83.9	3.6
Lake Minnewaska	14.8	6.3	0	4.5	12.7	57.7	4.0
Mud Creek	10.6	4.0	0	10.3	19.8	49.6	5.7
Shakopee Creek	5.0	4.7	0	3.8	6.6	76.9	3.0
Little Chippewa River	12.2	4.3	0	5.6	14.4	60.4	3.1
Headwaters Chippewa River	9.5	5.1	0	7.5	16.0	58.4	3.5
Chippewa River	0.7	6.1	0.1	1.6	4.7	80.2	6.6

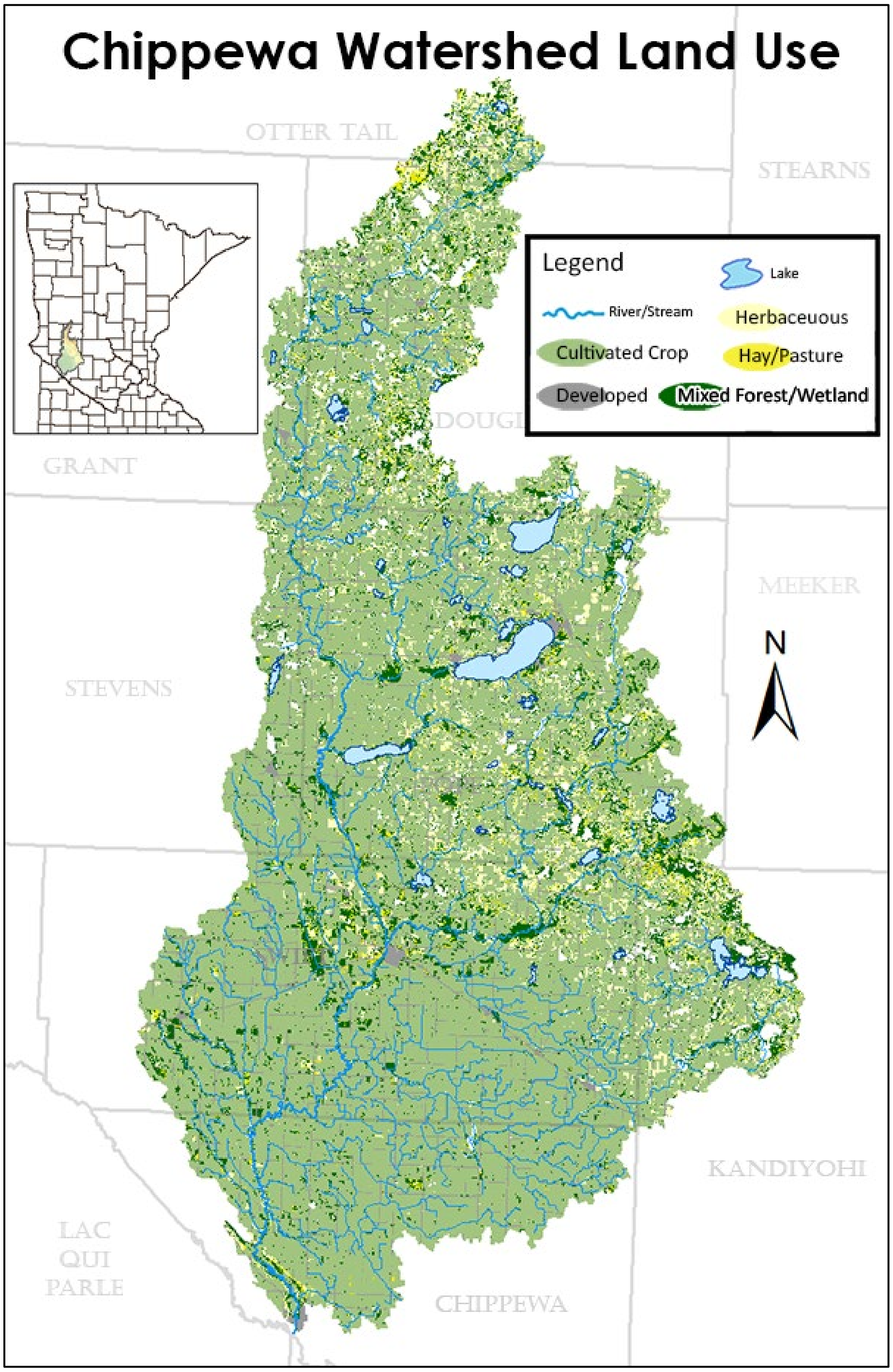

Figure 3.2: Land use of the Chippewa River Watershed

3.5 Current/Historic Water Quality

A summary of current water quality is provided in this section related to the *E. coli*, TSS, DO, IBI, and nutrient eutrophication impairments addressed in this TMDL report. Additional water quality data and analysis for impaired stream reaches can be found in the *Chippewa River Watershed Monitoring and Assessment Report* (MPCA 2012b) and the *Chippewa River Watershed Biotic Stressor Identification Report* (MPCA 2015).

3.5.1 Streams

3.5.1.1 *E. coli*

Bacteria data has been collected for multiple years in the Chippewa River Watershed. The summarized data is presented in Table 3.4. Geometric means were calculated using the following equation:

$$Geometric\ mean\ =\ \sqrt[n]{x_1 * \ x_2 * \ldots . x_n}$$

Table 3.4: Summary of *E. coli* data from 2007-2010 for stream reaches impaired for *E. coli*. Red indicates exceedances of the *E. coli* standard as listed in Minn. R. 7050.0222, subp. 4

Reach Name **Reach AUID #** EQuIS Station ID	**Range of data** (org/mL)	**% of samples exceeding 1260 org/100mL** [# of samples]	**Geometric Mean (org/mL)** [# of samples]						
			Apr	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**
Chippewa River **07020005-506** S000-383	**31-1,414**	**July** **25%** [4]	-	-	**143.3** [6]	**200.7** [4]	**239.6** [5]	-	-
Cottonwood Creek **07020005-511** S002-202	**170 - 1,553**	**June** **11%** [6]	-	-	**685.4** [6]	**280** [4]	**362.8** [5]	-	-
East Branch Chippewa River **07020005-515** S005-861	**20 - 2,400**	**July** **25%** [4]	-	**45.6** [6]	**184.4** [6]	**363.9** [4]	**467.1** [4]	-	-
South Mud Creek **07020005-518** S002-195	**50 - 1,553**	**Aug** **20%** [5]	-	-	**91.6** [6]	**83.4** [4]	**174.4** [5]	-	-
Outlet Creek **07020004-523** S000-898	**20 - 2,400**	**June** **16.7%** [6]	-	**34.9** [8]	**160.9** [6]	**119.1** [6]	**116.9** [5]	-	-
North Mud Creek **07020004-554** S005-633 S003-372	**115 - 1,352**	**June** **16.7%** [6]	-	-	**334.8** [6]	**184.5** [4]	**274.9** [6]	-	-

Reach Name Reach AUID # EQuIS Station ID	Range of data (org/mL)	% of samples exceeding 1260 org/100mL [# of samples]	Geometric Mean (org/mL) [# of samples]						
			Apr	May	June	July	Aug	Sep	Oct
Shakopee Creek **07020005-557** S005-374 S002-550	**4 – 2,419**	**June** **30.7%** [13] **July** **18.2%** [11]	**52.5** [2]	**29.9** [14]	**304** [13]	**326** [11]	**203.5** [8]	**399.9** [2]	-
County Ditch No. 3 **07020005-579** S003-507	**42-548**	**0%**	-	-	**265.7** [6]	**118.9** [4]	**120.6** [5]	-	-
Tributary to Chippewa River **07020005-584** S005-629	**64 – 2,419**	**June** **16.7%** [6]	-	-	**397.7** [6]	**170.2** [4]	**146.2** [5]	-	-
Trappers Run Creek **07020005-628** S005-631	**59 – 2,419**	**July** **25%** [4]	-	-	**144** [6]	**399.8** [4]	**375.4** [5]	-	-
Little Chippewa River **07020005-713** S004-705	**5 – 2,419**	**July** **11%** [9]	-	**37.1** [8]	**847.6** [12]	**603** [9]	**398.1** [10]	-	-
Huse Creek **07020005-917** S002-207	**1 – 2,400**	**April** **33.3%** [6]	**55.7** [6]	**9.3** [13]	**143.8** [8]	-	-	-	-

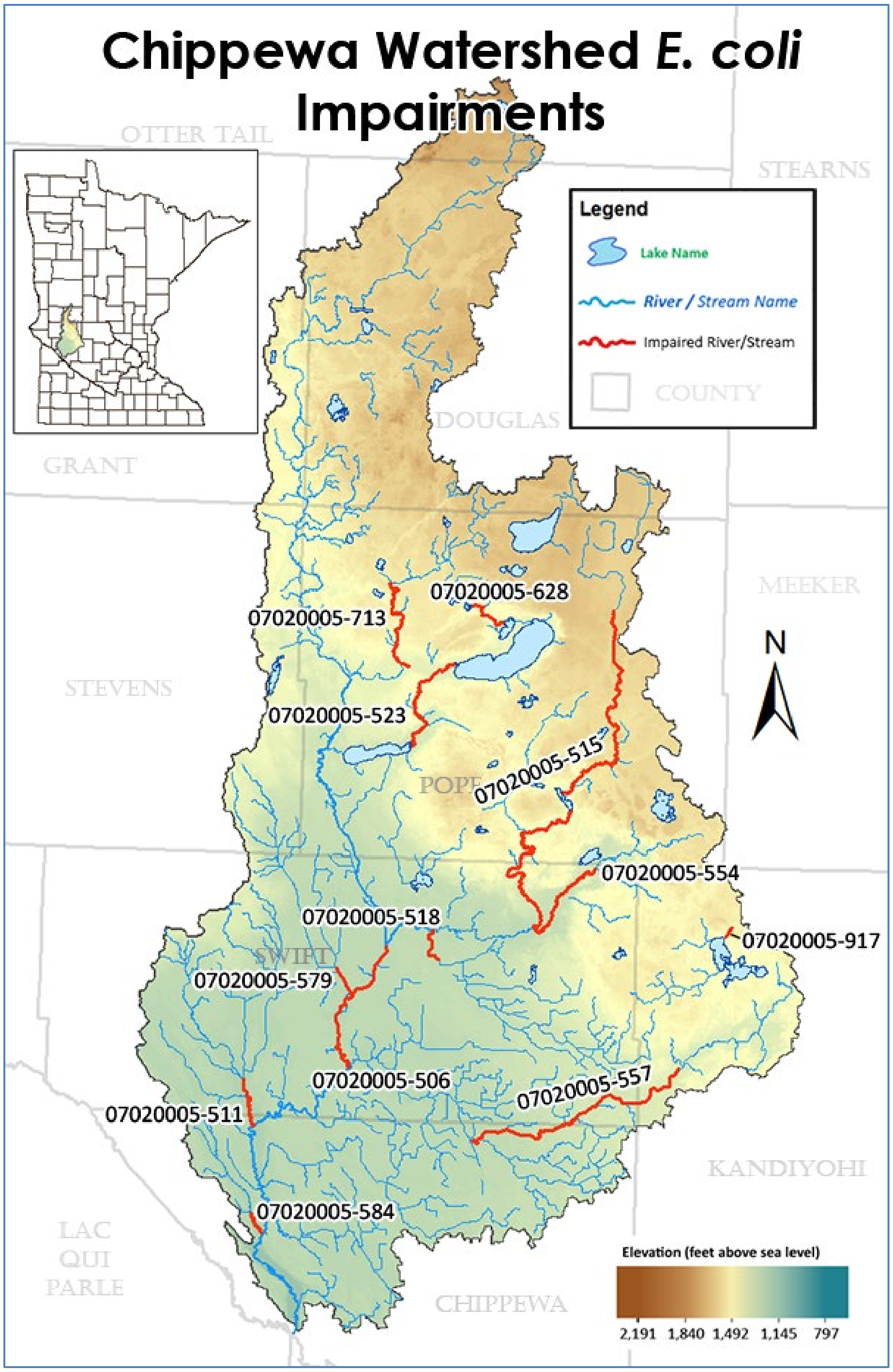

Figure 3.3: ***E. coli*** **stream reach impairments**

3.5.1.2 TSS

Transparency tube data has been collected for multiple years in the Chippewa River Watershed, the summarized data is presented in Tables 3.5-3.6.

Table 3.5: Summary of T-tube converted into S-tube equivalent data from 2002-2011 for stream reaches impaired for turbidity. Red indicates exceedances of the S-tube surrogate TSS standard

Stream Name **Reach AUID #** EQuIS Station ID	**Range of Data** (cm)	**% of Monthly Samples <10 cm** [# of samples]						**% of Total Samples <10cm** [# of samples]
		Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	
Chippewa River **07020005-507** S000-397; S000-398; S000-399; 09MN063; 09MN068	**8 – 69+**	**0%** [0]	**0%** [3]	**42%** [7]	**11%** [18]	**6%** [17]	**0%** [3]	**12.5%** [48]

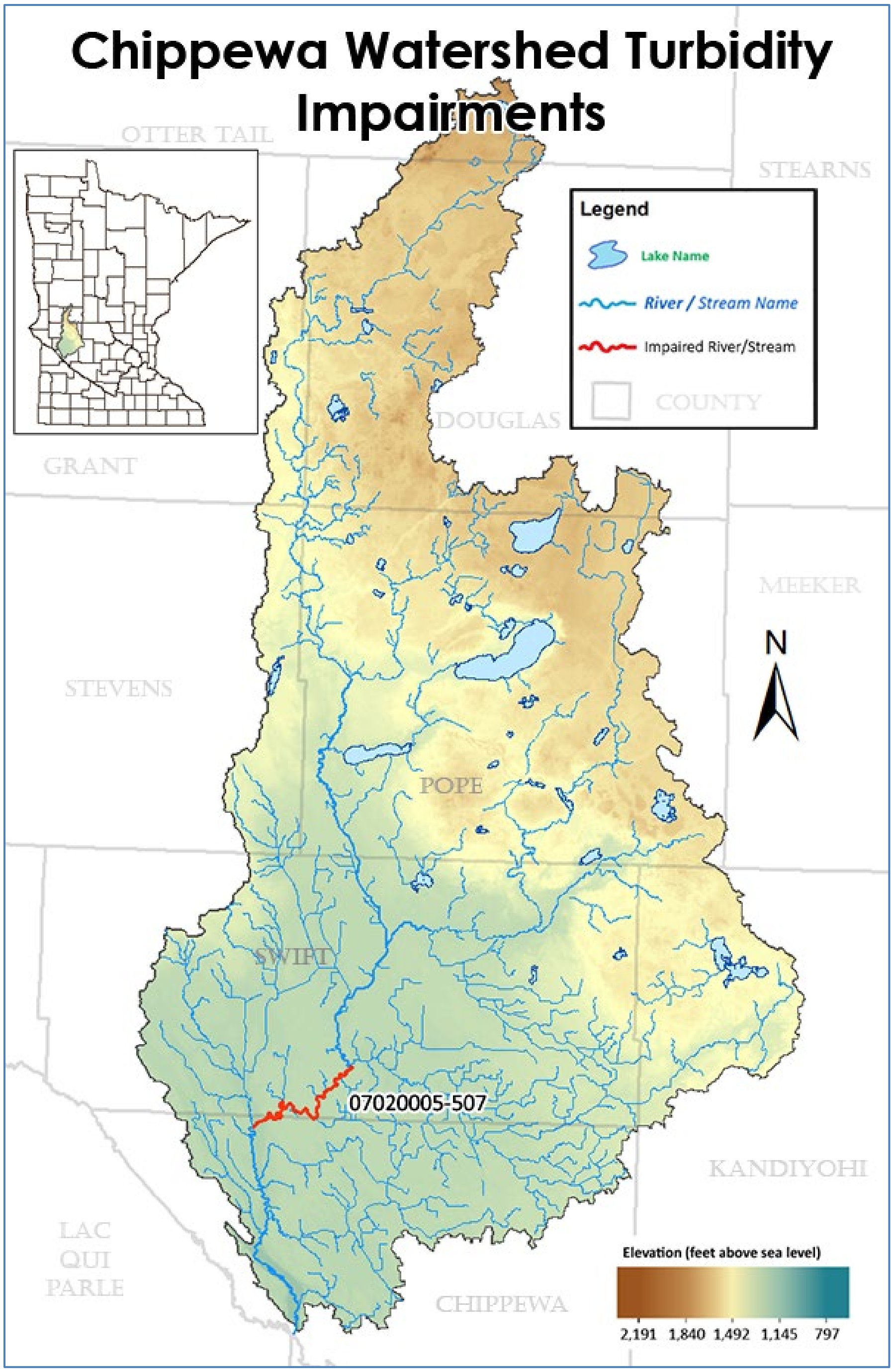

Figure 3.4: Turbidity stream reach impairments

3.5.1.3 Dissolved Oxygen

The DO data has been collected for multiple years in the Chippewa River Watershed, the summarized data is presented in Table 3.7.

Table 3.6: Summary of DO data from 2001-2008 for stream reaches impaired for low DO. Red indicates exceedances of standard

Reach Name **Reach AUID #**	**Station ID**	**% of measurements <5mg/L** [# of samples]
North Mud Creek **07020005-554**	09MN002; 03MN056; S005-629; S005-864	**12.7%** [71]
Tributary to Chippewa River **07020005-584**	S003-372; S005-633; S005-990	**16%** [31]

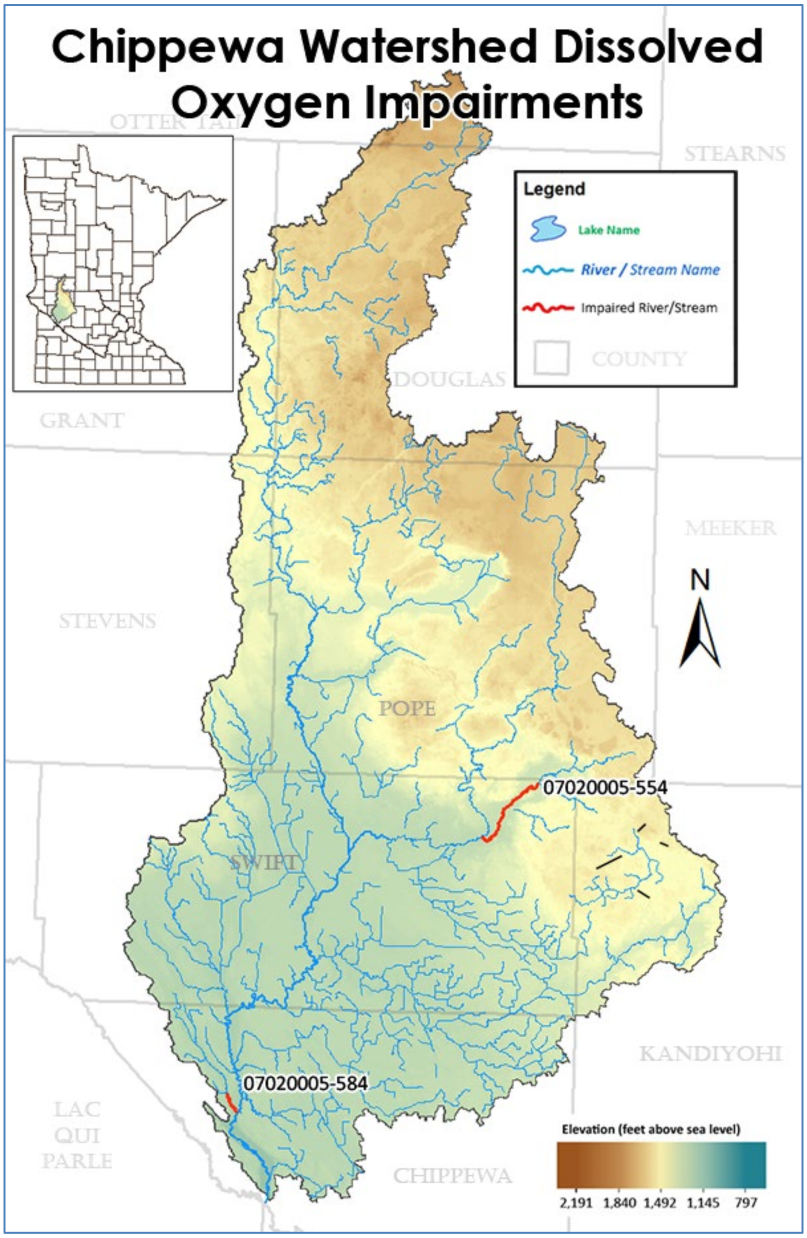

Figure 3.5: DO stream reach impairments

3.5.1.4 Index of Biological Integrity (IBI)

Minnesota's standard for biotic integrity is set forth in Minn. R. 7050.0150. The standard uses an IBI, which evaluates and integrates multiple attributes of the aquatic community or "metrics" to evaluate a complex biological system. Each metric is based upon a structural (e.g., species composition) or functional (e.g., feeding habits) aspect of the aquatic community that changes in a predictable way in response to human disturbance. Fish and macroinvertebrate IBIs are expressed as a score that ranges from 0 to 100, with 100 being the best score possible. The MPCA has evaluated fish and macroinvertebrate communities at numerous reference sites across Minnesota that have been minimally impacted by human activity, and has established IBI impairment thresholds based on stream drainage area, ecoregion and major basin. A stream's biota is considered to be impaired when the IBI for fish or macroinvertebrates falls below the threshold established for that category of stream.

Biological data has been collected for multiple years in the Chippewa River Watershed; the summarized data is presented in Table 3.7.

Table 3.7: Summary of IBI data from 2009 for stream reaches impaired for IBI score. Red indicates exceedances of and/or within the confidence interval of the standard

<table>
<tr><th>Reach Name
Reach AUID #
Station ID</th><th colspan="2">Macro Invertebrate IBI Score</th><th colspan="2">Fish IBI Score</th></tr>
<tr><td rowspan="2">Chippewa River
07020005-507
Invert Class 2
09MN063; 09MN068</td><td>8/6/2009</td><td>8/11/2009</td><td colspan="2" rowspan="2">N/A</td></tr>
<tr><td>34.41</td><td>39.49</td></tr>
<tr><td rowspan="2">Tributary to Chippewa River
07020005-523
Invert Class 7
Fish Class 2
09MN065; 09MN077</td><td colspan="2">8/12/2009</td><td>6/10/2009</td><td>6/17/2009</td></tr>
<tr><td colspan="2">33.45</td><td>41</td><td>49</td></tr>
</table>

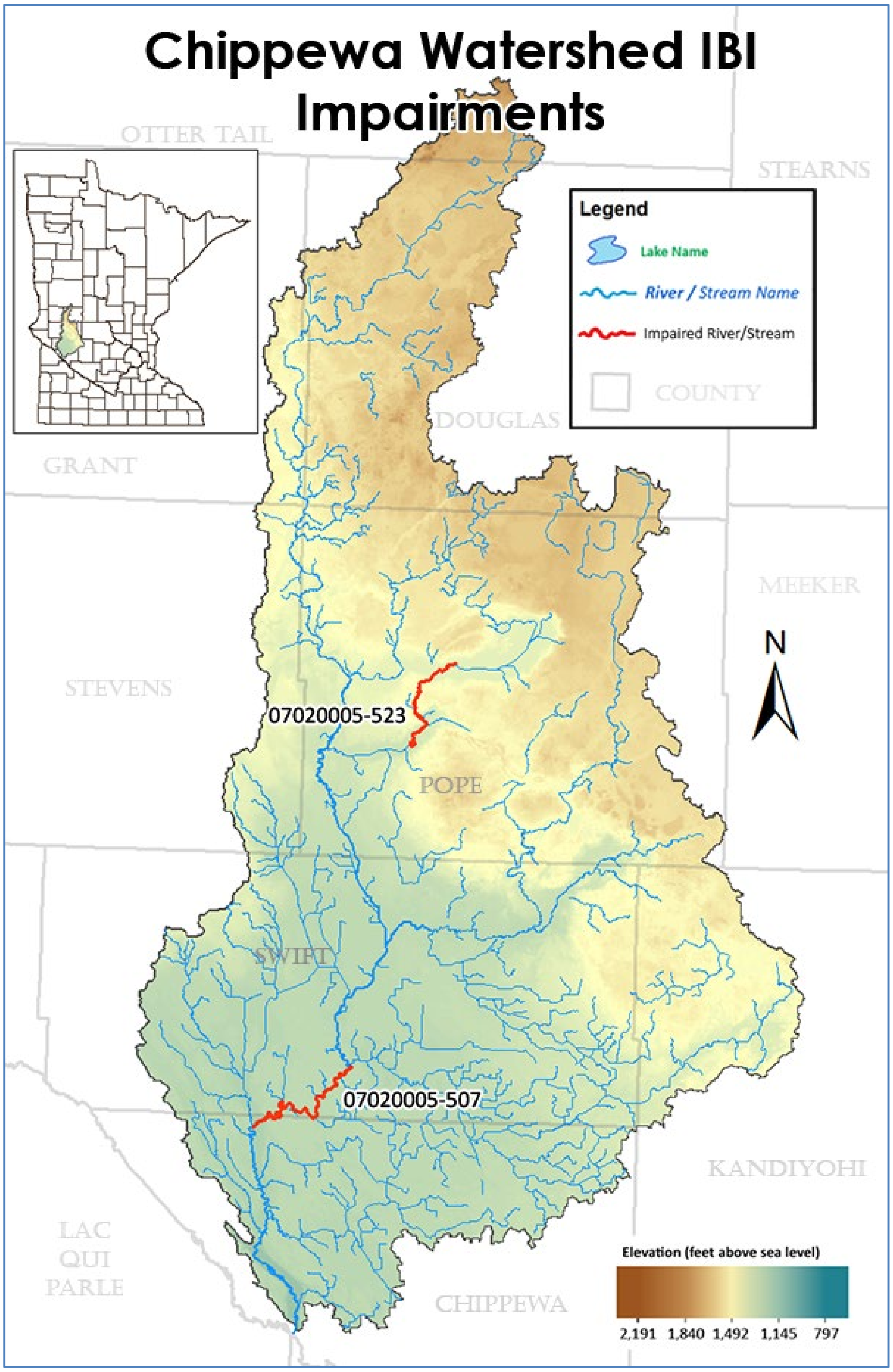

Figure 3.6: IBI stream reach impairments

3.5.2 Lakes

Current lake conditions are based on monitoring completed within the last 10 years. The summarized data presented in Table 3.8 indicates that the listed lakes have exceeded the nutrient eutrophication standard as listed in Minn. R. 7050.0222, subp. 4. and Table 2.2.

Table 3.8: Mean in-lake conditions for impaired lakes in the Chippewa River Watershed. The number of samples taken June through September is listed in brackets. Red indicates exceedances of the standard

Lake Name	DNR #	Ecoregion & Lake Type	Average Total Phosphorus (µg/L) [# of samples]	Average Chlorophyll-a (µg/L) [# of samples]	Average Secchi Disk Transparency (m) [# of samples]
Block	56-0079-00	**NCHF Lake**	**81** [12]	**33.3** [12]	**1.9** [20]
Danielson Slough	61-0194-00	**NGP Shallow Lake**	**147** [13]	**69.5** [13]	**0.7** [13]
Edwards	61-0106-00	**NCHF Shallow Lake**	**220** [12]	**105.8** [12]	**1.0** [12]
Gilbert	21-0189-00	**NCHF Lake**	**72** [10]	**36** [10]	**0.6** [34]
Hanson	61-0080-00	**NCHF Shallow Lake**	**111** [12]	**40.6** [12]	**0.7** [12]
Hassel	76-0086-00	**NCHF Shallow Lake**	**200** [9]	**72.8** [8]	**0.18** [9]
Hollerberg	76-0057-00	**NCHF Shallow Lake**	**76.1** [14]	**32.6** [14]	**0.77** [14]
Irgens	61-0211-00	**NCHF Shallow Lake**	**203** [12]	**90.8** [12]	**0.5** [12]
Jennie	21-0323-00	**NCHF Shallow Lake**	**158.8** [19]	**76.5** [18]	**0.41** [19]
Johanna	61-0006-00	**NCHF Shallow Lake**	**70.1** [29]	**45** [29]	**1.5** [29]
John	61-0123-00	**NCHF Shallow Lake**	**141** [12]	**81.1** [12]	**0.6** [12]
Jorgenson	61-0164-00	**NCHF Shallow Lake**	**210** [12]	**124.4** [12]	**0.5** [12]
Long	21-0343-00	**NCHF Lake**	**99** [8]	**44.5** [8]	**0.6** [8]
Long	75-0024-00	**NGP Shallow Lake**	**150** [8]	**31.8** [8]	**0.9** [8]
Mary	61-0099-00	**NCHF Shallow Lake**	**110** [12]	**81.5** [12]	**0.6** [11]
McIver	61-0199-00	**NCHF Shallow Lake**	**177** [12]	**103.8** [12]	**0.6** [12]

Monson	76-0033-00	**NCHF Shallow Lake**	**84.1** [8]	**39.6** [8]	**1.3** [49]
Norway	34-0251-02	**NCHF Lake**	**49.3** [30]	**55.5** [31]	**1.4** [34]
Rasmuson	61-0086-00	**NCHF Shallow Lake**	**149** [12]	**85.3** [12]	**0.7** [12]
Red Rock	21-0291-00	**NCHF Lake**	**131** [38]	**38** [27]	**1.67**[168]
Simon	61-0034-00	**NCHF Shallow Lake**	**124** [13]	**68.8** [13]	**0.31** [13]
Swenoda	61-0051-00	**NCHF Shallow Lake**	**91** [12]	**56.9** [12]	**0.6** [12]
Thompson	26-0020-00	**NCHF Lake**	**136** [8]	**38.6** [8]	**1.4** [8]
West Norway	34-0251-01	**NCHF Shallow Lake**	**78** [29]	**36.4** [29]	**1.4** [34]
Wicklund	61-0204-00	**NCHF Shallow Lake**	**178** [12]	**40.9** [12]	**0.8** [12]

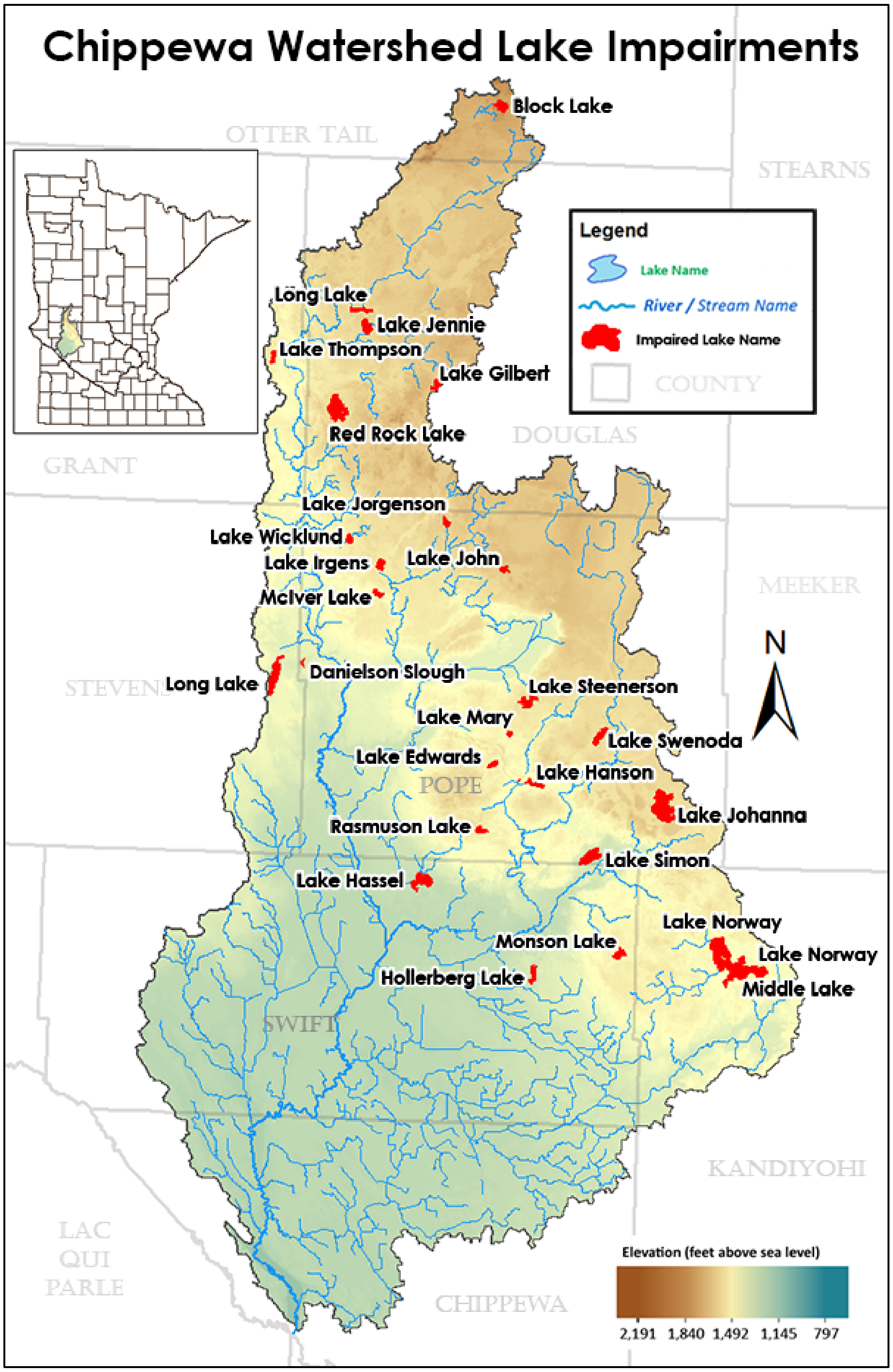

Figure 3.7: Lake nutrient eutrophication impairments as indicated from water monitoring data

3.6 Pollutant Source Summary

3.6.1 *E. coli*

Likely sources of bacteria in the Chippewa River Watershed include feedlot facilities, wastewater treatment facilities (WWTF), subsurface sewage treatment systems (SSTS), livestock manure field application, pasture, natural reproduction, wildlife, and pets. These are described in more detail below.

Feedlot Facilities – Feedlot facilities are present in the Chippewa River Watershed. Facility and livestock numbers by HUC10 watersheds, based on the MPCA record of registered feedlot facilities, are listed in Table 3.9. Out of the 934 feedlots, approximately 22 of them meet or exceed the EPA large CAFO threshold. The majority of the feedlots in the watershed are less than 500 animal units.

Livestock can contribute bacteria to the watershed through runoff from these feedlot facilities. In the Chippewa River Watershed there are 205 feedlots located within 1000 feet of a lake or 300 feet of a stream or river, an area generally defined as shoreland. One hundred eighty-five of these feedlots in shoreland have an open lot. Open lots present a potential pollution hazard if the runoff from the open lot is not treated prior to reaching surface water. Four of the feedlots in shoreland are operating under an Open Lot Agreement (OLA) with the MPCA. These feedlot sites have been identified as actually having a potential pollution hazard and have or will install short term measures to minimize untreated manure runoff until permanent measures can be installed.

Of the approximately of 934 feedlots in the CRW, there are 21 active NPDES permitted operations, of which all of them are Concentrated Animal Feeding Operation (CAFOs). In Minnesota, NPDES permits are issued to facilities with over 1,000 animal units (AUs), most of which are CAFOs (an EPA definition that implies not only a certain number of AUs but also specific animal types e.g. 2500 swine is a CAFO, 1000 cattle is a CAFO but a site with 2499 swine and 999 cattle is not a CAFO according to the EPA definition). The MPCA currently uses the federal definition of a CAFO in its regulation of animal feedlots. In Minnesota, the following types of livestock facilities are issued, and must operate under, a NPDES Permit: a) all federally defined CAFOs, some of which are under 1000 AUs in size; and b) all CAFOs and 60 non-CAFOs that have 1000 or more AUs. These feedlots must be designed to totally contain runoff, and manure management planning requirements are more stringent than for smaller feedlots. In accordance with the state of Minnesota's agreement with EPA, CAFOs with state-issued General NPDES Permits must be inspected twice during every five year permitting cycle and CAFOs with state issued Individual NPDES Permits are inspected annually. The number of AUs by animal type registered with the MPCA feedlot database is summarized in Table 3.9. Facility and livestock numbers by HUC10 subwatersheds, based on the MPCA record of registered feedlot facilities, are listed in Table 3.9. These numbers include both county permitted and NPDES permitted feedlot facilities, both of which are not allowed to discharge animal waste into surface waters. Manure from these feedlots is applied as fertilizer to agricultural fields and is discussed below.

Table 3.9: Number of feedlot facilities and animal units, by HUC10 subwatershed

HUC10 Subwatershed	# of Feedlot Facilities	Livestock Type	Animal Units
Entire Chippewa River Watershed	934	Birds, Bovines, Deer/Elk, Goats/Sheep, Horses, Llamas/Alpacas, Pigs, Other	184,282
Headwaters Chippewa River	255	Birds, Bovines, Goats/Sheep, Horses, Donkey/Mule, Llamas/Alpacas, Pigs	36,343
Little Chippewa River	86	Birds, Bovines, Goats/Sheep, Horses, Donkey/Mule, Llamas/Alpacas, Pigs, Other	13,299
Lake Minnewaska	83	Birds, Bovines, Goats/Sheep, Horses, Pigs	11,969
Mud Creek	71	Bovines, Deer/Elk, Horses, Pigs	9,780
Judicial Ditch 19	34	Birds, Bovines, Goats/Sheep, Horses, Pigs	5,724
East Branch Chippewa River	123	Birds, Bovines, Deer/Elk, Goats/Sheep, Pigs	21,183
County Ditch No. 3 – Chippewa River	85	Bovines, Pigs	23,830
Shakopee Creek	136	Birds, Bovines, Pigs, Goats/Sheep, Horses	37,456
Cottonwood Creek	22	Birds, Bovines, Donkey/Mule, Goats/Sheep, Horses, Pigs, Rabbit	12,283
Dry Weather Creek	15	Birds, Bovines, Goats/Sheep, Horses, Pigs	5,347
Chippewa River	24	Birds, Bovines, Donkey/Mule, Goats/Sheep, Horses, Pigs	7,069

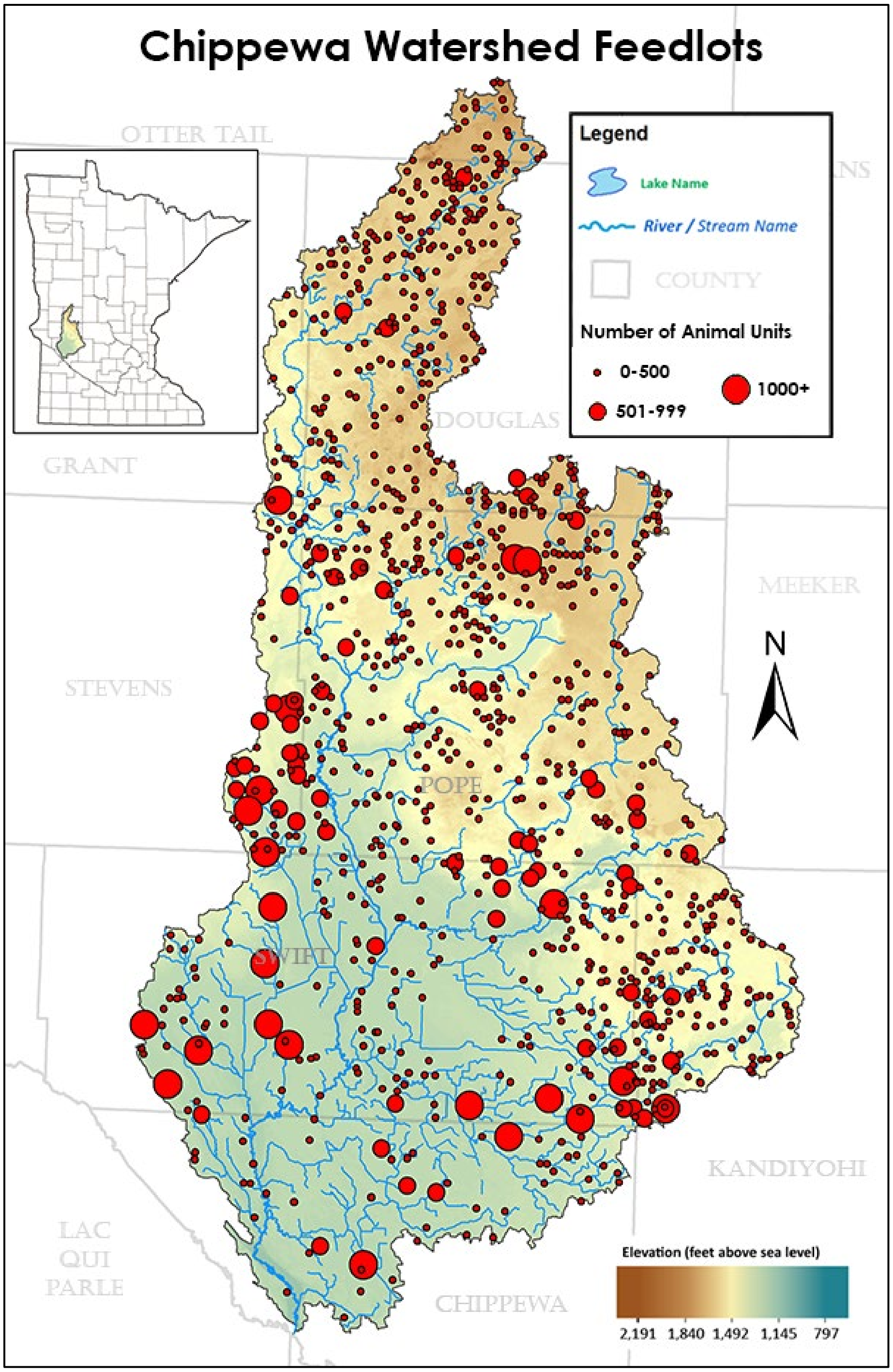

Figure 3.8: Feedlot facility locations of county permitted and state NPDES permitted facilities

Wastewater Treatment Facilities – Human waste can be a significant source of *E. coli* during low flow periods. Fourteen WWTFs discharge into the impaired stream reaches addressed in this TMDL report. Eleven of these facilities have controlled discharge (pond) systems with discharge windows during higher flows. These controlled discharge facilities are not likely to be a source during low flow periods. Three of the facilities are continuous discharge systems, constantly releasing treated wastewater. These continuous discharge facilities are not likely to be a source during low flow periods if the facilities meet their permit limits. Rarely, during extreme high flow conditions, WWTF may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a release.

SSTS – Each year counties are required to submit annual reports to the MPCA regarding SSTS activity within their respective county. While only aggregate information is reported by county and thus actual location of individual SSTS is not known, there is a large amount of failing and imminent public health threat classified SSTS systems in the eight counties in the Chippewa River Watershed. These failing systems are inspected and permitted by the counties. Excluding Grant, Kandiyohi, Otter Tail, and Stevens counties as they only have a small portion of their county in the watershed, the remaining four counties, Chippewa, Douglas, Pope and Swift, have a reported 17,535 SSTS located within these counties. Of the 17,535 SSTS, 3,773 are considered failing and an additional 2,118 are considered imminent public health threats, which could potentially discharge inadequately treated wastewater into waterways and are a potential source, especially during low flow conditions.

Manure – Manure is a by-product of animal production and large numbers of animals create large quantities of manure. This manure is usually stockpiled or held in liquid manure storage basins and then spread over agricultural fields to help fertilize the soil. There is significant amount of winter application of manure onto snow covered or frozen soils and can contribute to the initial bacteria that later reproduce.

Pasture – Livestock can contribute bacteria to the watershed through runoff from poorly maintained pasture lands as well as direct loading if livestock are allowed access to streams or lakes.

Natural Reproduction – *E. coli* bacteria may have the ability to reproduce naturally in water and sediment. Two Minnesota studies describe the presence and growth of "naturalized" or "indigenous" strains of *E. coli* in watershed soils (Ishii et al. 2006) and ditch sediment and water (Sadowsky et al. 2010). The latter study was conducted in the agriculturally-dominated Seven Mile Creek Watershed located in south central Minnesota. As much as 36% of *E. coli* strains found in the Seven Mile Study was represented by multiple isolates, suggesting persistence of specific *E. coli*. While the primary author of the study suggests 36% might be used as a rough indicator of "background" levels of bacteria during this study, this percentage is not directly transferable to the concentration and count data of *E. coli* used in water quality standards and TMDLs. Additionally, because the study is not definitive as to the ultimate origins of the bacteria, it would not be appropriate to consider it as "natural" background (MPCA 2012a). Caution should be used before extrapolating the results of the Seven Mile Creek Study to other watersheds.

Wildlife/Pets– *E. coli* bacteria comes from the digestive tracts of mammals and birds and as such, some *E. coli* may be present in the water from these sources.

3.6.2 TSS

Likely sources or causes of TSS in the Chippewa River Watershed include atmospheric deposition, WWTFs, overland erosion from land practices, and hydrologic changes within the watershed. These are described in more detail below.

Atmospheric Deposition– Windblown sediment is likely a source of TSS in surface waters in the Chippewa River Watershed. Dust from industrial and construction sites, bare soils, and developed areas can all contribute TSS to surface waters.

Wastewater Treatment Facilities– Human waste can be a source of TSS. Fourteen WWTFs discharge into the impaired stream reaches addressed in this TMDL report. Eleven of these facilities have controlled discharge (pond) systems with discharge windows during higher flows. These controlled discharge facilities are not likely to be a source during low flow periods. Three of the facilities are continuous discharge systems, constantly releasing treated wastewater. These continuous discharge facilities are not likely to be a source of during low flow periods if the facilities meet their permit limits. Rarely, during extreme high flow conditions, WWTF may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a release.

Overland Erosion – High TSS can occur when heavy rains fall on unprotected soils, dislodging soil particles, which are transported by surface runoff (SRO) into the rivers and streams (MPCA and MSUM 2009). First order streams, ephemeral streams, and gullies are typically higher up in the watershed and can flow intermittently, which makes them highly susceptible to disturbance. These sensitive areas have a very high erosion potential, which can be exacerbated by farming practices. According to Pierce, "In low-lying areas amenable to extensive row-cropping, forests and perennial grasslands are replaced with annual crops, leaving the land unvegetated (sic) for much of the year. It is well established that removal of vegetation leads to erosion, particularly when followed by recurring conventional tillage". (Pierce 2012). The majority of unprotected soil in the watershed is on agricultural fields, but a percentage every year is unprotected for a variety of reasons, such as construction, mining, or insufficiently vegetated pastures.

Hydrologic Changes – Hydrological changes in the landscape such as subsurface drainage tiling, channelization of waterways, riparian land cover alteration, and increases in impervious surfaces can all lead to increased TSS. There are several different ways that changing the hydrology of the watershed can affect water quality. Draining and tiling wetlands decreases water storage on the landscape. Wetlands often form in low areas where the landscape, soils, or a combination of both create an area where water collects. When a wetland is drained, water is moved off of the land at a higher velocity and in a shorter amount of time. The straightening and ditching of natural rivers, both for agricultural drainage or diversions around cities, increases the slope of the original watercourse and also moves water off of the land at a higher velocity and in a shorter amount of time. Changes to the way water moves through a watershed and how it makes its way into the river can lead to increases in water velocity, scouring of the river channel, and increased erosion of the river banks (Schottler et al. 2012) and ravines. Ravine contributions occur in locations where a flow path drops elevation drastically. The natural erosion rates of many ravines are exponentially increased as the amount of water traveling down the ravine is increased due to a drainage outlet discharging at the top a ravine. Figure 3.9 shows the altered hydrology within the Chippewa River Watershed. Velocity changes associated with unpermitted stormwater systems/drainage ditches are modeled in HSPF by partitioning runoff to SRO (rather than shallow or deeper groundwater) based on land use and impervious to pervious area. The SRO from an impervious area will arrive at the receiving waterbody sooner than shallow and deeper groundwater from pervious areas. The effects of ditching are captured in HSPF through GIS analysis during model framework development. A spatial analysis calculates the average distance from all the land area in a particular land category to the receiving waterbody. The presence of ditches reduces the average length of the overland flow plane for a land category. Therefore the presence of ditches reduces the time it takes for watershed runoff to arrive at the receiving waterbody. The effects of agricultural tiling is modeled by shallow groundwater/interflow arriving at the receiving waterbody sooner that deeper groundwater/baseflow.

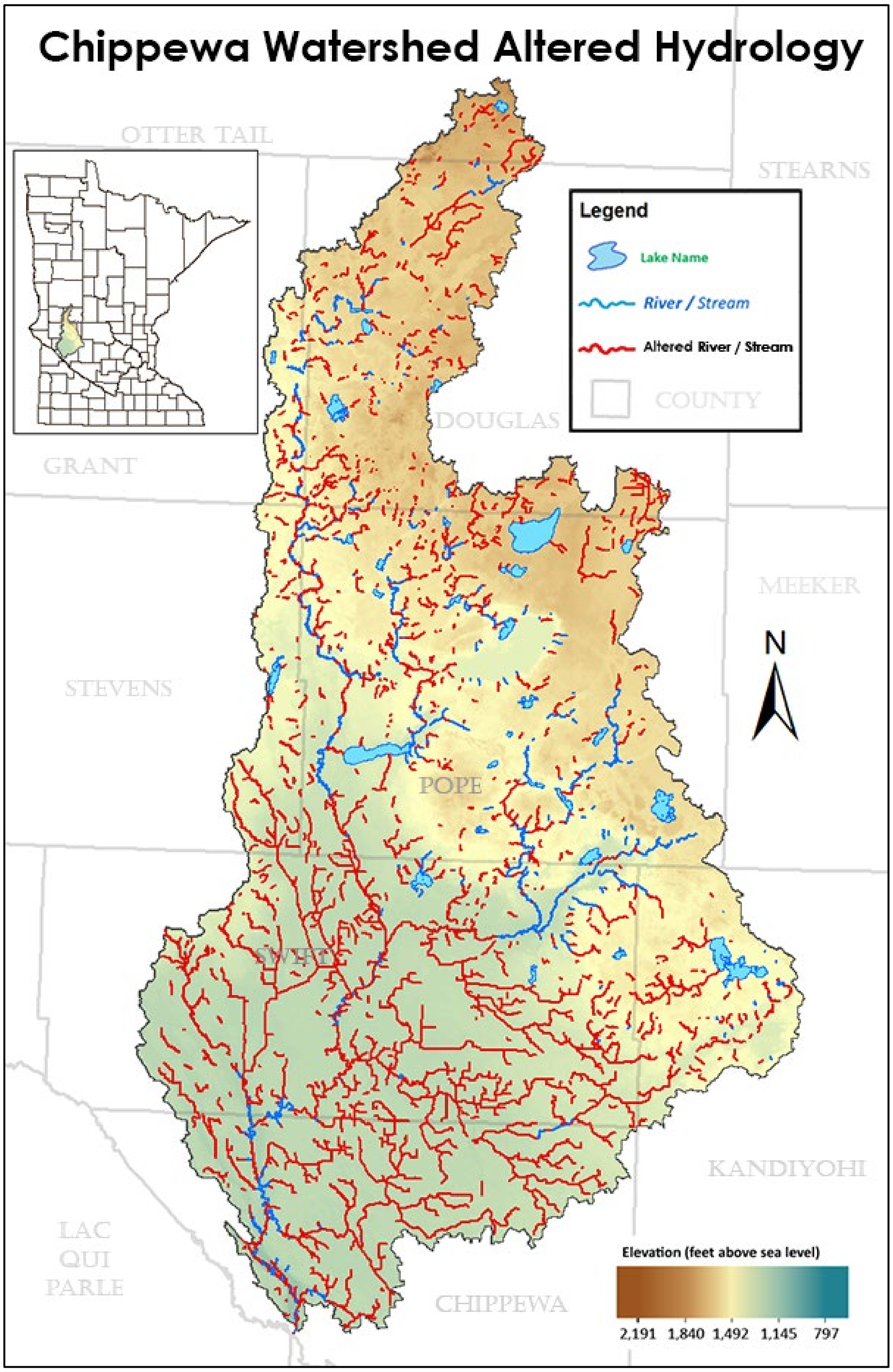

Figure 3.9: Altered hydrology of Chippewa River Watershed

3.6.3 Nutrient Eutrophication

Phosphorus source categories as well as runoff and phosphorus loads were extracted from the Chippewa River Watershed HSPF model. Likely sources of phosphorus in surface water of the Chippewa River Watershed include atmospheric load, SSTS, WWTFs, manure application on agricultural fields, upland erosion, fertilizer application, stream bank erosion, and internal loading. The pathways for pollutants to make their way into surface water include: overland and in-channel erosion, direct discharges, direct precipitation, open tile in-takes, tile lines, and WWTF. These are described in more detail below.

Atmospheric Deposition – Direct atmospheric deposition to the surface of the lakes was based on regional values (Verry and Timmons 1977). Sources of particulate phosphorus in the atmosphere may include pollen, soil erosion, oil and coal combustion and fertilizers. The atmospheric export coefficient used in the model was 0.3 kg/ha.

SSTS –The compliance rate of septic systems cannot be determined without individual inspections. Each year counties are required to submit annual reports to the MPCA regarding SSTS activity within their respective county. While only aggregate information is reported by county and thus actual location of individual SSTS is not known, there is a large amount of failing and imminent public health threat classified SSTS system in the eight counties in the Chippewa River Watershed. Excluding Grant, Kandiyohi, Otter Tail, and Stevens counties as they only have a small portion of their county in the watershed; the remaining four counties, Chippewa, Douglas, Pope and Swift, have a reported 17,535 SSTS located within these counties. Of the 17,535 SSTS, 3,773 are considered failing and an additional 2,118 are considered imminent public health threats. These systems could potentially discharge inadequately treated wastewater into waterways and are a source of nutrients. Phosphorus loads from septics were applied to the lake models using estimates from the HSPF model. The estimates of phosphorus load represented less than 1% of the external load for each of the lakes modeled.

Manure Application – Manure is a by-product of animal production and large numbers of animals create large quantities of manure. This manure is usually stockpiled or held in liquid manure storage basins and then spread over agricultural fields to help fertilize the soil. There is significant amount of winter application of manure onto snow covered or frozen soils. High intensity precipitation events during the spring can cause erosion of both the soil as well as the manure that is applied onto the soil.

Upland Erosion – Gullies and ephemeral streams are typically higher upstream in the watershed and can flow intermittently, which makes them highly susceptible to disturbance. These sensitive areas have a very high erosion potential, which can be magnified by some farming practices. Since phosphorus is adsorbed to the soil particles erosion of the soil causes nutrients to move into surface waters. The majority of unprotected soil in the watershed is on agricultural fields.

Fertilizer Application – During precipitation events, runoff from fields can contain nutrients from applied fertilizer. Due to overland erosion, runoff makes its way into open tile intakes, through a network of drainage tile, and eventually into surface waters.

Stream Bank Erosion – The increase in both the velocity and amount of water by drainage, channel widening, and channel straightening can increase flows, which increases stream energy. This energy can cause loading of sediment through streambank erosion. Phosphorus ions can be attached to this sediment and can excessively load waterbodies. Removal of vegetation and buffers along the stream can also increase erosion and streambank instability.

Internal Load – Under anoxic conditions, weak iron-phosphorus bonds break, releasing phosphorus in a highly available form for algal uptake. Carp and other rough fish present in lakes can lead to increased nutrients in the water column as they uproot aquatic macrophytes during feeding and spawning and re-suspend bottom sediments. Over-abundance of aquatic plants can limit recreation activities and invasive aquatic species such as curly-leaf pondweed can change the dynamics of internal phosphorus loading. Historical impacts, such as WWTF effluent discharge, can also affect internal phosphorus loading. The nutrient retention models within the BATHTUB framework already account for nutrient recycling. However, additional internal load was added to 12 of the lake models ranging from 0.1 to 2.5 $mg{*}m^{-2}{*}day^{-1}$ to bring predicted phosphorus concentrations more in line with the observed. Ideally, independent measurements of internal load would be available to verify the use of additional internal loading. Such data is not available for the impaired Chippewa River Watershed lakes. However, these internal loading values do fall within the range reported in the literature (Nürnberg 1984; Hoverson 2008). Despite the uncertainty as to the exact contribution internal loading has on phosphorus concentrations in the impaired Chippewa River Watershed Lakes, internal processes are likely a significant source of phosphorus loading and should be addressed in lake management plans.

Overland Erosion/Open Tile Intakes/Tile Lines – During some precipitation events, erosion can deliver phosphorus into surface waters. Phosphorus attached to soil particles and dissolved in water moves overland, which can directly discharge into surface waters or into open tile inlets and move through tile lines that discharge into surface waters.

The total external load coming into the lakes from different land use sources were estimated using HSPF for the entire Chippewa River Watershed and the percent that each land use source contributes out of the total external load are listed in Table 3.10.

Table 3.10: Land cover categories and ranges of relative coverage and TP load contribution in the lake catchments

Land Use Source	Description	% Area In Lake Catchments*	External Phosphorus Load (%)
Forest	Runoff from forested land can include decomposing vegetation and organic soils.	**3 - 53**	**< 1 - 12**
Cropland (Conventional and Conservation Tillage)	Runoff from agricultural lands can include applied manure, fertilizers, soil particles, and organic material from crops.	**11 - 84**	**22 - 92**
Grassland/Pasture	Surface runoff can deliver phosphorus from vegetation, livestock and wildlife waste, and soil loss.	**3 - 46**	**1 - 29**
Developed (Pervious and Impervious)	Runoff from residences and impervious surfaces can include fertilizer, leaf and grass litter, pet waste and numerous other sources of phosphorus.	**3 - 7**	**1 - 6**
Wetlands/ Open Water	Wetlands and open water can export phosphorus through suspended solids as well as organic debris that flow through waterways.	**2 - 23**	**< 1 – 62****

*Catchment area does not include area of the lake itself.

** Norway Lake directly connected to West Norway.

Wastewater Treatment Facilities– Human waste can be a source of phosphorus. Two WWTFs discharge into Long Lake (21-0343-00). Both facilities are controlled discharge (pond) systems with discharge windows during higher flows. These controlled discharge facilities are not likely to be a source during low flow periods. Rarely, during extreme high flow conditions, WWTF may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a release.

4. TMDL Development

A TMDL for a waterbody that is impaired as a result of excessive loading of a particular pollutant can be described by the following equation:

TMDL = LC = ∑WLA + ∑LA + MOS + RC

Where:

LC = loading capacity, or the greatest pollutant load a waterbody can receive without violating water quality standards;
WLA = wasteload allocation; the portion of the TMDL allocated to existing or future permitted point sources of the relevant pollutant;
LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant;
MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The MOS can be provided implicitly through analytical assumptions or explicitly by reserving a portion of LC (EPA 1999).
RC = reserve capacity, an allocation of future growth. This is an MPCA-required element, if applicable. Not applicable in this TMDL.

Per Code of Federal Regulations (40CFR 130.2(1)) TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For the Chippewa River Watershed impairments addressed in this TMDL report, the TMDLs, allocations and margins of safety are expressed in mass/day. Each of the TMDL components is discussed in greater detail below.

4.1 Data Sources

4.1.1 Hydrologic Simulation Program – FORTRAN (HSPF)

The HSPF model was built and calibrated by RESPEC, an environmental consulting company contracted by the MPCA. It is used to simulate DO, phosphorus, and flow in the Chippewa River Watershed; this output was used for analysis and TMDL calculations.

The HSPF model is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and NPS models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed.

The HSPF watershed model contains components to address runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/transformation of chemical constituents in stream reaches. Primary external forcing is provided by the specification of meteorological time series. The model operates on a lumped basis within subwatersheds. Upland responses within a subwatershed are simulated on a per-acre basis and converted to net loads on linkage to stream reaches. Within each subwatershed, the upland areas are separated into multiple land use categories.

Multiple spatial and temporal data sources are used to inform the model. Meteorological data originated from the National Weather Service's North Central River Forecasting Center and from the EPA's Basins software, as well as from other Minnesota River Basin sources. Land use/land cover data is taken from the National Landcover Dataset (NLCD). Soil data for each subbasin is based on U.S. Department of Agricultural Soil Survey Geographic Database (SSURGO) GIS data and slope data was calculated using 30 meter DEM data. Land use/land cover, soil, and slope data inform the development of subwatersheds within HSPF and therefore the movement of water and other model constituents from the landscape to stream reaches. The subbasins are delineated based on Minnesota Department of Natural Resources GIS data.

One USGS gage and four non-USGS gages were used to calibrate flow. The non-USGS gages usually only operated from April to September. For some gage data, the frequency at which rating curves were field measured and adjusted was less than USGS standards (*See* Appendix C: HSPF Calibration Reports). The gages used for the model are:

- Chippewa River at Benson (Gage #: H26037001)
- Chippewa River at Cyrus (Gage #: H26003001)
- **USGS gage** on the Chippewa River near Milan (Gage #: USGS 05340500)
- Dry Weather Creek (Gage #: H26078001)
- Shakopee Creek (Gage #: H26038001)

The accuracy of the information used for HSPF is reflected by the strong hydrologic calibration of the model. There is a good fit between observed and simulated flow data, albeit storm flows are sometimes over-predicted between simulations years 1995 and 2002. Because of this strong calibration of simulated data, the model is appropriate in the use of Load Duration Curves.

The MPCA has used HSPF models in this matter to support the Lower Minnesota River DO TMDL. More recently, the MPCA has used HSPF models to support DO TMDLs in both the Pomme de Terre River Watershed and the Le Sueur River Watershed. All of these TMDLs have been approved by the EPA.

4.1.2 Environmental Quality Information System (EQuIS)

The MPCA uses a system called Environmental Quality Information System (EQuIS) to store water quality data from more than 17,000 sampling locations across the state. The EQuIS contains information from Minnesota streams and lakes dating back to 1926.

All discreet water quality sampling data utilized for assessments and data analysis for this TMDL report are stored in this accessible database: *Environmental Data Access* (MPCA 2014c).

4.2 Loading Capacity Methodology

The load duration curve method is based on an analysis that encompasses the cumulative frequency of historic flow data over a specified period. Because this method uses a long-term record of daily flow volumes virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL equation tables of this report (Tables 4.10 – 4.12) only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA.

4.2.1 Streams, *E. coli*

The duration curve approach (EPA 2007) was utilized to address *E. coli* impairments. A flow duration curve was developed using April through October 1996 through 2012 daily average flow data provided by the Chippewa River Watershed HSPF model. This period is selected based on available data at the time the model was developed (2012). A 16-year period provides simulations of the watershed in varying high- and low-flow years. Flow zones were determined for very high, high, mid, low and very low flow conditions. The mid-range flow value for each flow zone was then multiplied by the standard of 126 org/100ml to calculate the LC. For example, for the "very high flow" zone, the LC is based on the flow value at the 5th percentile. The conversion factors used to compute a flow value and pollutant sample value into a load are shown in Table 4.1. Computed load duration curve graphs are shown in Appendix A.

Table 4.1: Unit conversion factors used for *E. coli* load calculations

Load (billion/day) = Flow (cfs) * Concentration (126 organisms/100 ml) * Conversion Factor						
1	Start with Flow				=	ft^3/sec
2	Multiply by **28,316.8** ml/ft^3 to convert	ft^3	à	ml	ft^3	ml/sec
3	Multiply by **#** organisms (Standard set at 126 MPN/100ml)				=	organisms/sec
4	Divide by **100** ml					
5	Multiply by **60** sec/min to convert	seconds	à	minutes	=	organisms/min
6	Multiply by **60** min/hr to convert	minutes	à	hours	=	organisms/hour
7	Multiply by **24** hours/day to convert	hours	à	days	=	organisms/day
8	Divide by **1 Billion** to convert	organisms	à	billion organisms	=	billion organisms/day

Table 4.14 shows LAs for stream reaches impaired by *E. coli*. Only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the components of the TMDL equation could be illustrated for any point on the entire curve. The load duration curve method can be used to display collected *E. coli* monitoring data and allows for estimation of load reductions necessary for attainment of the *E. coli* water quality standard. Load duration curves for the *E. coli* impaired stream reaches are contained in Appendix A.

Estimated percent reductions for each of the bacteria impaired stream reaches are presented in Table 4.2. Reduction values were computed using a load duration curve and *E. coli* sample data for each impaired reach. The above conversion shown in Table 4.1 was used to compute loads for days when samples were taken. The sample concentration (CFU/100mL) was converted into a load (billion organisms per day) using the daily average flow value for that day and inserting the sample concentration values into Step 3 in Table 4.1. These actual observed load values were then summed up for all days samples were collected. This observed load, calculated from actual monitoring data, was then compared to the load if the water sample concentration was equivalent to the water quality standard. The process is described further below.

Observed Load

The sample concentration (CFU/100mL) was converted into a load (billion org per day) using the daily average flow value for that day and inserting the sample concentration values into Step 3 in Table 4.1. These actual load values were then summed up for all sample days.

Load at Water Quality Standard

The load value if the concentration of the water met the *E. coli* standard (126 cfu/100ml) was computed using the daily average flow value for the same sample days and multiplying that value through the steps in Table 4.1 using the *E. coli* standard value of 126 cfu/100ml in Step 3. These standard load values were then summed up for all the days a sample was collected and represent the total maximum load that the river is able to take and still meet the water quality standards for the flows on those dates.

The sum of the actual observed loads was compared to the sum of the water quality standard loads. The percent difference is used for the estimated percent reduction values.

Table 4.2: Percent reductions for *E. coli* impaired stream reaches based on 2002-2011 monitoring data

HUC10 Subwatershed	**Stream Name** Stream Reach AUID#	**Observed Load** (billion org) [# of samples]	**Load Set at 126 org /100mL Standard** (billion org)	**Estimated Reduction Needed To Get < 126 org/100 mL**
Chippewa River	**Unnamed Creek** 07020005-584	**1,257.3** [15]	**298.9**	**76.2%**
Cottonwood Creek	**Cottonwood Creek** 07020005-511	**6,221.7** [15]	**1,252.4**	**79.9%**
County Ditch No. 3	**County Ditch 3** 07020005-579	**2,190.3** [15]	**1,041.3**	**52.5%**
County Ditch No. 3 - Chippewa River	**Chippewa River** 07020005-506	**35,622.7** [15]	**13,511.4**	**62.1%**
East Branch Chippewa River	**East Branch Chippewa River** 07020005-515	**11,375.1** [15]	**3,752.2**	**67%**
Judicial Ditch No. 19	**Mud Creek** 07020005-518	**1,517.7** [17]	**1,248.1**	**17.8%**
Lake Minnewaska	**Outlet Creek**	**3,336.9** [28]	**1,428.1**	**57.2%**

HUC10 Subwatershed	**Stream Name** Stream Reach AUID#	**Observed Load** (billion org) [# of samples]	**Load Set at 126 org /100mL Standard** (billion org)	**Estimated Reduction Needed To Get < 126 org/100 mL**
	07020005-523			
	Trappers Run Creek 07020005-628	**1,084.4** [15]	**365.9**	**66.3%**
Little Chippewa River	**Little Chippewa River** 07020005-713	**17,356** [41]	**3,425.6**	**80.3%**
Mud Creek	**Mud Creek** 07020005-554	**24,484.3** [33]	**3,756.6**	**84.7%**
Shakopee Creek	**Shakopee Creek** 07020005-557	**28,416** [53]	**6,978.3**	**75.4%**
	Judicial Ditch 29 07020005-566	**449.3** [39]	**126.2**	**64%**
	County Ditch 29 07020005-567	**1,051.55** [35]	**414.6**	**60.6%**
	County Ditch 27 07020005-570	**5,495.5** [42]	**994.3**	**81.9%**
	Huse Creek 07020005-917	**209.3** [27]	**107.9**	**48%**

The resulting reduction percentage is only intended as a rough approximation. Reduction percentages are not a required element of a TMDL (and do not supersede the allocations provided), but are included here to provide a starting point to assess the magnitude of the effort needed in the watershed to achieve the standard.

4.2.2 Streams, TSS

The duration curve approach (EPA 2007) was utilized to address turbidity impairments. For reasons explained in Section 2, the current southern streams region TSS standard of 65mg/L was chosen to develop the TMDL. A flow duration curve was developed using April through September 1996 through 2012 daily average flow data provided by the Chippewa River Watershed HSPF model. This period is selected based on available data at the time the model was developed (2012). A 16-year period provides simulations of the watershed in varying high- and low-flow years. Flow zones were determined for very high, high, mid, low and very low flow conditions. The mid-range flow value for each flow zone was then multiplied by the TSS southern streams standard of 65 mg/L to calculate the LC. For example, for the "very high flow" zone, the LC is based on the flow value at the 5th percentile. The conversion factors used to compute a flow value and pollutant sample value into a load are shown in Table 4.3. Computed load duration curve graphs are shown in Appendix A.

Table 4.3: Unit conversion factors used for TSS load calculations

Load (tons/day) = Concentration (mg/1000mL) * Flow (cfs) * Factor						
1	Start with Flow				**=**	ft^3/sec
2	Multiply by **28,316.8** ml/ft^3 to convert	ft^3	à	ml	**=**	ml/sec
3	Multiply by **#** mg (Standard set at 65 mg/L)				**=**	mg/sec
4	Divide by **1000** ml					
5	Divide by **453,592** mg/lb to convert	mg	à	lbs	**=**	lbs/sec
6	Multiply by **60** sec/min to convert	seconds	à	minutes	**=**	lbs/min
7	Multiply by **60** min/hr to convert	minutes	à	hours	**=**	lbs/hour
8	Multiply by **24** hours/day to convert	hours	à	days	**=**	lbs/day
9	Divide by **2000** lbs/ton to convert	lbs	à	tons	**=**	tons/day

Table 4.15 shows LAs for TSS for stream reaches impaired for TSS. Only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the components of the TMDL equation could be illustrated for any point on the entire curve. The load duration curve method can be used to display collected TSS monitoring data and allows for estimation of load reductions necessary for attainment of the TSS water quality standard. Load duration curves for the TSS impaired stream reaches are contained in Appendix A.

The TSS was identified as a stressor in reaches 07020005-507 and 07020005-523, impaired for IBI. Since reach 07020005-507 was also impaired for turbidity the load duration curve for TSS was used to address the TSS stressor (Table 4.15). In order to address the IBI impairment for reach 07020005-523 a load duration curve was developed for TSS (Table 4.17).

Estimated percent reductions for each of the TSS impaired stream reaches are presented in Table 4.4. Reduction values were computed using a load duration curve and TSS sample data for each impaired reach. The above conversion shown in Table 4.3 was used to compute loads for days when samples were collected. The sample concentration (mg/L) was converted into a load (tons per day) using the daily average flow value for that day and inserting the sample concentration values into Step 3 in Table 4.3. These actual observed load values were then summed up for all days samples were collected. This observed load, calculated from actual monitoring data, was then compared to the load if the water sample concentration was equivalent to the water quality standard. The process is described further below.

Observed Load

The sample concentration (mg/L) was converted into a load (tons per day) using the daily average flow value for that day and inserting the sample concentration values into Step 3 in Table 4.3. These actual load values were then summed up for all sample days.

Load at Water Quality Standard

The load value if the concentration of the water met the TSS standard (65 mg/L) was computed using the daily average flow value for the same sample days and multiplying that value through the steps in Table 4.3 using the TSS standard value of 65 mg/L in Step 3. These standard load values were then summed up for all the days a sample was collected and represent the total maximum load that the river is able to take and still meet the water quality standards for the flow values on those dates.

The sum of the actual observed loads was compared to the sum of the standard loads. The percent difference is used for the estimated percent reduction values.

Table 4.4: Percent reductions for TSS impaired stream reaches based on 2002-2011 TSS data

HUC10 Subwatershed Stream Reach AUID #	**Observed Load (Tons TSS)** [# of samples]	**Load Set at 65 mg/L Standard** (Tons TSS)	**Estimated Reduction Needed To Get 65 mg/L**
Chippewa River 07020005-507	**44,0006.9** [229]	**38,921.3**	**11.6%**

Due to the lack of TSS data within stream reach 07020005-507, TSS data from site S002-203 was used to determine the percent reduction for this stream reach. Site S002-203 is located within five miles of the end of reach 07020005-507 and it was determined to adequately represent the conditions within the impaired reach. The resulting reduction percentage is only intended as a rough approximation. Reduction percentages are not a required element of a TMDL (and do not supersede the allocations provided), but are included here to provide a starting point to assess the magnitude of the effort needed in the watershed to achieve the standard.

4.2.3 Dissolved Oxygen

The Chippewa River Watershed HSPF model was used to support the development of a TMDL on the DO impaired reaches. A compliance scenario was developed through several iterative runs of the calibrated model. In each case the baseline scenario, which was calibrated to the existing DO data, indicated excursions of DO concentrations below the 5 mg/l minimum standard. The modeler then reduced the phosphorus loading to the impaired receiving reach. The modeler then extracted the reduction in algal biomass caused by that reduction in phosphorus load to the channel. That percent reduction in algal biomass was then applied to the simulated sediment oxygen demand. A second simulation was then run with both reductions in TP delivered to the stream and in-stream sediment oxygen demand. This approach is taken since a reduction in algal biomass will result in less dead organic material settling to the bed of the reach and therefore reduce the replenishment of sediment oxygen demand. In this manner, phosphorus loading and sediment oxygen demand (SOD) were reduced in lock step, with the reduction in SOD being determined by the percent reduction in algal biomass caused by the reduction in phosphorus loadings. The modeler continued to reduce phosphorus loadings and SOD in a stepwise fashion until all excursions below the minimum 5mg/l standard were eliminated from the simulated output. At that point, the model simulation is deemed to have achieved compliance.

The calibrated Chippewa HSPF model confirms that high TP concentrations are likely causing low DO; model scenarios demonstrate that DO is sensitive to TP. The need for a decrease in TP and an increase in DO corroborates *Chippewa River Biotic SID Report* (MPCA 2015) findings, which states that high phosphorus concentrations contribute to low DO and is a stressor to the biologically impaired stream reaches. Data used to develop the model framework included: precipitation, evaporation, animal units, watershed area, topography, land use (MRLC 2011), flow and water quality, septic systems and NPDES dischargers.

For each model run, once the NPS TP was reduced by a given percentage, the percent reduction of phytoplankton settling as a result was viewed. The phytoplankton reduction was then applied to the SOD constant to get a subsequent reduction in SOD. This is due to the fact that a reduction in phosphorus would result in a reduction in algal growth, death, and settling to the bottom, which reduces the SOD. A 26% to 32% reduction of nonpoint TP resulted in a modeled attainment of the DO standard. Phosphorus allocations were subsequently developed with consideration of these model results to address the DO impairment. This HSPF model application tabulated loads on an hourly time step. These hourly loads were then summed to give both daily and annual loadings.

Table 4.5: Percent reductions for DO impaired stream reaches based on HSPF model reductions in phosphorus using 2009-2010 DO and phosphorus data

HUC10 Subwatershed Stream Name Stream Reach AUID #	**Annual TP Load** (Pounds of Phosphorus)	**Annual TP Load Reduction + - Error Range** (Pounds of Phosphorus)	**Approximate TP % Reduction Needed**
Chippewa River unnamed creek 07020005-584	**3,460**	**1,106 + - 55**	**32%**
Mud Creek Mud Creek 07020005-554	**12,930**	**3,285 + - 164**	**26%**

4.2.4 Lakes, Nutrient Eutrophication

The BATHTUB (version 6.14; Walker 1999) model framework was used to model phosphorus and water balance for lakes within the Chippewa River Watershed. Data used to develop the model framework included: precipitation, evaporation, lake morphometry, lake water quality, animal units, watershed area, land use, flow and water quality, septic systems and NPDES dischargers. For more detail on the Chippewa sources of model data, refer to the *Chippewa River Watershed Monitoring and Assessment Report* (MPCA 2012b).

BATHTUB's Canfield Bachmann lake and reservoir models were used to estimate loads to the impaired lakes. The nutrient sedimentation models in BATHTUB have been empirically calibrated, so the effects of internal phosphorus loading from sediments are accounted for in the model parameter values (Walker 1999). As such, the model does not explicitly provide an estimate of the internal load. However, in the Chippewa River Watershed, several lake models required additional internal loading for the predicted in-lake phosphorus concentrations to approximate the average phosphorus concentrations based on water quality samples. For some of the lakes in the Chippewa Watershed, internal load is a significant source of phosphorus and in-lake efforts will be important to achieve water quality standards. However, any improvements to water quality derived from in-lake efforts will be temporary if external sources are not better controlled so as to reduce the build-up of internal phosphorus.

To calculate the phosphorus load capacity that allowed each lake to achieve its water quality standard, phosphorus loads were reduced within the model until the predicted in-lake concentration matched the appropriate standard (columns 4-6 in Table 4.6). This was achieved by reducing TP concentrations from land use categories that exceeded the river/stream eutrophication standards down to the applicable concentration standard (150 µg/L). The land use categories most often affected by these adjustments were cropland and developed land. In addition, contribution from septic systems was reduced to zero. In cases where reducing the TP concentration from the contributing landscape and setting the load from septic systems to zero was not sufficient to meet the lake water quality standard, the internal load was reduced. Using the modeled annual load and the annual load capacity, the load reduction was calculated (column 7 in Table 4.6). Modeled lake LC summaries are shown in Table 4.18.

Table 4.6: Observed and modeled mean phosphorus conditions in Chippewa River Watershed lakes; phosphorus load reduction necessary to meet the water quality standard

Lake Name **DNR #**	**Observed Average TP** (µg/L)	**Modeled TP** (µg/L)	**TP Standard** (µg/L)	**Modeled Annual TP Load** (lbs)	**Modeled Annual TP Load Capacity** (lbs)	**Load Reduction to Achieve TP Standard** (%)
Block 56-0079-00	**81.1**	**80**	**40**	**1,191**	**343**	**71**
Danielson Slough 61-0194-00	**147**	**156**	**90**	**1,993**	**959**	**52**
Edwards 61-0106-00	**220**	**219**	**60**	**1,180**	**325**	**72**
Gilbert 21-0189-00	**72**	**72**	**60**	**564**	**387**	**31**
Hanson 61-0080-00	**111**	**123**	**60**	**4,370**	**1,953**	**55**
Hassel 76-0086-00	**200**	**197**	**60**	**8,351**	**1,930**	**77**
Hollerberg 76-0057-00	**76.1**	**89**	**60**	**1,053**	**506**	**52**

Lake Name DNR #	Observed Average TP (µg/L)	Modeled TP (µg/L)	TP Standard (µg/L)	Modeled Annual TP Load (lbs)	Modeled Annual TP Load Capacity (lbs)	Load Reduction to Achieve TP Standard (%)
Irgens 61-0211-00	**203**	**198**	**60**	**4,020**	**935**	**77**
Jennie 21-0323-00	**159**	**152**	**60**	**693.1**	**136**	**80**
Johanna 61-0006-00	**70.6**	**78**	**60**	**3,008**	**1,678**	**44**
John 61-0123-00	**140.5**	**141**	**60**	**2,140**	**634**	**70**
Jorgenson 61-0164-00	**209.7**	**205**	**60**	**848**	**117**	**86**
Long 21-0343-00	**99.5**	**117**	**60**	**16,029**	**6,938**	**57**
Long 75-0024-00	**150**	**148**	**90**	**2,798**	**??**	**59**
Mary 61-0099-00	**110**	**110**	**60**	**464**	**192**	**58**
McIver 61-0199-00	**177**	**173**	**60**	**1,372**	**283**	**79**
Monson 76-0033-00	**84**	**75**	**60**	**377**	**248**	**34**
Norway 34-0251-02	**49.3**	**49**	**40**	**2,500**	**1,828**	**27**
Rasmuson 61-0086-00	**149**	**147**	**60**	**836**	**185**	**78**
Red Rock 21-0291-00	**131**	**130**	**40**	**6,911**	**809**	**88**
Simon 61-0034-00	**124**	**123**	**60**	**2,532**	**708**	**72**
Swenoda 61-0051-00	**90.7**	**89**	**60**	**452**	**231**	**49**
Thompson 26-0020-00	**136**	**132**	**40**	**1,605**	**188**	**88**
West Norway 34-0251-01	**78**	**85**	**60**	**7,509**	**3,987**	**47**
Wicklund 61-0204-00	**178**	**178**	**60**	**2,042**	**515**	**75**

4.3 Wasteload Allocation Methodology

Wastewater WLAs are given to individual wastewater or industrial facilities that discharge wastewater into an impaired lake or stream. Stormwater WLAs are calculated in accordance with EPA guidance (EPA 2002) and presented as categorical WLAs. Categorical WLAs are pollutant loads that are equivalent for multiple permittees (several regulated Municipal Separate Storm Sewer System (MS4s)), or a group of permittees (e.g. construction stormwater).

4.3.1 Wastewater Treatment Facilities

The WWTFs are NPDES/SDS permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). These include city or sanitary district treatment facilities, wayside rest areas, national or state parks, mobile home parks, and resorts. Relevant WWTF for impaired stream reaches and lakes are shown in Table 4.7.

Table 4.7: WWTF permits applicable to this TMDL report

HUC10 Subwatershed	City WWTF	Permit #	System Type	Impairment	Stream Reach/Lake AUID #
Cottonwood Creek	Danvers	MNG580119	Controlled Discharge	*E. coli*	07020005-511
County Ditch 3 – Chippewa River	Benson	MN0020036	Continuous Discharge	*E. coli*	07020005-506
				TSS	07020005-507
	Clontarf	MNG580108	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
	Hancock	MN0023582	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
Headwaters Chippewa River	Evansville	MN0023329	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				Nutrient Eutrophication	21-0343-00
	Farwell Kensington	MNG580220	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
	Hoffman	MNG580134	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
	Millerville	MN0054305	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				Nutrient Eutrophication	21-0343-00
	Urbank	MN0068446	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				Nutrient Eutrophication	21-0343-00
Lake Minnewaska	Starbuck	MN0021415	Continuous Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				E. coli	07020005-523
Little Chippewa River	Lowry	MN0024007	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507

HUC10 Subwatershed	City WWTF	Permit #	System Type	Impairment	Stream Reach/Lake AUID #
				E. coli	07020005-523
				E. coli	07020005-628
Mud Creek	Sunburg	MNG580125	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				E. coli/ Dissolved Oxygen	07020005-554
Shakopee Creek	Kerkhoven	MN0020583	Continuous Discharge	TSS	07020005-507
				E. coli	07020005-557
				E. coli	07020005-579
	Murdock	MNG580086	Controlled Discharge	*E. coli*	07020005-506
				TSS	07020005-507
				E. coli	07020005-518

For the *E. coli* impaired stream reaches controlled discharge WWTF allocations were determined by multiplying the permit limit of 126 org/100ml by the maximum permitted discharge flow (for controlled systems, this is based on a six-inch per day discharge from the facility's secondary ponds). Individual *E. coli* WLA calculations and allocations are shown in Table 4.8.

Table 4.8: Individual WWTF *E. coli* WLA calculations

City WWTF	A **Permit Limit** (billion org/100ml)	B **Max Permitted Discharge Flow** (mgd)	C **Conversion factor**	A*B*C **Load** (billion org/day)
Benson	126	0.985	0.03785	4.7
Clontarf		0.212		1.01
Danvers		0.189		0.9
Evansville		0.749		3.57
Farwell Kensington		0.570		2.72
Hancock		1.372		6.54
Hoffman		2.5		11.8
Kerkhoven		0.15		0.72
Lowry		0.422		2.01
Millerville		0.254		1.21
Murdock		0.319		1.52
Starbuck		0.35		1.67
Sunburg		0.119		0.57
Urbank		0.080		0.38

For the turbidity impaired stream reaches controlled discharge WWTF allocations were determined by multiplying the TSS permit limit (30 – 45 mg/L) by the maximum permitted discharge flow (for controlled systems, this is based on a six inches per day discharge from the facility's secondary ponds). Individual TSS WLA calculations and allocations are shown in Table 4.9.

Table 4.9: Individual WWTF Total Suspended Solids WLA calculations

City WWTF	A	B	C	A*B*C
	TSS Permit Limit (mg/liter)	**Max Daily Flow or Max Permitted Discharge Flow** (mgd)	**Conversion factor**	**Load** (tons/day)
Benson	30	0.985	0.0041722	0.10
Clontarf	45	0.212		0.04
Evansville	45	0.749		0.14
Farwell Kensington	45	0.570		0.11
Hancock	45	1.372		0.26
Hoffman	45	2.476		0.47
Kerkhoven	30	0.15		0.02
Lowry	45	0.422		0.08
Millerville	45	0.254		0.05
Murdock	45	0.319		0.06
Starbuck	30	0.35		0.04
Sunburg	45	0.119		0.02
Urbank	45	0.080		0.01

For the nutrient eutrophication impairments, daily phosphorus WLAs were calculated from the one to two mg/L effluent concentration assumption and the maximum permitted effluent flow rate of six inches per day over the area of the facility's discharging cell(s) (Table 4.10). 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 WLAs do not represent their annual WLAs divided by the days in a year. Evansville WWTP could discharge up to 2.8 kgP/day, Millerville WWTP could discharge up to 1.9 kgP/day and Urbank WWTP could discharge up to 0.6 kgP/day, for any particular day and still be in compliance so long as they do not exceed the annual loads that are specified in their permits.

Table 4.10: Individual WWTF Total Phosphorus WLA calculations

City WWTF	A	B	C	D	E	F
	Average Wet Weather Design Flow (mgd)	Secondary Pond Area (ac)	6"/day Maximum Daily Flow (mgd)	Effluent Concentration Assumption (mg/L)	Daily WLA (kg/day) WLA = C*D*3.785	Annual WLA (kg/year) WLA = A*D*3.785 *365
Evansville	0.1	4.6	0.75	1.0	2.8	138
Millerville	0.0195	1.56	0.25	2.0	1.9	54
Urbank	0.011	0.49	0.08	2.0	0.6	30

4.3.2 Industrial Process Wastewater

There is one industrial facility that discharges water into the Chippewa River Watershed.

Table 4.11: Industrial Wastewater permitted facilities applicable to this TMDL report

Facility Name	Permit #	Facility	System Type	Stream Reach AUID #
Chippewa Valley Ethanol Company	MN0062898	Ethanol Plant	Controlled Discharge	07020005-502 07020005-503 07020005-506 07020005-507

Table 4.12: Industrial Wastewater facility Total Suspended Solids WLA calculations

Facility Name	Permit Number	A	B	C	A*B*C
		TSS Permit Limit (mg/L)	Design Flow (mgd)	Conversion Factor	Load (tons/day)
Chippewa Valley Ethanol Company	MN0062898	30	0.1325	0.0018925	0.01

4.3.3 Stormwater

Urban and suburban stormwater runoff both from developing and built-out areas carry pollutant loads that can match or exceed agricultural run-off on a per-acre basis. This runoff can increase flows, which contributes to channel instability and streambank erosion. Pollutants from stormwater runoff can include pesticides, fertilizer, oil, chemicals, metals, pathogens, salt, sediment, litter, and other debris. The MPCA has three categories for stormwater permits: municipal, construction, and industrial.

Municipal – In 1987, the CWA was amended to include provisions for a two-phase program to address stormwater runoff. In March of 2003, the second phase of the program began. Phase II includes permitting and regulation of smaller construction sites, municipalities MS4 Permits, and industrial facilities. There are currently no MS4 communities that discharge into any impaired stream reach addressed in this report. There are also no communities likely to become subject to MS4 Permit requirements in the near future. As a result, 0% of the TMDL is apportioned to the MS4 allocation.

Construction – The MPCA issues construction permits for any construction activities disturbing:

- One acre or more of soil
- Less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre
- Less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources

Construction stormwater permit application records indicate approximately 0.7% out of the total land area of the watershed has been subject to construction over the last 10 years. As part of the permit requirements, the sites may be required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP uses BMPs designed to eliminate or minimize erosion due to stormwater on exposed soils at construction sites. The WLAs stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the best management practices (BMPs) and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

Industrial – Industrial sites might contribute to stormwater pollution when water comes in contact with pollutants such as toxic metals, oil, grease, de-icing salts and other chemicals from rooftops, roads, parking lots, and from activities such as storage and material handling. Examples of exposed materials that would require a facility to apply for an Industrial Stormwater Permit include: fuels, solvents, stockpiled sand, wood dust, gravel, metal and a variety of other materials. As part of the permit requirements, the facilities are required to develop and implement a SWPPP. The SWPPP uses BMPs designed to eliminate or minimize stormwater contact with significant materials that might result in polluted stormwater discharges from the industrial site. The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES Industrial Stormwater Permit coverage is required as well as BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. Industrial Stormwater Permit application records indicate approximately 1.3% out of the total land area of the watershed has been subject to permitted industrial activity over the last 10 years. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS General Permit for Nonmetallic Mining and Associated Activities facilities (MNG490000). If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local stormwater management requirements must also be met.

Since approximately 2% of the land area every year is either under construction or an industrial facility, 2% of the LC is allocated to this category. 0.2% was added in order to account for the potential for higher rates of construction or additional industrial facilities. Therefore, 2.2% of the LC is apportioned to these activities through a categorical WLA.

Livestock Facilities – The NPDES livestock facilities are zero discharge facilities and therefore are given a WLA of zero and should not impact water quality in the watershed as a point source. Livestock facilities with NPDES Permits located within each subwatershed is shown in Table 4.11. These are general feedlot permits and are covered as such under Minnesota's General Feedlot Permit, MNG440000. Discharge of phosphorus from fields where manure has been land-applied are covered under the LA portion of the TMDLs, provided the manure is applied in accordance with the permit.

Table 4.13: Large CAFO livestock facilities by subwatershed

Aggregated HUC12 Subwatershed	NPDES Permit Number	Feedlot Name	Total Animal Units
Cottonwood Creek	MNG440107	Jennie-O Turkey Store – Commerford Grower	**2937.78**
	MNG440107	Jennie-O Turkey Store - Commerford Brood	**1080**
County Ditch 3 – Chippewa River	MNG440305	Canadian Connection - Sec 14	**1800**
	MNG440855	Hancock Pro Pork Inc - Sec 14	**550**
	MNG440856	Hancock Pro Pork Inc	**1533**
Dry Weather Creek	MNG440127	Tri-R-Pork Inc	**1080**
	MNG441050	Eric Meyer Farm	**990**
East Branch Chippewa River	MNG440595	Jennie-O Turkey Store - Olson North Farm	**989.6**
	MNG440595	Jennie-O Turkey Store - Olson South Farm	**990**
	MNG441256	Jennie-O Turkey Store - Riverside Farm	**953.7**
	MNG440747	Stan Schaefer Inc	**1057.5**
	MNG440748	Riverview LLP - Moore Calves	**1698**
Lake Minnewaska	MNG441303	Blair West Site	**1900**
Mud Creek	MNG440595	Jennie-O Turkey Store - Camp Lake Farm	**989**
Shakopee Creek	MNG440742	Willmar Poultry Farms Inc - Kerkhoven	**500**
	MNG441049	Carlson Dairy LLP - Sec 28	**2240**
	MNG441264	Johnson Dairy Inc	**1990.2**
	MNG440472	Riverview LLP - Dublin Dairy	**3952.9**
	MNG440797	Riverview LLP - East Dublin Dairy	**8890**
	MNG441254	Gerald Tofte Farm	**1510**
	MNG441023	East Dublin Dairy LLP - Chippewa Calves	**999.8**

4.3.4 Straight Pipe Septic Systems

Straight pipe septic systems are illegal and therefore receive a WLA of zero. According to Minn. Stat. 115.55, subd. 1, a straight pipe "means a sewage disposal system that includes toilet waste and transports raw or partially settled sewage directly to a lake, a stream, a drainage system, or ground surface".

4.4 Load Allocation Methodology

Once the WLA and MOS were determined for each watershed, the LA was assigned the remaining LC. The LA includes nonpoint pollution sources that are not subject to NPDES Permit requirements, as well as "natural background", as defined in Minn. R. 7050.0150, subp. 4.

4.5 Margin of Safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards.

4.5.1 E. coli

The Chippewa River Watershed HSPF model was calibrated and validated using 17 years (1996 through 2012) of flow data from USGS gaging station 05304500 and 12 years (1999 through 2010) of water chemistry data. Calibration results indicate that the HSPF model is a valid representation of hydrological conditions in the watershed. See Appendix C of this report for the HSPF model calibration and validation results. The *E. coli* Load Duration Curves were developed using HSPF modeled daily flow data from April thru October. The *E. coli* TMDLs applied a MOS to each flow zone along the duration curves by subtracting 10% of the flow zones loading capacity.

4.5.2 TSS

The Chippewa River Watershed HSPF model was calibrated and validated using 17 years (1996 through 2012) of flow data from USGS gaging station 05304500 and 12 years (1999 through 2010) of water chemistry data. Calibration results indicate that the HSPF model is a valid representation of hydrological and chemical conditions in the watershed. See Appendix C of this report for the HSPF model calibration and validation results. The TSS stream Load Duration Curves were developed using HSPF modeled daily flow data from April thru September. The TSS TMDLs applied a MOS to each flow zone along the duration curves by subtracting 10% of the flow zones loading capacity.

4.5.3 Nutrient Eutrophication

The Chippewa River Watershed HSPF model was calibrated and validated using 17 years (1996 through 2012) of flow data from USGS gaging station 05304500 and 12 years (1999 through 2010) of water chemistry data. Calibration results indicate that the HSPF model is a valid representation of hydrological and water quality conditions in the watershed. See Appendix C of this report for the HSPF model calibration and validation results. The external phosphorus load estimates delivered to each lake from the surrounding land were developed using HSPF modeled daily flow data and loads. In some instances, the external loading estimates did not result in sufficient phosphorus load for the modeled in-lake phosphorus concentrations to match the average phosphorus concentrations. Internal load adjustments were made within the BATHTUB model until the modeled TP value matched the mean value of the observed samples. Because of the calibration and validation of the HSPF model as well as the morphometric factors suggesting internal load is a source of phosphorus in these lakes, the MPCA believes the BATHTUB models are an appropriate representation of the natural system. Therefore, an explicit MOS of 10% was deemed appropriate for the nutrient eutrophication TMDLs.

4.5.4 Dissolved Oxygen

The calibration sequence for the in-stream simulation is: hydrology, water temperature, sediment, phosphorus, nitrogen, oxygen demand, Chl-*a*, and DO. This sequence must be complete before any model can be used to support the development of any DO TMDL. The Chippewa River Watershed HSPF model was calibrated and validated using 17 years (1996 through 2012) of flow data from USGS gaging station 05304500 and 12 years (1999 through 2010) of water chemistry data. Further calibration was done specifically on the DO impaired reaches using two years (2009-2010) of observed DO concentration measurements. Calibration results indicate that the HSPF model is a valid representation of in-stream conditions. The MOS was applied to the stream TMDLs by subtracting 10% of the streams loading capacity.

4.6 Seasonal Variation

4.6.1 Streams, *E. coli*

Concentrations of *E. coli* vary throughout the summer in the Chippewa River Watershed. The standard is based on a monthly geometric mean and must be met for the months April through October. Exceedances of the *E. coli* standard in the impaired stream reaches occur primarily in the months June through August and vary by reach (Table 3.4). The duration curve approach uses multiple years of flow data and the applicable time period of the standard will provide sufficient water quality protection during the critical summer period.

4.6.2 Streams, TSS

Turbidity, transparency tube, and TSS data were all collected in the Chippewa River Watershed and was used to determine whether stream reaches met the TSS standard of 65 mg/L. Elevated TSS is prevalent throughout much of the year (Table 3.5), there are likely differing sources contributing to TSS in different parts of the watershed in different years. The duration curve approach using multiple years of flow data helps to account for some of this variation and will provide adequate protection during the differing times of the year when the standard is exceeded. The standard applies from April through September.

4.6.3 Streams, DO

DO data was collected in the Chippewa River Watershed and was used to determine whether stream reaches met the DO standard of 5 mg/L. Low DO is a consequence of high algae growth and subsequent decay of algal biomass. The calibrated Chippewa HSPF model confirms that high TP concentrations are likely causing increases in algal growth. The DO standard applies year round. Because of this, the model is run for the entire year; however, daily minimum DO concentrations are usually at their lowest and algal growth at its highest, in the summer low flow season. By meeting the standard during this critical time period, the standard should be met for the rest of the year.

4.6.4 Lakes, Nutrient Eutrophication

Water quality monitoring suggests the in-lake TP concentrations vary over the course of the growing season and generally peaks in mid to late summer (Table 3.8). The standard applies from June through September. The MPCA eutrophication water quality guideline for assessing TP is defined as the June through September mean concentration. The BATHTUB model was used to calculate the load capacities of each lake, incorporating mean growing season TP values. TP loadings were calculated to meet the water quality standards during the summer growing season, the most critical period of the year. Calibration to this critical period will provide adequate protection during times of the year with reduced loading.

4.7 TMDL Summary

4.7.1 Bacteria Impaired Stream Reach Loading Capacities

Table 4.14: *E. coli* loading capacities and allocations for stream reaches

E. coli					
Chippewa River E Br Chippewa River to Shakopee Creek AUID# 07020005-506	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* (billion organisms per day)**				
Average Daily Loading Capacity	5112.0	2163.5	1089.2	518.4	224.5
Margin of Safety	511.2	216.4	108.9	51.8	22.5
Wasteload Allocation					
Cities of Clontarf, Evansville, Farwell/Kensington, Hancock, Hoffman, Lowry, Millerville, Murdock, Starbuck, Sunburg, and Urbank Wastewater Treatment Facilities**	33	33	33	33	33
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	4,567.8	1,914.1	947.3	433.6	169
Cottonwood Creek T120 R41W S21, west line to Chippewa River AUID# 07020005-511	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* (billion organisms per day)**				
Average Daily Loading Capacity	525.5	192.4	91.1	46.0	19.0
Margin of Safety	52.3	19.2	9.1	4.6	1.9
Wasteload Allocation					
City of Danvers Wastewater Treatment Facility	0.9	0.9	0.9	0.9	0.9
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	472.3	172.3	81.1	40.5	16.2

E. coli					
East Branch Chippewa River Headwaters (Amelia Lake 61-0064-00) to Mud Creek AUID# 07020005-515	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* (billion organisms per day)**				
Average Daily Loading Capacity	826.0	336.7	173.8	88.4	37.0
Margin of Safety	82.6	33.7	17.4	8.8	3.7
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	*	*	*	*	*
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	743.4	303	156.4	79.6	33.3
South Mud Creek T121 R39W S2, south line to East Branch Chippewa River AUID# 07020005-518	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* (billion organisms per day)**				
Average Daily Loading Capacity	420.5	175.3	87.2	40.9	20.1
Margin of Safety	42.1	17.5	8.7	4.1	2.0
Wasteload Allocation					
City of Murdock	1.52	1.52	1.52	1.52	1.52
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	376.9	156.3	77	35.3	16.6
Outlet Creek Lake Minnewaska to Lake Emily AUID# 07020005-523	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* (billion organisms per day)**				
Average Daily Loading Capacity	359.3	110.4	38.7	18.1	7.2
Margin of Safety	35.9	11.0	3.9	1.8	0.7
Wasteload Allocation					
Cities of Lowry and Starbuck Wastewater Treatment Facilities	3.68	3.68	3.68	3.68	3.68
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	319.7	95.7	31.1	12.6	2.8
North Mud Creek CD 15 to East Branch Chippewa River AUID# 07020005-554	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**

E. coli					
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	553.8	222.9	104.8	50.9	22.9
Margin of Safety	55.4	22.3	10.5	5.1	2.3
City of Sunburg Wastewater Treatment Facility	0.57	0.57	0.57	0.57	0.57
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	497.8	200	93.7	45.2	20
Shakopee Creek Swan Lake to Shakopee Lake AUID# 07020005-557	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	617.4	235.6	98.0	36.2	9.8
Margin of Safety	61.7	23.6	9.8	3.6	1.0
Wasteload Allocation					
City of Kerkhoven Wastewater Treatment Facility	0.72	0.72	0.72	0.72	0.72
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	555	211.3	87.5	31.9	8.1
County Ditch 3 County Ditch 7 to Chippewa River AUID# 07020005-579	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	397.6	154.9	78.0	39.6	17.1
Margin of Safety	39.8	15.5	7.8	4.0	1.7
Wasteload Allocation					
City of Kerkhoven Wastewater Treatment Facility	0.72	0.72	0.72	0.72	0.72
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	357.1	138.7	69.5	34.9	14.7
Tributary to Chippewa River Unnamed creek to Chippewa River AUID# 07020005-584	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	124.5	45.5	21.3	10.6	4.4
Margin of Safety	12.5	4.6	2.1	1.1	0.4

E. coli					
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	*	*	*	*	*
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	112	40.9	19.2	9.5	4

Trappers Run Creek Strandness Lake to Pelican Lake AUID# 07020005-628	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	134.2	54.8	29.3	14.4	6.0
Margin of Safety	13.4	5.5	2.9	1.4	0.6
Wasteload Allocation					
City of Lowry Wastewater Treatment Facility	2.01	2.01	2.01	2.01	2.01
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	118.8	47.3	24.4	11	3.4

Little Chippewa River Unnamed creek to County Ditch 2 AUID# 07020005-713	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	352.7	143.5	77.2	36.9	14.6
Margin of Safety	35.3	14.4	7.7	3.7	1.5
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	*	*	*	*	*
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	317.4	129.1	69.5	33.2	13.1

Huse Creek Headwaters to Norway Lake AUID# 07020005-917	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **(billion organisms per day)**				
Average Daily Loading Capacity	10.0	4.0	1.8	0.9	0.4
Margin of Safety	1.0	0.4	0.2	0.09	0.04
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	*	*	*	*	*
Livestock facilities requiring NPDES permits	0	0	0	0	0

E. coli					
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	9	3.6	1.6	0.8	0.36

*None located within watershed

** See section 4.3.1 for individual WWTF permit limits

4.7.2 TSS Impaired Stream Reach Loading Capacities

Table 4.15: Loading capacities and allocations for stream reaches impaired for TSS

TSS					
Chippewa River Shakopee Creek to Cottonwood Creek AUID# 07020005-507	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	TSS (tons per day)				
Average Daily Loading Capacity	402.4	168.4	87.6	41.6	17.6
Margin of Safety	40.2	16.8	8.8	4.2	1.8
Wasteload Allocation					
Cities of Benson, Clontarf, Evansville, Farwell Kensington, Hancock, Hoffman, Kerkhoven, Lowry, Millerville, Murdock, Starbuck, Sunburg, and Urbank Wastewater Treatment Facilities*	1.4	1.4	1.4	1.4	1.4
Livestock facilities requiring NPDES permits	0	0	0	0	0
“Straight Pipe” Septic Systems	0	0	0	0	0
Chippewa Valley Ethanol Wastewater	0.01	0.01	0.01	0.01	0.01
Construction and Industrial Stormwater 2.2%	8.9	3.7	1.9	0.9	0.4
Load Allocation	351.9	146.5	75.5	35.1	14.0

* See section 4.3.1 for individual WWTF permit limits

4.7.3 Dissolved Oxygen Phosphorus Loading Capacities

Table 4.16: Loading capacities and allocations for stream reaches impaired for DO

Phosphorus (DO)	
Mud Creek County Ditch 15 to East Branch Chippewa River AUID# 07020005-554	**Pounds per Day** (P)
Average Daily Loading Capacity	26.4
Margin of Safety	2.6
Wasteload Allocation	
City of Sunburg Wastewater Treatment Facility	**
Livestock facilities requiring NPDES permits	0
"Straight Pipe" Septic Systems	0
Construction and Industrial Stormwater 2.2%	0.6
Load Allocation	23.2
Tributary to Chippewa River Unnamed creek to Chippewa River AUID# 07020005-584	**Pounds per Day** (P)
Average Daily Loading Capacity	6.5
Margin of Safety	0.7
Wasteload Allocation	
Permitted Wastewater Treatment Facilities	*
Livestock facilities requiring NPDES permits	0
"Straight Pipe" Septic Systems	0
Construction and Industrial Stormwater 2.2%	0.1
Load Allocation	5.7

*None located within watershed

** Sunburg WWTP does not (and will not) have a daily phosphorus limit. Upon reissuance of their permit the facility will have a 12 month moving total annual phosphorus limit of 43 kg/year, which is equivalent to the facility's draft Lake Pepin TMDL WLA. This limit/WLA was calculated from the permit's average wet weather design flow (0.0157 mgd) and a 2 mg/L effluent concentration assumption. Sunburg WWTF will be prohibited from discharging during the months of July and August, which has been determined to be the critical period for stream reach 07020004-554. Therefore, the facilities permit is consistent with the phosphorus requirements of the DO impairment.

4.7.4 Index of Biological Integrity TSS Stressor Loading Capacities

Table 4.17: TSS Loading capacities and allocations for IBI impaired stream reaches

IBI TSS Stressor					
Outlet Creek Lake Minnewaska to Lake Emily AUID# 07020005-523	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	TSS (tons per day)				
Average Daily Loading Capacity	23	7	2.4	1.2	0.5
Margin of Safety	2.3	0.7	0.2	0.1	0.05
Wasteload Allocation					
Cities of Lowry and Starbuck Wastewater Treatment Facilities	0.12	0.12	0.12	0.12	0.12
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Construction and Industrial Stormwater 2.2%	0.5	0.2	0.05	0.03	0.01
Load Allocation	20.1	6.0	2.0	1.0	0.3

4.7.5 Impaired Lake Loading Capacities

Table 4.18: Total phosphorus loading capacities and allocations for impaired lakes within the Chippewa River Watershed

Block 56-0079-00	**TP lbs/day**	**Danielson Slough** 61-0194-00	**TP lbs/day**
Loading Capacity	0.94	**Loading Capacity**	2.63
Margin of Safety	0.09	**Margin of Safety**	0.26
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.02	Construction and industrial stormwater	0.06
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0	"Straight pipe" septic systems	0
Load Allocation**	0.83	**Load Allocation****	2.31
Edwards 61-0106-00	**TP lbs/day**	**Gilbert** 21-0189-00	**TP lbs/day**
Loading Capacity	0.89	**Loading Capacity**	1.06
Margin of Safety	0.09	**Margin of Safety**	0.1
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial	0.02	Construction and industrial	0.02

stormwater - 1%		stormwater	
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	0.78	**Load Allocation****	0.94
Hanson 61-0080-00	**TP lbs/day**	**Hassel** 76-0086-00	**TP lbs/day**
Loading Capacity	5.35	**Loading Capacity**	5.29
Margin of Safety	0.52	**Margin of Safety**	0.52
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.11	Construction and industrial stormwater	0.12
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	4.72	**Load Allocation****	4.65
Hollerberg 76-0057-00	**TP lbs/day**	**Irgens** 61-0211-00	**TP lbs/day**
Loading Capacity	1.38	**Loading Capacity**	2.56
Margin of Safety	0.14	**Margin of Safety**	0.25
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.03	Construction and industrial stormwater	0.06
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	1.21	**Load Allocation****	2.25
Jennie 21-0323-00	**TP lbs/day**	**Johanna** 61-0006-00	**TP lbs/day**
Loading Capacity	0.37	**Loading Capacity**	4.6
Margin of Safety	0.036	**Margin of Safety**	0.46
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.01	Construction and industrial stormwater	0.1

Livestock facilities requiring NPDES permits	0		Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0		“Straight pipe” septic systems	0
Load Allocation**	0.32		**Load Allocation****	4.04
John 61-0123-00	**TP lbs/day**		**Jorgenson** 61-0164-00	**TP lbs/day**
Loading Capacity	1.74		**Loading Capacity**	0.32
Margin of Safety	0.17		**Margin of Safety**	0.03
Wasteload Allocation*			**Wasteload Allocation***	
Construction and industrial stormwater	0.04		Construction and industrial stormwater	0.01
Livestock facilities requiring NPDES permits	0		Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0		“Straight pipe” septic systems	0
Load Allocation**	1.53		**Load Allocation****	0.28
Long 21-0343-00	**TP lbs/day**	**TP lbs/year**	**Long** 75-0024-00	**TP lbs/day**
Loading Capacity	19.01	6,938.6	**Loading Capacity**	3.11
Margin of Safety	1.9	693.8	**Margin of Safety**	0.3
Wasteload Allocation*			**Wasteload Allocation***	
Construction and industrial stormwater	0.12	126.7	Construction and industrial stormwater	0.07
Livestock facilities requiring NPDES permits	0	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	0	“Straight pipe” septic systems	0
Evansville WWTP Millerville WWTP Urbank WWTP	6.17 4.19 1.3	304.2 119 66.1		
Load Allocation**	5.33	5,633.2	**Load Allocation****	2.74
Mary 61-0099-00	**TP lbs/day**		**McIver** 61-0199-00	**TP lbs/day**
Loading Capacity	0.53		**Loading Capacity**	0.78
Margin of Safety	0.05		**Margin of Safety**	0.08

Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.01	Construction and industrial stormwater	0.02
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	0.47	**Load Allocation****	0.68
Monson 76-0033-00	**TP lbs/day**	**Norway** 34-0251-02	**TP lbs/day**
Loading Capacity	0.68	**Loading Capacity**	5.01
Margin of Safety	0.07	**Margin of Safety**	0.5
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.015	Construction and industrial stormwater	0.1
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	0.6	**Load Allocation****	4.41
Rasmuson 61-0086-00	**TP lbs/day**	**Red Rock** 21-0291-00	**TP lbs/day**
Loading Capacity	0.51	**Loading Capacity**	2.22
Margin of Safety	0.05	**Margin of Safety**	0.22
Wasteload Allocation*		**Wasteload Allocation***	
Construction and industrial stormwater	0.01	Construction and industrial stormwater	0.05
Livestock facilities requiring NPDES permits	0	Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0	“Straight pipe” septic systems	0
Load Allocation**	0.45	**Load Allocation****	1.95
Simon 61-0034-00	**TP lbs/day**	**Swenoda** 61-0051-00	**TP lbs/day**
Loading Capacity	1.94	**Loading Capacity**	0.63
Margin of Safety	0.19	**Margin of Safety**	0.06

Wasteload Allocation*	
Construction and industrial stormwater	0.04
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation**	1.71
Thompson 26-0020-00	**TP lbs/day**
Loading Capacity	0.52
Margin of Safety	0.05
Wasteload Allocation*	
Construction and industrial stormwater	0.01
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation**	0.46
Wicklund 61-0204-00	**TP lbs/day**
Loading Capacity	1.41
Margin of Safety	0.14
Wasteload Allocation*	
Construction and industrial stormwater	0.03
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation**	1.24

Wasteload Allocation*	
Construction and industrial stormwater	0.01
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation**	0.56
West Norway 34-0251-01	**TP lbs/day**
Loading Capacity	10.92
Margin of Safety	1.09
Wasteload Allocation*	
Construction and industrial stormwater	0.22
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation	9.61

* No Communities Subject to MS4 NPDES requirements or Industrial process wastewater discharges located in the watershed

** Load allocations sub-divided into watershed, atmospheric load (precipitation) and internal load in Appendix B.

5 Future Growth Considerations

Potential changes in population and land use over time in the Chippewa River Watershed could result in changing sources of pollutants. Overall, there is likely very little to no anticipated future growth in the watershed. Possible changes and how they may or may not impact TMDL allocations are discussed below.

5.1 New or Expanding Permitted MS4 WLA Transfer Process

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
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 a U.S. Census Bureau 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 the allocations in this TMDL. In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

5.2 New or Expanding Wastewater (TSS and *E. coli* TMDLs only)

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 2012c). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

There are currently three unsewered communities in the Chippewa River Watershed. The MPCA has completed a report for small community wastewater needs with the goal of eliminating these sources of pollution (MPCA 2008). It is unlikely that any new communities will develop in the future. All noncompliant SSTS upgrades are being addressed through local ordinances, though some additional programs will be utilized if deemed necessary.

For more information on the overall process visit the MPCA's TMDL Policy and Guidance (MPCA 2014b) webpage.

6 Reasonable Assurance

Point sources were not identified as a primary source of *E. coli*, TSS, or TP in the Chippewa River Watershed. The permitted facilities in the watershed discharge at concentrations that meet the applicable water quality standards. No point source reductions have been identified within the Chippewa River Watershed. Point source permitting staff works closely with facilities to adjust permits as necessary for limits, adjustments in release times, and/or adjustments to when releases can occur based on current stream flow to ensure the continued compliance of the facilities with minimal disruption to current facility operations. This hands-on approach has proven successful for multiple point source reductions in Minnesota and provides reasonable assurance that any future point source reductions will be achieved.

In order for the impaired waters to meet water quality standards the majority of pollutant reductions in the Chippewa River Watershed will need to come from non-point source contributors. Of these sources, agricultural drainage and surface runoff are the dominant sources, while other non-point sources contribute a small portion of the pollutant loads. There is reasonable assurance that adopting the various practices and strategies in the required amounts will allow surface waters to meet water quality standards. However, due to the lack of existing state and federal regulations, the current federal exemptions in creating regulations, and the monetary incentives for practices that can degrade water quality, there is no guarantee that landowners will do the necessary practices and BMPs to meet these standards. Agencies, organizations, and citizens alike need to recognize that resigning waters to an impaired condition is not acceptable.

See Table 10 of the *Chippewa River WRAPS Report* (MPCA 2016) for strategies that summarize the conditions discussed in Section 3 of the WRAPS report: the pollutants/stressors of concern, the current water quality conditions for each pollutant/stressor, and the watershed-wide water quality goals and targets. This table also presents the allocations of the pollutant/stressor goals and targets to the primary sources and the estimated years to meet the goal (both developed by the WRAPS Workshop Team) and an estimate. While these model summaries indicate that wide-scale adoption of agricultural BMPs will allow waters to meet water quality standards, there is no way to guarantee that citizens and communities will voluntarily adopt the necessary practices at the necessary rate. To best assure that NPS reductions are achieved, a large emphasis has been placed on citizen engagement, where the citizens and communities that hold the power to improve water quality conditions are involved in discussions and decision-making so that local water planners organize and develop focused implementation plans on a watershed scale. Both counties and SWCDs administer and track water quality BMP implementation projects that are funded by BWSR. Areas are identified as possible BMP projects by a strategy of prioritizing and targeting geographic areas that focus on critical conditions and pathways to impaired lakes and streams. Refer to Section 9 for citizen engagement that has occurred in the Chippewa River Watershed.

In addition to citizen engagement, several government programs have been created to support a political and social infrastructure that aims to increase the adoption of strategies that will improve watershed conditions. Selection of sites for implementation of BMPs will be led by local units of government and SWCDs with guidance and support from BWSR. One example of a program is the Minnesota Agricultural Water Quality Certification Program (AWQCP), which provides regulatory security and incentives to landowners who adopt conservation practices. Additional financial programs include the Clean Water Act Section 319 grant programs, and BWSR and NRCS incentive programs. Programs and activities are also occurring at the local government level, where county staff, commissioners, and residents are beginning to come together to address water quality issues.

7 Monitoring Plan

Data from three water quality monitoring programs enables water quality condition assessment and creates a long-term data set to track progress towards water quality goals. BMPs implemented by local units of government will be tracked through BWSR's e-Link system. These programs will continue to collect and analyze data in the Chippewa River Watershed as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA 2011a). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. These monitoring programs are summarized below:

Intensive Watershed Monitoring (MPCA 2012a) data provides a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at roughly 100 stream and 50 lake monitoring stations across the watershed in 1 to 2 years, every 10 years. To measure pollutants across the watershed the MPCA will re-visit and re-assess the watershed, as well as have capacity to visit new sites in areas with BMP implementation activity. This work is scheduled to start its second iteration in the Chippewa River Watershed in 2019.

Watershed Pollutant Load Monitoring Network (MPCA 2013a) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment, and nutrient loads. In the Chippewa River Watershed, there is an annual site near the outlet of the Chippewa River and three seasonal (spring through fall) subwatershed sites.

Citizen Stream and Lake Monitoring Program (MPCA 2013b) data provide a continuous record of waterbody transparency throughout much of the watershed. This program relies on a network of private citizen volunteers who make monthly lake and river measurements annually. Approximately 43 citizen monitoring locations exist in the Chippewa River Watershed.

8 Implementation Strategy Summary

8.1 Permitted Sources

8.1.1 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

8.1.2 Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES Industrial Stormwater Permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local stormwater management requirements must also be met.

8.1.3 MS4

The MPCA oversees all regulated MS4 entities in stormwater management accounting activities. There are no MS4 permitted communities that discharge into any impaired stream Assessment Unit IDs (AUIDs) addressed in this report. For any cities that may become a MS4 in the future, the baseline year for implementation will be 2004, the mid-range year of the flow data used for development of the load duration curves. The rationale for this is that projects undertaken recently may take a few years to influence water quality. Any load-reducing BMP implemented since the baseline year will be eligible to "count" toward an MS4's load reductions. If a BMP was implemented during or just prior to the baseline year, the MPCA is open to presentation of evidence by the MS4 permit holder to demonstrate that it should be considered as a credit.

8.1.4 Wastewater

The MPCA issues permits for WWTFs that discharge into waters of the state. The permits have site specific limits that are based on water quality standards. Permits regulate discharges with the goals of 1) protecting public health and aquatic life, and 2) assuring that every facility treats wastewater. In addition, SDS Permits set limits and establish controls for land application of sewage.

8.2 Non-Permitted Sources

A group of professional water quality, planning, and conservation staff collaboratively will develop the strategies presented in the *Chippewa River WRAPS Report* (MPCA 2016). These strategies, adopted at generally wide-scale and integrated in suites, are expected to bring waters in the Chippewa River Watershed into a supporting status. Refer to the *Chippewa River WRAPS Report* (MPCA 2016) for details and adoption rates. Below is a summary of the recommended strategies, all of which cannot be credited toward WLA reductions for MS4 communities with permit requirements:

- No-till or strip till conservation tillage
- Cover crops and grassed waterways
- Perennial cover on sensitive areas
- Nutrient, manure, and animal management
- Water retention and increased evapotranspiration from the landscape (basins, wetlands, extended retention)
- Field and riparian vegetated buffers
- Drainage volume reductions by system design
- Drainage water pollutant reductions through edge-of-field treatments (bioreactors, saturated buffers, treatment wetlands)
- Citizen education and discussions
- Urban stormwater BMPs
- Changes in policy and increased funding and other support
- Protect currently higher quality areas

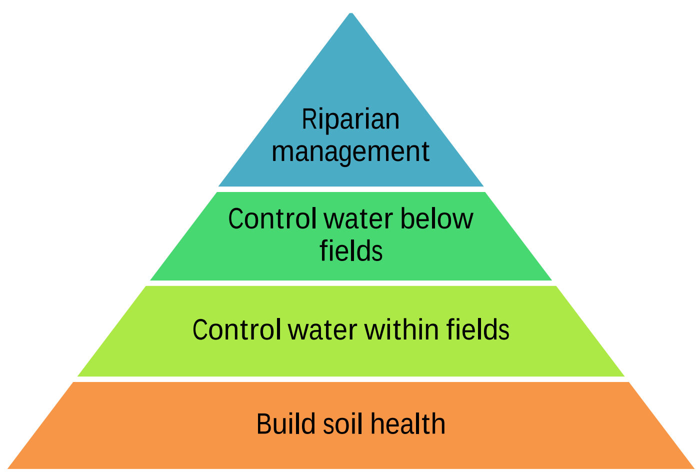

Figure 8.1 A conceptual model to address water quality impairments in agriculturally dominated watersheds

The strategies and corresponding adoption rates presented in the *Chippewa River WRAPS Report* (MPCA 2016) are intended to meet interim water quality targets. To fully address the widespread water quality impairments in agriculturally dominated watersheds such as the Chippewa River Watershed, an integrated and multi-faceted approach using suites of BMPs is likely necessary. Initial activity for lake impairments will focus on reducing external loading. Internal load controls will be identified within Section 3, Restoration, and Protection, of the *Chippewa River WRAPS Report* (MPCA 2016). Several models/methods have been developed and are very similar to Figure 8.1 and described in the reports: *Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning* (Tomer et al. 2013), the Minnesota Nutrient Reduction Strategy (MPCA 2013c), and the *"Treatment Train" approach as being demonstrated in the Elm Creek Watershed* (ENRTF 2013).

8.3 Cost

Estimating the cost of bringing waters in the Chippewa River Watershed into a supporting status is more an exercise of scale than a practical dollar estimate. Specifically, the costs are highly variable and include many assumptions. Furthermore, the costs will change as progressive practices are voluntarily adopted as the new farming standard. For these reasons, a rough estimate of cost was developed using NRCS cost-share rates, an estimated land value for crops taken out of production, and with assumptions regarding the specific items needed for a practice. This number is a representation of the scale of change that is needed more so than an actual tax-payer or individual burden. The cost also does not include ecosystem benefits, which if considered, could off-set much of the cost. The costs are based on the watershed-wide adoption rates as presented in the *Chippewa River WRAPS Report* (MPCA 2016).

The estimated cost of agricultural BMPs to meet the Chippewa River WRAPS 10-year water quality targets is roughly $230 million. The 10-year targets represent pollutant (or stressor) reductions that range from 5% to 27%. So very roughly, this number can be extrapolated by (considering the ratio of the total goal to the 10-year target) a factor of five to roughly $1.15 billion to estimate the total agricultural BMP expenditure necessary for waters to meet water quality standards. Additional costs to implement city stormwater, resident, and lake-specific BMPs are roughly estimated to total $100 million based on the scale of reductions needed from these sources.

8.4 Adaptive Management

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. The state of Minnesota has a unique opportunity to adaptively manage water resource plans and implementation activities every 10 years (Figure 8.2). This opportunity resulted from a voter-approved tax increase to improve state waters. The resulting interagency coordination effort is referred to as the Minnesota Water Quality Framework (Figure 8.3), which works to monitor and assess Minnesota's 80 major watersheds every 10 years. This Framework supports ongoing implementation and adaptive management of conservation activities and watershed-based local planning efforts.

Implementation of TMDL related activities can take many years, and water quality benefits associated with these activities can also take many years. As the pollutant source dynamics within the watershed are better understood, implementation strategies and activities will be adjusted and refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired stream reaches. The follow up water monitoring program outlined in Section 7 will be integral to the adaptive management approach, providing assurance that implementation measures are succeeding in attaining water quality standards.

Adaptive management does not include changes to water quality standards or LC. Any changes to water quality standards or LC must be preceded by appropriate administrative processes, including public notice and an opportunity for public review and comment.

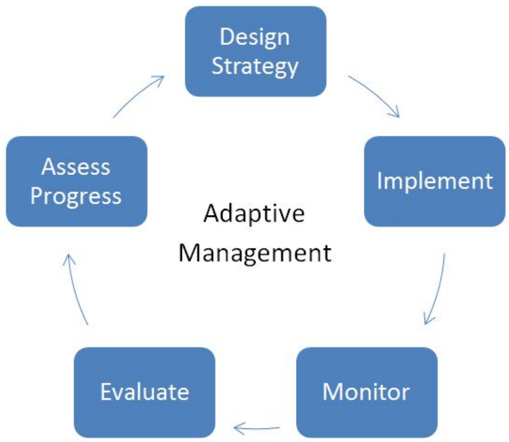

Figure 8.2: Adaptive Management

Figure 8.3: Minnesota water quaility framework

9 Public Participation

This section summarizes civic engagement/public participation efforts sponsored by the MPCA in collaboration with local partners: 1) Chippewa River Watershed Project, 2) SWCD staff, 3) NRCS staff, 4) state agencies, 5) citizen and farmer participants, and 6) county and township officials.

Chippewa River Watershed

The *Chippewa River Watershed Project* is a non-regulatory, cooperative partnership and citizen based approach focused on improving water quality and watershed life in the Chippewa River and its tributaries. The summarized recommendations of the project include:

- Buffer strips
- Wetland restoration
- Reduced tillage/increased residue
- Water and sediment retention basins
- Grassed waterways
- Shoreline stabilization with native plants
- Perennial Cover
- Alternative tile intakes
- Cover crops
- Rotational grazing

- Terraces
- Side and/or drop inlets on ditches/streams
- Septic system compliance

Public Meetings

In addition to a meeting held in April of 2013 to survey the opinions and values in a Zonation Analysis, a similar watershed survey was conducted of citizens who are interested in improving and protecting the waters within the Chippewa River Watershed. These efforts were part of a greater interactive community assessment and civic engagement effort that included one on one meetings with farmers and residents, meetings with local conservation staff and regional public meetings. The findings of these meetings and survey were:

Values that progress clean water

- Leaving a legacy for future generations
- Clean surface water for outdoor recreation
- Clean ground water for drinking
- Local pride and stewardship ethos
- Education and continual learning
- Recognition that marginal ground may be better for conservation

Values that hinder clean water

- Fear of unknown/resistance to change
- Financial risk avoidance
- High agricultural productivity/yield
- Lack of ownership/responsibility for problem
- Lack of understanding/trust in government

Constraints to higher BMP adoption

- Policies (Farm Bill), rules, and funding that perpetuate status quo
- BMP practices may not be flexible enough to fit into residents' system
- Inability to guarantee income when making changes
- Unwillingness to break from status quo/differ from those one trusts
- Lack of knowledge of problems and solutions
- Ineffective/conflicting communication/messaging

Opportunities to get higher BMP adoption

- BMPs need to work for the adopters and meet their needs beyond conservation

- Policies (e.g. Farm Bill) need to facilitate change, flexibility, and less bureaucracy
- Funding for more practices and to prevent income loss when transitioning farms to sustainable practices
- Developing/identifying water friendly practices that also increase farm profitability
- Funding needs to be flexible so that BMPs can be adapted to local conditions
- Identify and foster early sustainable farming BMP adopters to be leaders to community
- More/better education on sustainable practices, technologies, benefits, and progress
- Build trust to perpetuate cooperation and stewardship

Recommendations for Engagement, Education, and Networking

- Peer-leader and peer-to-peer networking events such as fields days and one on one engagement
- Collaboration with and education/information sharing with Ag professionals: co-ops, crop consultants, etc.
- Community events/gatherings including clean-ups, banquets, citizen groups, school education
- Increased messaging and education including advertisements, social media, billboards, documentaries

Public Notice

This TMDL report will be published for public comments on ________.

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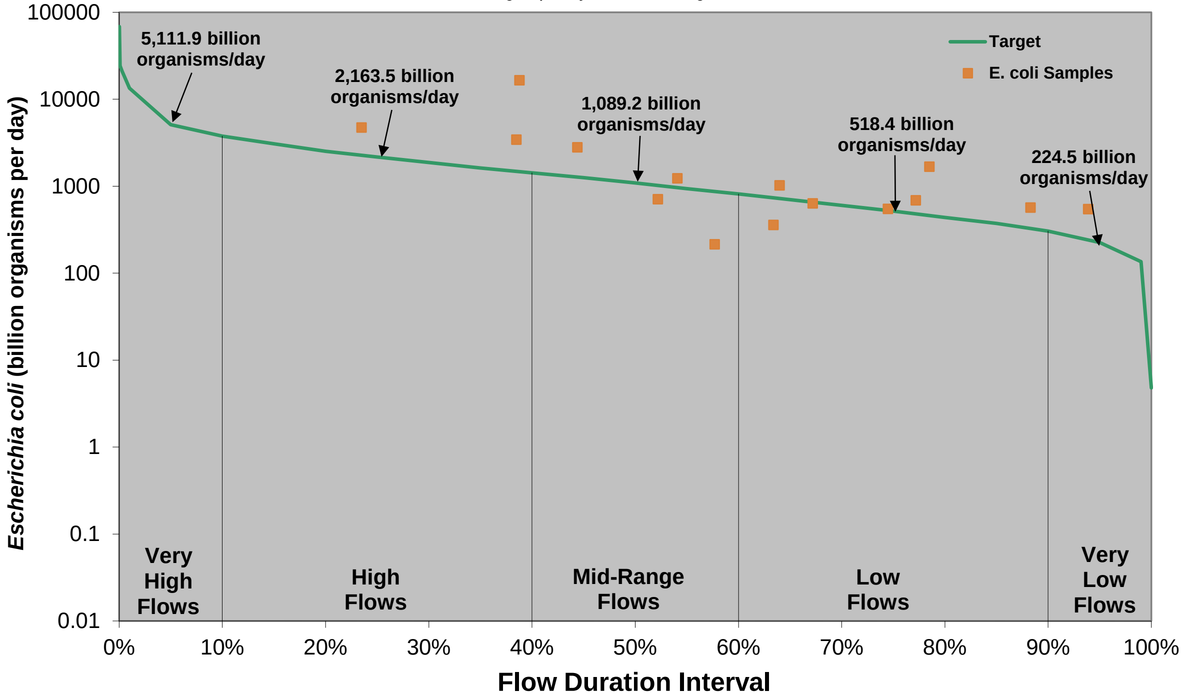
Appendix A: Load duration curves for stream reach impairments

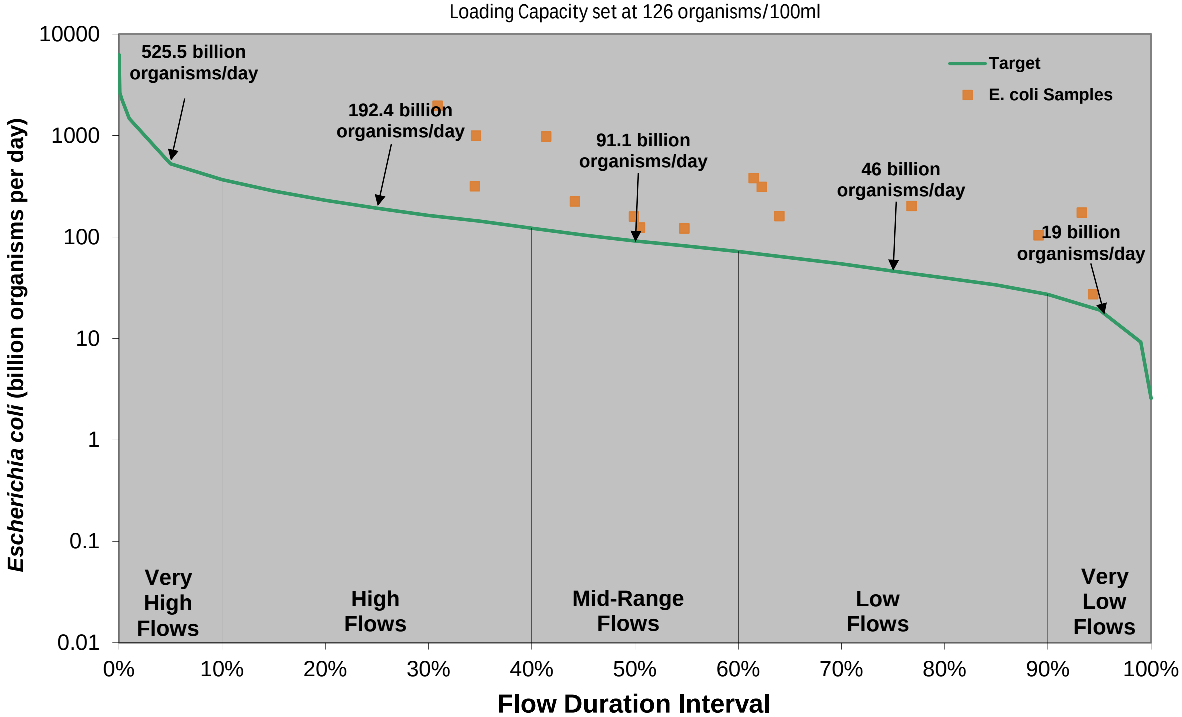
Chippewa River AUID# 07020005-506

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2009-2010 *E. coli* samples from EQuIS monitoring station S000-383
Loading Capacity set at 126 organisms/100ml



Cottonwood Creek AUID# 07020005-511

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2009-2010 *E. coli* samples from EQuIS monitoring station S002-202
Loading Capacity set at 126 organisms/100ml



East Branch Chippewa River AUID# 07020005-515

1996-2012 Modeled Flows from Chippewa River HSPF model using April-October Average Daily Flows
2009-2010 *E. coli* samples from EQuIS monitoring station S005-861
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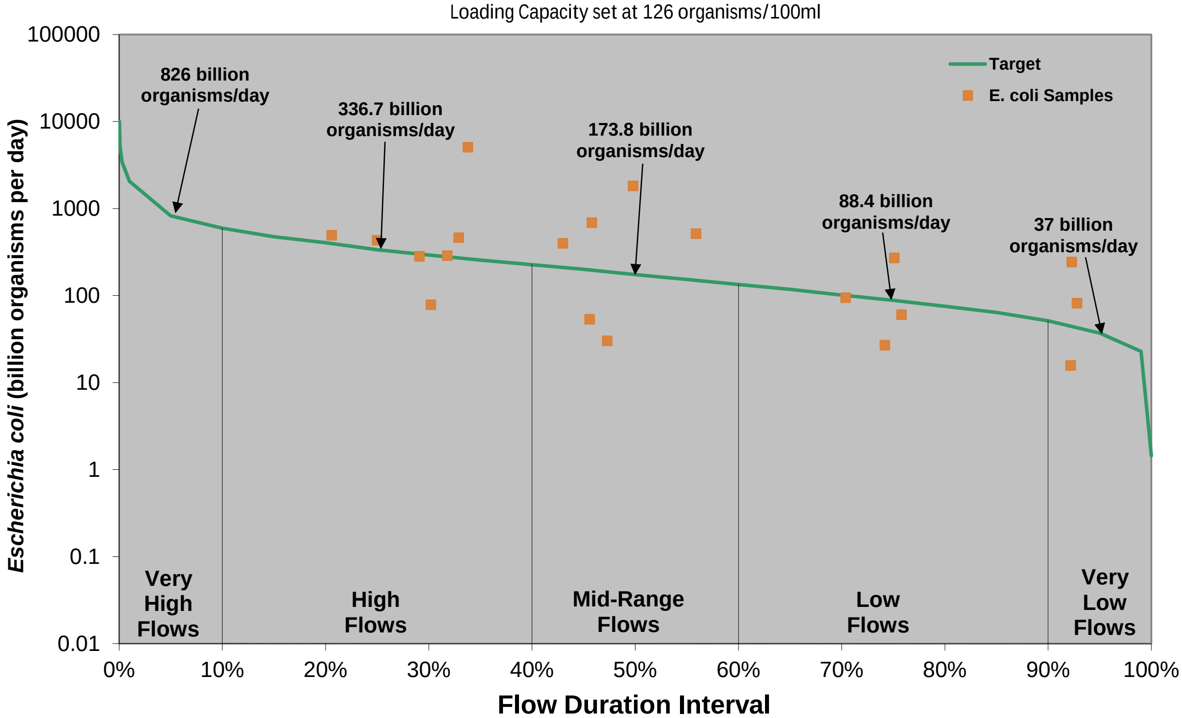

Mud Creek AUID# 07020005-518

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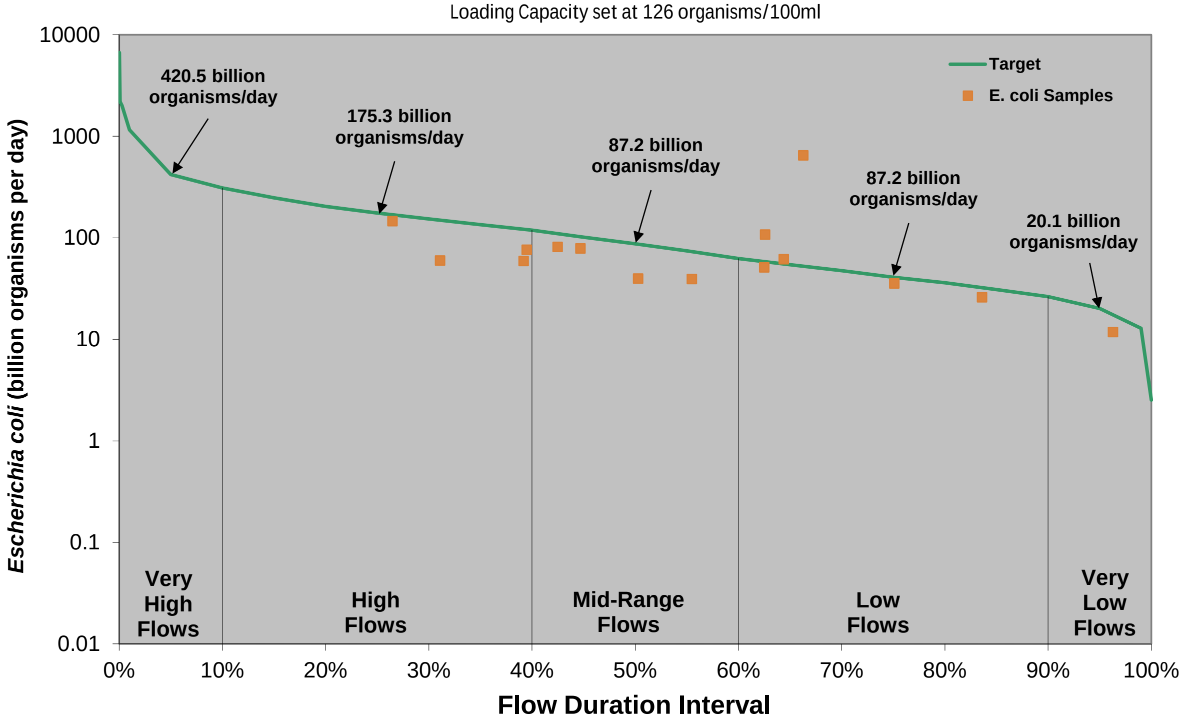
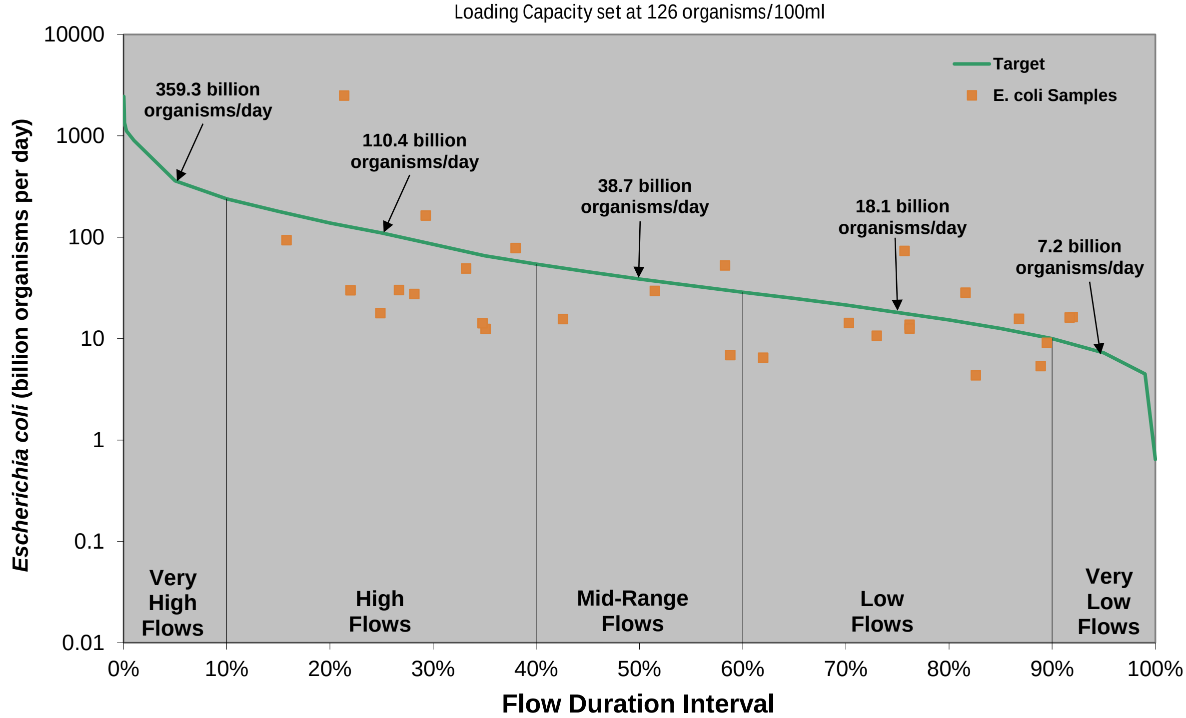
2009-2010 *E. coli* samples from EQuIS monitoring station S002-195
Loading Capacity set at 126 organisms/100ml



Outlet Creek AUID# 07020005-523

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2007-2009 *E. coli* samples from EQuIS monitoring station S000-898
Loading Capacity set at 126 organisms/100ml



Mud Creek AUID# 07020005-554

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
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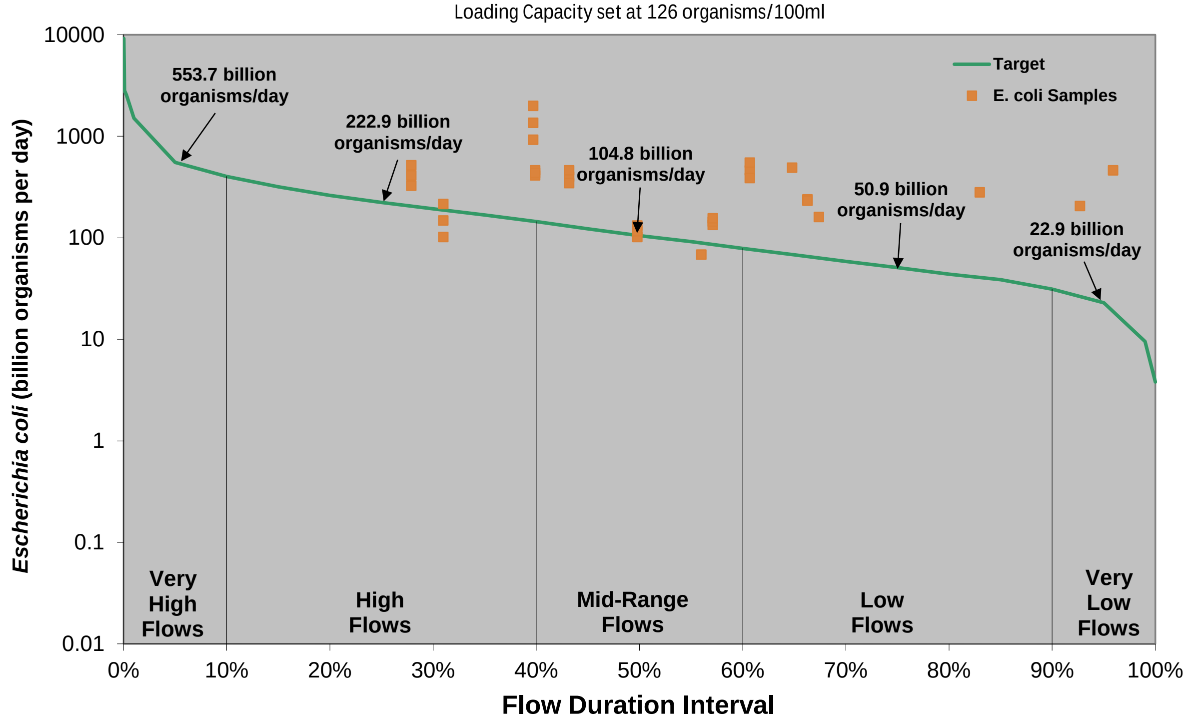

Shakopee Creek AUID# 07020005-557

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2008-2010 *E. coli* samples from EQuIS monitoring stations S005-374, S002-550
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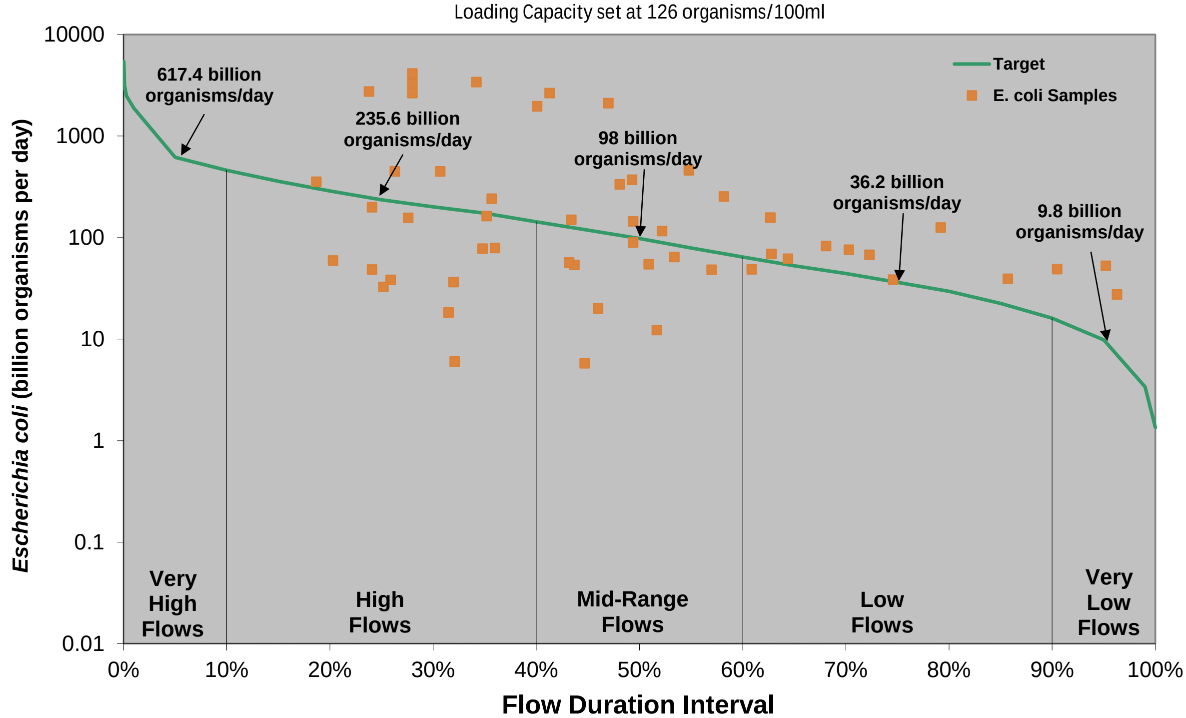
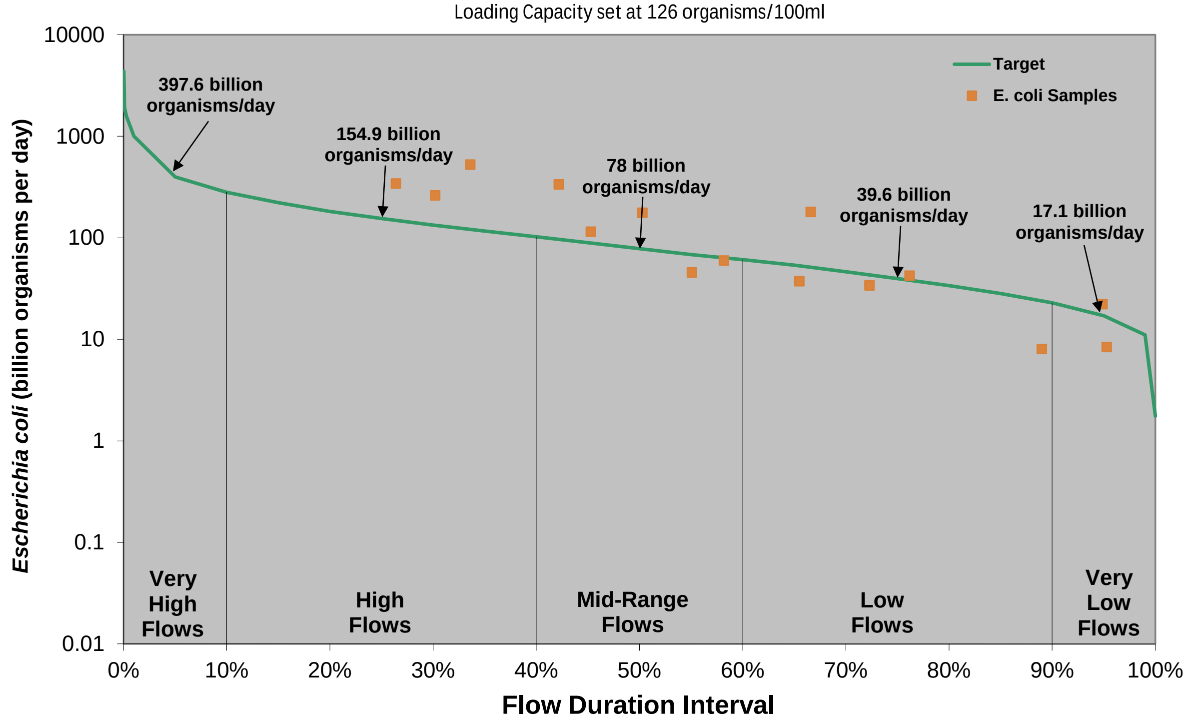


County Ditch 3 AUID# 07020005-579

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2009-2010 *E. coli* samples from EQuIS monitoring station S003-507
Loading Capacity set at 126 organisms/100ml



Tributary to Chippewa River AUID# 07020005-584

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
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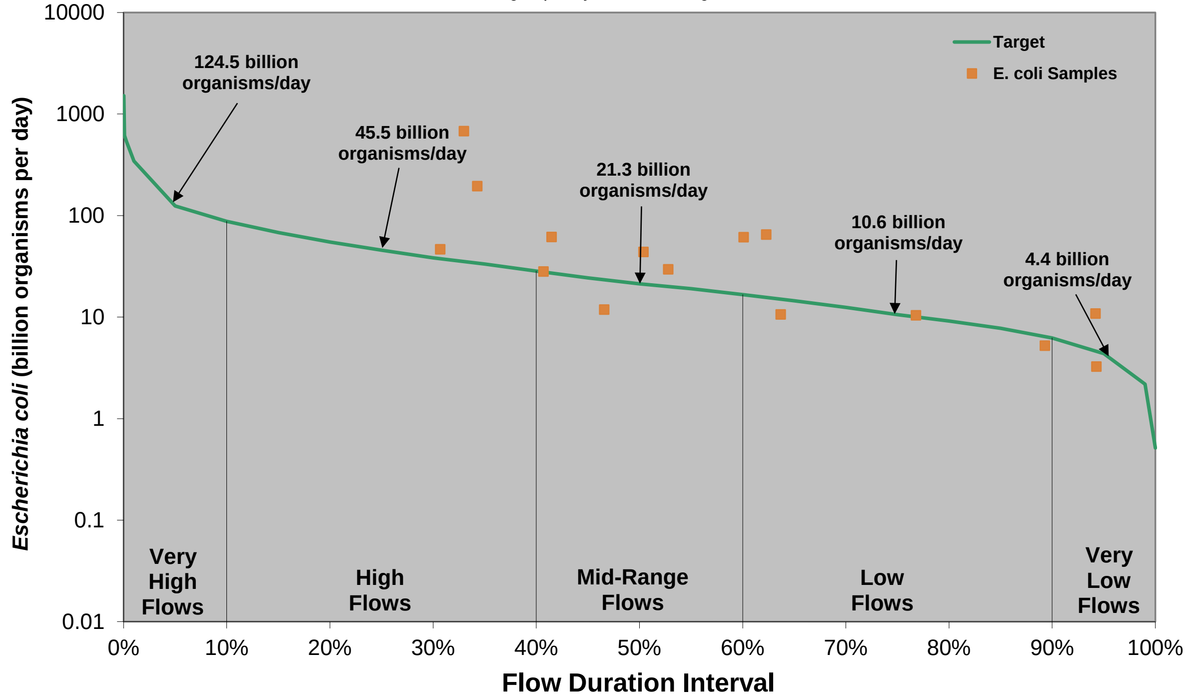

Trappers Run Creek AUID# 07020005-628

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
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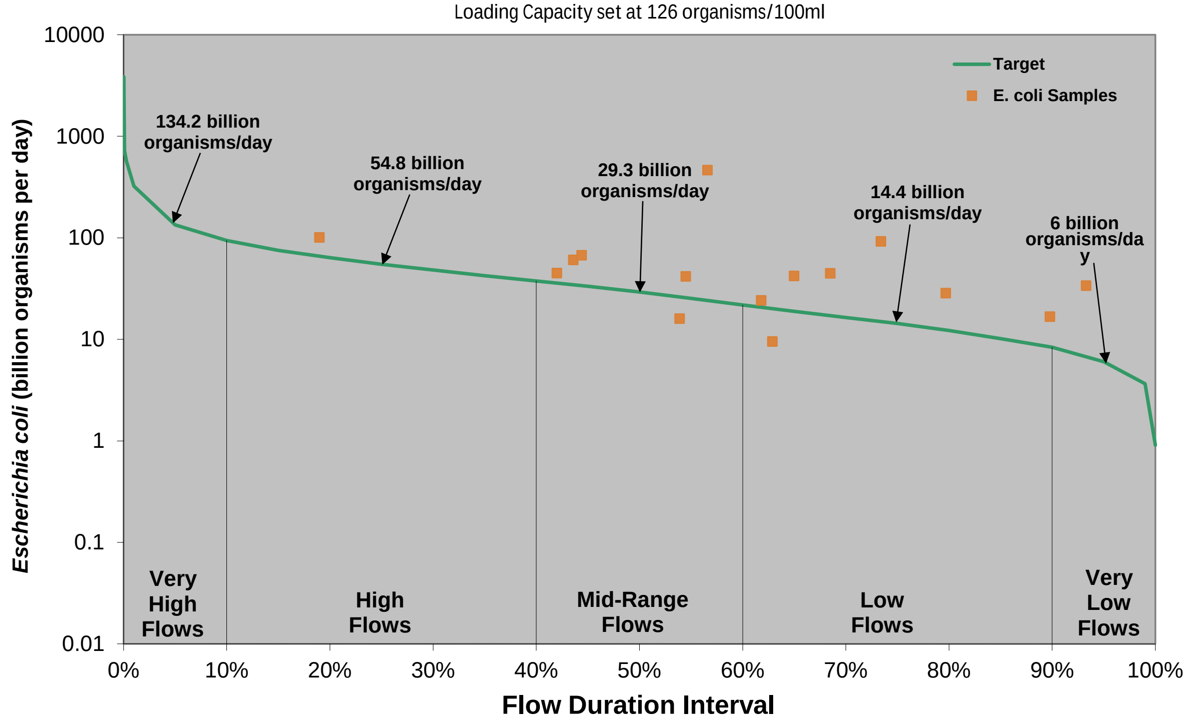
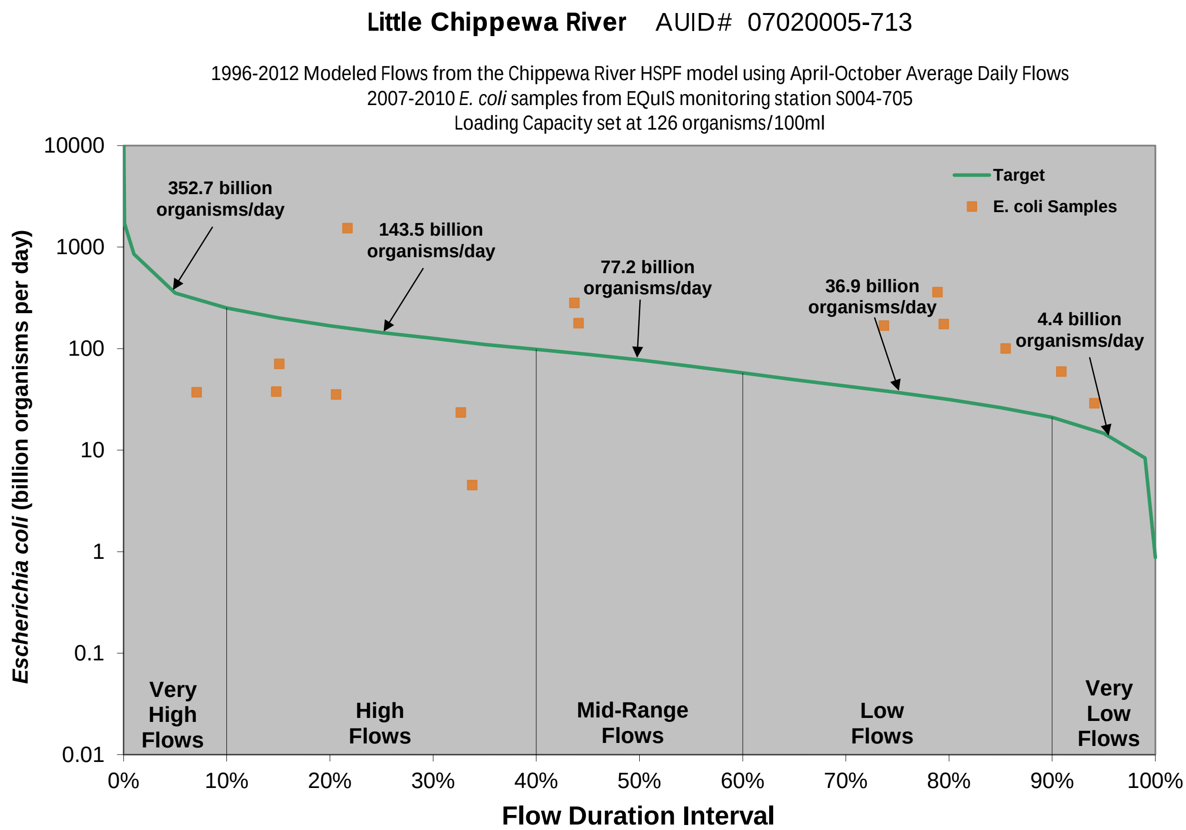
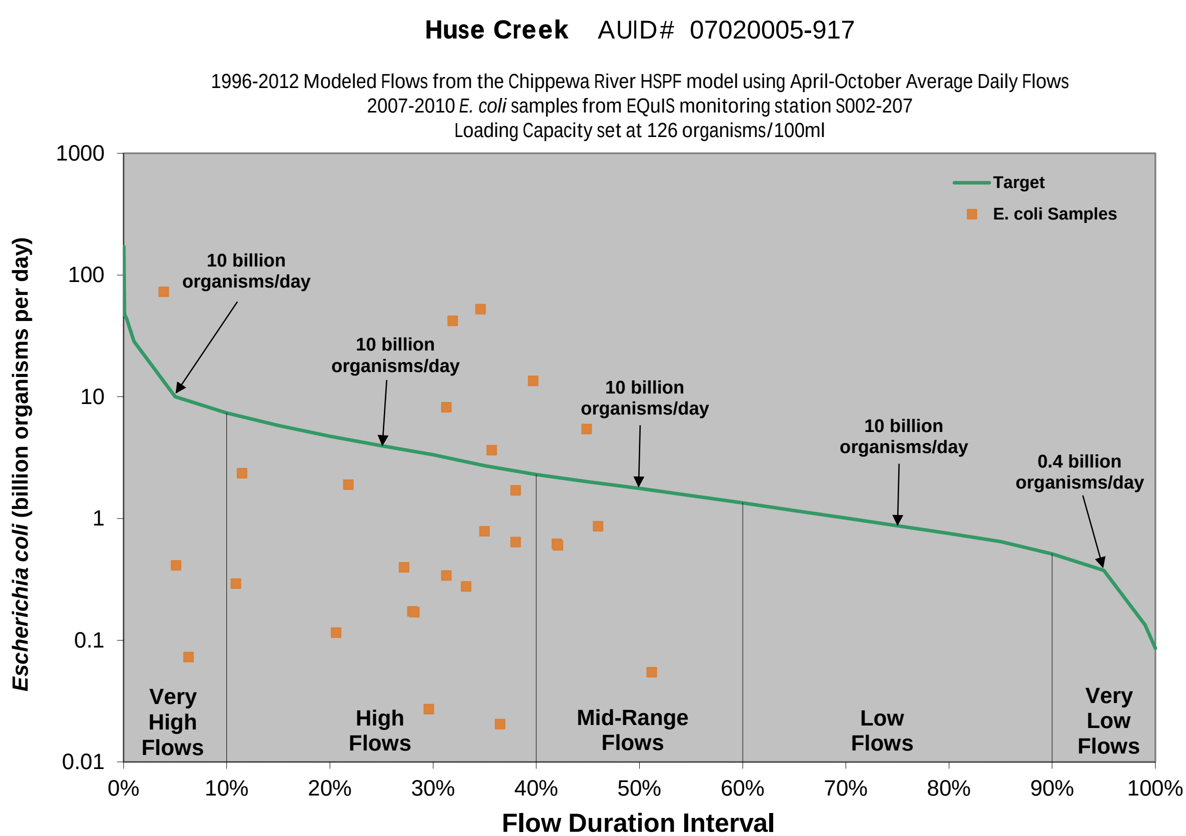
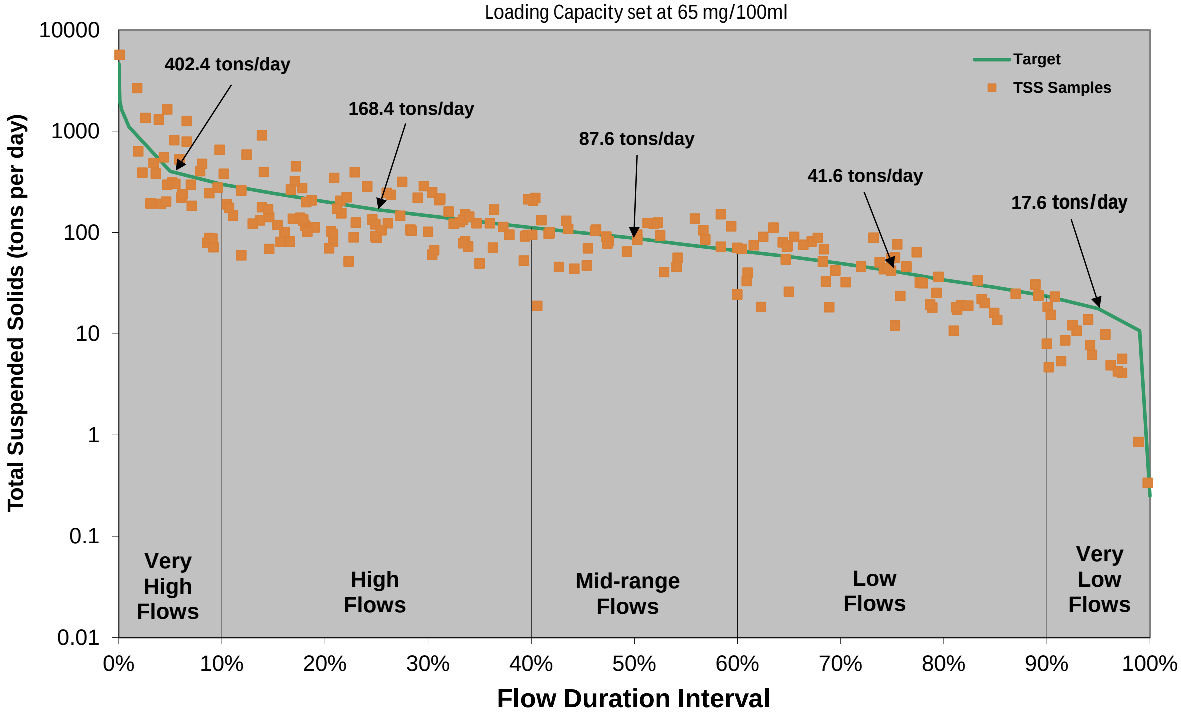



Little Chippewa River AUID# 07020005-713
1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2007-2010 E. coli samples from EQuIS monitoring station S004-705
Loading Capacity set at 126 organisms/100ml
Target
E. coli Samples
352.7 billion organisms/day
143.5 billion organisms/day
77.2 billion organisms/day
36.9 billion organisms/day
4.4 billion organisms/day
Very High Flows
High Flows
Mid-Range Flows
Low Flows
Very Low Flows
Escherichia coli (billion organisms per day)
Flow Duration Interval
10000
1000
100
10
1
0.1
0.01
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Huse Creek AUID# 07020005-917
1996-2012 Modeled Flows from the Chippewa River HSPF model using April-October Average Daily Flows
2007-2010 E. coli samples from EQuIS monitoring station S002-207
Loading Capacity set at 126 organisms/100ml
Target
E. coli Samples
10 billion organisms/day
10 billion organisms/day
10 billion organisms/day
10 billion organisms/day
0.4 billion organisms/day
Very High Flows
High Flows
Mid-Range Flows
Low Flows
Very Low Flows
Escherichia coli (billion organisms per day)
Flow Duration Interval
1000
100
10
1
0.1
0.01
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

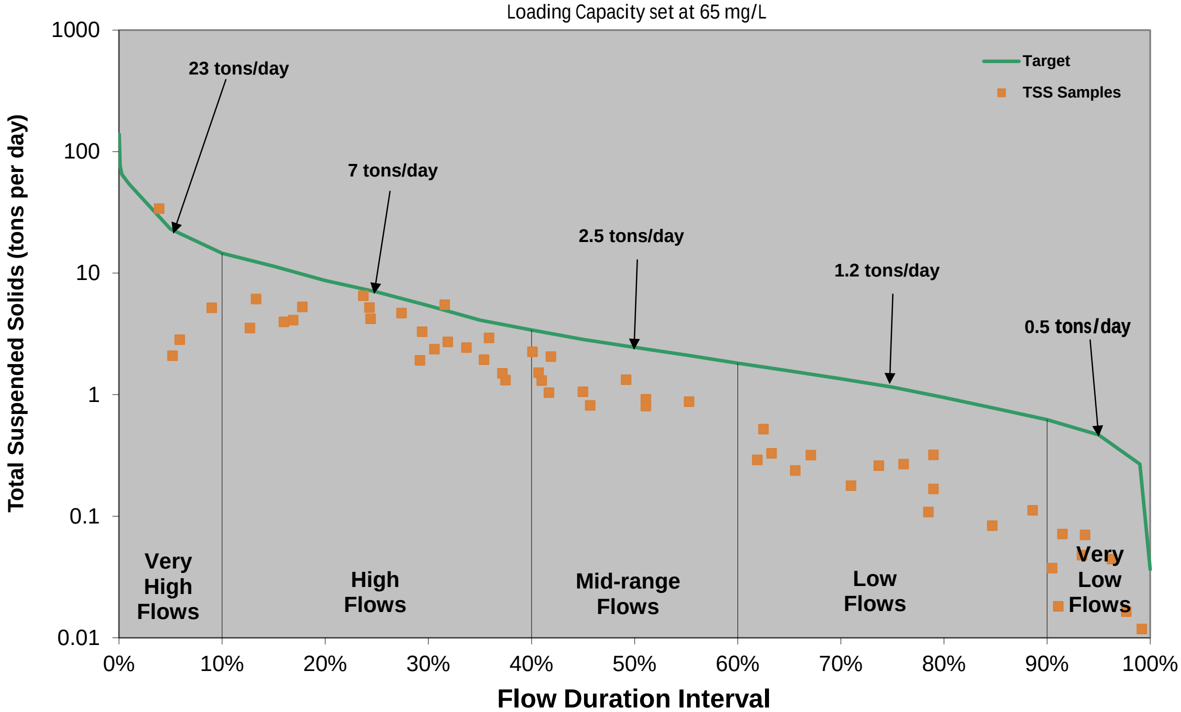
Chippewa River AUID# 07020004-507

1996-2012 Modeled Flows from the Hawk Creek HSPF model using April-September Average Daily Flows
2002-2011 TSS samples from EQuIS monitoring station S002-203
Loading Capacity set at 65 mg/100ml



Outlet Creek AUID# 07020005-523

1996-2012 Modeled Flows from the Chippewa River HSPF model using April-September Average Daily Flows
2007-2009 TSS samples from EQuIS monitoring stations S000-898; 09MN065; 09MN077
Loading Capacity set at 65 mg/L



Appendix B: BATHTUB outputs for lake models

Block Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Block Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				1.2	0.7	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				1.2	1.4	0.00E+00	0.00	1.21
ADVECTIVE OUTFLOW				1.2	0.1	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				1.2	0.1	0.00E+00	0.00	0.12
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	SSTS	0.0	0.0%	0.00E+00		0.00	4.3	
2	2	1	Block Lake Shed	120.6	22.3%	0.00E+00		0.00	168.9	
PRECIPITATION				35.1	6.5%	3.08E+02	100.0%	0.50	50.6	30.0
INTERNAL LOAD				384.6	71.2%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.0	0.0%	0.00E+00		0.00	4.3	
NONPOINT INFLOW				120.6	22.3%	0.00E+00		0.00	168.9	
***TOTAL INFLOW				540.4	100.0%	3.08E+02	100.0%	0.03	381.1	461.9
ADVECTIVE OUTFLOW				11.5	2.1%	2.41E+01		0.43	80.3	9.8
***TOTAL OUTFLOW				11.5	2.1%	2.41E+01		0.43	80.3	9.8
***RETENTION				528.9	97.9%	3.25E+02		0.03		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.6785
Hydraulic Resid. Time (yrs)	31.9740	Turnover Ratio	1.5
Reservoir Conc (mg/m3)	80	Retention Coef.	0.979

Block Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance					Averaging Period =		1.00	years
				Area	Flow	Variance	CV	Runoff
Trb	Type	Seg	Name	km^2	hm^3/yr	$(hm3/yr)^2$	-	m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Block Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				1.2	0.7	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				1.2	1.4	0.00E+00	0.00	1.21
ADVECTIVE OUTFLOW				1.2	0.1	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				1.2	0.1	0.00E+00	0.00	0.12
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon				Predicted		Outflow & Reservoir Concentrations				
Component:				TOTAL P						
				Load		Load Variance			Conc	Export
Trb	Type	Seg	Name	kg/yr	%Total	$(kg/yr)^2$	%Total	CV	mg/m^3	$kg/km^2/yr$
2	2	1	Block Lake Shed	86.1	55.3%	0.00E+00		0.00	120.5	
PRECIPITATION				35.1	22.5%	3.08E+02	100.0%	0.50	50.6	30.0
INTERNAL LOAD				34.6	22.2%	0.00E+00		0.00		
NONPOINT INFLOW				86.1	55.3%	0.00E+00		0.00	120.5	
***TOTAL INFLOW				155.8	100.0%	3.08E+02	100.0%	0.11	109.9	133.2
ADVECTIVE OUTFLOW				5.7	3.7%	6.00E+00		0.43	40.3	4.9
***TOTAL OUTFLOW				5.7	3.7%	6.00E+00		0.43	40.3	4.9
***RETENTION				150.0	96.3%	3.01E+02		0.12		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	1.1801
Hydraulic Resid. Time (yrs)	31.9740	Turnover Ratio	0.8
Reservoir Conc (mg/m3)	40	Retention Coef.	0.963

Danielson Slough Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Danielson Lake Shed		2.5	0.00E+00	0.00	
PRECIPITATION				0.6	0.1	0.00E+00	0.00	0.24
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.5	0.00E+00	0.00	
***TOTAL INFLOW				0.6	2.7	0.00E+00	0.00	4.61
ADVECTIVE OUTFLOW				0.6	2.4	0.00E+00	0.00	4.17
***TOTAL OUTFLOW				0.6	2.4	0.00E+00	0.00	4.17
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	0.8	0.1%	0.00E+00		0.00	78.0	
2	2	1	Danielson Lake Shed	882.4	98.0%	0.00E+00		0.00	352.5	
PRECIPITATION				17.3	1.9%	7.44E+01	100.0%	0.50	125.0	30.0
TRIBUTARY INFLOW				0.8	0.1%	0.00E+00		0.00	78.0	
NONPOINT INFLOW				882.4	98.0%	0.00E+00		0.00	352.5	
***TOTAL INFLOW				900.4	100.0%	7.44E+01	100.0%	0.01	339.6	1566.0
ADVECTIVE OUTFLOW				374.2	41.6%	9.36E+03		0.26	156.1	650.9
***TOTAL OUTFLOW				374.2	41.6%	9.36E+03		0.26	156.1	650.9
***RETENTION				526.2	58.4%	9.39E+03		0.18		

Overflow Rate (m/yr)	4.2	Nutrient Resid. Time (yrs)	0.1495
Hydraulic Resid. Time (yrs)	0.3597	Turnover Ratio	6.7
Reservoir Conc (mg/m3)	156	Retention Coef.	0.584

Danielson Slough Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Danielson Lake Shed		2.5	0.00E+00	0.00	
PRECIPITATION				0.6	0.1	0.00E+00	0.00	0.24
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.5	0.00E+00	0.00	
***TOTAL INFLOW				0.6	2.7	0.00E+00	0.00	4.61
ADVECTIVE OUTFLOW				0.6	2.4	0.00E+00	0.00	4.17
***TOTAL OUTFLOW				0.6	2.4	0.00E+00	0.00	4.17
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Danielson Lake Shed	418.0	96.0%	0.00E+00		0.00	167.0	
PRECIPITATION				17.3	4.0%	7.44E+01	100.0%	0.50	125.0	30.0
NONPOINT INFLOW				418.0	96.0%	0.00E+00		0.00	167.0	
***TOTAL INFLOW				435.2	100.0%	7.44E+01	100.0%	0.02	164.2	756.9
ADVECTIVE OUTFLOW				216.8	49.8%	2.34E+03		0.22	90.4	377.0
***TOTAL OUTFLOW				216.8	49.8%	2.34E+03		0.22	90.4	377.0
***RETENTION				218.5	50.2%	2.36E+03		0.22		

Overflow Rate (m/yr)	4.2	Nutrient Resid. Time (yrs)	0.1791
Hydraulic Resid. Time (yrs)	0.3597	Turnover Ratio	5.6
Reservoir Conc (mg/m3)	90	Retention Coef.	0.502

Edwards Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Edwards Lake Shed		2.1	0.00E+00	0.00	
PRECIPITATION				0.7	0.4	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.1	0.00E+00	0.00	
***TOTAL INFLOW				0.7	2.5	0.00E+00	0.00	3.70
ADVECTIVE OUTFLOW				0.7	1.8	0.00E+00	0.00	2.66
***TOTAL OUTFLOW				0.7	1.8	0.00E+00	0.00	2.66
***EVAPORATION					0.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.5	0.1%	0.00E+00		0.00	54.2	
2	2	1	Edwards Lake Shed	343.9	64.2%	0.00E+00		0.00	166.3	
PRECIPITATION				20.0	3.7%	1.00E+02	100.0%	0.50	50.8	30.0
INTERNAL LOAD				170.8	31.9%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.5	0.1%	0.00E+00		0.00	54.2	
NONPOINT INFLOW				343.9	64.2%	0.00E+00		0.00	166.3	
***TOTAL INFLOW				535.3	100.0%	1.00E+02	100.0%	0.02	216.4	801.3
ADVECTIVE OUTFLOW				389.1	72.7%	2.30E+03		0.12	218.8	582.5
***TOTAL OUTFLOW				389.1	72.7%	2.30E+03		0.12	218.8	582.5
***RETENTION				146.1	27.3%	2.26E+03		0.33		

Overflow Rate (m/yr)	2.7	Nutrient Resid. Time (yrs)	0.2730
Hydraulic Resid. Time (yrs)	0.3756	Turnover Ratio	3.7
Reservoir Conc (mg/m3)	219	Retention Coef.	0.273

Edwards Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Edwards Lake Shed		2.1	0.00E+00	0.00	
PRECIPITATION				0.7	0.4	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.1	0.00E+00	0.00	
***TOTAL INFLOW				0.7	2.5	0.00E+00	0.00	3.70
ADVECTIVE OUTFLOW				0.7	1.8	0.00E+00	0.00	2.66
***TOTAL OUTFLOW				0.7	1.8	0.00E+00	0.00	2.66
***EVAPORATION					0.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	Load Variance %Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Edwards Lake Shed	127.3	86.4%	0.00E+00		0.00	61.5	
PRECIPITATION				20.0	13.6%	1.00E+02	100.0%	0.50	50.8	30.0
NONPOINT INFLOW				127.3	86.4%	0.00E+00		0.00	61.5	
***TOTAL INFLOW				147.3	100.0%	1.00E+02	100.0%	0.07	59.6	220.6
ADVECTIVE OUTFLOW				107.1	72.7%	2.23E+02		0.14	60.2	160.4
***TOTAL OUTFLOW				107.1	72.7%	2.23E+02		0.14	60.2	160.4
***RETENTION				40.2	27.3%	1.78E+02		0.33		

Overflow Rate (m/yr)	2.7	Nutrient Resid. Time (yrs)	0.2730
Hydraulic Resid. Time (yrs)	0.3756	Turnover Ratio	3.7
Reservoir Conc (mg/m3)	60	Retention Coef.	0.273

Gilbert Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Gilbert Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				0.8	1.2	0.00E+00	0.00	1.47
ADVECTIVE OUTFLOW				0.8	0.3	0.00E+00	0.00	0.38
***TOTAL OUTFLOW				0.8	0.3	0.00E+00	0.00	0.38
***EVAPORATION					0.9	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	SSTS	0.2	0.1%	0.00E+00		0.00	18.6	
2	2	1	Gilbert Lake Shed	231.1	90.3%	0.00E+00		0.00	326.4	
PRECIPITATION				24.5	9.6%	1.50E+02	100.0%	0.50	50.6	30.0
TRIBUTARY INFLOW				0.2	0.1%	0.00E+00		0.00	18.6	
NONPOINT INFLOW				231.1	90.3%	0.00E+00		0.00	326.4	
***TOTAL INFLOW				255.8	100.0%	1.50E+02	100.0%	0.05	212.7	313.2
ADVECTIVE OUTFLOW				22.5	8.8%	8.10E+01		0.40	72.4	27.5
***TOTAL OUTFLOW				22.5	8.8%	8.10E+01		0.40	72.4	27.5
***RETENTION				233.4	91.2%	2.18E+02		0.06		

Overflow Rate (m/yr)	0.4	Nutrient Resid. Time (yrs)	0.4163
Hydraulic Resid. Time (yrs)	4.7378	Turnover Ratio	2.4
Reservoir Conc (mg/m3)	72	Retention Coef.	0.912

Gilbert Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Gilbert Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.59
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				0.8	1.2	0.00E+00	0.00	1.47
ADVECTIVE OUTFLOW				0.8	0.3	0.00E+00	0.00	0.38
***TOTAL OUTFLOW				0.8	0.3	0.00E+00	0.00	0.38
***EVAPORATION					0.9	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Gilbert Lake Shed	151.0	86.0%	0.00E+00		0.00	213.3	
PRECIPITATION				24.5	14.0%	1.50E+02	100.0%	0.50	50.6	30.0
NONPOINT INFLOW				151.0	86.0%	0.00E+00		0.00	213.3	
***TOTAL INFLOW				175.6	100.0%	1.50E+02	100.0%	0.07	146.0	214.9
ADVECTIVE OUTFLOW				18.6	10.6%	5.35E+01		0.39	59.9	22.8
***TOTAL OUTFLOW				18.6	10.6%	5.35E+01		0.39	59.9	22.8
***RETENTION				157.0	89.4%	1.88E+02		0.09		

Overflow Rate (m/yr)	0.4	Nutrient Resid. Time (yrs)	0.5018
Hydraulic Resid. Time (yrs)	4.7378	Turnover Ratio	2.0
Reservoir Conc (mg/m3)	60	Retention Coef.	0.894

Hanson Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hanson Lake Shed		11.9	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.62
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					11.9	0.00E+00	0.00	
***TOTAL INFLOW				0.8	12.4	0.00E+00	0.00	16.29
ADVECTIVE OUTFLOW				0.8	11.5	0.00E+00	0.00	15.20
***TOTAL OUTFLOW				0.8	11.5	0.00E+00	0.00	15.20
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	3.2	0.2%	0.00E+00		0.00	316.2	
2	2	1	Hanson Lake Shed	1956.2	98.7%	0.00E+00		0.00	164.4	
PRECIPITATION				22.8	1.2%	1.30E+02	100.0%	0.50	48.5	30.0
TRIBUTARY INFLOW				3.2	0.2%	0.00E+00		0.00	316.2	
NONPOINT INFLOW				1956.2	98.7%	0.00E+00		0.00	164.4	
***TOTAL INFLOW				1982.1	100.0%	1.30E+02	100.0%	0.01	160.1	2608.1
ADVECTIVE OUTFLOW				1424.7	71.9%	3.20E+04		0.13	123.4	1874.6
***TOTAL OUTFLOW				1424.7	71.9%	3.20E+04		0.13	123.4	1874.6
***RETENTION				557.4	28.1%	3.20E+04		0.32		

Overflow Rate (m/yr)	15.2	Nutrient Resid. Time (yrs)	0.0473
Hydraulic Resid. Time (yrs)	0.0658	Turnover Ratio	21.1
Reservoir Conc (mg/m3)	123	Retention Coef.	0.281

Hanson Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hanson Lake Shed		11.9	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.62
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					11.9	0.00E+00	0.00	
***TOTAL INFLOW				0.8	12.4	0.00E+00	0.00	16.29
ADVECTIVE OUTFLOW				0.8	11.5	0.00E+00	0.00	15.20
***TOTAL OUTFLOW				0.8	11.5	0.00E+00	0.00	15.20
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
2	2	1	Hanson Lake Shed	863.0	97.4%	0.00E+00		0.00	72.5	
PRECIPITATION				22.8	2.6%	1.30E+02	100.0%	0.50	48.5	30.0
NONPOINT INFLOW				863.0	97.4%	0.00E+00		0.00	72.5	
***TOTAL INFLOW				885.8	100.0%	1.30E+02	100.0%	0.01	71.6	1165.5
ADVECTIVE OUTFLOW				697.2	78.7%	4.47E+03		0.10	60.4	917.3
***TOTAL OUTFLOW				697.2	78.7%	4.47E+03		0.10	60.4	917.3
***RETENTION				188.6	21.3%	4.42E+03		0.35		

Overflow Rate (m/yr)	15.2	Nutrient Resid. Time (yrs)	0.0518
Hydraulic Resid. Time (yrs)	0.0658	Turnover Ratio	19.3
Reservoir Conc (mg/m3)	60	Retention Coef.	0.213

Hassel Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hassel Lake Shed		11.0	0.00E+00	0.00	
PRECIPITATION				2.9	1.5	0.00E+00	0.00	0.53
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					11.0	0.00E+00	0.00	
***TOTAL INFLOW				2.9	12.5	0.00E+00	0.00	4.37
ADVECTIVE OUTFLOW				2.9	9.8	0.00E+00	0.00	3.43
***TOTAL OUTFLOW				2.9	9.8	0.00E+00	0.00	3.43
***EVAPORATION					2.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	3.0	0.1%	0.00E+00		0.00	303.5	
2	2	1	Hassel Lake Shed	1818.7	48.0%	0.00E+00		0.00	165.8	
PRECIPITATION				85.8	2.3%	1.84E+03	100.0%	0.50	56.2	30.0
INTERNAL LOAD				1880.3	49.6%	0.00E+00		0.00		
TRIBUTARY INFLOW				3.0	0.1%	0.00E+00		0.00	303.5	
NONPOINT INFLOW				1818.7	48.0%	0.00E+00		0.00	165.8	
***TOTAL INFLOW				3787.9	100.0%	1.84E+03	100.0%	0.01	302.8	1324.4
ADVECTIVE OUTFLOW				1929.2	50.9%	1.77E+05		0.22	196.6	674.5
***TOTAL OUTFLOW				1929.2	50.9%	1.77E+05		0.22	196.6	674.5
***RETENTION				1858.7	49.1%	1.77E+05		0.23		

Overflow Rate (m/yr)	3.4	Nutrient Resid. Time (yrs)	0.0891
Hydraulic Resid. Time (yrs)	0.1749	Turnover Ratio	11.2
Reservoir Conc (mg/m3)	197	Retention Coef.	0.491

Hassel Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hassel Lake Shed		11.0	0.00E+00	0.00	
PRECIPITATION				2.9	1.5	0.00E+00	0.00	0.53
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					11.0	0.00E+00	0.00	
***TOTAL INFLOW				2.9	12.5	0.00E+00	0.00	4.37
ADVECTIVE OUTFLOW				2.9	9.8	0.00E+00	0.00	3.43
***TOTAL OUTFLOW				2.9	9.8	0.00E+00	0.00	3.43
***EVAPORATION					2.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Hassel Lake Shed	789.6	90.2%	0.00E+00		0.00	72.0	
PRECIPITATION				85.8	9.8%	1.84E+03	100.0%	0.50	56.2	30.0
NONPOINT INFLOW				789.6	90.2%	0.00E+00		0.00	72.0	
***TOTAL INFLOW				875.4	100.0%	1.84E+03	100.0%	0.05	70.0	306.1
ADVECTIVE OUTFLOW				586.5	67.0%	8.03E+03		0.15	59.8	205.1
***TOTAL OUTFLOW				586.5	67.0%	8.03E+03		0.15	59.8	205.1
***RETENTION				288.9	33.0%	7.78E+03		0.31		

Overflow Rate (m/yr)	3.4	Nutrient Resid. Time (yrs)	0.1172
Hydraulic Resid. Time (yrs)	0.1749	Turnover Ratio	8.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.330

Hollerberg Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hollerberg Lake Shed		1.4	0.00E+00	0.00	
PRECIPITATION				1.0	0.6	0.00E+00	0.00	0.54
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.4	0.00E+00	0.00	
***TOTAL INFLOW				1.0	2.0	0.00E+00	0.00	1.89
ADVECTIVE OUTFLOW				1.0	1.0	0.00E+00	0.00	0.93
***TOTAL OUTFLOW				1.0	1.0	0.00E+00	0.00	0.93
***EVAPORATION					1.0	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.4	0.1%	0.00E+00		0.00	44.1	
2	2	1	Hollerberg Lake Shed	445.5	93.3%	0.00E+00		0.00	316.7	
PRECIPITATION				31.5	6.6%	2.48E+02	100.0%	0.50	56.0	30.0
TRIBUTARY INFLOW				0.4	0.1%	0.00E+00		0.00	44.1	
NONPOINT INFLOW				445.5	93.3%	0.00E+00		0.00	316.7	
***TOTAL INFLOW				477.5	100.0%	2.48E+02	100.0%	0.03	241.2	454.7
ADVECTIVE OUTFLOW				86.9	18.2%	9.77E+02		0.36	88.8	82.7
***TOTAL OUTFLOW				86.9	18.2%	9.77E+02		0.36	88.8	82.7
***RETENTION				390.6	81.8%	1.18E+03		0.09		

Overflow Rate (m/yr)	0.9	Nutrient Resid. Time (yrs)	0.1952
Hydraulic Resid. Time (yrs)	1.0728	Turnover Ratio	5.1
Reservoir Conc (mg/m3)	89	Retention Coef.	0.818

Hollerberg Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Hollerberg Lake Shed		1.4	0.00E+00	0.00	
PRECIPITATION				1.0	0.6	0.00E+00	0.00	0.54
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.4	0.00E+00	0.00	
***TOTAL INFLOW				1.0	2.0	0.00E+00	0.00	1.89
ADVECTIVE OUTFLOW				1.0	1.0	0.00E+00	0.00	0.93
***TOTAL OUTFLOW				1.0	1.0	0.00E+00	0.00	0.93
***EVAPORATION					1.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Hollerberg Lake Shed	198.1	86.3%	0.00E+00		0.00	140.8	
PRECIPITATION				31.5	13.7%	2.48E+02	100.0%	0.50	56.0	30.0
NONPOINT INFLOW				198.1	86.3%	0.00E+00		0.00	140.8	
***TOTAL INFLOW				229.6	100.0%	2.48E+02	100.0%	0.07	116.0	218.7
ADVECTIVE OUTFLOW				58.6	25.5%	3.74E+02		0.33	59.8	55.8
***TOTAL OUTFLOW				58.6	25.5%	3.74E+02		0.33	59.8	55.8
***RETENTION				171.0	74.5%	5.51E+02		0.14		

Overflow Rate (m/yr)	0.9	Nutrient Resid. Time (yrs)	0.2736
Hydraulic Resid. Time (yrs)	1.0728	Turnover Ratio	3.7
Reservoir Conc (mg/m3)	60	Retention Coef.	0.745

Irgens Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Irgens Lake Shed		5.1	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.58
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					5.1	0.00E+00	0.00	
***TOTAL INFLOW				0.8	5.6	0.00E+00	0.00	7.03
ADVECTIVE OUTFLOW				0.8	4.8	0.00E+00	0.00	5.96
***TOTAL OUTFLOW				0.8	4.8	0.00E+00	0.00	5.96
***EVAPORATION					0.9	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	1.5	0.1%	0.00E+00		0.00	153.3	
2	2	1	Irgens Lake Shed	1798.1	98.6%	0.00E+00		0.00	350.4	
PRECIPITATION				23.9	1.3%	1.43E+02	100.0%	0.50	51.8	30.0
TRIBUTARY INFLOW				1.5	0.1%	0.00E+00		0.00	153.3	
NONPOINT INFLOW				1798.1	98.6%	0.00E+00		0.00	350.4	
***TOTAL INFLOW				1823.6	100.0%	1.43E+02	100.0%	0.01	325.5	2288.1
ADVECTIVE OUTFLOW				940.3	51.6%	4.08E+04		0.21	197.9	1179.7
***TOTAL OUTFLOW				940.3	51.6%	4.08E+04		0.21	197.9	1179.7
***RETENTION				883.3	48.4%	4.09E+04		0.23		

Overflow Rate (m/yr)	6.0	Nutrient Resid. Time (yrs)	0.0865
Hydraulic Resid. Time (yrs)	0.1678	Turnover Ratio	11.6
Reservoir Conc (mg/m3)	198	Retention Coef.	0.484

Irgens Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Irgens Lake Shed		5.1	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.58
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					5.1	0.00E+00	0.00	
***TOTAL INFLOW				0.8	5.6	0.00E+00	0.00	7.03
ADVECTIVE OUTFLOW				0.8	4.8	0.00E+00	0.00	5.96
***TOTAL OUTFLOW				0.8	4.8	0.00E+00	0.00	5.96
***EVAPORATION					0.9	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Irgens Lake Shed	400.8	94.4%	0.00E+00		0.00	78.1	
PRECIPITATION				23.9	5.6%	1.43E+02	100.0%	0.50	51.8	30.0
NONPOINT INFLOW				400.8	94.4%	0.00E+00		0.00	78.1	
***TOTAL INFLOW				424.7	100.0%	1.43E+02	100.0%	0.03	75.8	532.8
ADVECTIVE OUTFLOW				286.6	67.5%	1.77E+03		0.15	60.3	359.6
***TOTAL OUTFLOW				286.6	67.5%	1.77E+03		0.15	60.3	359.6
***RETENTION				138.1	32.5%	1.75E+03		0.30		

Overflow Rate (m/yr)	6.0	Nutrient Resid. Time (yrs)	0.1132
Hydraulic Resid. Time (yrs)	0.1678	Turnover Ratio	8.8
Reservoir Conc (mg/m3)	60	Retention Coef.	0.325

Jennie Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Jennie Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				1.3	0.7	0.00E+00	0.00	0.56
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				1.3	1.4	0.00E+00	0.00	1.13
ADVECTIVE OUTFLOW				1.3	0.1	0.00E+00	0.00	0.09
***TOTAL OUTFLOW				1.3	0.1	0.00E+00	0.00	0.09
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.2	0.1%	0.00E+00		0.00	24.5	
2	2	1	Jennie Lake Shed	275.8	87.7%	0.00E+00		0.00	389.3	
PRECIPITATION				38.4	12.2%	3.69E+02	100.0%	0.50	53.2	30.0
TRIBUTARY INFLOW				0.2	0.1%	0.00E+00		0.00	24.5	
NONPOINT INFLOW				275.8	87.7%	0.00E+00		0.00	389.3	
***TOTAL INFLOW				314.4	100.0%	3.69E+02	100.0%	0.06	218.3	245.7
ADVECTIVE OUTFLOW				16.6	5.3%	4.79E+01		0.42	152.3	13.0
***TOTAL OUTFLOW				16.6	5.3%	4.79E+01		0.42	152.3	13.0
***RETENTION				297.8	94.7%	3.94E+02		0.07		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.3720
Hydraulic Resid. Time (yrs)	7.0313	Turnover Ratio	2.7
Reservoir Conc (mg/m3)	152	Retention Coef.	0.947

Jennie Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance					Averaging Period =		1.00 years	
				Area	Flow	Variance	CV	Runoff
Trb	Type	Seg	Name	km^2	hm^3/yr	(hm3/yr)^2	-	m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Jennie Lake Shed		0.7	0.00E+00	0.00	
PRECIPITATION				1.3	0.7	0.00E+00	0.00	0.56
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.7	0.00E+00	0.00	
***TOTAL INFLOW				1.3	1.4	0.00E+00	0.00	1.13
ADVECTIVE OUTFLOW				1.3	0.1	0.00E+00	0.00	0.09
***TOTAL OUTFLOW				1.3	0.1	0.00E+00	0.00	0.09
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Component:				Predicted TOTAL P		Outflow & Reservoir Concentrations				
				Load		Load Variance			Conc	Export
Trb	Type	Seg	Name	kg/yr	%Total	(kg/yr)^2	%Total	CV	mg/m^3	kg/km^2/yr
2	2	1	Jennie Lake Shed	23.3	37.8%	0.00E+00		0.00	32.9	
PRECIPITATION				38.4	62.2%	3.69E+02	100.0%	0.50	53.2	30.0
NONPOINT INFLOW				23.3	37.8%	0.00E+00		0.00	32.9	
***TOTAL INFLOW				61.7	100.0%	3.69E+02	100.0%	0.31	42.8	48.2
ADVECTIVE OUTFLOW				6.5	10.5%	7.91E+00		0.43	59.5	5.1
***TOTAL OUTFLOW				6.5	10.5%	7.91E+00		0.43	59.5	5.1
***RETENTION				55.2	89.5%	3.31E+02		0.33		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.7408
Hydraulic Resid. Time (yrs)	7.0313	Turnover Ratio	1.3
Reservoir Conc (mg/m3)	60	Retention Coef.	0.895

Johanna Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance					Averaging Period =	1.00	years	
				Area	Flow	Variance	CV	Runoff
Trb	Type	Seg	Name	km^2	hm^3/yr	$(hm3/yr)^2$	-	m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Johanna Lake Shed		3.8	0.00E+00	0.00	
PRECIPITATION				5.8	3.6	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					3.8	0.00E+00	0.00	
***TOTAL INFLOW				5.8	7.4	0.00E+00	0.00	1.29
ADVECTIVE OUTFLOW				5.8	1.0	0.00E+00	0.00	0.18
***TOTAL OUTFLOW				5.8	1.0	0.00E+00	0.00	0.18
***EVAPORATION					6.4	0.00E+00	0.00	

Overall Mass Balance Based Upon				Predicted		Outflow & Reservoir Concentrations				
Component:				TOTAL P						
				Load		Load Variance			Conc	Export
Trb	Type	Seg	Name	kg/yr	%Total	$(kg/yr)^2$	%Total	CV	mg/m^3	$kg/km^2/yr$
1	1	1	SSTS	1.0	0.1%	0.00E+00		0.00	95.3	
2	2	1	Johanna Lake Shed	1190.3	87.2%	0.00E+00		0.00	312.9	
PRECIPITATION				173.1	12.7%	7.49E+03	100.0%	0.50	47.8	30.0
TRIBUTARY INFLOW				1.0	0.1%	0.00E+00		0.00	95.3	
NONPOINT INFLOW				1190.3	87.2%	0.00E+00		0.00	312.9	
***TOTAL INFLOW				1364.4	100.0%	7.49E+03	100.0%	0.06	183.6	236.5
ADVECTIVE OUTFLOW				80.1	5.9%	1.10E+03		0.41	78.1	13.9
***TOTAL OUTFLOW				80.1	5.9%	1.10E+03		0.41	78.1	13.9
***RETENTION				1284.2	94.1%	8.19E+03		0.07		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	0.3301
Hydraulic Resid. Time (yrs)	5.6195	Turnover Ratio	3.0
Reservoir Conc (mg/m3)	78	Retention Coef.	0.941

Johanna Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance						**Averaging Period =**		**1.00 years**
				Area	**Flow**	**Variance**	**CV**	**Runoff**
Trb	**Type**	**Seg**	**Name**	**km^2**	**hm^3/yr**	**$(hm3/yr)^2$**	**-**	**m/yr**
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Johanna Lake Shed		3.8	0.00E+00	0.00	
PRECIPITATION				5.8	3.6	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					3.8	0.00E+00	0.00	
***TOTAL INFLOW				5.8	7.4	0.00E+00	0.00	1.29
ADVECTIVE OUTFLOW				5.8	1.0	0.00E+00	0.00	0.18
***TOTAL OUTFLOW				5.8	1.0	0.00E+00	0.00	0.18
***EVAPORATION					6.4	0.00E+00	0.00	

Overall Mass Balance Based Upon				**Predicted**		**Outflow & Reservoir Concentrations**				
Component:				**TOTAL P**						
				Load		**Load Variance**			**Conc**	**Export**
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**$(kg/yr)^2$**	**%Total**	**CV**	**mg/m^3**	**$kg/km^2/yr$**
2	2	1	Johanna Lake Shed	587.8	77.3%	0.00E+00		0.00	154.5	
PRECIPITATION				173.1	22.7%	7.49E+03	100.0%	0.50	47.8	30.0
NONPOINT INFLOW				587.8	77.3%	0.00E+00		0.00	154.5	
***TOTAL INFLOW				760.9	100.0%	7.49E+03	100.0%	0.11	102.4	131.9
ADVECTIVE OUTFLOW				61.6	8.1%	6.24E+02		0.41	60.0	10.7
***TOTAL OUTFLOW				61.6	8.1%	6.24E+02		0.41	60.0	10.7
***RETENTION				699.3	91.9%	7.56E+03		0.12		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	0.4547
Hydraulic Resid. Time (yrs)	5.6195	Turnover Ratio	2.2
Reservoir Conc (mg/m3)	60	Retention Coef.	0.919

John Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	John Lake Shed		2.8	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.62
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.8	0.00E+00	0.00	
***TOTAL INFLOW				0.5	3.1	0.00E+00	0.00	6.52
ADVECTIVE OUTFLOW				0.5	2.5	0.00E+00	0.00	5.38
***TOTAL OUTFLOW				0.5	2.5	0.00E+00	0.00	5.38
***EVAPORATION					0.5	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	0.8	0.1%	0.00E+00		0.00	81.2	
2	2	1	John Lake Shed	955.9	98.5%	0.00E+00		0.00	346.7	
PRECIPITATION				14.1	1.4%	4.95E+01	100.0%	0.50	48.4	30.0
TRIBUTARY INFLOW				0.8	0.1%	0.00E+00		0.00	81.2	
NONPOINT INFLOW				955.9	98.5%	0.00E+00		0.00	346.7	
***TOTAL INFLOW				970.8	100.0%	4.95E+01	100.0%	0.01	317.5	2069.8
ADVECTIVE OUTFLOW				356.6	36.7%	9.93E+03		0.28	141.4	760.4
***TOTAL OUTFLOW				356.6	36.7%	9.93E+03		0.28	141.4	760.4
***RETENTION				614.1	63.3%	9.96E+03		0.16		

Overflow Rate (m/yr)	5.4	Nutrient Resid. Time (yrs)	0.0820
Hydraulic Resid. Time (yrs)	0.2231	Turnover Ratio	12.2
Reservoir Conc (mg/m3)	141	Retention Coef.	0.633

John Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	John Lake Shed		2.8	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.62
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.8	0.00E+00	0.00	
***TOTAL INFLOW				0.5	3.1	0.00E+00	0.00	6.52
ADVECTIVE OUTFLOW				0.5	2.5	0.00E+00	0.00	5.38
***TOTAL OUTFLOW				0.5	2.5	0.00E+00	0.00	5.38
***EVAPORATION					0.5	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	John Lake Shed	273.3	95.1%	0.00E+00		0.00	99.1	
PRECIPITATION				14.1	4.9%	4.95E+01	100.0%	0.50	48.4	30.0
NONPOINT INFLOW				273.3	95.1%	0.00E+00		0.00	99.1	
***TOTAL INFLOW				287.4	100.0%	4.95E+01	100.0%	0.02	94.0	612.7
ADVECTIVE OUTFLOW				152.6	53.1%	1.02E+03		0.21	60.5	325.5
***TOTAL OUTFLOW				152.6	53.1%	1.02E+03		0.21	60.5	325.5
***RETENTION				134.7	46.9%	1.03E+03		0.24		

Overflow Rate (m/yr)	5.4	Nutrient Resid. Time (yrs)	0.1185
Hydraulic Resid. Time (yrs)	0.2231	Turnover Ratio	8.4
Reservoir Conc (mg/m3)	60	Retention Coef.	0.469

Jorgenson Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Jorgenson Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.5	0.7	0.00E+00	0.00	1.49
ADVECTIVE OUTFLOW				0.5	0.2	0.00E+00	0.00	0.45
***TOTAL OUTFLOW				0.5	0.2	0.00E+00	0.00	0.45
***EVAPORATION					0.5	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted **Outflow & Reservoir Concentrations**

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.1	0.0%	0.00E+00		0.00	13.8	
2	2	1	Jorgenson Lake Shed	159.8	41.5%	0.00E+00		0.00	368.5	
PRECIPITATION				14.4	3.7%	5.18E+01	100.0%	0.50	52.6	30.0
INTERNAL LOAD				210.4	54.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.1	0.0%	0.00E+00		0.00	13.8	
NONPOINT INFLOW				159.8	41.5%	0.00E+00		0.00	368.5	
***TOTAL INFLOW				384.7	100.0%	5.18E+01	100.0%	0.02	536.4	801.4
ADVECTIVE OUTFLOW				44.6	11.6%	2.99E+02		0.39	204.6	92.9
***TOTAL OUTFLOW				44.6	11.6%	2.99E+02		0.39	204.6	92.9
***RETENTION				340.1	88.4%	3.44E+02		0.05		

Overflow Rate (m/yr)	0.5	Nutrient Resid. Time (yrs)	0.2553
Hydraulic Resid. Time (yrs)	2.2019	Turnover Ratio	3.9
Reservoir Conc (mg/m3)	205	Retention Coef.	0.884

Jorgenson Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Jorgenson Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.5	0.7	0.00E+00	0.00	1.49
ADVECTIVE OUTFLOW				0.5	0.2	0.00E+00	0.00	0.45
***TOTAL OUTFLOW				0.5	0.2	0.00E+00	0.00	0.45
***EVAPORATION					0.5	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Jorgenson Lake Shed	38.8	72.9%	0.00E+00		0.00	89.5	
PRECIPITATION				14.4	27.1%	5.18E+01	100.0%	0.50	52.6	30.0
NONPOINT INFLOW				38.8	72.9%	0.00E+00		0.00	89.5	
***TOTAL INFLOW				53.2	100.0%	5.18E+01	100.0%	0.14	74.2	110.9
ADVECTIVE OUTFLOW				13.0	24.5%	2.01E+01		0.34	59.8	27.2
***TOTAL OUTFLOW				13.0	24.5%	2.01E+01		0.34	59.8	27.2
***RETENTION				40.2	75.5%	5.53E+01		0.19		

Overflow Rate (m/yr)	0.5	Nutrient Resid. Time (yrs)	0.5394
Hydraulic Resid. Time (yrs)	2.2019	Turnover Ratio	1.9
Reservoir Conc (mg/m3)	60	Retention Coef.	0.755

Long Lake (Douglas County) Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Long Lake Shed		8.7	0.00E+00	0.00	
3	1	1	Stowe Lake Outflow	291.0	28.5	0.00E+00	0.00	0.10
4	1	1	Point source		0.1	0.00E+00	0.00	
PRECIPITATION				0.8	0.6	0.00E+00	0.00	0.67
TRIBUTARY INFLOW				291.0	28.6	0.00E+00	0.00	0.10
NONPOINT INFLOW					8.7	0.00E+00	0.00	
***TOTAL INFLOW				291.8	37.8	0.00E+00	0.00	0.13
ADVECTIVE OUTFLOW				291.8	37.0	0.00E+00	0.00	0.13
***TOTAL OUTFLOW				291.8	37.0	0.00E+00	0.00	0.13
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance (kg/yr)²	Load Variance %Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	1.3	0.0%	0.00E+00		0.00	128.0	
2	2	1	Long Lake Shed	4074.0	56.0%	0.00E+00		0.00	470.3	
3	1	1	Stowe Lake Outflow	3014.2	41.5%	0.00E+00		0.00	105.8	10.4
4	1	1	Point source	156.5	2.2%	0.00E+00		0.00	1630.7	
PRECIPITATION				24.9	0.3%	1.55E+02	100.0%	0.50	44.8	30.0
TRIBUTARY INFLOW				3172.0	43.6%	0.00E+00		0.00	110.9	10.9
NONPOINT INFLOW				4074.0	56.0%	0.00E+00		0.00	470.3	
***TOTAL INFLOW				7270.9	100.0%	1.55E+02	100.0%	0.00	192.2	24.9
ADVECTIVE OUTFLOW				4320.6	59.4%	6.08E+05		0.18	116.6	14.8
***TOTAL OUTFLOW				4320.6	59.4%	6.08E+05		0.18	116.6	14.8
***RETENTION				2950.3	40.6%	6.08E+05		0.26		

Overflow Rate (m/yr)	44.6	Nutrient Resid. Time (yrs)	0.0240
Hydraulic Resid. Time (yrs)	0.0403	Turnover Ratio	41.7
Reservoir Conc (mg/m3)	117	Retention Coef.	0.406

Long Lake (Douglas County) Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Long Lake Shed		8.7	0.00E+00	0.00	
3	1	1	Stowe Lake Outflow	291.0	28.5	0.00E+00	0.00	0.10
4	1	1	Point source		0.1	0.00E+00	0.00	
PRECIPITATION				0.8	0.6	0.00E+00	0.00	0.67
TRIBUTARY INFLOW				291.0	28.6	0.00E+00	0.00	0.10
NONPOINT INFLOW					8.7	0.00E+00	0.00	
***TOTAL INFLOW				291.8	37.8	0.00E+00	0.00	0.13
ADVECTIVE OUTFLOW				291.8	37.0	0.00E+00	0.00	0.13
***TOTAL OUTFLOW				291.8	37.0	0.00E+00	0.00	0.13
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Long Lake Shed	486.3	15.5%	0.00E+00		0.00	56.1	
3	1	1	Stowe Lake Outflow	2479.5	78.8%	0.00E+00		0.00	87.0	8.5
4	1	1	Point source	156.5	5.0%	0.00E+00		0.00	1630.7	
PRECIPITATION				24.9	0.8%	1.55E+02	100.0%	0.50	44.8	30.0
TRIBUTARY INFLOW				2636.0	83.8%	0.00E+00		0.00	92.2	9.1
NONPOINT INFLOW				486.3	15.5%	0.00E+00		0.00	56.1	
***TOTAL INFLOW				3147.3	100.0%	1.55E+02	100.0%	0.00	83.2	10.8
ADVECTIVE OUTFLOW				2221.1	70.6%	8.51E+04		0.13	60.0	7.6
***TOTAL OUTFLOW				2221.1	70.6%	8.51E+04		0.13	60.0	7.6
***RETENTION				926.2	29.4%	8.50E+04		0.31		

Overflow Rate (m/yr)	44.6	Nutrient Resid. Time (yrs)	0.0285
Hydraulic Resid. Time (yrs)	0.0403	Turnover Ratio	35.1
Reservoir Conc (mg/m3)	60	Retention Coef.	0.294

Long Lake (Stevens County) Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Long_S Lake Shed		1.3	0.00E+00	0.00	
PRECIPITATION				2.4	1.5	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.3	0.00E+00	0.00	
***TOTAL INFLOW				2.4	2.8	0.00E+00	0.00	1.18
ADVECTIVE OUTFLOW				2.4	0.1	0.00E+00	0.00	0.03
***TOTAL OUTFLOW				2.4	0.1	0.00E+00	0.00	0.03
***EVAPORATION					2.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.4	0.0%	0.00E+00		0.00	44.8	
2	2	1	Long_S Lake Shed	502.0	38.2%	0.00E+00		0.00	383.2	
PRECIPITATION				71.4	5.4%	1.27E+03	100.0%	0.50	47.9	30.0
INTERNAL LOAD				738.9	56.3%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.4	0.0%	0.00E+00		0.00	44.8	
NONPOINT INFLOW				502.0	38.2%	0.00E+00		0.00	383.2	
***TOTAL INFLOW				1312.7	100.0%	1.27E+03	100.0%	0.03	467.2	551.6
ADVECTIVE OUTFLOW				11.0	0.8%	2.26E+01		0.43	150.4	4.6
***TOTAL OUTFLOW				11.0	0.8%	2.26E+01		0.43	150.4	4.6
***RETENTION				1301.8	99.2%	1.29E+03		0.03		

Overflow Rate (m/yr)	0.0	Nutrient Resid. Time (yrs)	0.4091
Hydraulic Resid. Time (yrs)	49.0324	Turnover Ratio	2.4
Reservoir Conc (mg/m3)	150	Retention Coef.	0.992

Long Lake (Stevens County) Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Long_S Lake Shed		1.3	0.00E+00	0.00	
PRECIPITATION				2.4	1.5	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.3	0.00E+00	0.00	
***TOTAL INFLOW				2.4	2.8	0.00E+00	0.00	1.18
ADVECTIVE OUTFLOW				2.4	0.1	0.00E+00	0.00	0.03
***TOTAL OUTFLOW				2.4	0.1	0.00E+00	0.00	0.03
***EVAPORATION					2.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Long_S Lake Shed	189.1	36.7%	0.00E+00		0.00	144.3	
PRECIPITATION				71.4	13.9%	1.27E+03	100.0%	0.50	47.9	30.0
INTERNAL LOAD				255.1	49.5%	0.00E+00		0.00		
NONPOINT INFLOW				189.1	36.7%	0.00E+00		0.00	144.3	
***TOTAL INFLOW				515.5	100.0%	1.27E+03	100.0%	0.07	183.5	216.6
ADVECTIVE OUTFLOW				6.6	1.3%	8.10E+00		0.43	90.2	2.8
***TOTAL OUTFLOW				6.6	1.3%	8.10E+00		0.43	90.2	2.8
***RETENTION				508.9	98.7%	1.26E+03		0.07		

Overflow Rate (m/yr)	0.0	Nutrient Resid. Time (yrs)	0.6249
Hydraulic Resid. Time (yrs)	49.0324	Turnover Ratio	1.6
Reservoir Conc (mg/m3)	90	Retention Coef.	0.987

Mary Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Mary Lake Shed		0.6	0.00E+00	0.00	
PRECIPITATION				0.4	0.2	0.00E+00	0.00	0.41
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.6	0.00E+00	0.00	
***TOTAL INFLOW				0.4	0.8	0.00E+00	0.00	2.03
ADVECTIVE OUTFLOW				0.4	0.5	0.00E+00	0.00	1.31
***TOTAL OUTFLOW				0.4	0.5	0.00E+00	0.00	1.31
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.2	0.1%	0.00E+00		0.00	18.0	
2	2	1	Mary Lake Shed	109.1	51.9%	0.00E+00		0.00	168.7	
PRECIPITATION				12.1	5.8%	3.69E+01	100.0%	0.50	73.2	30.0
INTERNAL LOAD				88.8	42.2%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.2	0.1%	0.00E+00		0.00	18.0	
NONPOINT INFLOW				109.1	51.9%	0.00E+00		0.00	168.7	
***TOTAL INFLOW				210.2	100.0%	3.69E+01	100.0%	0.03	255.4	519.1
ADVECTIVE OUTFLOW				58.5	27.8%	3.47E+02		0.32	110.0	144.3
***TOTAL OUTFLOW				58.5	27.8%	3.47E+02		0.32	110.0	144.3
***RETENTION				151.8	72.2%	3.70E+02		0.13		

Overflow Rate (m/yr)	1.3	Nutrient Resid. Time (yrs)	0.2967
Hydraulic Resid. Time (yrs)	1.0670	Turnover Ratio	3.4
Reservoir Conc (mg/m3)	110	Retention Coef.	0.722

Mary Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Mary Lake Shed		0.6	0.00E+00	0.00	
PRECIPITATION				0.4	0.2	0.00E+00	0.00	0.41
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.6	0.00E+00	0.00	
***TOTAL INFLOW				0.4	0.8	0.00E+00	0.00	2.03
ADVECTIVE OUTFLOW				0.4	0.5	0.00E+00	0.00	1.31
***TOTAL OUTFLOW				0.4	0.5	0.00E+00	0.00	1.31
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Mary Lake Shed	74.8	86.0%	0.00E+00		0.00	115.6	
PRECIPITATION				12.1	14.0%	3.69E+01	100.0%	0.50	73.2	30.0
NONPOINT INFLOW				74.8	86.0%	0.00E+00		0.00	115.6	
***TOTAL INFLOW				87.0	100.0%	3.69E+01	100.0%	0.07	105.7	214.7
ADVECTIVE OUTFLOW				31.8	36.6%	8.19E+01		0.28	59.9	78.6
***TOTAL OUTFLOW				31.8	36.6%	8.19E+01		0.28	59.9	78.6
***RETENTION				55.1	63.4%	9.96E+01		0.18		

Overflow Rate (m/yr)	1.3	Nutrient Resid. Time (yrs)	0.3904
Hydraulic Resid. Time (yrs)	1.0670	Turnover Ratio	2.6
Reservoir Conc (mg/m3)	60	Retention Coef.	0.634

McIver Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	McIver Lake Shed		1.0	0.00E+00	0.00	
PRECIPITATION				0.6	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.0	0.00E+00	0.00	
***TOTAL INFLOW				0.6	1.4	0.00E+00	0.00	2.38
ADVECTIVE OUTFLOW				0.6	0.8	0.00E+00	0.00	1.32
***TOTAL OUTFLOW				0.6	0.8	0.00E+00	0.00	1.32
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.4	0.1%	0.00E+00		0.00	35.8	
2	2	1	McIver Lake Shed	395.2	63.5%	0.00E+00		0.00	385.9	
PRECIPITATION				17.2	2.8%	7.41E+01	100.0%	0.50	52.3	30.0
INTERNAL LOAD				209.7	33.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.4	0.1%	0.00E+00		0.00	35.8	
NONPOINT INFLOW				395.2	63.5%	0.00E+00		0.00	385.9	
***TOTAL INFLOW				622.5	100.0%	7.41E+01	100.0%	0.01	456.4	1084.4
ADVECTIVE OUTFLOW				130.6	21.0%	2.06E+03		0.35	172.9	227.5
***TOTAL OUTFLOW				130.6	21.0%	2.06E+03		0.35	172.9	227.5
***RETENTION				491.9	79.0%	2.11E+03		0.09		

Overflow Rate (m/yr)	1.3	Nutrient Resid. Time (yrs)	0.2392
Hydraulic Resid. Time (yrs)	1.1399	Turnover Ratio	4.2
Reservoir Conc (mg/m3)	173	Retention Coef.	0.790

McIver Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	McIver Lake Shed		1.0	0.00E+00	0.00	
PRECIPITATION				0.6	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.0	0.00E+00	0.00	
***TOTAL INFLOW				0.6	1.4	0.00E+00	0.00	2.38
ADVECTIVE OUTFLOW				0.6	0.8	0.00E+00	0.00	1.32
***TOTAL OUTFLOW				0.6	0.8	0.00E+00	0.00	1.32
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	McIver Lake Shed	111.3	86.6%	0.00E+00		0.00	108.6	
PRECIPITATION				17.2	13.4%	7.41E+01	100.0%	0.50	52.3	30.0
NONPOINT INFLOW				111.3	86.6%	0.00E+00		0.00	108.6	
***TOTAL INFLOW				128.5	100.0%	7.41E+01	100.0%	0.07	94.2	223.8
ADVECTIVE OUTFLOW				45.4	35.4%	1.73E+02		0.29	60.1	79.1
***TOTAL OUTFLOW				45.4	35.4%	1.73E+02		0.29	60.1	79.1
***RETENTION				83.1	64.6%	2.10E+02		0.17		

Overflow Rate (m/yr)	1.3	Nutrient Resid. Time (yrs)	0.4031
Hydraulic Resid. Time (yrs)	1.1399	Turnover Ratio	2.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.646

Monson Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Monson Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.64
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.8	1.0	0.00E+00	0.00	1.16
ADVECTIVE OUTFLOW				0.8	0.0	0.00E+00	0.00	0.03
***TOTAL OUTFLOW				0.8	0.0	0.00E+00	0.00	0.03
***EVAPORATION					1.0	0.00E+00	0.00	

Overall Mass Balance Based Upon — Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.1	0.1%	0.00E+00		0.00	11.8	
2	2	1	Monson Lake Shed	145.9	85.2%	0.00E+00		0.00	342.5	
PRECIPITATION				25.3	14.8%	1.60E+02	100.0%	0.50	46.9	30.0
TRIBUTARY INFLOW				0.1	0.1%	0.00E+00		0.00	11.8	
NONPOINT INFLOW				145.9	85.2%	0.00E+00		0.00	342.5	
***TOTAL INFLOW				171.2	100.0%	1.60E+02	100.0%	0.07	175.8	203.4
ADVECTIVE OUTFLOW				1.7	1.0%	5.34E-01		0.43	74.8	2.0
***TOTAL OUTFLOW				1.7	1.0%	5.34E-01		0.43	74.8	2.0
***RETENTION				169.5	99.0%	1.58E+02		0.07		

Overflow Rate (m/yr)	0.0	Nutrient Resid. Time (yrs)	0.7360
Hydraulic Resid. Time (yrs)	74.9378	Turnover Ratio	1.4
Reservoir Conc (mg/m3)	75	Retention Coef.	0.990

Monson Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Monson Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.8	0.5	0.00E+00	0.00	0.64
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.8	1.0	0.00E+00	0.00	1.16
ADVECTIVE OUTFLOW				0.8	0.0	0.00E+00	0.00	0.03
***TOTAL OUTFLOW				0.8	0.0	0.00E+00	0.00	0.03
***EVAPORATION					1.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Monson Lake Shed	87.4	77.6%	0.00E+00		0.00	205.1	
PRECIPITATION				25.3	22.4%	1.60E+02	100.0%	0.50	46.9	30.0
NONPOINT INFLOW				87.4	77.6%	0.00E+00		0.00	205.1	
***TOTAL INFLOW				112.6	100.0%	1.60E+02	100.0%	0.11	115.6	133.8
ADVECTIVE OUTFLOW				1.3	1.2%	3.40E-01		0.44	59.5	1.6
***TOTAL OUTFLOW				1.3	1.2%	3.40E-01		0.44	59.5	1.6
***RETENTION				111.3	98.8%	1.58E+02		0.11		

Overflow Rate (m/yr)	0.0	Nutrient Resid. Time (yrs)	0.8899
Hydraulic Resid. Time (yrs)	74.9378	Turnover Ratio	1.1
Reservoir Conc (mg/m3)	60	Retention Coef.	0.988

Norway Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	1	1	West Norway basin		8.3	0.00E+00	0.00	
3	2	1	South Norway drainage area		0.9	0.00E+00	0.00	
PRECIPITATION				4.8	3.2	0.00E+00	0.00	0.67
TRIBUTARY INFLOW					8.3	0.00E+00	0.00	
NONPOINT INFLOW					0.9	0.00E+00	0.00	
***TOTAL INFLOW				4.8	12.5	0.00E+00	0.00	2.60
ADVECTIVE OUTFLOW				4.8	6.7	0.00E+00	0.00	1.40
***TOTAL OUTFLOW				4.8	6.7	0.00E+00	0.00	1.40
***EVAPORATION					5.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	2.6	0.2%	0.00E+00		0.00	263.5	
2	1	1	West Norway basin	706.1	62.3%	0.00E+00		0.00	85.1	
3	2	1	South Norway drainage a	281.0	24.8%	0.00E+00		0.00	298.6	
PRECIPITATION				144.0	12.7%	5.18E+03	100.0%	0.50	44.8	30.0
TRIBUTARY INFLOW				708.7	62.5%	0.00E+00		0.00	85.3	
NONPOINT INFLOW				281.0	24.8%	0.00E+00		0.00	298.6	
***TOTAL INFLOW				1133.8	100.0%	5.18E+03	100.0%	0.06	90.9	236.2
ADVECTIVE OUTFLOW				329.0	29.0%	1.08E+04		0.32	49.1	68.5
***TOTAL OUTFLOW				329.0	29.0%	1.08E+04		0.32	49.1	68.5
***RETENTION				804.7	71.0%	1.39E+04		0.15		

Overflow Rate (m/yr)	1.4	Nutrient Resid. Time (yrs)	0.5690
Hydraulic Resid. Time (yrs)	1.9609	Turnover Ratio	1.8
Reservoir Conc (mg/m3)	49	Retention Coef.	0.710

Norway Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	1	1	West Norway basin		8.3	0.00E+00	0.00	
3	2	1	South Norway drainage area		0.9	0.00E+00	0.00	
PRECIPITATION				4.8	3.2	0.00E+00	0.00	0.67
TRIBUTARY INFLOW					8.3	0.00E+00	0.00	
NONPOINT INFLOW					0.9	0.00E+00	0.00	
***TOTAL INFLOW				4.8	12.5	0.00E+00	0.00	2.60
ADVECTIVE OUTFLOW				4.8	6.7	0.00E+00	0.00	1.40
***TOTAL OUTFLOW				4.8	6.7	0.00E+00	0.00	1.40
***EVAPORATION					5.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — **Outflow & Reservoir Concentrations**

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	1	1	West Norway basin	497.7	60.0%	0.00E+00		0.00	60.0	
3	2	1	South Norway drainage a	187.3	22.6%	0.00E+00		0.00	199.0	
PRECIPITATION				144.0	17.4%	5.18E+03	100.0%	0.50	44.8	30.0
TRIBUTARY INFLOW				497.7	60.0%	0.00E+00		0.00	59.9	
NONPOINT INFLOW				187.3	22.6%	0.00E+00		0.00	199.0	
***TOTAL INFLOW				829.0	100.0%	5.18E+03	100.0%	0.09	66.5	172.7
ADVECTIVE OUTFLOW				265.8	32.1%	6.59E+03		0.31	39.6	55.4
***TOTAL OUTFLOW				265.8	32.1%	6.59E+03		0.31	39.6	55.4
***RETENTION				563.2	67.9%	9.49E+03		0.17		

Overflow Rate (m/yr)	1.4	Nutrient Resid. Time (yrs)	0.6287
Hydraulic Resid. Time (yrs)	1.9609	Turnover Ratio	1.6
Reservoir Conc (mg/m3)	40	Retention Coef.	0.679

Rasmuson Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Rasmuson Lake Shed		0.5	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.66
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.5	0.00E+00	0.00	
***TOTAL INFLOW				0.5	0.8	0.00E+00	0.00	1.54
ADVECTIVE OUTFLOW				0.5	0.2	0.00E+00	0.00	0.39
***TOTAL OUTFLOW				0.5	0.2	0.00E+00	0.00	0.39
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**
Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.1	0.0%	0.00E+00		0.00	11.8	
2	2	1	Rasmuson Lake Shed	75.4	19.9%	0.00E+00		0.00	164.8	
PRECIPITATION				15.8	4.2%	6.23E+01	100.0%	0.50	45.7	30.0
INTERNAL LOAD				288.2	76.0%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.1	0.0%	0.00E+00		0.00	11.8	
NONPOINT INFLOW				75.4	19.9%	0.00E+00		0.00	164.8	
***TOTAL INFLOW				379.4	100.0%	6.22E+01	100.0%	0.02	467.2	721.4
ADVECTIVE OUTFLOW				29.7	7.8%	1.44E+02		0.40	146.5	56.4
***TOTAL OUTFLOW				29.7	7.8%	1.44E+02		0.40	146.5	56.4
***RETENTION				349.8	92.2%	2.00E+02		0.04		

Overflow Rate (m/yr)	0.4	Nutrient Resid. Time (yrs)	0.3656
Hydraulic Resid. Time (yrs)	4.6742	Turnover Ratio	2.7
Reservoir Conc (mg/m3)	147	Retention Coef.	0.922

Rasmuson Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Rasmuson Lake Shed		0.5	0.00E+00	0.00	
PRECIPITATION				0.5	0.3	0.00E+00	0.00	0.66
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.5	0.00E+00	0.00	
***TOTAL INFLOW				0.5	0.8	0.00E+00	0.00	1.54
ADVECTIVE OUTFLOW				0.5	0.2	0.00E+00	0.00	0.39
***TOTAL OUTFLOW				0.5	0.2	0.00E+00	0.00	0.39
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — **Outflow & Reservoir Concentrations**

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
2	2	1	Rasmuson Lake Shed	62.8	75.1%	0.00E+00		0.00	137.4	
PRECIPITATION				15.8	18.9%	6.23E+01	100.0%	0.50	45.7	30.0
INTERNAL LOAD				5.1	6.1%	0.00E+00		0.00		
NONPOINT INFLOW				62.8	75.1%	0.00E+00		0.00	137.4	
***TOTAL INFLOW				83.7	100.0%	6.23E+01	100.0%	0.09	103.0	159.1
ADVECTIVE OUTFLOW				12.1	14.5%	2.12E+01		0.38	59.9	23.1
***TOTAL OUTFLOW				12.1	14.5%	2.12E+01		0.38	59.9	23.1
***RETENTION				71.5	85.5%	7.25E+01		0.12		

Overflow Rate (m/yr)	0.4	Nutrient Resid. Time (yrs)	0.6777
Hydraulic Resid. Time (yrs)	4.6742	Turnover Ratio	1.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.855

Red Rock Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Red Rock Lake Shed		2.1	0.00E+00	0.00	
PRECIPITATION				3.2	2.2	0.00E+00	0.00	0.69
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.1	0.00E+00	0.00	
***TOTAL INFLOW				3.2	4.3	0.00E+00	0.00	1.37
ADVECTIVE OUTFLOW				3.2	0.3	0.00E+00	0.00	0.10
***TOTAL OUTFLOW				3.2	0.3	0.00E+00	0.00	0.10
***EVAPORATION					4.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	SSTS	0.6	0.0%	0.00E+00		0.00	62.6	
2	2	1	Red Rock Lake Shed	731.7	23.3%	0.00E+00		0.00	342.3	
PRECIPITATION				94.8	3.0%	2.25E+03	100.0%	0.50	43.7	30.0
INTERNAL LOAD				2308.4	73.6%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.6	0.0%	0.00E+00		0.00	62.6	
NONPOINT INFLOW				731.7	23.3%	0.00E+00		0.00	342.3	
***TOTAL INFLOW				3135.5	100.0%	2.25E+03	100.0%	0.02	726.6	992.3
ADVECTIVE OUTFLOW				41.8	1.3%	3.25E+02		0.43	130.0	13.2
***TOTAL OUTFLOW				41.8	1.3%	3.25E+02		0.43	130.0	13.2
***RETENTION				3093.8	98.7%	2.54E+03		0.02		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.4586
Hydraulic Resid. Time (yrs)	34.4196	Turnover Ratio	2.2
Reservoir Conc (mg/m3)	130	Retention Coef.	0.987

Red Rock Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Red Rock Lake Shed		2.1	0.00E+00	0.00	
PRECIPITATION				3.2	2.2	0.00E+00	0.00	0.69
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.1	0.00E+00	0.00	
***TOTAL INFLOW				3.2	4.3	0.00E+00	0.00	1.37
ADVECTIVE OUTFLOW				3.2	0.3	0.00E+00	0.00	0.10
***TOTAL OUTFLOW				3.2	0.3	0.00E+00	0.00	0.10
***EVAPORATION					4.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Red Rock Lake Shed	272.3	74.2%	0.00E+00		0.00	127.4	
PRECIPITATION				94.8	25.8%	2.25E+03	100.0%	0.50	43.7	30.0
NONPOINT INFLOW				272.3	74.2%	0.00E+00		0.00	127.4	
***TOTAL INFLOW				367.1	100.0%	2.25E+03	100.0%	0.13	85.1	116.2
ADVECTIVE OUTFLOW				12.8	3.5%	2.99E+01		0.43	39.8	4.0
***TOTAL OUTFLOW				12.8	3.5%	2.99E+01		0.43	39.8	4.0
***RETENTION				354.3	96.5%	2.19E+03		0.13		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	1.1980
Hydraulic Resid. Time (yrs)	34.4196	Turnover Ratio	0.8
Reservoir Conc (mg/m3)	40	Retention Coef.	0.965

Simon Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Simon Lake Shed		1.4	0.00E+00	0.00	
PRECIPITATION				2.3	1.4	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.4	0.00E+00	0.00	
***TOTAL INFLOW				2.3	2.8	0.00E+00	0.00	1.23
ADVECTIVE OUTFLOW				2.3	0.3	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				2.3	0.3	0.00E+00	0.00	0.12
***EVAPORATION					2.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.2	0.0%	0.00E+00		0.00	21.8	
2	2	1	Simon Lake Shed	323.2	28.1%	0.00E+00		0.00	234.8	
PRECIPITATION				69.0	6.0%	1.19E+03	100.0%	0.50	48.0	30.0
INTERNAL LOAD				756.1	65.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.2	0.0%	0.00E+00		0.00	21.8	
NONPOINT INFLOW				323.2	28.1%	0.00E+00		0.00	234.8	
***TOTAL INFLOW				1148.5	100.0%	1.19E+03	100.0%	0.03	406.7	499.3
ADVECTIVE OUTFLOW				33.2	2.9%	2.00E+02		0.42	122.8	14.5
***TOTAL OUTFLOW				33.2	2.9%	2.00E+02		0.42	122.8	14.5
***RETENTION				1115.2	97.1%	1.35E+03		0.03		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.4672
Hydraulic Resid. Time (yrs)	16.1415	Turnover Ratio	2.1
Reservoir Conc (mg/m3)	123	Retention Coef.	0.971

Simon Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Simon Lake Shed		1.4	0.00E+00	0.00	
PRECIPITATION				2.3	1.4	0.00E+00	0.00	0.63
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					1.4	0.00E+00	0.00	
***TOTAL INFLOW				2.3	2.8	0.00E+00	0.00	1.23
ADVECTIVE OUTFLOW				2.3	0.3	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				2.3	0.3	0.00E+00	0.00	0.12
***EVAPORATION					2.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Simon Lake Shed	252.1	78.5%	0.00E+00		0.00	183.2	
PRECIPITATION				69.0	21.5%	1.19E+03	100.0%	0.50	48.0	30.0
NONPOINT INFLOW				252.1	78.5%	0.00E+00		0.00	183.2	
***TOTAL INFLOW				321.1	100.0%	1.19E+03	100.0%	0.11	113.7	139.6
ADVECTIVE OUTFLOW				16.3	5.1%	4.67E+01		0.42	60.2	7.1
***TOTAL OUTFLOW				16.3	5.1%	4.67E+01		0.42	60.2	7.1
***RETENTION				304.8	94.9%	1.17E+03		0.11		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.8188
Hydraulic Resid. Time (yrs)	16.1415	Turnover Ratio	1.2
Reservoir Conc (mg/m3)	60	Retention Coef.	0.949

Swenoda Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swenoda Lake Shed		0.8	0.00E+00	0.00	
PRECIPITATION				1.2	0.7	0.00E+00	0.00	0.61
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.8	0.00E+00	0.00	
***TOTAL INFLOW				1.2	1.5	0.00E+00	0.00	1.31
ADVECTIVE OUTFLOW				1.2	0.3	0.00E+00	0.00	0.23
***TOTAL OUTFLOW				1.2	0.3	0.00E+00	0.00	0.23
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.2	0.1%	0.00E+00		0.00	18.8	
2	2	1	Swenoda Lake Shed	127.0	61.9%	0.00E+00		0.00	156.7	
PRECIPITATION				35.1	17.1%	3.08E+02	100.0%	0.50	49.0	30.0
INTERNAL LOAD				42.7	20.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.2	0.1%	0.00E+00		0.00	18.8	
NONPOINT INFLOW				127.0	61.9%	0.00E+00		0.00	156.7	
***TOTAL INFLOW				205.0	100.0%	3.08E+02	100.0%	0.09	133.4	175.2
ADVECTIVE OUTFLOW				24.4	11.9%	9.02E+01		0.39	89.4	20.8
***TOTAL OUTFLOW				24.4	11.9%	9.02E+01		0.39	89.4	20.8
***RETENTION				180.6	88.1%	3.55E+02		0.10		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	0.5104
Hydraulic Resid. Time (yrs)	4.2918	Turnover Ratio	2.0
Reservoir Conc (mg/m3)	89	Retention Coef.	0.881

Swenoda Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swenoda Lake Shed		0.8	0.00E+00	0.00	
PRECIPITATION				1.2	0.7	0.00E+00	0.00	0.61
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.8	0.00E+00	0.00	
***TOTAL INFLOW				1.2	1.5	0.00E+00	0.00	1.31
ADVECTIVE OUTFLOW				1.2	0.3	0.00E+00	0.00	0.23
***TOTAL OUTFLOW				1.2	0.3	0.00E+00	0.00	0.23
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
2	2	1	Swenoda Lake Shed	69.5	66.4%	0.00E+00		0.00	85.8	
PRECIPITATION				35.1	33.6%	3.08E+02	100.0%	0.50	49.0	30.0
NONPOINT INFLOW				69.5	66.4%	0.00E+00		0.00	85.8	
***TOTAL INFLOW				104.6	100.0%	3.08E+02	100.0%	0.17	68.1	89.4
ADVECTIVE OUTFLOW				16.2	15.5%	3.90E+01		0.38	59.6	13.9
***TOTAL OUTFLOW				16.2	15.5%	3.90E+01		0.38	59.6	13.9
***RETENTION				88.4	84.5%	2.89E+02		0.19		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	0.6661
Hydraulic Resid. Time (yrs)	4.2918	Turnover Ratio	1.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.845

Thompson Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swenoda Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.6	0.4	0.00E+00	0.00	0.61
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.6	0.8	0.00E+00	0.00	1.29
ADVECTIVE OUTFLOW				0.6	0.1	0.00E+00	0.00	0.16
***TOTAL OUTFLOW				0.6	0.1	0.00E+00	0.00	0.16
***EVAPORATION					0.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	0.1	0.0%	0.00E+00		0.00	14.3	
2	2	1	Swenoda Lake Shed	159.1	21.9%	0.00E+00		0.00	396.8	
PRECIPITATION				18.1	2.5%	8.18E+01	100.0%	0.50	49.0	30.0
INTERNAL LOAD				550.6	75.6%	0.00E+00		0.00		
TRIBUTARY INFLOW				0.1	0.0%	0.00E+00		0.00	14.3	
NONPOINT INFLOW				159.1	21.9%	0.00E+00		0.00	396.8	
***TOTAL INFLOW				728.0	100.0%	8.18E+01	100.0%	0.01	933.2	1207.3
ADVECTIVE OUTFLOW				13.0	1.8%	3.13E+01		0.43	132.1	21.6
***TOTAL OUTFLOW				13.0	1.8%	3.13E+01		0.43	132.1	21.6
***RETENTION				715.0	98.2%	1.12E+02		0.01		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	0.4486
Hydraulic Resid. Time (yrs)	25.0554	Turnover Ratio	2.2
Reservoir Conc (mg/m3)	132	Retention Coef.	0.982

Thompson Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swenoda Lake Shed		0.4	0.00E+00	0.00	
PRECIPITATION				0.6	0.4	0.00E+00	0.00	0.61
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					0.4	0.00E+00	0.00	
***TOTAL INFLOW				0.6	0.8	0.00E+00	0.00	1.29
ADVECTIVE OUTFLOW				0.6	0.1	0.00E+00	0.00	0.16
***TOTAL OUTFLOW				0.6	0.1	0.00E+00	0.00	0.16
***EVAPORATION					0.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Swenoda Lake Shed	58.7	68.7%	0.00E+00		0.00	146.3	
PRECIPITATION				18.1	21.2%	8.18E+01	100.0%	0.50	49.0	30.0
INTERNAL LOAD				8.7	10.2%	0.00E+00		0.00		
NONPOINT INFLOW				58.7	68.7%	0.00E+00		0.00	146.3	
***TOTAL INFLOW				85.5	100.0%	8.18E+01	100.0%	0.11	109.5	141.7
ADVECTIVE OUTFLOW				4.0	4.6%	2.79E+00		0.42	40.2	6.6
***TOTAL OUTFLOW				4.0	4.6%	2.79E+00		0.42	40.2	6.6
***RETENTION				81.5	95.4%	8.03E+01		0.11		

Overflow Rate (m/yr)	0.2	Nutrient Resid. Time (yrs)	1.1619
Hydraulic Resid. Time (yrs)	25.0554	Turnover Ratio	0.9
Reservoir Conc (mg/m3)	40	Retention Coef.	0.954

West Norway Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	CD-27		5.7	0.00E+00	0.00	
3	2	1	CD-29		3.2	0.00E+00	0.00	
4	2	1	Huse Creek		1.0	0.00E+00	0.00	
5	2	1	Shoreland		0.9	0.00E+00	0.00	
PRECIPITATION				4.7	3.1	0.00E+00	0.00	0.67
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					10.8	0.00E+00	0.00	
***TOTAL INFLOW				4.7	13.9	0.00E+00	0.00	2.98
ADVECTIVE OUTFLOW				4.7	8.3	0.00E+00	0.00	1.78
***TOTAL OUTFLOW				4.7	8.3	0.00E+00	0.00	1.78
***EVAPORATION					5.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	Load Variance %Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	2.6	0.1%	0.00E+00		0.00	263.5	
2	2	1	CD-27	1876.8	55.1%	0.00E+00		0.00	327.9	
3	2	1	CD-29	939.8	27.6%	0.00E+00		0.00	296.7	
4	2	1	Huse Creek	182.0	5.3%	0.00E+00		0.00	183.8	
5	2	1	Shoreland	264.5	7.8%	0.00E+00		0.00	293.2	
PRECIPITATION				140.4	4.1%	4.93E+03	100.0%	0.50	44.8	30.0
TRIBUTARY INFLOW				2.6	0.1%	0.00E+00		0.00	263.5	
NONPOINT INFLOW				3263.1	95.8%	0.00E+00		0.00	302.6	
***TOTAL INFLOW				3406.2	100.0%	4.93E+03	100.0%	0.02	244.5	727.8
ADVECTIVE OUTFLOW				706.1	20.7%	6.06E+04		0.35	84.9	150.9
***TOTAL OUTFLOW				706.1	20.7%	6.06E+04		0.35	84.9	150.9
***RETENTION				2700.0	79.3%	6.44E+04		0.09		

Overflow Rate (m/yr)	1.8	Nutrient Resid. Time (yrs)	0.1926
Hydraulic Resid. Time (yrs)	0.9288	Turnover Ratio	5.2
Reservoir Conc (mg/m3)	85	Retention Coef.	0.793

West Norway Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	CD-27		5.7	0.00E+00	0.00	
3	2	1	CD-29		3.2	0.00E+00	0.00	
4	2	1	Huse Creek		1.0	0.00E+00	0.00	
5	2	1	Shoreland		0.9	0.00E+00	0.00	
PRECIPITATION				4.7	3.1	0.00E+00	0.00	0.67
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					10.8	0.00E+00	0.00	
***TOTAL INFLOW				4.7	13.9	0.00E+00	0.00	2.98
ADVECTIVE OUTFLOW				4.7	8.3	0.00E+00	0.00	1.78
***TOTAL OUTFLOW				4.7	8.3	0.00E+00	0.00	1.78
***EVAPORATION					5.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Component: TOTAL P — Outflow & Reservoir Concentrations

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	CD-27	924.2	51.1%	0.00E+00		0.00	161.5	
3	2	1	CD-29	485.9	26.9%	0.00E+00		0.00	153.4	
4	2	1	Huse Creek	117.5	6.5%	0.00E+00		0.00	118.7	
5	2	1	Shoreland	140.2	7.8%	0.00E+00		0.00	155.4	
PRECIPITATION				140.4	7.8%	4.93E+03	100.0%	0.50	44.8	30.0
NONPOINT INFLOW				1667.9	92.2%	0.00E+00		0.00	154.7	
***TOTAL INFLOW				1808.3	100.0%	4.93E+03	100.0%	0.04	129.8	386.4
ADVECTIVE OUTFLOW				497.7	27.5%	2.54E+04		0.32	59.9	106.3
***TOTAL OUTFLOW				497.7	27.5%	2.54E+04		0.32	59.9	106.3
***RETENTION				1310.6	72.5%	2.87E+04		0.13		

Overflow Rate (m/yr)	1.8	Nutrient Resid. Time (yrs)	0.2556
Hydraulic Resid. Time (yrs)	0.9288	Turnover Ratio	3.9
Reservoir Conc (mg/m3)	60	Retention Coef.	0.725

Wicklund Lake Bathtub Model Output – Modeled to Observed In-Lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Wicklund Lake Shed		2.7	0.00E+00	0.00	
PRECIPITATION				0.6	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.7	0.00E+00	0.00	
***TOTAL INFLOW				0.6	3.0	0.00E+00	0.00	5.07
ADVECTIVE OUTFLOW				0.6	2.4	0.00E+00	0.00	4.02
***TOTAL OUTFLOW				0.6	2.4	0.00E+00	0.00	4.02
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	Load Variance %Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	SSTS	0.8	0.1%	0.00E+00		0.00	82.1	
2	2	1	Wicklund Lake Shed	907.4	98.0%	0.00E+00		0.00	337.8	
PRECIPITATION				18.0	1.9%	8.07E+01	100.0%	0.50	52.4	30.0
TRIBUTARY INFLOW				0.8	0.1%	0.00E+00		0.00	82.1	
NONPOINT INFLOW				907.4	98.0%	0.00E+00		0.00	337.8	
***TOTAL INFLOW				926.2	100.0%	8.07E+01	100.0%	0.01	304.8	1546.2
ADVECTIVE OUTFLOW				428.2	46.2%	1.04E+04		0.24	177.7	714.8
***TOTAL OUTFLOW				428.2	46.2%	1.04E+04		0.24	177.7	714.8
***RETENTION				498.0	53.8%	1.04E+04		0.21		

Overflow Rate (m/yr)	4.0	Nutrient Resid. Time (yrs)	0.1149
Hydraulic Resid. Time (yrs)	0.2486	Turnover Ratio	8.7
Reservoir Conc (mg/m3)	178	Retention Coef.	0.538

Wicklund Lake Bathtub Model Output – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Wicklund Lake Shed		2.7	0.00E+00	0.00	
PRECIPITATION				0.6	0.3	0.00E+00	0.00	0.57
TRIBUTARY INFLOW					0.0	0.00E+00	0.00	
NONPOINT INFLOW					2.7	0.00E+00	0.00	
***TOTAL INFLOW				0.6	3.0	0.00E+00	0.00	5.07
ADVECTIVE OUTFLOW				0.6	2.4	0.00E+00	0.00	4.02
***TOTAL OUTFLOW				0.6	2.4	0.00E+00	0.00	4.02
***EVAPORATION					0.6	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Wicklund Lake Shed	215.8	92.3%	0.00E+00		0.00	80.3	
PRECIPITATION				18.0	7.7%	8.07E+01	100.0%	0.50	52.4	30.0
NONPOINT INFLOW				215.8	92.3%	0.00E+00		0.00	80.3	
***TOTAL INFLOW				233.8	100.0%	8.07E+01	100.0%	0.04	76.9	390.2
ADVECTIVE OUTFLOW				144.4	61.8%	6.24E+02		0.17	59.9	241.0
***TOTAL OUTFLOW				144.4	61.8%	6.24E+02		0.17	59.9	241.0
***RETENTION				89.4	38.2%	6.23E+02		0.28		

Overflow Rate (m/yr)	4.0	Nutrient Resid. Time (yrs)	0.1535
Hydraulic Resid. Time (yrs)	0.2486	Turnover Ratio	6.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.382

Appendix C: HSPF Calibration and Validation

Hydrologic Calibration and Validation for the Chippewa River HSPF Model

1 Chippewa River near Milan, Calibration

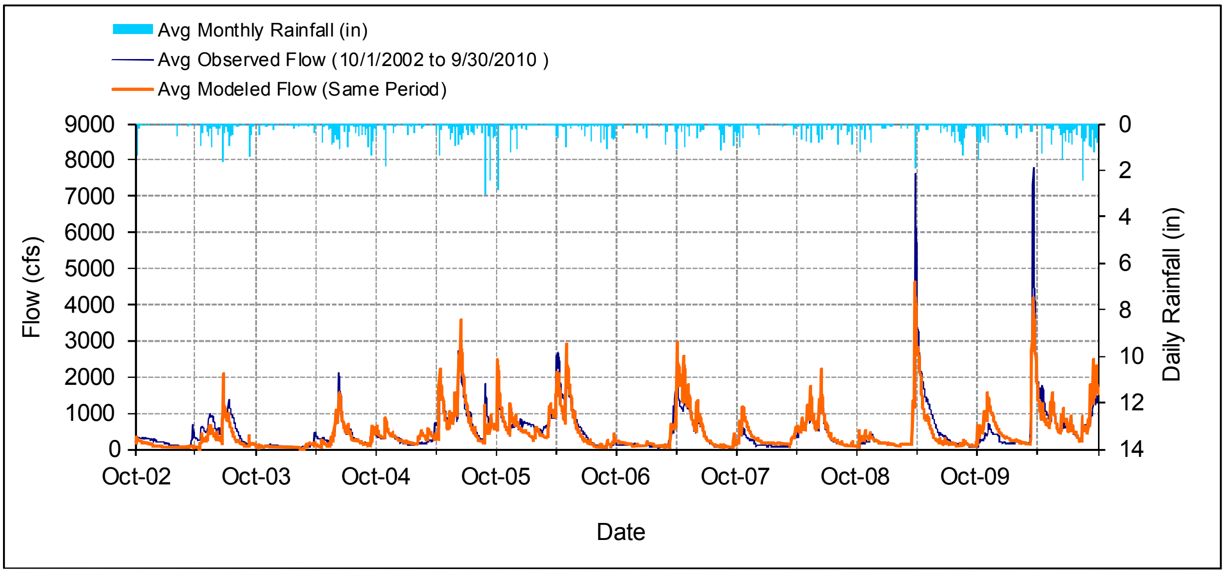


Figure 1. Mean daily flow: USGS 05304500 Chippewa River near Milan, MN (calibration)

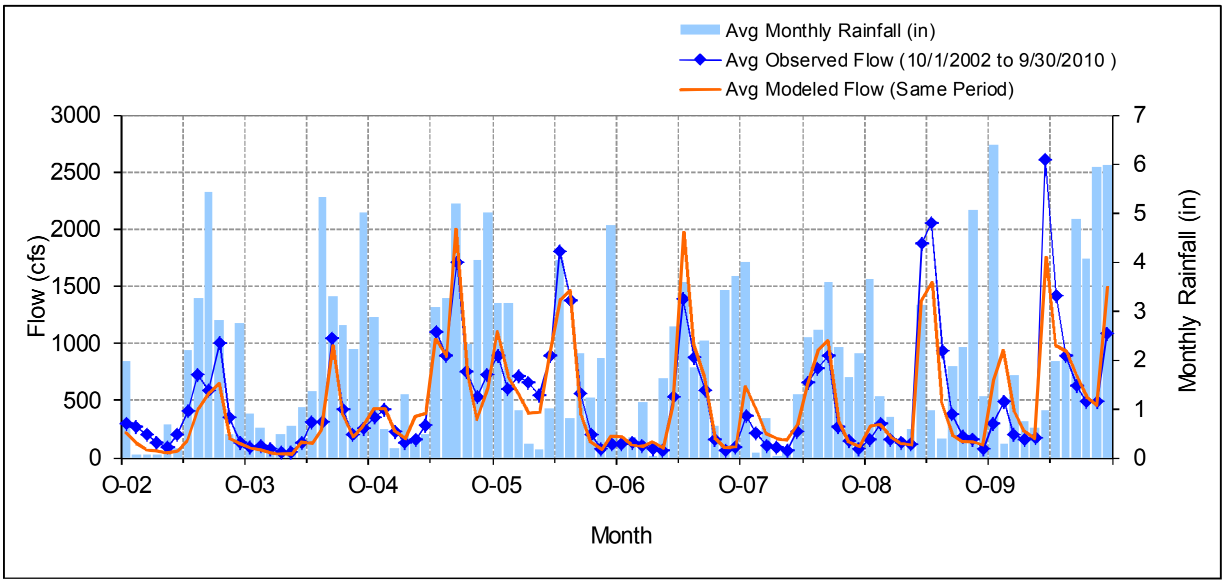


Figure 2. Mean monthly flow: USGS 05304500 Chippewa River near Milan, MN (calibration)

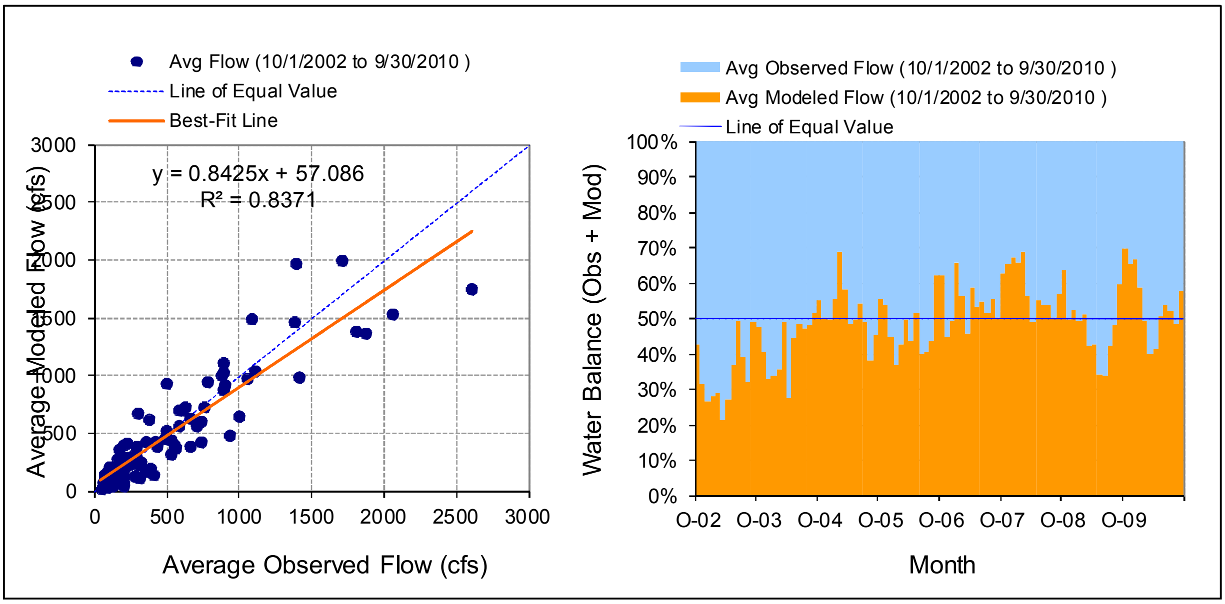


Figure 3 . Monthly flow regression and temporal variation: USGS 05304500 Chippewa River near Milan, MN (calibration)

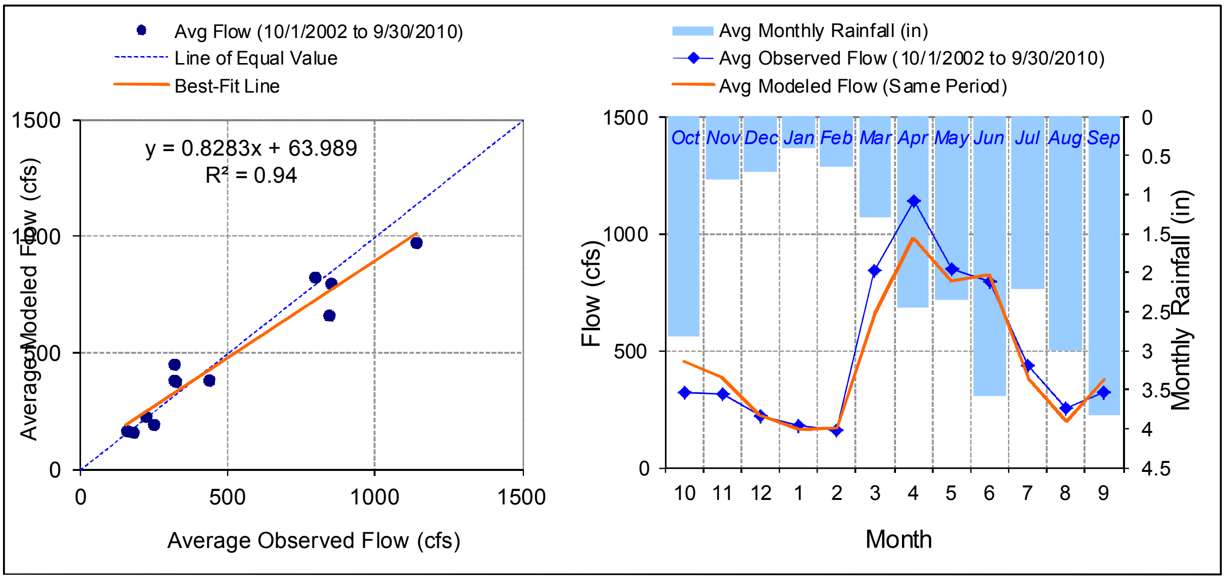


Figure 4 . Seasonal regression and temporal aggregate: USGS 05304500 Chippewa River near Milan, MN (calibration)

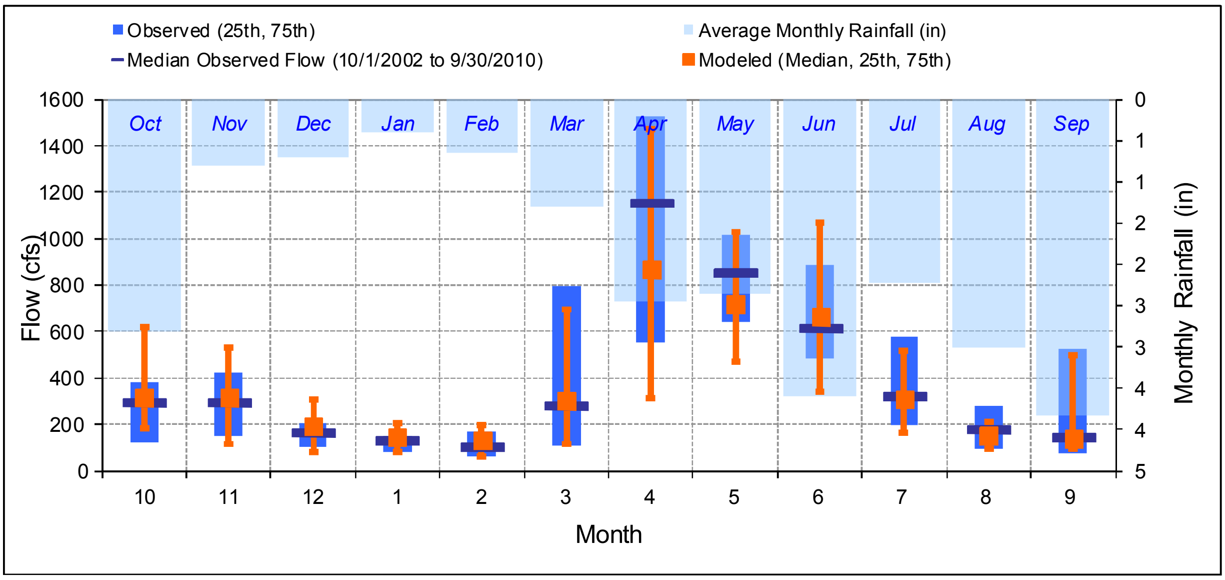


Figure 5. Seasonal medians and ranges: USGS 05304500 Chippewa River near Milan, MN (calibration)

Table 1. Seasonal summary: USGS 05304500 Chippewa River near Milan, MN (calibration)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	319.92	287.50	121.00	378.00	449.88	314.99	184.17	618.82
Nov	317.23	286.00	152.75	421.50	383.56	316.84	113.67	531.36
Dec	222.21	161.00	100.00	202.00	224.21	192.32	79.36	305.22
Jan	177.44	123.00	82.50	151.00	161.23	148.82	82.02	206.42
Feb	155.68	100.50	62.25	173.00	166.07	131.98	59.63	199.51
Mar	841.70	273.50	110.75	794.00	663.87	304.26	114.38	691.85
Apr	1140.21	1145.00	551.75	1522.50	977.36	866.15	314.15	1471.56
May	849.43	849.50	636.75	1012.50	797.39	716.01	466.80	1030.13
Jun	797.05	612.00	484.50	887.25	822.44	662.01	340.42	1068.60
Jul	437.43	318.50	194.50	578.25	380.29	306.84	162.94	520.81
Aug	250.60	177.00	92.00	281.00	195.70	155.10	97.30	213.04
Sep	322.33	137.50	75.50	525.50	376.01	140.79	95.96	494.50

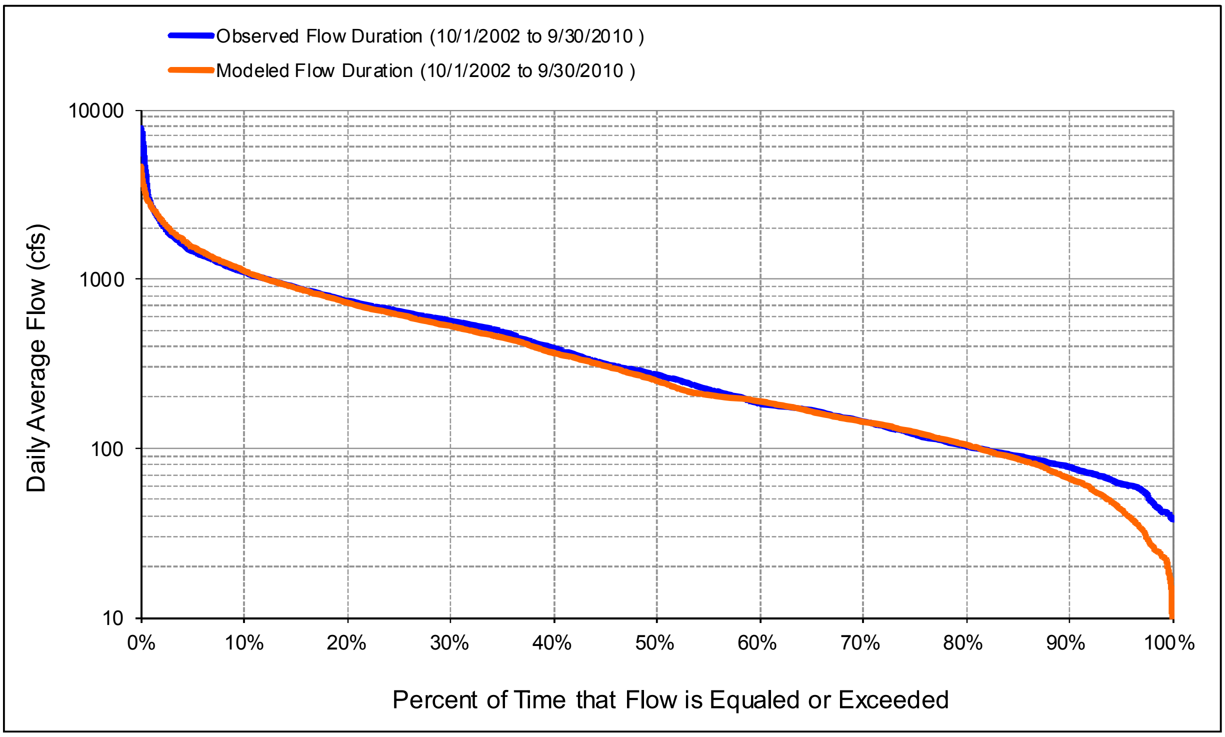


Figure 6. Flow exceedence: USGS 05304500 Chippewa River near Milan, MN (calibration)

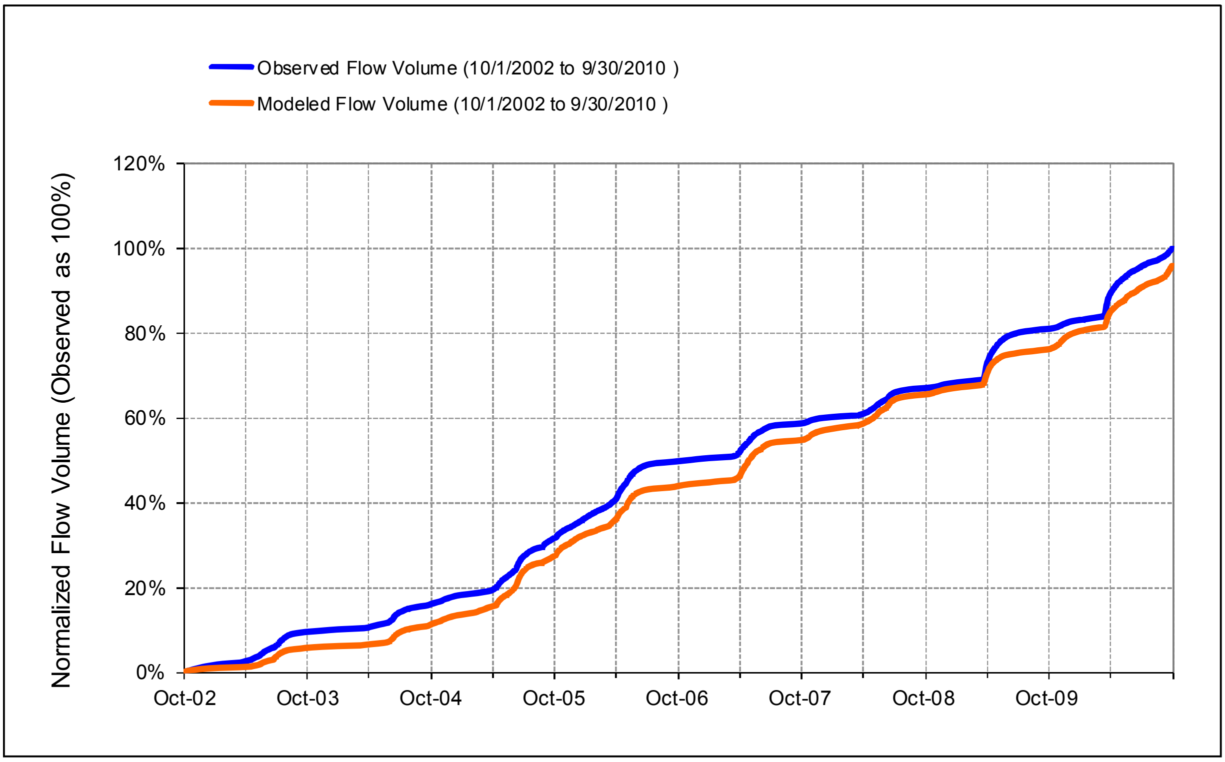


Figure 7. Flow accumulation: USGS 05304500 Chippewa River near Milan, MN (calibration)

Table 2. Summary statistics: USGS 05304500 Chippewa River near Milan, MN (calibration)

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 105 8-Year Analysis Period: 10/1/2002 - 9/30/2010 Flow volumes are (inches/year) for upstream drainage area		USGS 05304500 CHIPPEWA RIVER NEAR MILAN, MN Hydrologic Unit Code: 7020005 Latitude: 45.108292 Longitude: -95.7989224 Drainage Area (sq-mi): 1880		
Total Simulated In-stream Flow:	**3.37**	Total Observed In-stream Flow:		**3.52**
Total of simulated highest 10% flows:	**1.29**	Total of Observed highest 10% flows:		**1.34**
Total of Simulated lowest 50% flows:	**0.45**	Total of Observed Lowest 50% flows:		**0.48**
Simulated Summer Flow Volume (months 7-9):	**0.58**	Observed Summer Flow Volume (7-9):		**0.61**
Simulated Fall Flow Volume (months 10-12):	**0.64**	Observed Fall Flow Volume (10-12):		**0.52**
Simulated Winter Flow Volume (months 1-3):	**0.60**	Observed Winter Flow Volume (1-3):		**0.71**
Simulated Spring Flow Volume (months 4-6):	**1.56**	Observed Spring Flow Volume (4-6):		**1.67**
Total Simulated Storm Volume:	**0.80**	Total Observed Storm Volume:		**0.72**
Simulated Summer Storm Volume (7-9):	**0.12**	Observed Summer Storm Volume (7-9):		**0.11**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	-4.07	10	-1.81	-1.75
Error in 50% lowest flows:	-5.16	10	0.81	1.17
Error in 10% highest flows:	-4.08	15	-3.20	-2.90
Seasonal volume error - Summer:	-6.01	30	-2.73	-3.05
Seasonal volume error - Fall:	23.10 >>	30	26.44 Clear	26.69
Seasonal volume error - Winter:	-15.90	30	-13.92	-13.33
Seasonal volume error - Spring:	-6.79	30	-5.12	-5.21
Error in storm volumes:	11.14	20	10.76	12.77
Error in summer storm volumes:	16.15	50	15.51	17.84
Nash-Sutcliffe Coefficient of Efficiency, E:	0.792	Model accuracy increases	0.794	0.778
Baseline adjusted coefficient (Garrick), E':	0.604	as E or E' approaches 1.0	0.603	0.597
Monthly NSE	0.878			

2 Chippewa River near Milan, Validation

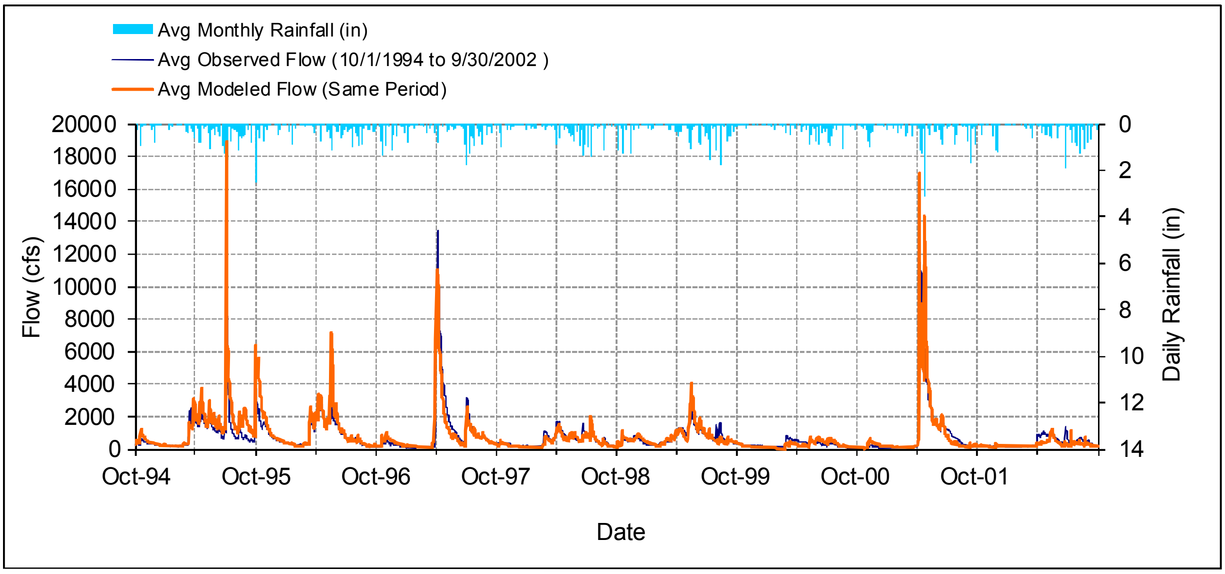


Figure 8. Mean daily flow: USGS 05304500 Chippewa River near Milan, MN (validation)

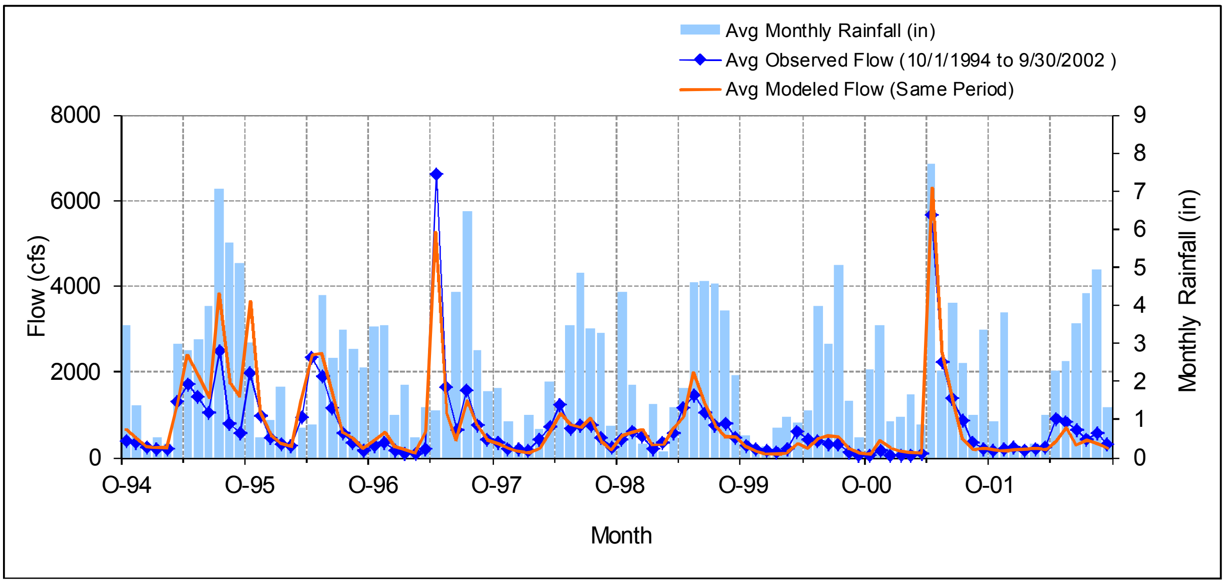


Figure 9. Mean monthly flow: USGS 05304500 Chippewa River near Milan, MN (validation)

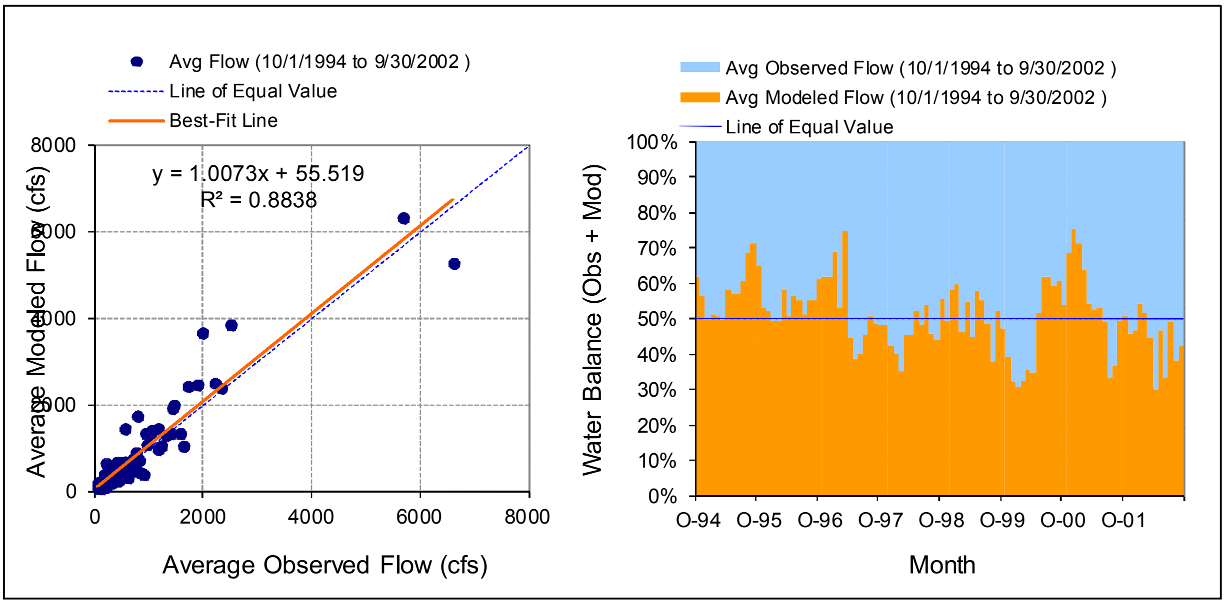


Figure 10. Monthly flow regression and temporal variation: USGS 05304500 Chippewa River near Milan, MN (validation)

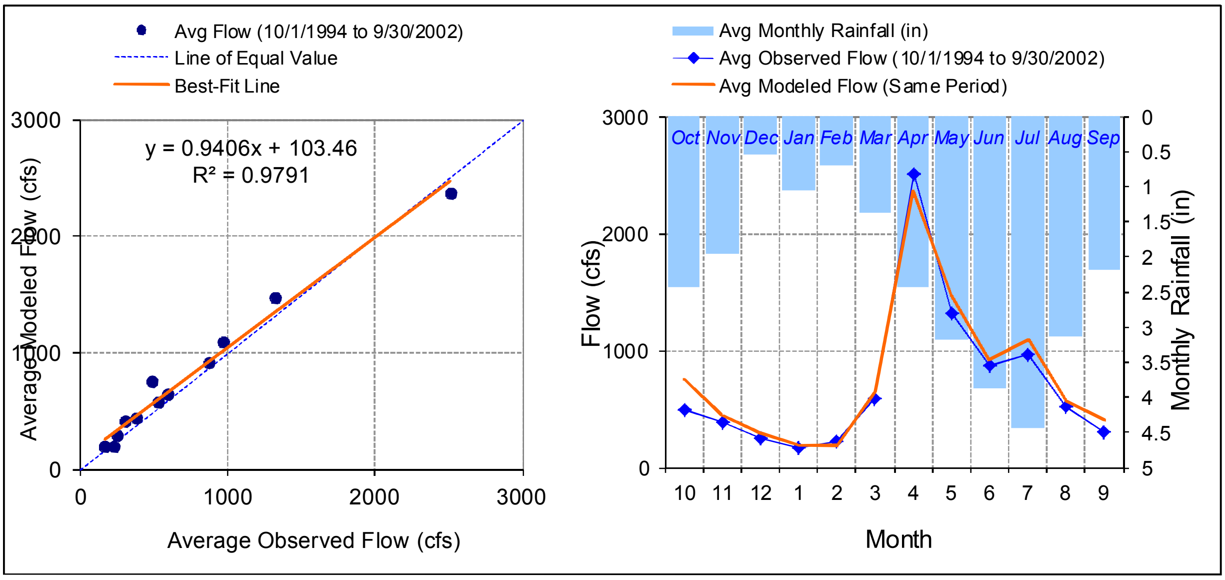


Figure 11. Seasonal regression and temporal aggregate: USGS 05304500 Chippewa River near Milan, MN (validation)

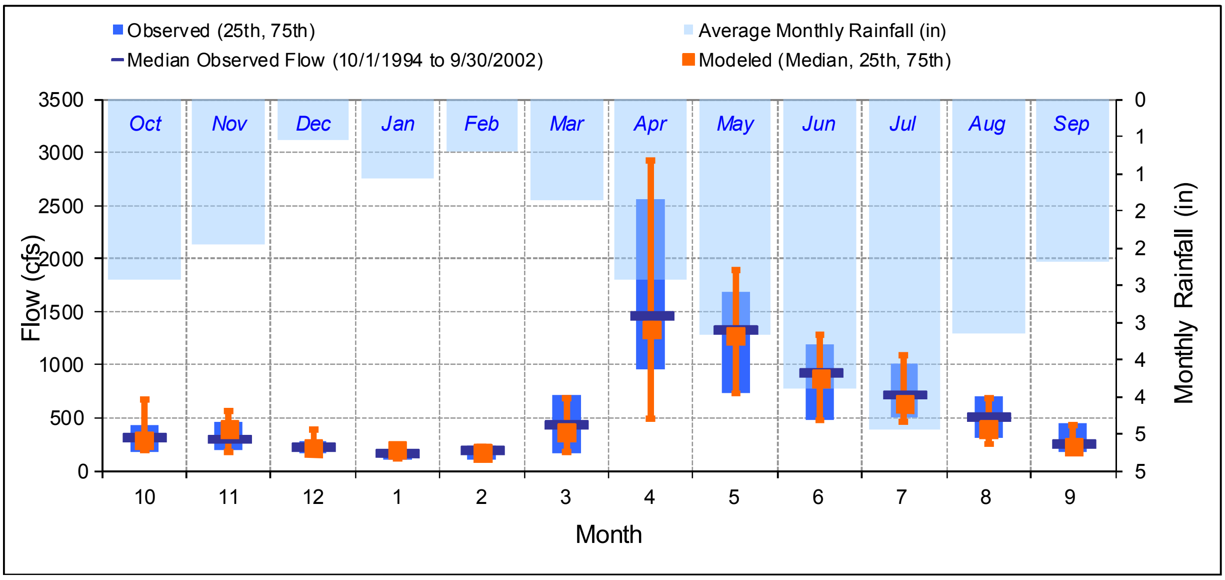


Figure 12. Seasonal medians and ranges: USGS 05304500 Chippewa River near Milan, MN (validation)

Table 3. Seasonal summary: USGS 05304500 Chippewa River near Milan, MN (validation)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	491.85	303.00	184.75	436.50	757.10	283.12	187.02	674.45
Nov	383.84	293.00	188.75	457.00	447.16	393.11	181.24	572.16
Dec	255.92	215.00	170.00	287.25	293.29	218.42	169.99	387.18
Jan	168.24	161.00	99.50	200.00	192.57	198.81	125.54	234.38
Feb	226.54	192.00	107.00	243.00	192.43	175.27	105.12	224.92
Mar	589.49	431.00	162.75	717.75	645.86	358.11	184.59	685.98
Apr	2511.04	1445.00	957.75	2562.50	2366.54	1336.75	496.63	2919.97
May	1320.76	1315.00	730.00	1680.00	1469.67	1276.68	724.90	1898.61
Jun	873.25	920.50	469.75	1190.00	921.08	870.63	469.64	1285.22
Jul	971.77	707.00	500.75	1012.50	1089.04	634.97	468.38	1093.16
Aug	525.92	499.00	310.50	704.00	570.87	388.61	246.51	684.65
Sep	307.37	240.50	182.50	441.75	409.55	228.53	186.92	439.07

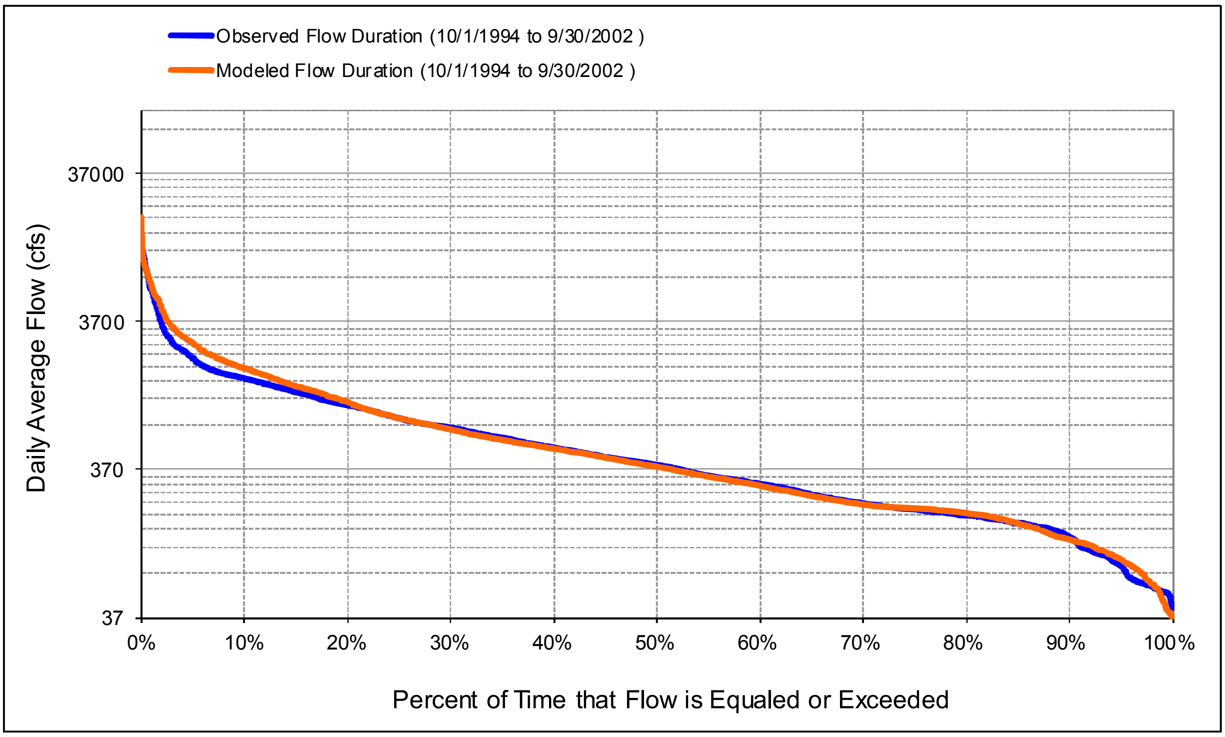


Figure 13. Flow exceedence: USGS 05304500 Chippewa River near Milan, MN (validation)

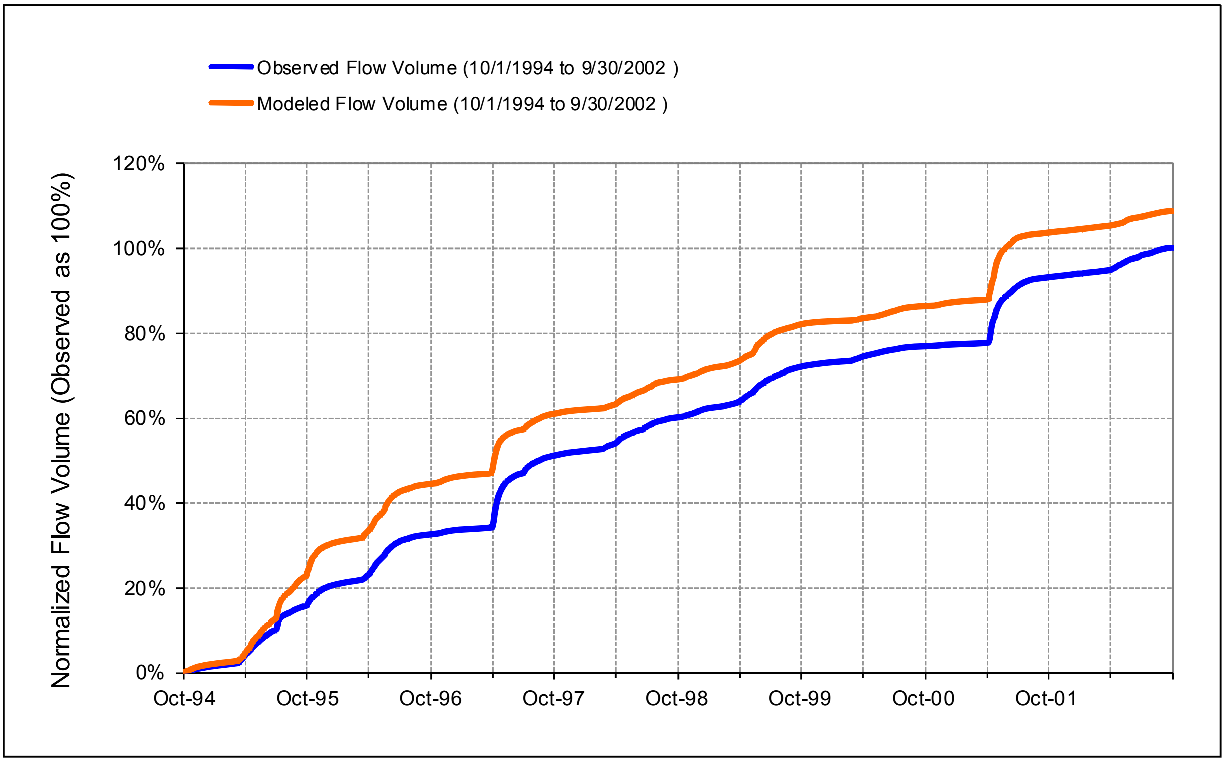


Figure 14. Flow accumulation: USGS 05304500 Chippewa River near Milan, MN (validation)

Table 4. Summary statistics: USGS 05304500 Chippewa River near Milan, MN (validation)

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 105 8-Year Analysis Period: 10/1/1994 - 9/30/2002 Flow volumes are (inches/year) for upstream drainage area		USGS 05304500 CHIPPEWA RIVER NEAR MILAN, MN Hydrologic Unit Code: 7020005 Latitude: 45.108292 Longitude: -95.7989224 Drainage Area (sq-mi): 1880		
Total Simulated In-stream Flow:	**5.64**	Total Observed In-stream Flow:		**5.20**
Total of simulated highest 10% flows:	**2.55**	Total of Observed highest 10% flows:		**2.18**
Total of Simulated lowest 50% flows:	**0.74**	Total of Observed Lowest 50% flows:		**0.75**
Simulated Summer Flow Volume (months 7-9):	**1.26**	Observed Summer Flow Volume (7-9):		**1.10**
Simulated Fall Flow Volume (months 10-12):	**0.91**	Observed Fall Flow Volume (10-12):		**0.69**
Simulated Winter Flow Volume (months 1-3):	**0.62**	Observed Winter Flow Volume (1-3):		**0.59**
Simulated Spring Flow Volume (months 4-6):	**2.85**	Observed Spring Flow Volume (4-6):		**2.82**
Total Simulated Storm Volume:	**1.45**	Total Observed Storm Volume:		**1.14**
Simulated Summer Storm Volume (7-9):	**0.35**	Observed Summer Storm Volume (7-9):		**0.27**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	8.61	10	10.31	8.55
Error in 50% lowest flows:	-0.75	10	3.20	2.05
Error in 10% highest flows:	**16.93**	**15**	**17.59**	**15.67**
Seasonal volume error - Summer:	14.55	30	16.59	14.82
Seasonal volume error - Fall:	**32.51** >>	**30**	**35.25**	Clear **30.31**
Seasonal volume error - Winter:	5.15	30	7.02	5.16
Seasonal volume error - Spring:	1.20	30	2.47	1.51
Error in storm volumes:	**27.27**	**20**	**26.38**	**26.08**
Error in summer storm volumes:	27.92	50	26.76	26.61
Nash-Sutcliffe Coefficient of Efficiency, E:	0.700	Model accuracy increases	0.692	0.705
Baseline adjusted coefficient (Garrick), E':	0.571	as E or E' approaches 1.0	0.566	0.583
Monthly NSE	0.883			

3 Chippewa River near Cyrus

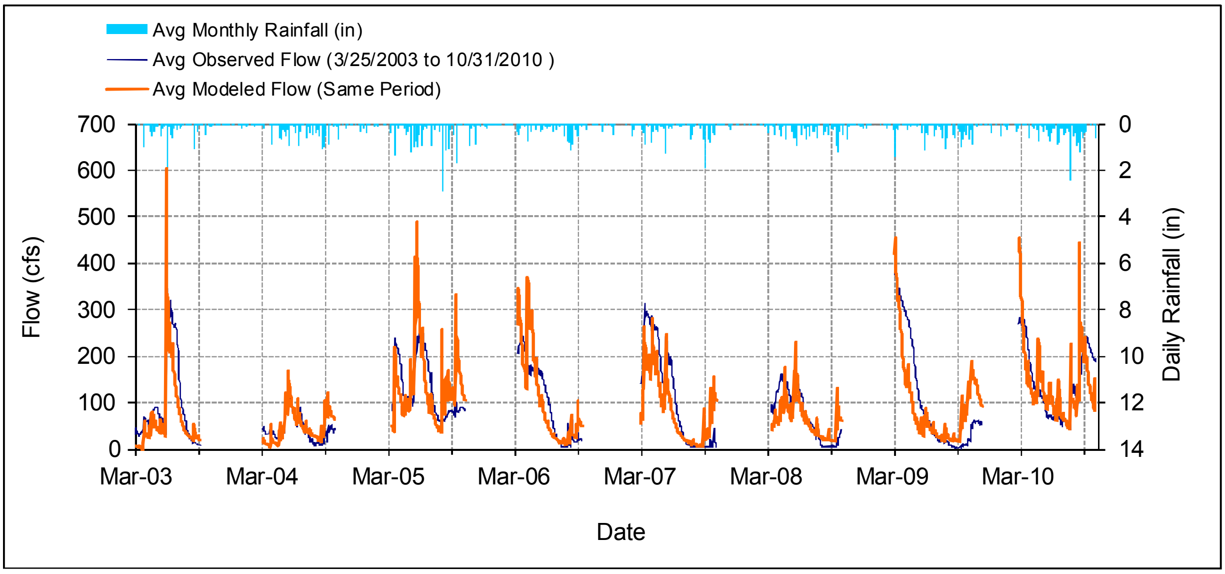


Figure 15. Mean daily flow: 26003001 Chippewa River at Cyrus, MN

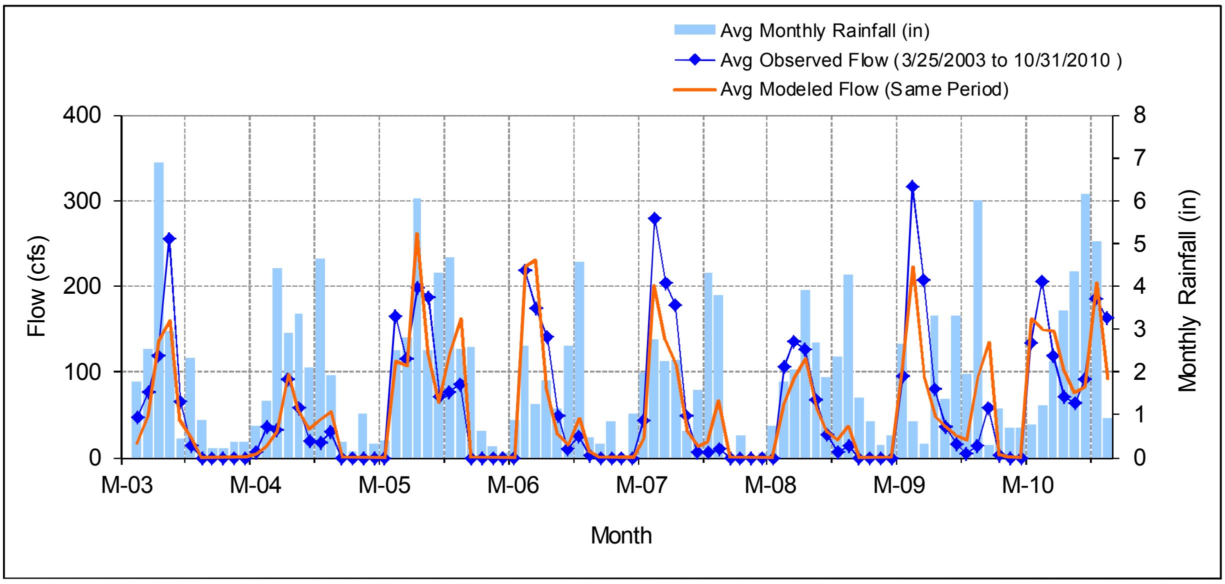


Figure 16. Mean monthly flow: 26003001 Chippewa River at Cyrus, MN

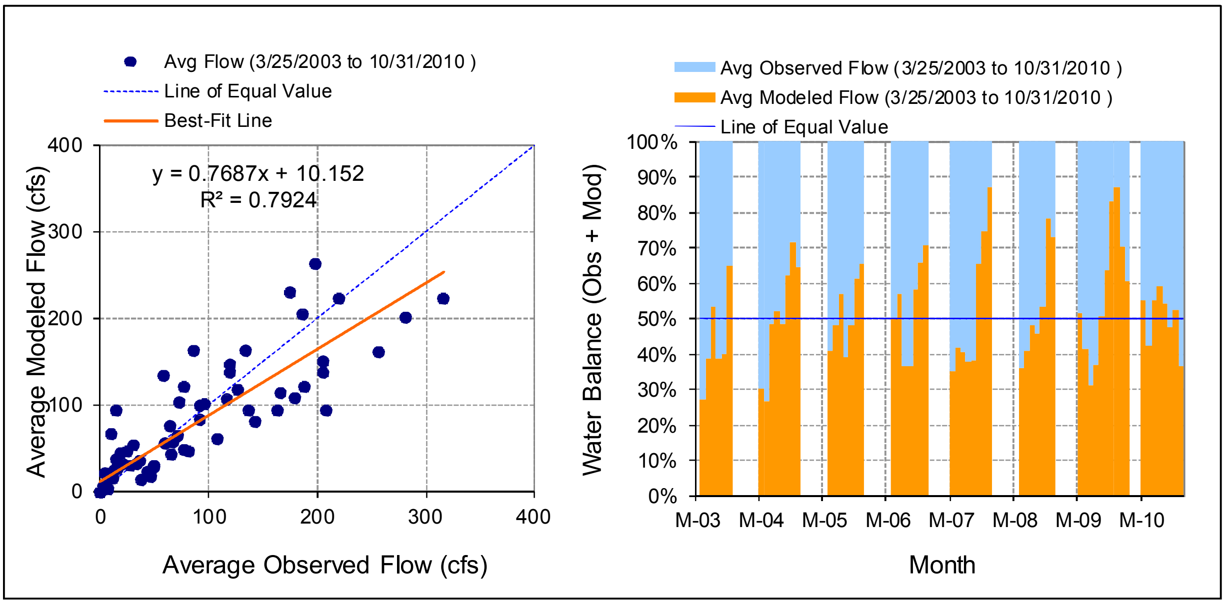


Figure 17. Monthly flow regression and temporal variation: 26003001 Chippewa River at Cyrus, MN

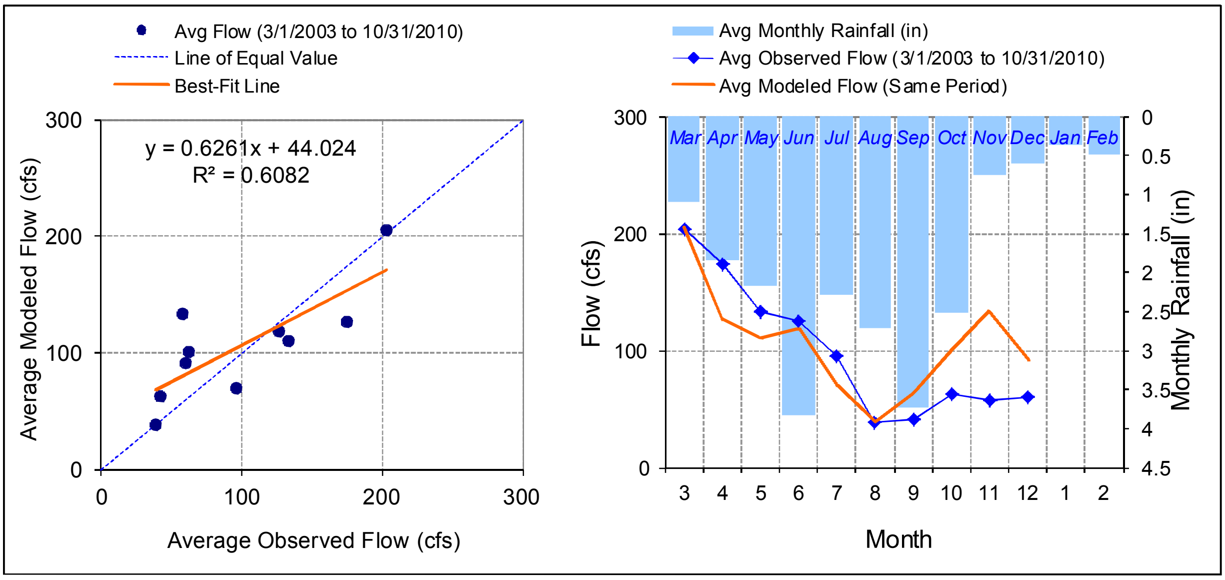


Figure 18. Seasonal regression and temporal aggregate: 26003001 Chippewa River at Cyrus, MN

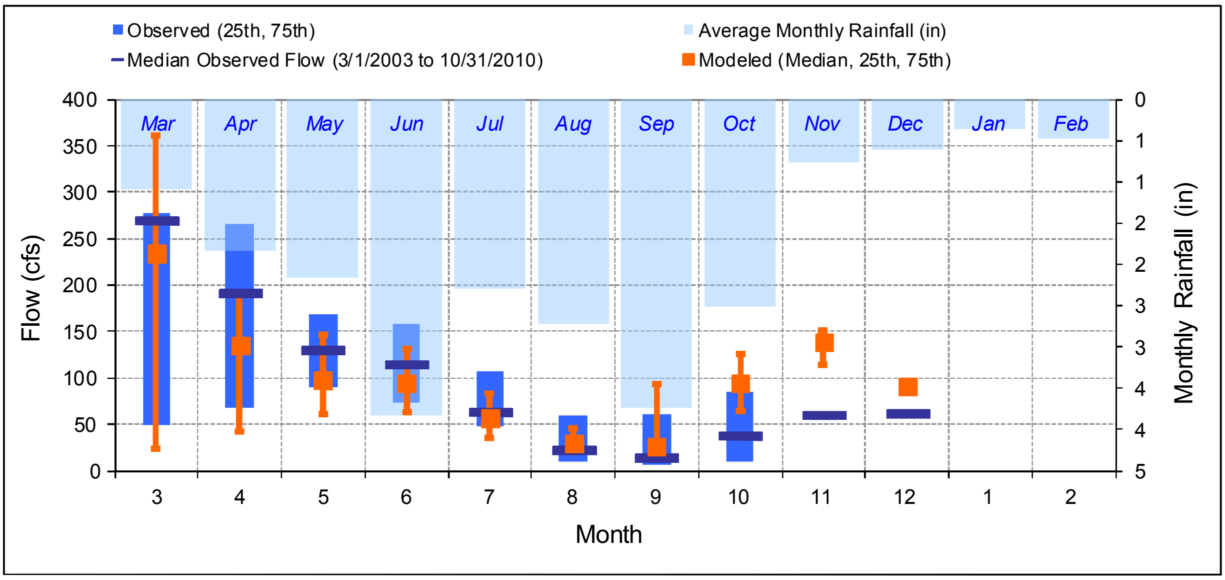


Figure 19. Seasonal medians and ranges: 26003001 Chippewa River at Cyrus, MN

Table 5. Seasonal summary: 26003001 Chippewa River at Cyrus, MN

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	202.91	268.00	49.32	278.25	205.72	234.23	23.13	360.28
Apr	174.02	189.77	68.53	265.94	126.65	135.11	41.89	189.19
May	133.13	129.00	90.99	167.91	111.03	98.30	61.01	146.77
Jun	125.59	113.99	73.00	158.71	119.08	94.89	63.17	130.90
Jul	95.58	62.98	47.90	106.65	70.45	56.37	35.70	83.75
Aug	38.30	22.01	9.77	60.42	38.69	29.98	19.77	45.97
Sep	41.84	12.93	6.04	60.80	62.89	25.93	20.02	94.42
Oct	62.35	36.87	10.04	85.76	100.57	94.19	64.95	125.65
Nov	57.37	58.50	55.00	61.00	134.04	138.87	113.63	151.00
Dec	60.00	60.00	60.00	60.00	91.65	91.65	91.65	91.65
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

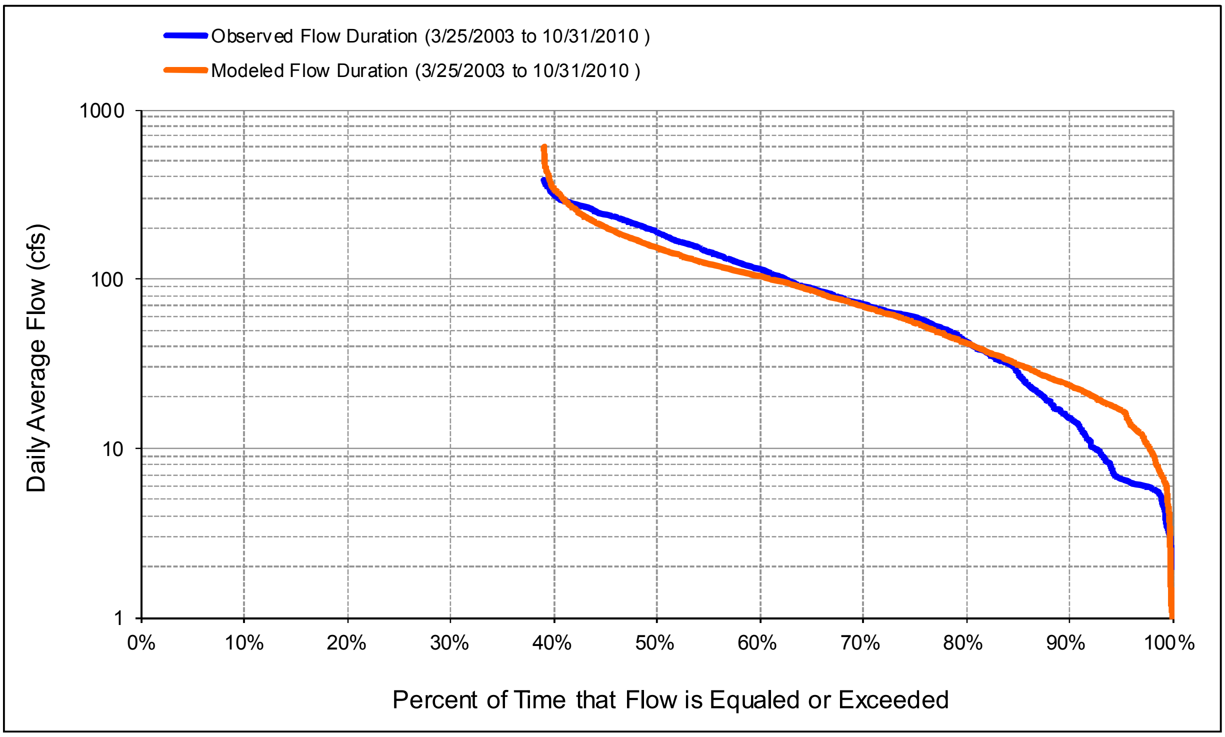


Figure 20. Flow exceedence: 26003001 Chippewa River at Cyrus, MN

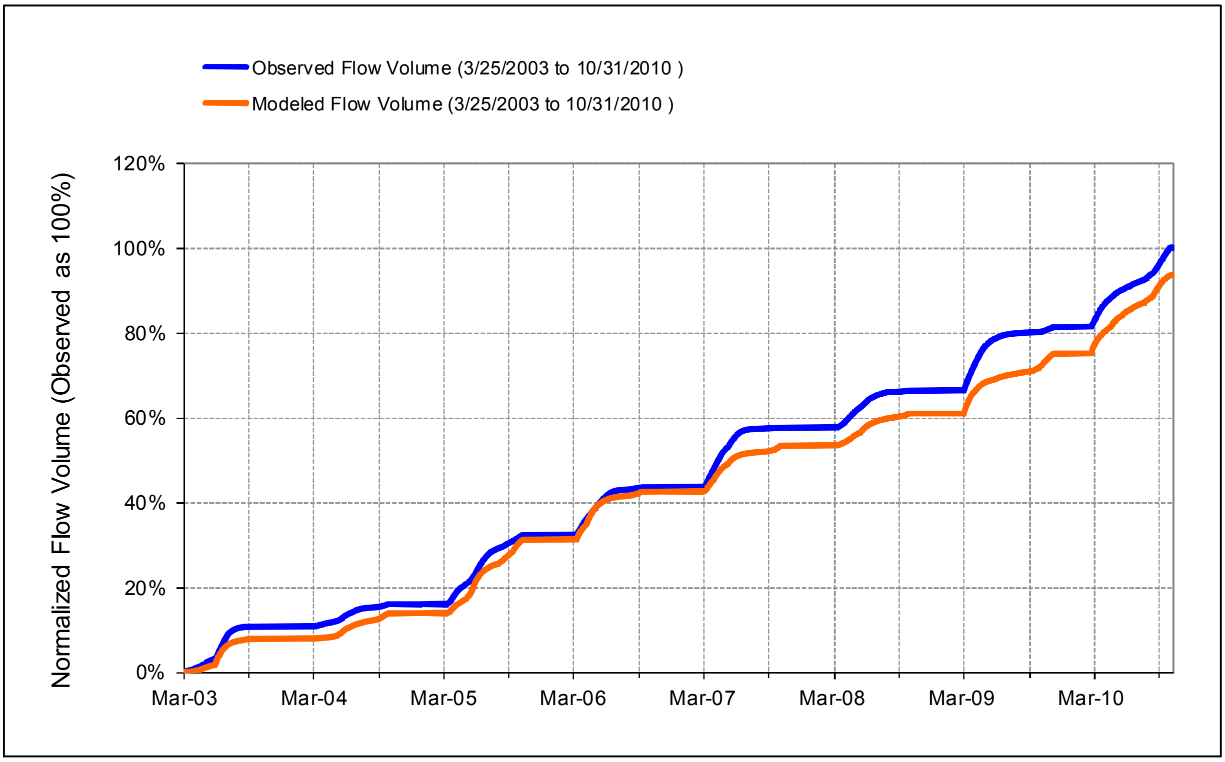


Figure 21. Flow accumulation: 26003001 Chippewa River at Cyrus, MN

Table 6. Summary statistics: 26003001 Chippewa River at Cyrus, MN

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 101 7.61-Year Analysis Period: 3/1/2003 - 10/31/2010 Flow volumes are (inches/year) for upstream drainage area		CHIPPEWA RIVER AT CYRUS Manually Entered Data Drainage Area (sq-mi): 342		
Total Simulated In-stream Flow:	**2.25**	Total Observed In-stream Flow:		**2.40**
Total of simulated highest 10% flows:	**0.68**	Total of Observed highest 10% flows:		**0.68**
Total of Simulated lowest 50% flows:	**0.42**	Total of Observed Lowest 50% flows:		**0.39**
Simulated Summer Flow Volume (months 7-9):	**0.60**	Observed Summer Flow Volume (7-9):		**0.62**
Simulated Fall Flow Volume (months 10-12):	**0.29**	Observed Fall Flow Volume (10-12):		**0.17**
Simulated Winter Flow Volume (months 1-3):	**0.13**	Observed Winter Flow Volume (1-3):		**0.13**
Simulated Spring Flow Volume (months 4-6):	**1.23**	Observed Spring Flow Volume (4-6):		**1.49**
Total Simulated Storm Volume:	**0.40**	Total Observed Storm Volume:		**0.23**
Simulated Summer Storm Volume (7-9):	**0.10**	Observed Summer Storm Volume (7-9):		**0.08**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	-6.47	10	-6.64	-6.52
Error in 50% lowest flows:	8.30	10	7.42	4.21
Error in 10% highest flows:	-1.22	15	-1.14	0.76
Seasonal volume error - Summer:	-2.56	30	-2.92	-6.90
Seasonal volume error - Fall:	71.97 >>	30	72.28 Clear	71.27
Seasonal volume error - Winter:	1.39	30	1.39	7.42
Seasonal volume error - Spring:	-17.50	30	-17.66	-16.22
Error in storm volumes:	75.26	20	78.11	79.86
Error in summer storm volumes:	30.95	50	34.95	30.89
Nash-Sutcliffe Coefficient of Efficiency, E:	0.574	Model accuracy increases	0.569	0.577
Baseline adjusted coefficient (Garrick), E':	0.424	as E or E' approaches 1.0	0.420	0.431
Monthly NSE	0.916			

4 Dry Weather Creek near Watson

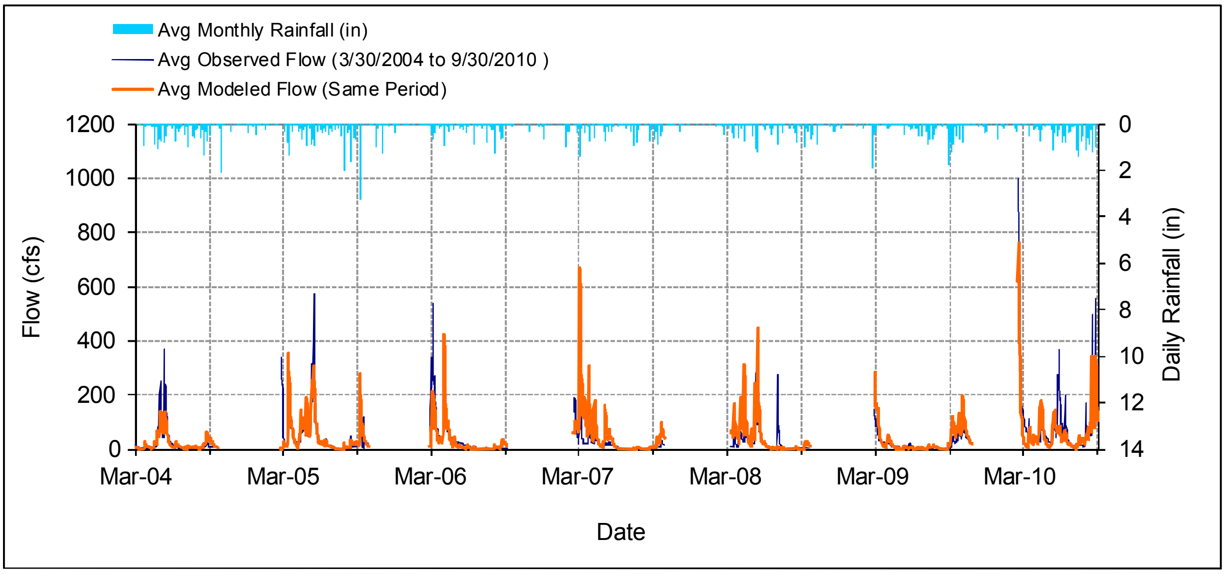


Figure 22. Mean daily flow: 26078001 Dry Weather Creek near Watson, MN

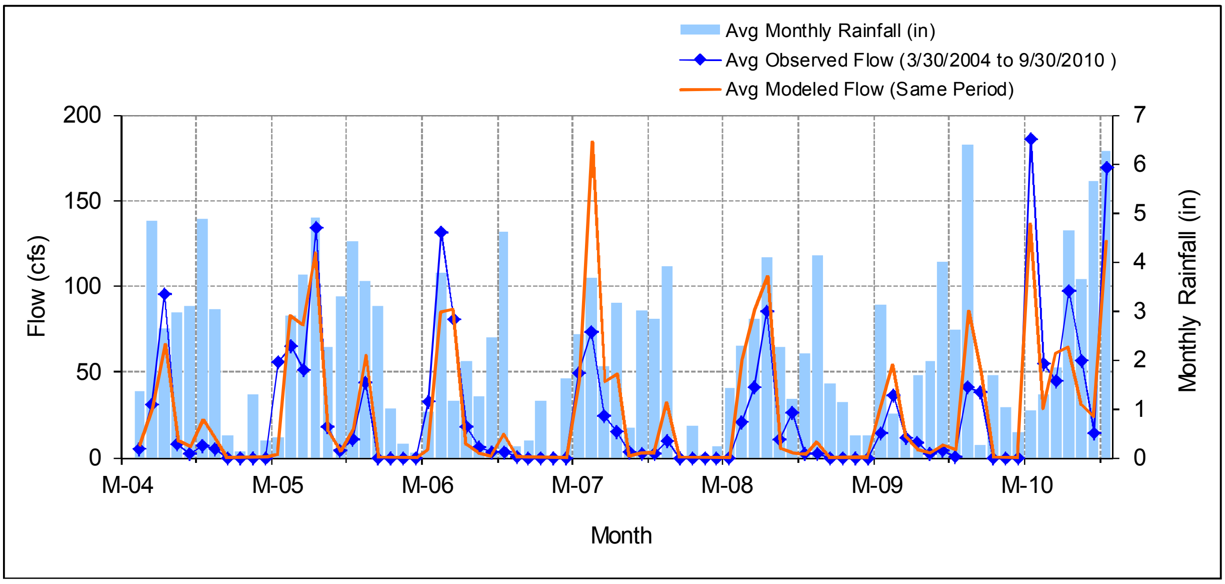


Figure 23. Mean monthly flow: 26078001 Dry Weather Creek near Watson, MN

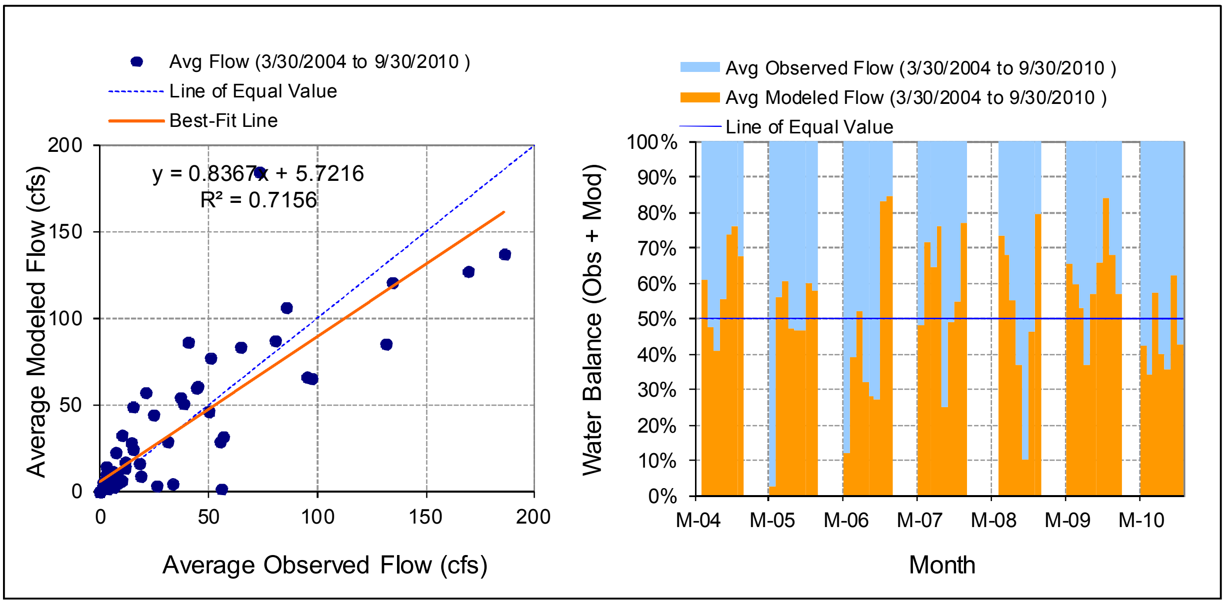


Figure 24. Monthly flow regression and temporal variation: 26078001 Dry Weather Creek near Watson, MN

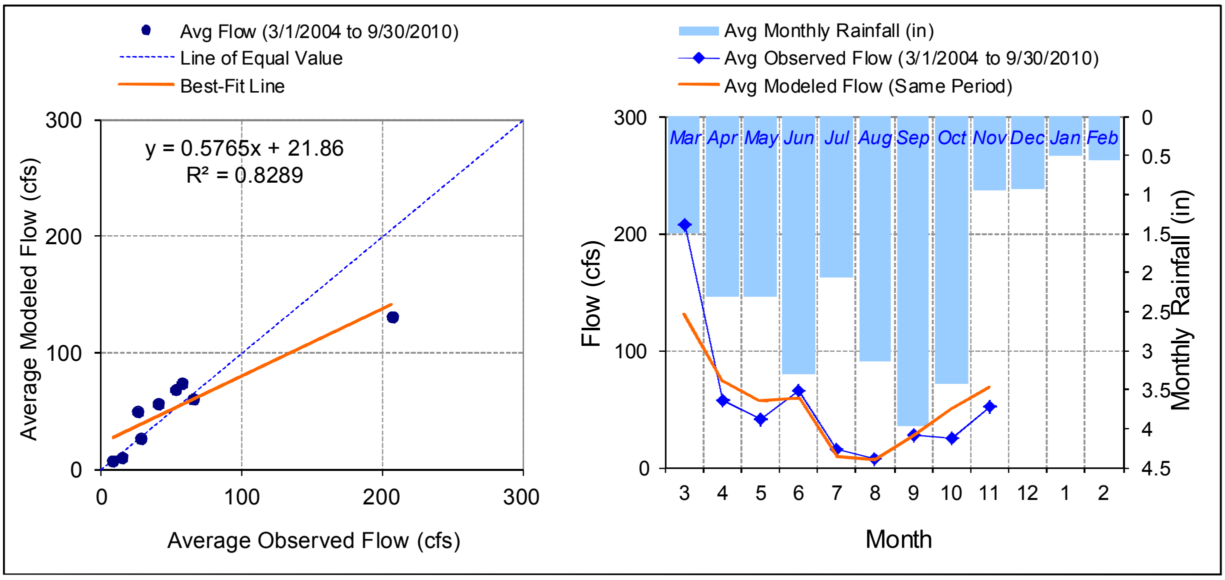


Figure 25. Seasonal regression and temporal aggregate: 26078001 Dry Weather Creek near Watson, MN

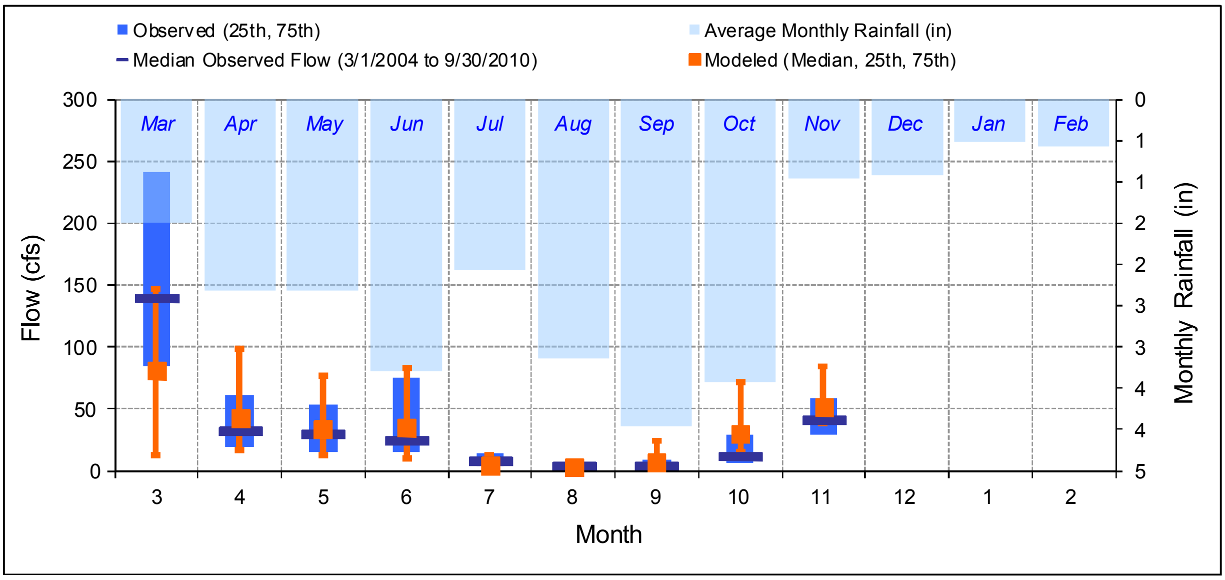


Figure 26. Seasonal medians and ranges: 26078001 Dry Weather Creek near Watson, MN

Table 7. Seasonal summary: 26078001 Dry Weather Creek near Watson, MN

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	206.86	138.00	84.50	240.94	131.24	81.64	13.06	146.79
Apr	57.12	31.00	19.00	61.00	73.80	42.85	17.02	98.08
May	40.55	29.00	15.00	53.88	56.62	33.63	12.47	76.77
Jun	64.92	24.03	15.87	74.75	59.92	35.08	9.95	83.10
Jul	14.88	6.40	3.70	14.00	9.88	4.97	1.91	13.06
Aug	8.07	3.14	2.40	6.90	6.84	3.76	1.00	7.73
Sep	27.96	2.80	2.19	9.18	27.06	6.86	1.57	24.47
Oct	25.36	11.12	6.10	29.00	49.48	30.49	14.73	71.27
Nov	52.64	40.50	29.50	59.00	69.21	52.27	38.06	84.86
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

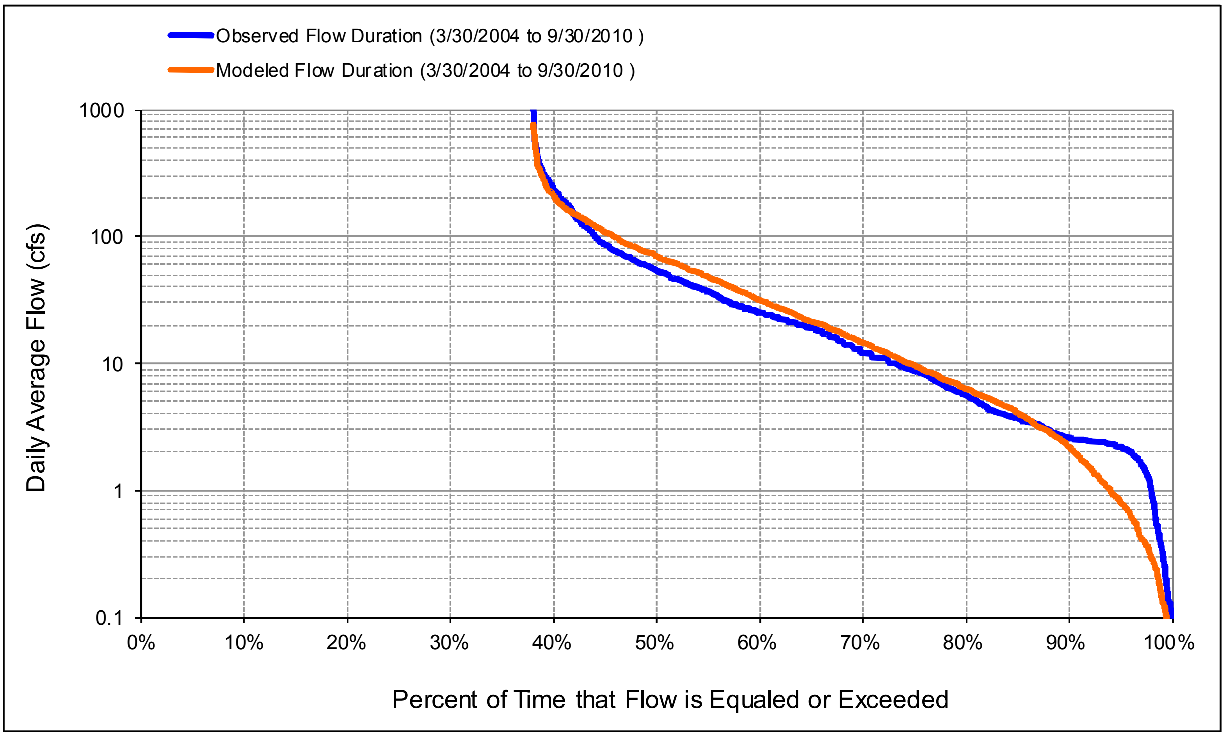


Figure 27. Flow exceedence: 26078001 Dry Weather Creek near Watson, MN

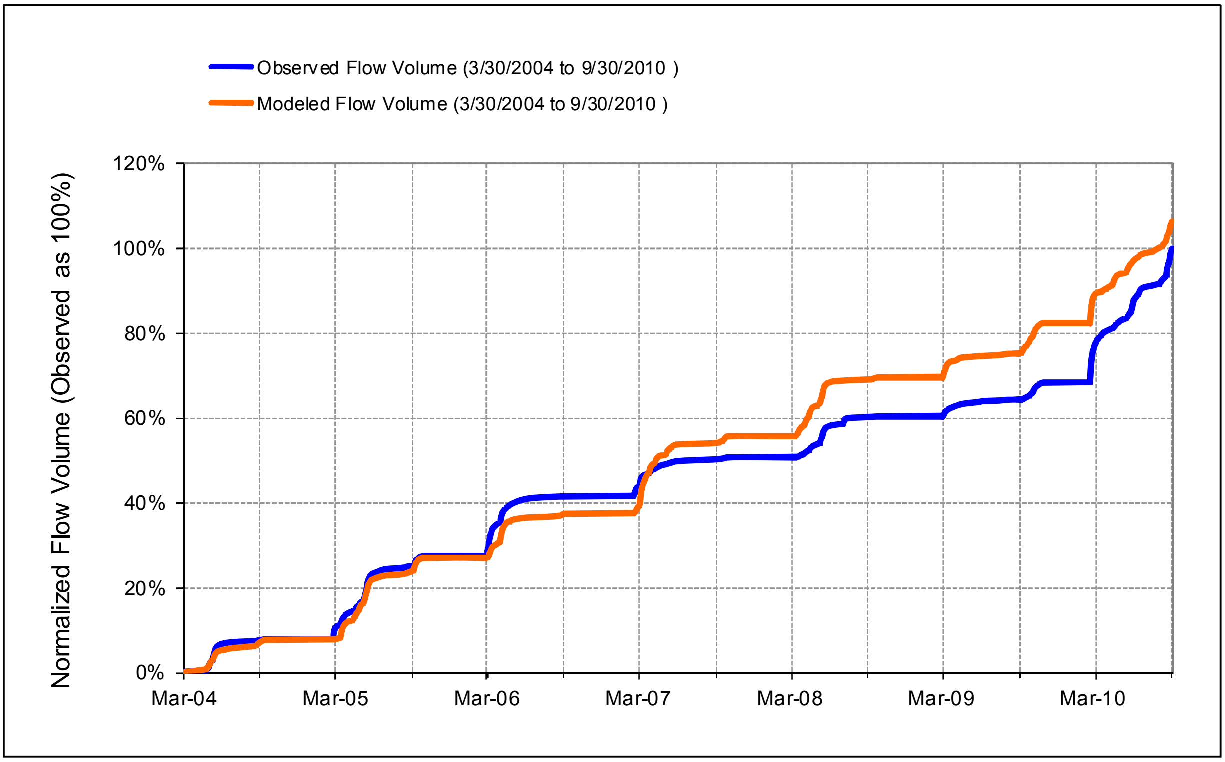


Figure 28. Flow accumulation: 26078001 Dry Weather Creek near Watson, MN

Table 8. Summary statistics: 26078001 Dry Weather Creek near Watson, MN

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 104 6.51-Year Analysis Period: 3/1/2004 - 9/30/2010 Flow volumes are (inches/year) for upstream drainage area		DRY WEATHER CREEK NEAR WATSON Manually Entered Data Drainage Area (sq-mi): 105		
Total Simulated In-stream Flow:	**3.46**	Total Observed In-stream Flow:		**3.25**
Total of simulated highest 10% flows:	**1.69**	Total of Observed highest 10% flows:		**1.82**
Total of Simulated lowest 50% flows:	**0.21**	Total of Observed Lowest 50% flows:		**0.20**
Simulated Summer Flow Volume (months 7-9):	**0.51**	Observed Summer Flow Volume (7-9):		**0.59**
Simulated Fall Flow Volume (months 10-12):	**0.42**	Observed Fall Flow Volume (10-12):		**0.24**
Simulated Winter Flow Volume (months 1-3):	**0.36**	Observed Winter Flow Volume (1-3):		**0.57**
Simulated Spring Flow Volume (months 4-6):	**2.17**	Observed Spring Flow Volume (4-6):		**1.85**
Total Simulated Storm Volume:	**1.27**	Total Observed Storm Volume:		**1.18**
Simulated Summer Storm Volume (7-9):	**0.18**	Observed Summer Storm Volume (7-9):		**0.26**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	6.37	10	6.37	-2.95
Error in 50% lowest flows:	5.44	10	5.44	-2.19
Error in 10% highest flows:	-7.42	15	-7.41	-16.08
Seasonal volume error - Summer:	-14.19	30	-14.19	-19.20
Seasonal volume error - Fall:	**78.07** >>	**30**	**78.07** Clear	**53.81**
Seasonal volume error - Winter:	**-36.56**	**30**	**-36.56**	**-43.69**
Seasonal volume error - Spring:	17.11	30	17.11	7.64
Error in storm volumes:	7.62	20	7.64	0.99
Error in summer storm volumes:	-28.63	50	-28.62	-33.90
Nash-Sutcliffe Coefficient of Efficiency, E:	0.618	Model accuracy increases	0.618	0.618
Baseline adjusted coefficient (Garrick), E':	0.445	as E or E' approaches 1.0	0.445	0.454
Monthly NSE	0.907			

5 Shakopee Creek near Benson

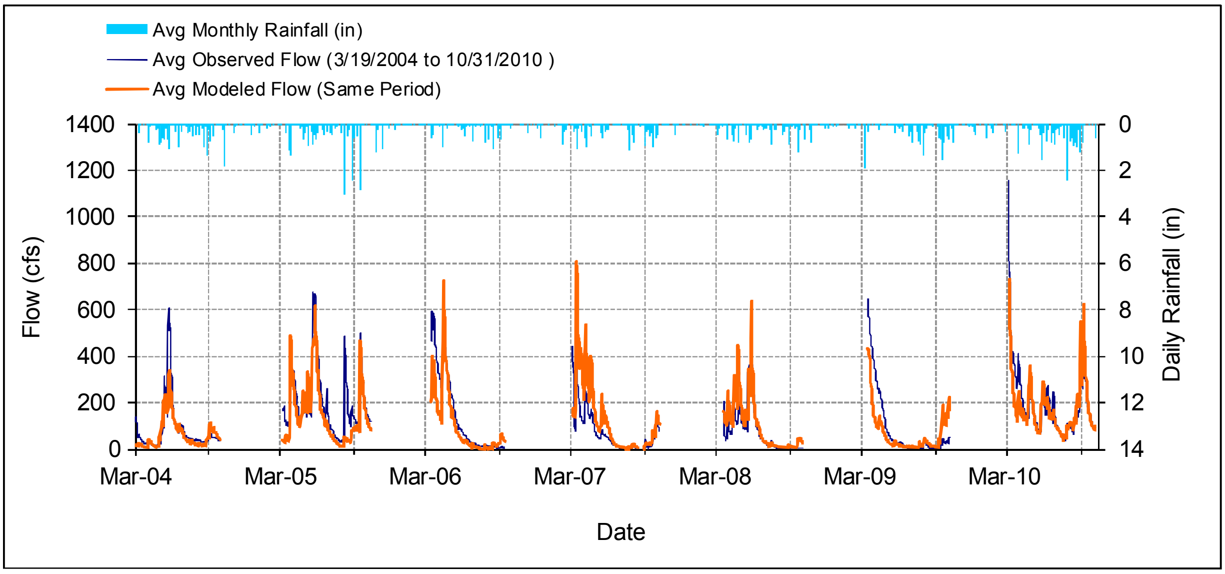


Figure 29. Mean daily flow: 26038001 Shakopee Creek near Benson, MN

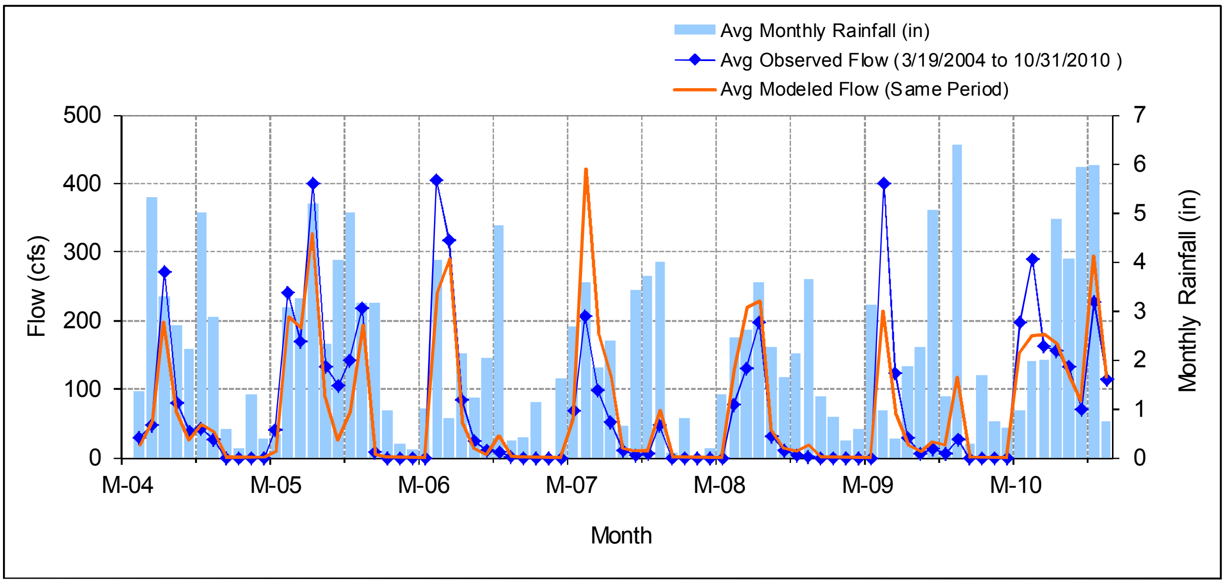


Figure 30. Mean monthly flow: 26038001 Shakopee Creek near Benson, MN

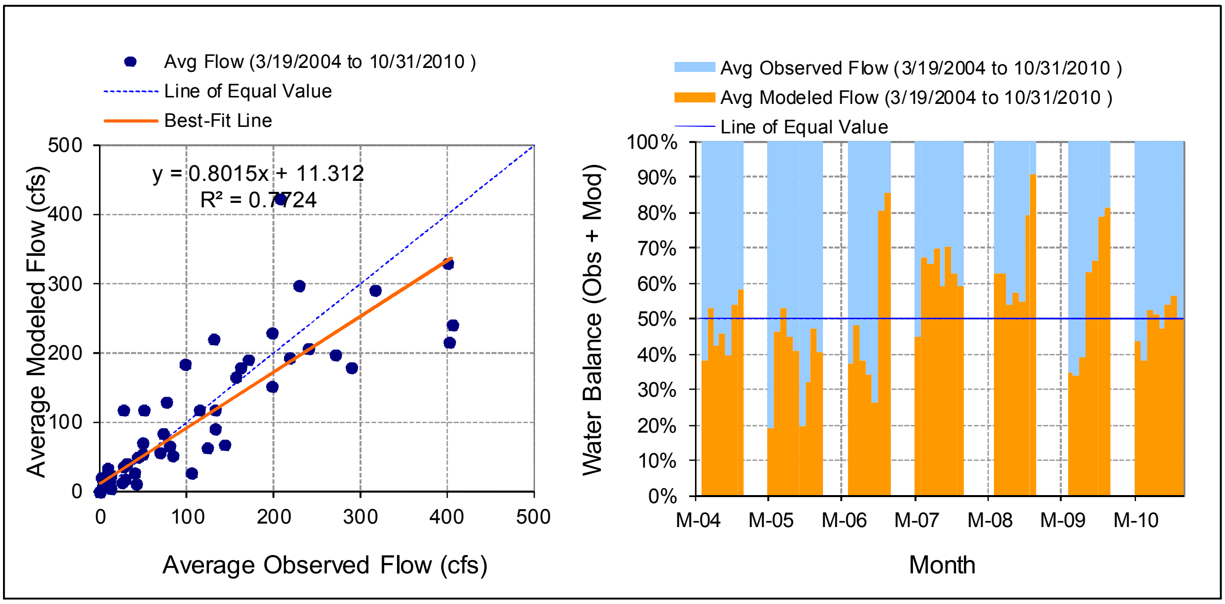


Figure 31. Monthly flow regression and temporal variation: 26038001 Shakopee Creek near Benson, MN

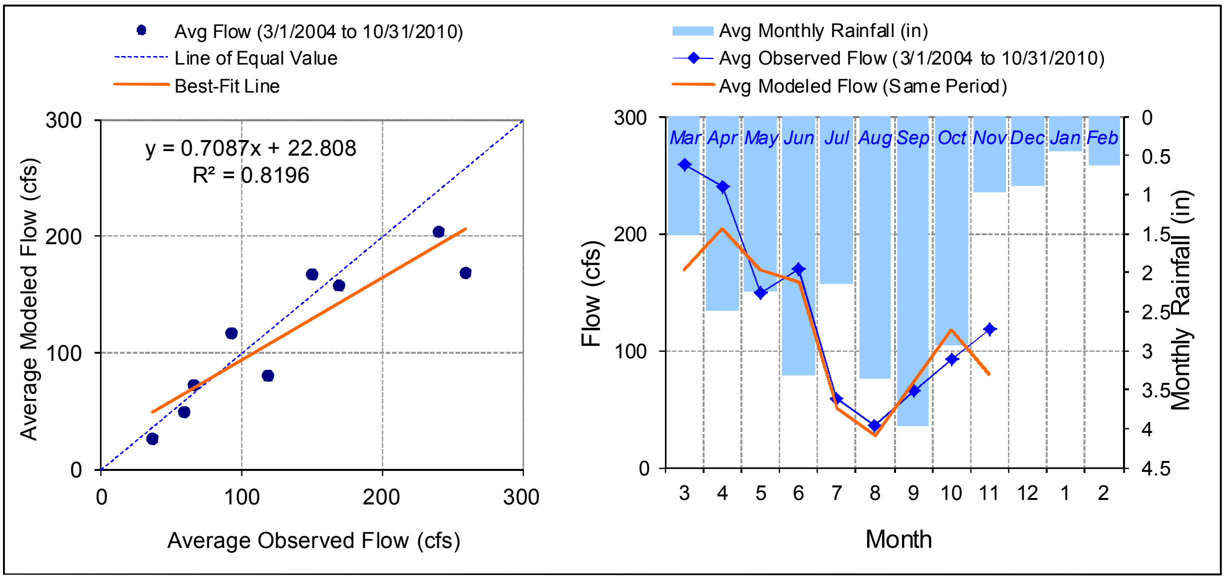


Figure 32. Seasonal regression and temporal aggregate: 26038001 Shakopee Creek near Benson, MN

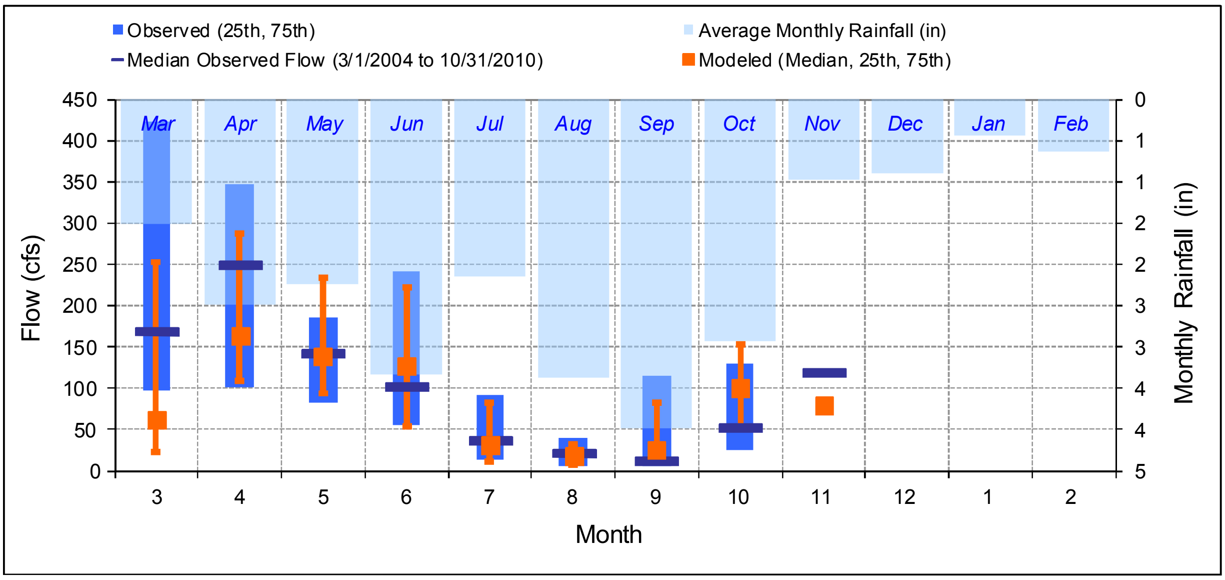


Figure 33. Seasonal medians and ranges: 26038001 Shakopee Creek near Benson, MN

Table 9. Seasonal summary: 26038001 Shakopee Creek near Benson, MN

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	258.96	166.61	98.36	424.00	169.54	62.89	22.55	253.00
Apr	239.57	248.29	100.92	345.75	204.64	164.40	109.21	287.53
May	149.38	140.29	82.32	185.00	168.31	138.88	94.01	233.34
Jun	169.24	100.20	55.55	242.00	157.73	126.53	54.19	222.83
Jul	58.88	35.00	12.46	91.77	49.95	31.63	11.35	82.21
Aug	36.20	21.00	6.20	40.89	26.38	17.52	6.71	31.61
Sep	65.59	10.88	4.93	115.53	73.04	25.72	13.92	81.89
Oct	91.90	51.45	25.50	129.88	117.07	101.44	51.31	153.04
Nov	118.06	118.06	117.03	119.09	80.38	80.38	79.47	81.30
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

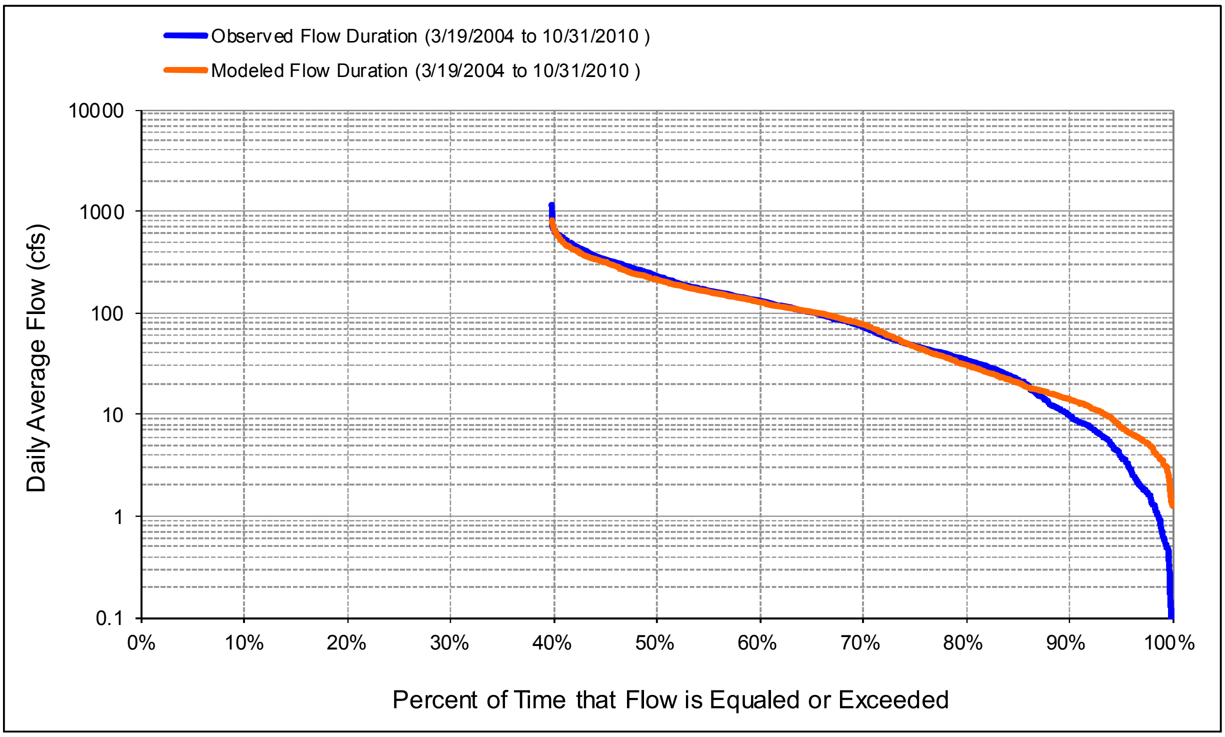


Figure 34. Flow exceedence: 26038001 Shakopee Creek near Benson, MN

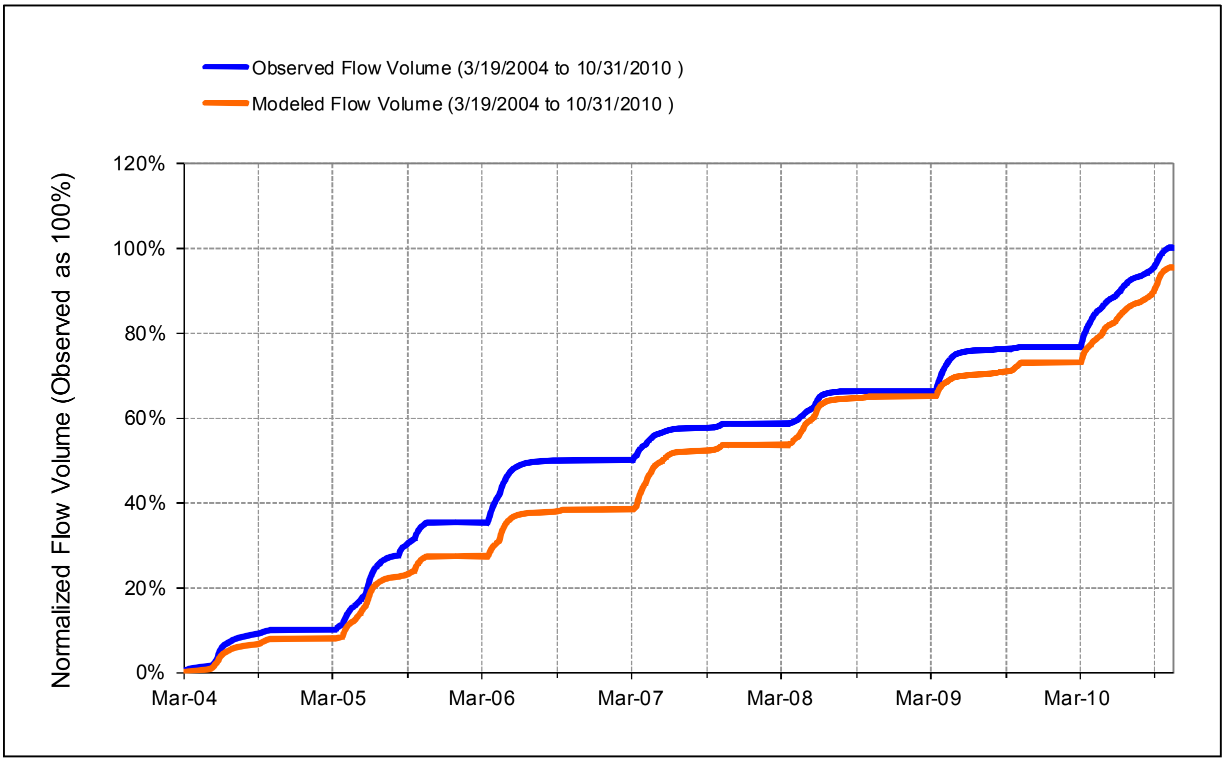


Figure 35. Flow accumulation: 26038001 Shakopee Creek near Benson, MN

Table 10. Summary statistics: 26038001 Shakopee Creek near Benson, MN

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 103 6.62-Year Analysis Period: 3/1/2004 - 10/31/2010 Flow volumes are (inches/year) for upstream drainage area		SHAKOPEE CREEK NEAR BENSON Manually Entered Data Drainage Area (sq-mi): 259		
Total Simulated In-stream Flow:	**3.63**	Total Observed In-stream Flow:		**3.80**
Total of simulated highest 10% flows:	**1.31**	Total of Observed highest 10% flows:		**1.41**
Total of Simulated lowest 50% flows:	**0.42**	Total of Observed Lowest 50% flows:		**0.40**
Simulated Summer Flow Volume (months 7-9):	**0.67**	Observed Summer Flow Volume (7-9):		**0.73**
Simulated Fall Flow Volume (months 10-12):	**0.38**	Observed Fall Flow Volume (10-12):		**0.30**
Simulated Winter Flow Volume (months 1-3):	**0.15**	Observed Winter Flow Volume (1-3):		**0.23**
Simulated Spring Flow Volume (months 4-6):	**2.42**	Observed Spring Flow Volume (4-6):		**2.54**
Total Simulated Storm Volume:	**0.94**	Total Observed Storm Volume:		**0.81**
Simulated Summer Storm Volume (7-9):	**0.16**	Observed Summer Storm Volume (7-9):		**0.16**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	-4.64	10	-4.64	
Error in 50% lowest flows:	4.27	10	4.27	
Error in 10% highest flows:	-7.39	15	-7.39	
Seasonal volume error - Summer:	-7.71	30	-7.71	
Seasonal volume error - Fall:	26.37	>> 30	26.37	Clear
Seasonal volume error - Winter:	-34.53	30	-34.53	
Seasonal volume error - Spring:	-4.69	30	-4.69	
Error in storm volumes:	15.55	20	15.55	
Error in summer storm volumes:	-3.42	50	-3.42	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.667	Model accuracy increases	0.667	
Baseline adjusted coefficient (Garrick), E':	0.518	as E or E' approaches 1.0	0.518	
Monthly NSE	0.900			

6 Chippewa River at Benson

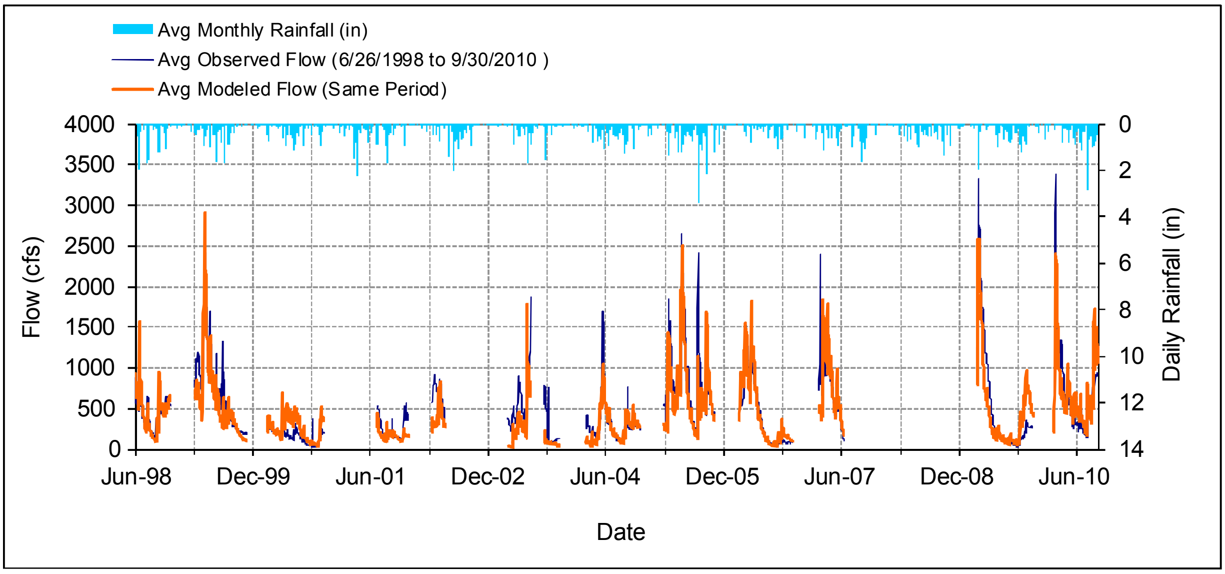


Figure 36. Mean daily flow: 26037001 Chippewa River at Benson, MN

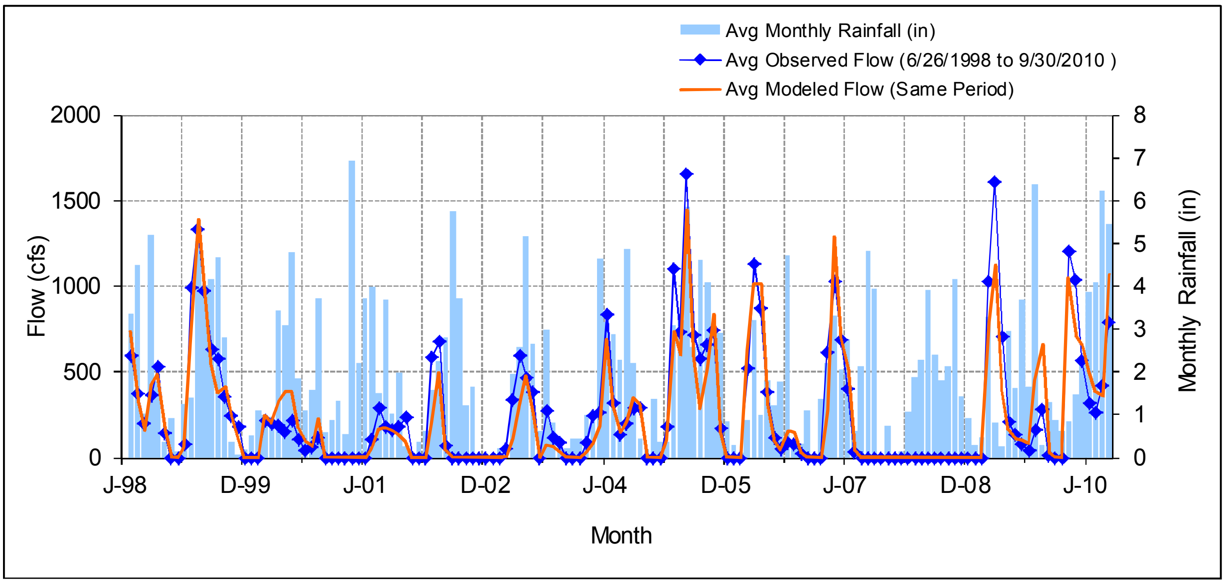


Figure 37. Mean monthly flow: 26037001 Chippewa River at Benson, MN

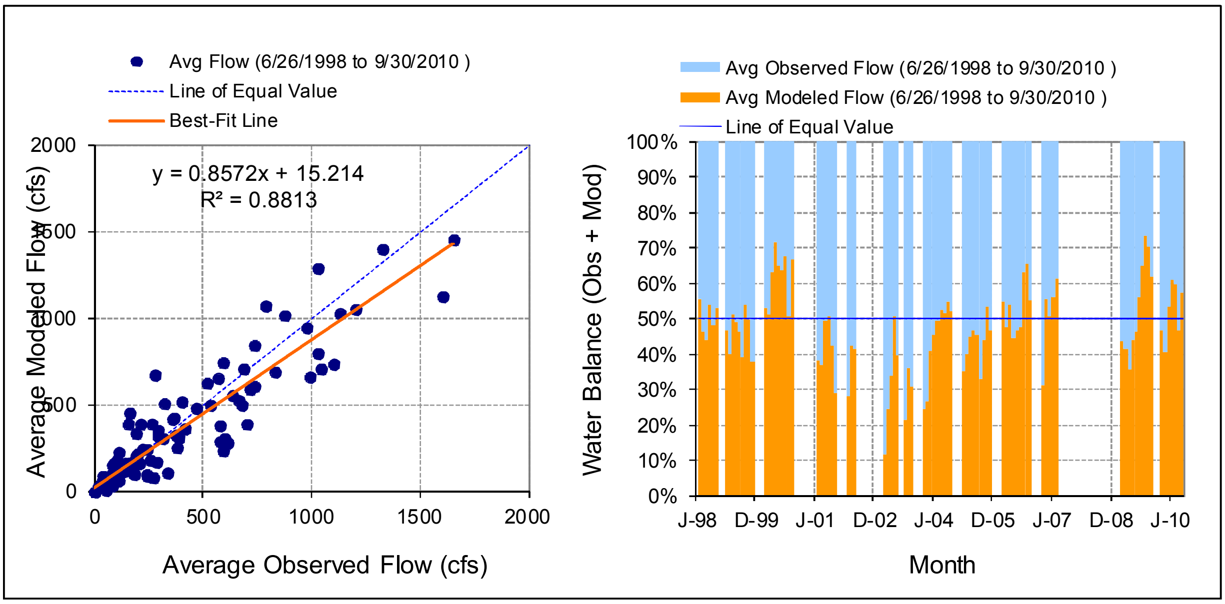


Figure 38. Monthly flow regression and temporal variation: 26037001 Chippewa River at Benson, MN

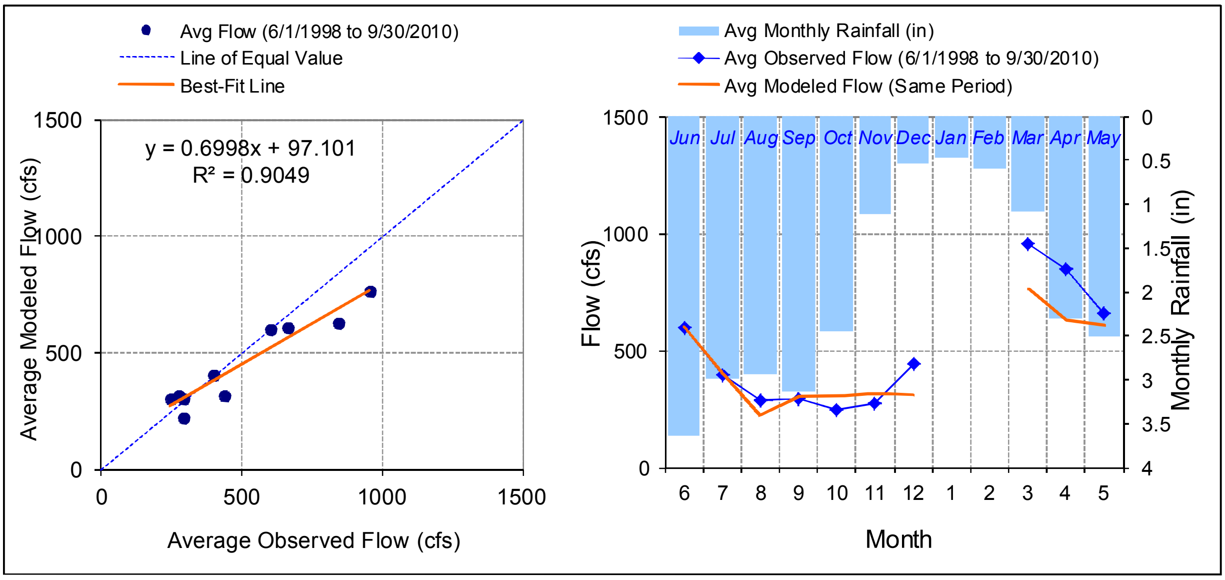


Figure 39. Seasonal regression and temporal aggregate: 26037001 Chippewa River at Benson, MN

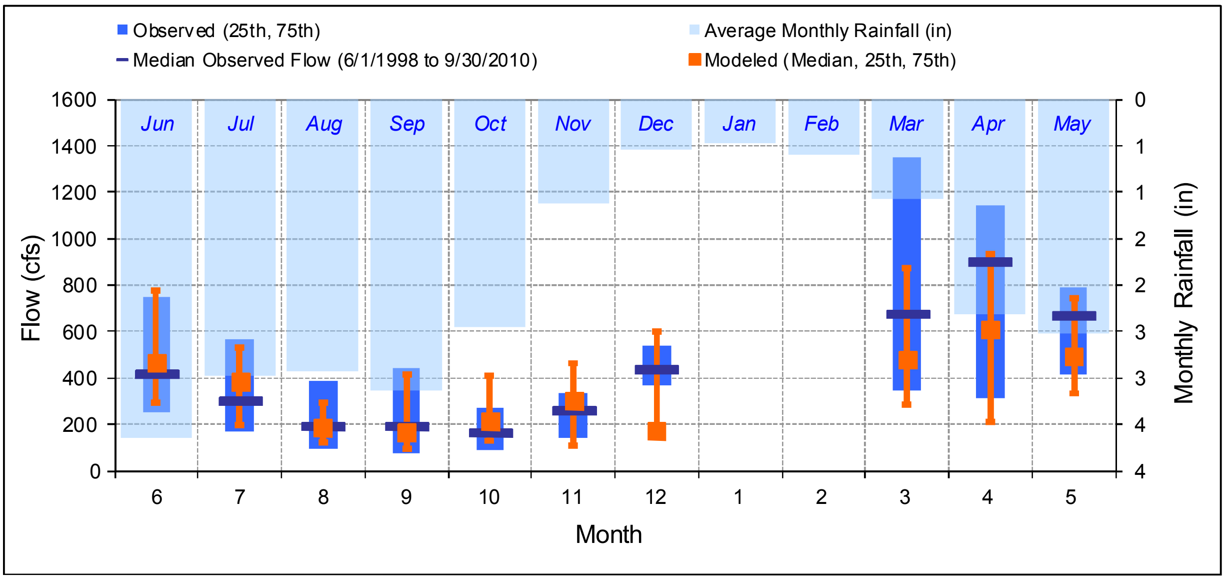


Figure 40. Seasonal medians and ranges: 26037001 Chippewa River at Benson, MN

Table 11. Seasonal summary: 26037001 Chippewa River at Benson, MN

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Jun	600.81	409.93	253.67	745.90	601.95	468.05	295.16	773.28
Jul	398.54	297.36	168.27	562.61	403.39	381.67	195.92	529.85
Aug	290.13	184.80	93.53	385.97	221.47	183.88	121.10	294.46
Sep	292.75	185.77	77.58	443.39	303.90	169.88	94.27	413.01
Oct	245.64	159.65	89.72	272.55	304.61	214.54	126.61	407.16
Nov	273.29	253.92	140.78	331.76	317.25	306.31	110.16	463.36
Dec	439.66	432.31	367.87	538.49	314.14	174.54	164.03	597.12
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	956.09	667.41	348.77	1350.00	766.79	482.37	287.77	870.99
Apr	844.66	898.71	312.96	1141.37	631.19	610.58	211.02	934.55
May	661.79	664.59	415.74	790.57	607.48	490.25	330.95	743.94

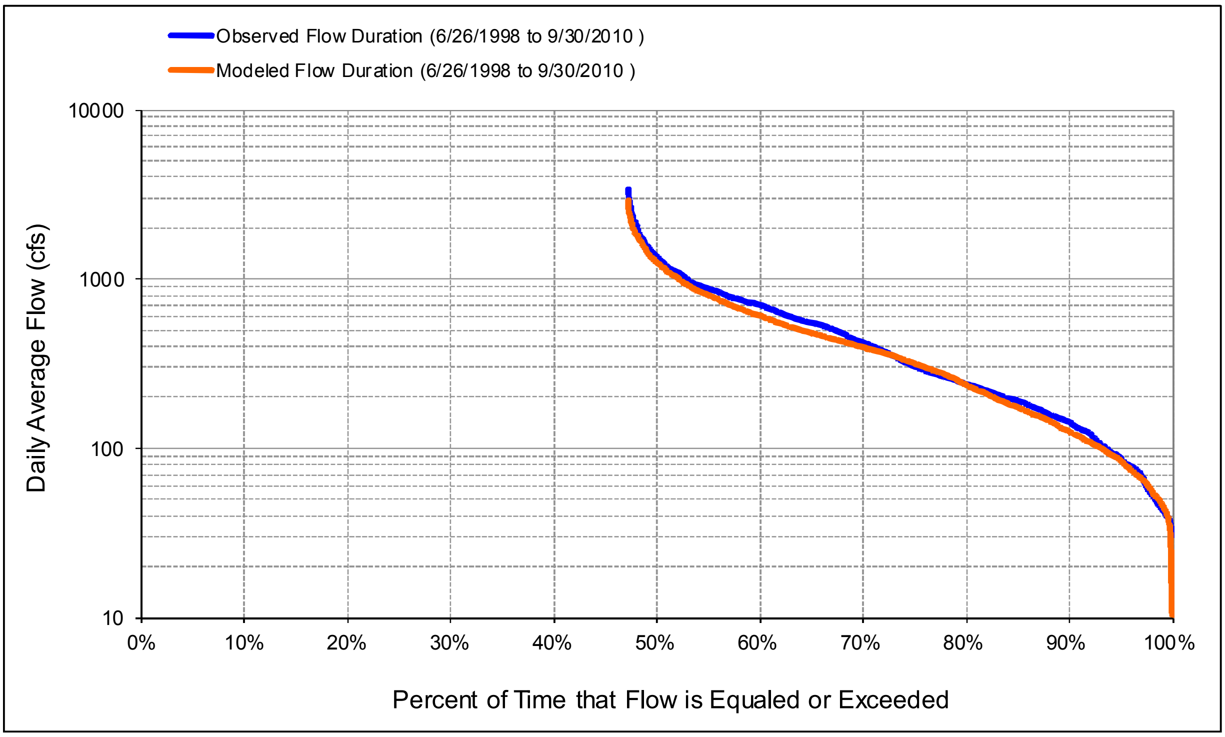


Figure 41. Flow exceedence: 26037001 Chippewa River at Benson, MN

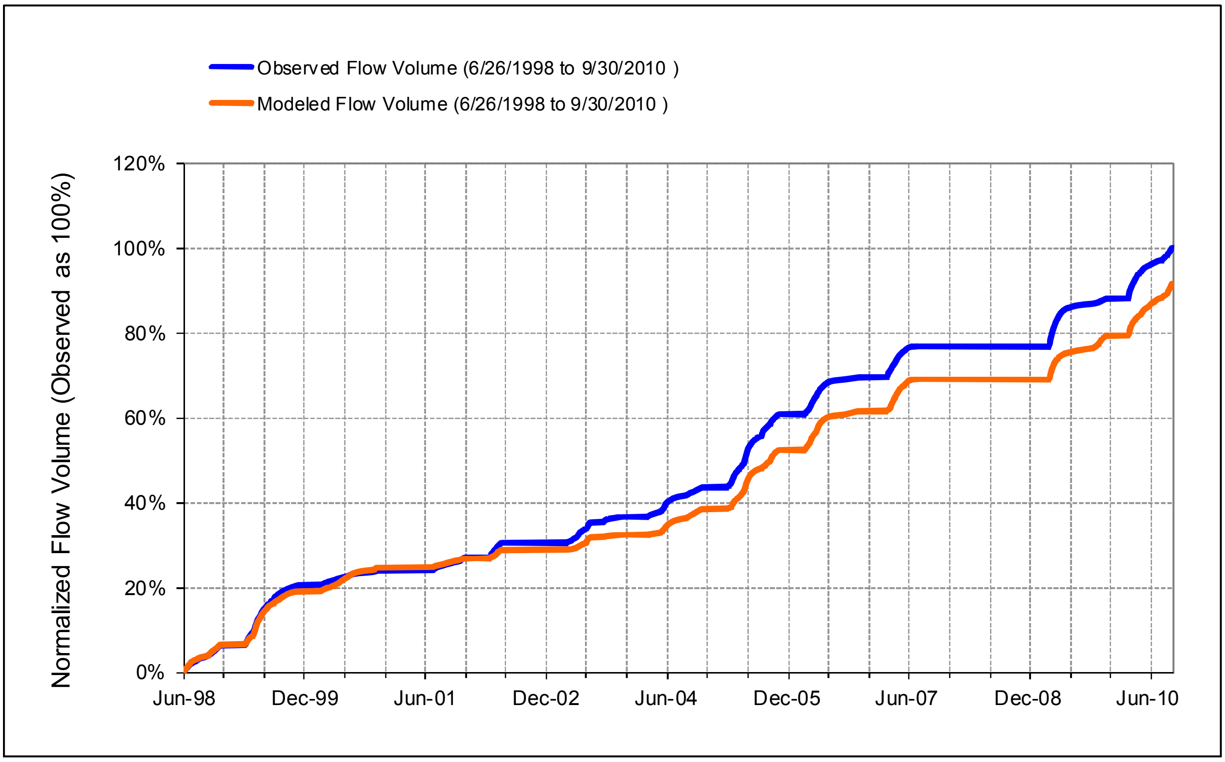


Figure 42. Flow accumulation: 26037001 Chippewa River at Benson, MN

Table 12. Summary statistics: 26037001 Chippewa River at Benson, MN

HSPF Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM DSN 102 12.27-Year Analysis Period: 6/1/1998 - 9/30/2010 Flow volumes are (inches/year) for upstream drainage area		CHIPPEWA RIVER AT BENSON, MN Manually Entered Data Drainage Area (sq-mi): 1270		
Total Simulated In-stream Flow:	**2.53**	Total Observed In-stream Flow:		**2.76**
Total of simulated highest 10% flows:	**0.79**	Total of Observed highest 10% flows:		**0.87**
Total of Simulated lowest 50% flows:	**0.47**	Total of Observed Lowest 50% flows:		**0.49**
Simulated Summer Flow Volume (months 7-9):	**0.62**	Observed Summer Flow Volume (7-9):		**0.65**
Simulated Fall Flow Volume (months 10-12):	**0.38**	Observed Fall Flow Volume (10-12):		**0.33**
Simulated Winter Flow Volume (months 1-3):	**0.24**	Observed Winter Flow Volume (1-3):		**0.29**
Simulated Spring Flow Volume (months 4-6):	**1.29**	Observed Spring Flow Volume (4-6):		**1.48**
Total Simulated Storm Volume:	**0.54**	Total Observed Storm Volume:		**0.51**
Simulated Summer Storm Volume (7-9):	**0.11**	Observed Summer Storm Volume (7-9):		**0.11**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*Run (n-1)*	*Run (n-2)*
Error in total volume:	-8.33	10	-5.97	-6.20
Error in 50% lowest flows:	-2.76	10	2.65	2.51
Error in 10% highest flows:	-8.74	15	-7.65	-7.25
Seasonal volume error - Summer:	-5.32	30	-1.85	-2.47
Seasonal volume error - Fall:	16.04	30	19.49	19.33
Seasonal volume error - Winter:	-19.80	30	-19.09	-18.72
Seasonal volume error - Spring:	-12.73	30	-10.78	-10.98
Error in storm volumes:	6.12	20	5.04	6.73
Error in summer storm volumes:	4.49	50	2.10	4.02
Nash-Sutcliffe Coefficient of Efficiency, E:	0.724	Model accuracy increases	0.730	0.702
Baseline adjusted coefficient (Garrick), E':	0.536	as E or E' approaches 1.0	0.541	0.532
Monthly NSE	0.892			

>> Clear

Water Quality Calibration and Validation for the Chippewa River Watershed HSPF Model

1 Chippewa River at Cyrus (S002-190)

Table 1. Summary Statistics, TSS, Chippewa River at Cyrus (S002-190)

	Calibration (1999-2005)	Validation (2006-2010)
Count	105	99
Concentration Average Error	24.48%	-13.55%
Concentration Median Error	7.00%	-0.50%
Paired Load Average Error	85.84%	-2.59%
Paired Load Median Error	1.29%	-0.36%
Paired t Test on Concentration Means (p value)	0.34	0.82
Paired t Test on Load Means (p value)	0.00	0.94
Difference in Slope, Load vs. Flow	105.62%	62.24%

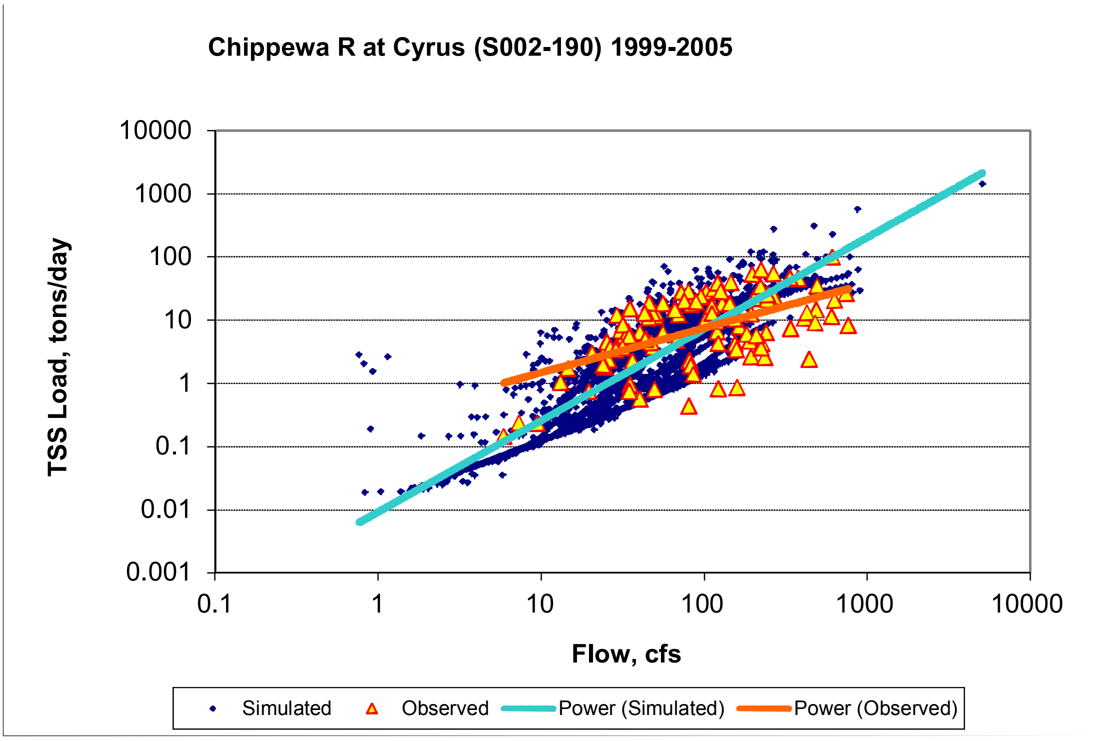


Figure 1. TSS Load Power Plot, Calibration Period, Chippewa River at Cyrus (S002-190)

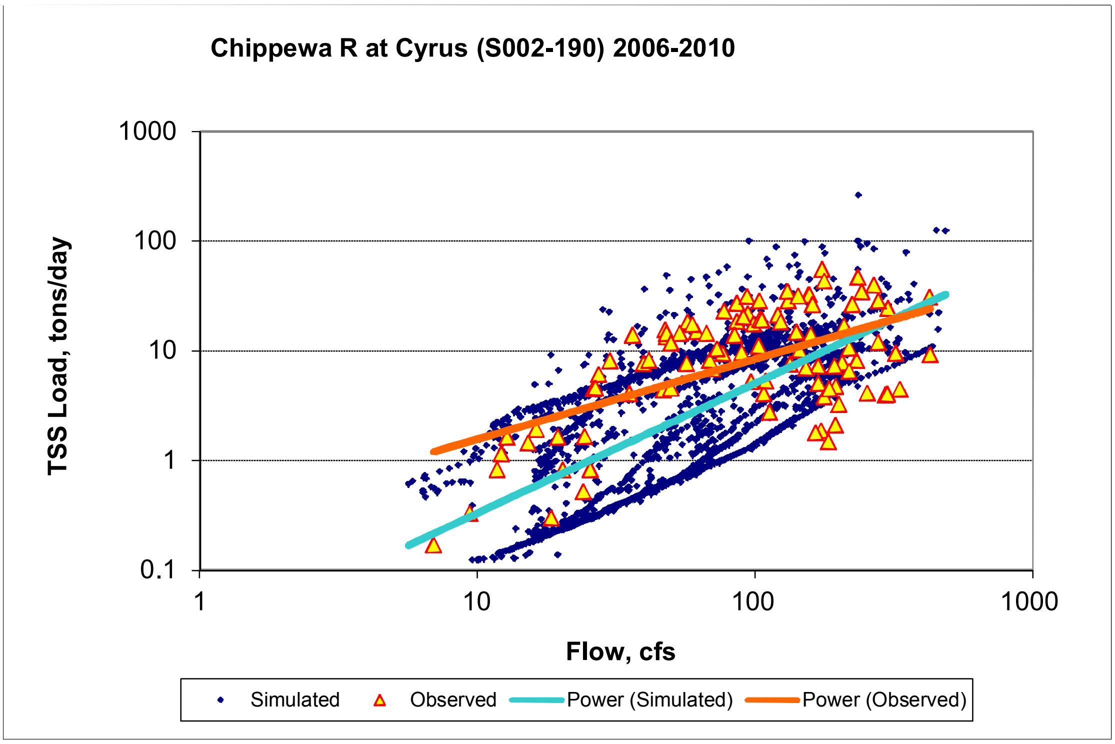


Figure 2. TSS Load Power Plot, Validation Period, Chippewa River at Cyrus (S002-190)

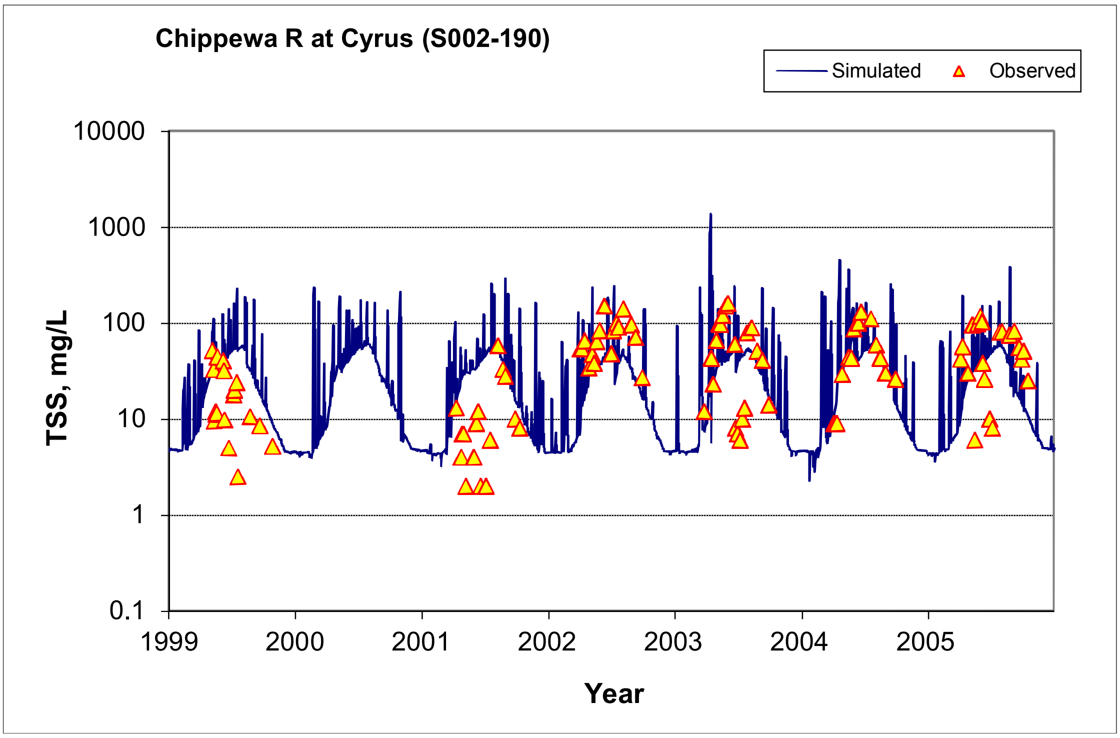


Figure 3. TSS Concentration Time Series, Calibration Period, Chippewa River at Cyrus (S002-190)

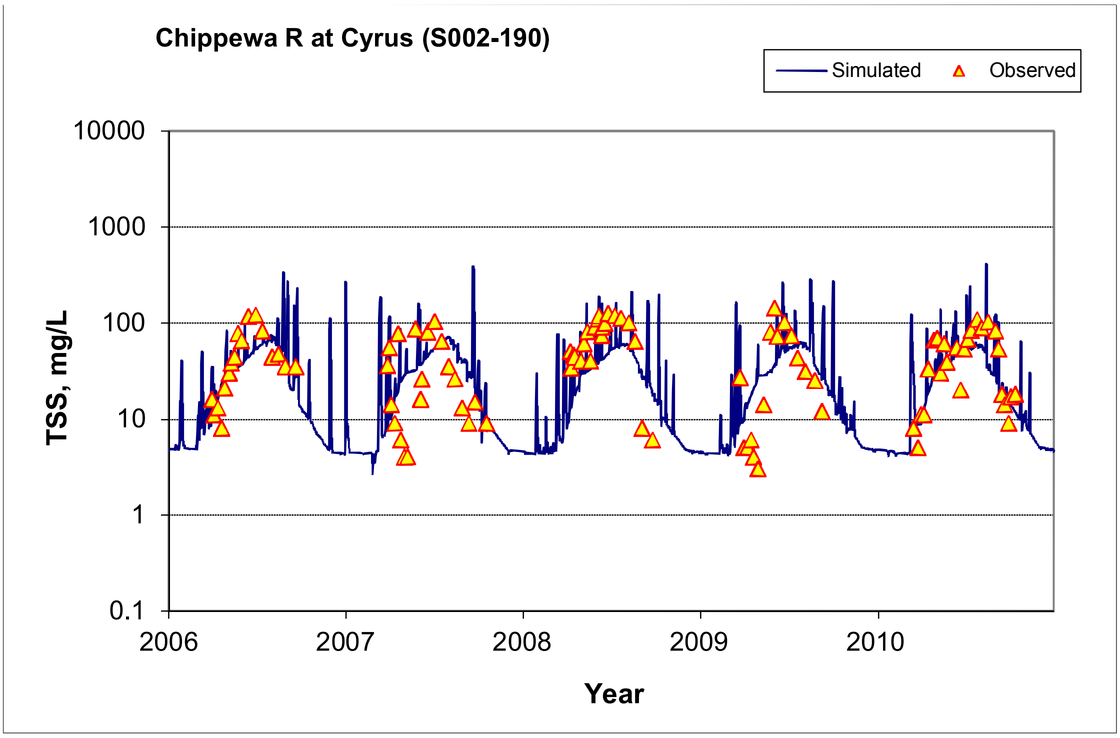


Figure 4. TSS Concentration Time Series, Validation Period, Chippewa River at Cyrus (S002-190)

Table 2. Summary Statistics, Ortho P, Chippewa River at Cyrus (S002-190)

	Calibration (1999-2005)	Validation (2006-2010)
Count	102	70
Concentration Average Error	10.46%	24.28%
Concentration Median Error	10.72%	23.98%
Paired Load Average Error	-12.34%	-37.37%
Paired Load Median Error	2.30%	6.10%
Paired t Test on Concentration Means (p value)	0.74	0.42
Paired t Test on Load Means (p value)	0.64	0.26
Difference in Slope, Load vs. Flow	-49.65%	-25.61%

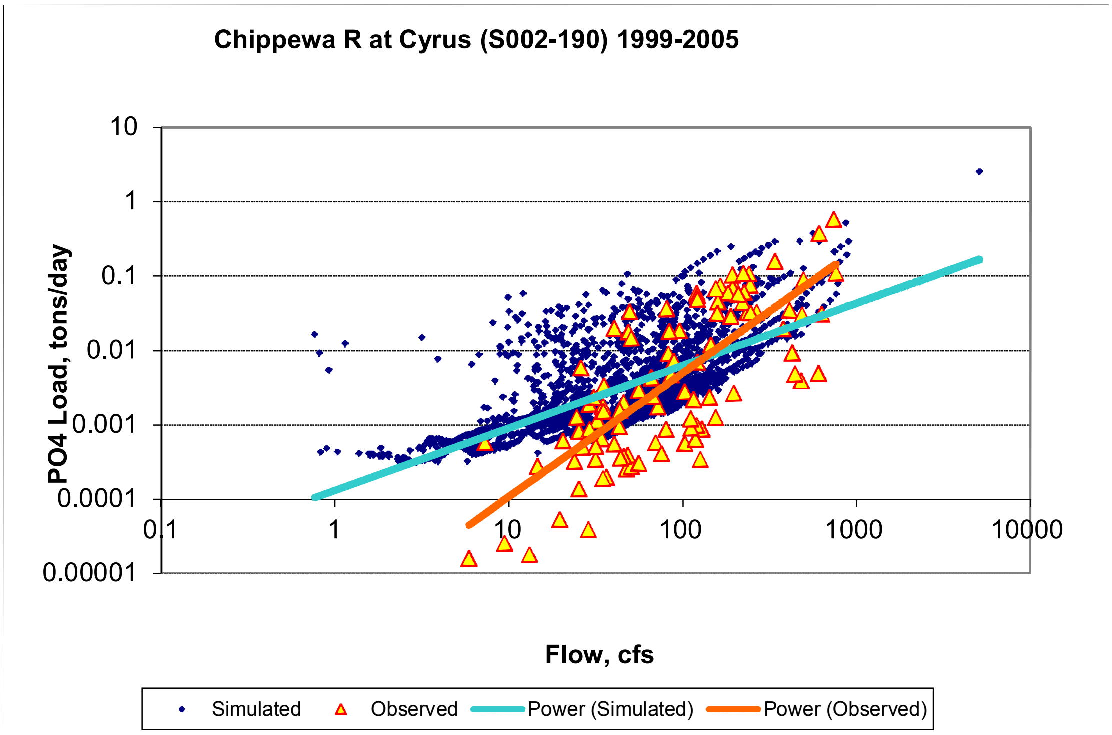


Figure 5. Ortho P Load Power Plot, Calibration Period, Chippewa River at Cyrus (S002-190)

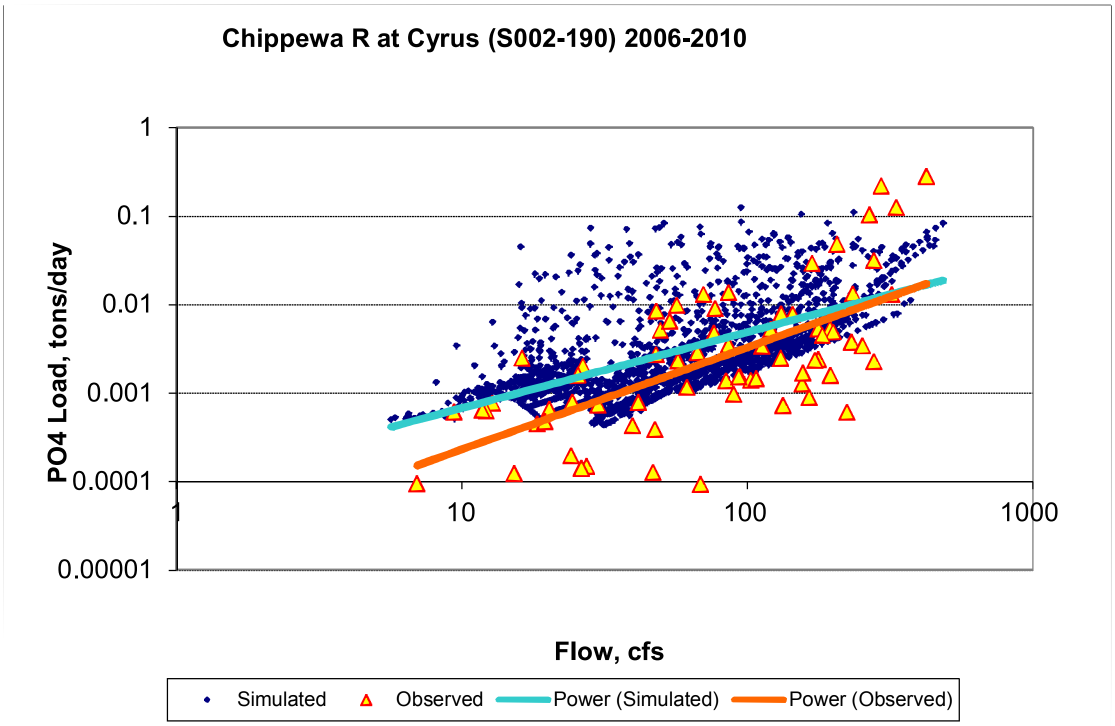


Figure 6. Ortho P Load Power Plot, Validation Period, Chippewa River at Cyrus (S002-190)

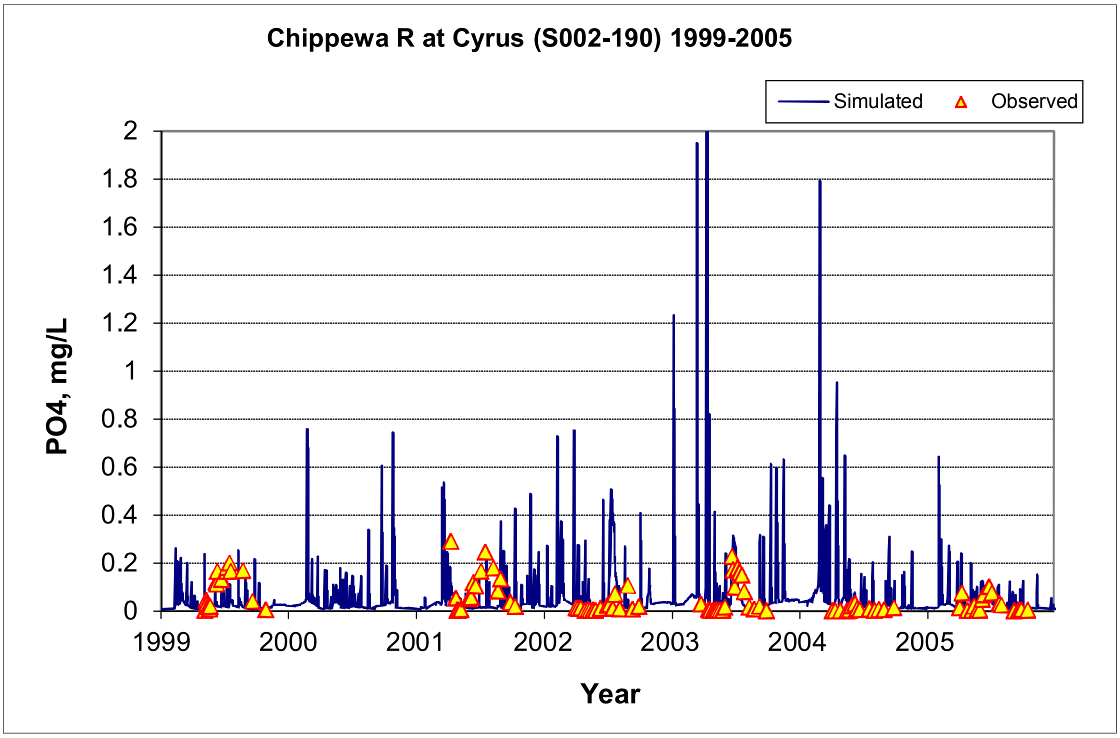


Figure 7. Ortho P Concentration Time Series, Calibration Period, Chippewa River at Cyrus (S002-190)

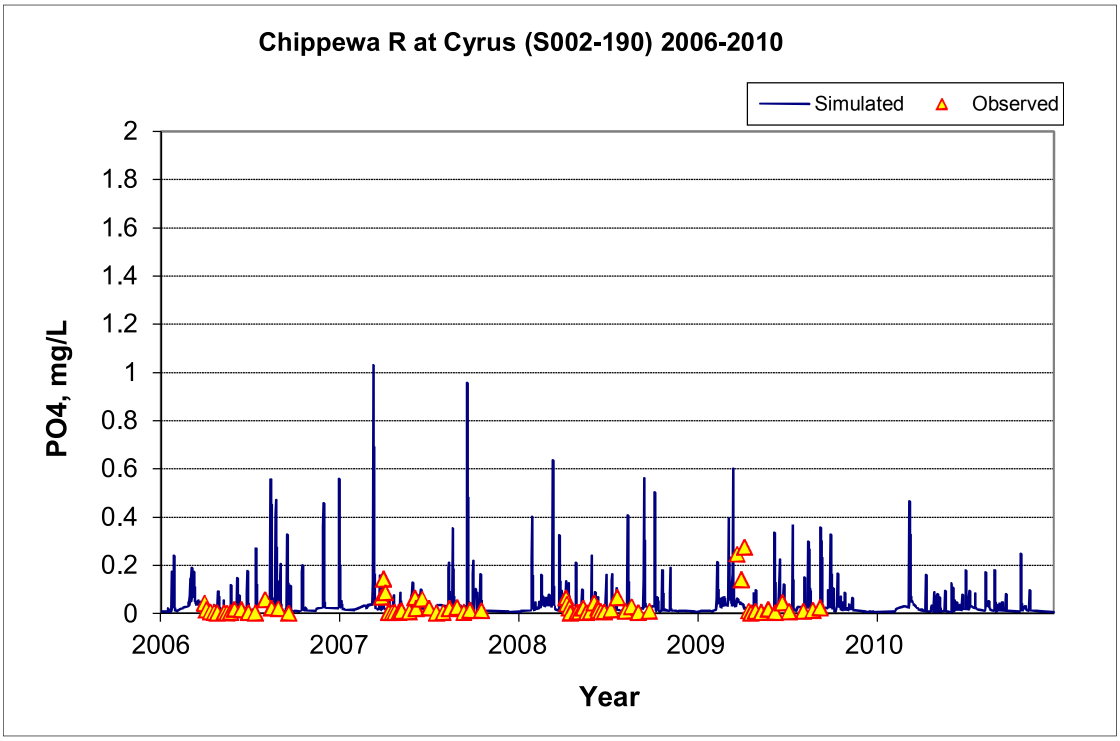


Figure 8. Ortho P Concentration Time Series, Validation Period, Chippewa River at Cyrus (S002-190)

Table 3. Summary Statistics, Total P, Chippewa River at Cyrus (S002-190)

	Calibration (1999-2005)	Validation (2006-2010)
Count	85	99
Concentration Average Error	-8.56%	-7.51%
Concentration Median Error	-3.24%	-6.30%
Paired Load Average Error	-4.82%	-18.80%
Paired Load Median Error	-1.03%	-4.12%
Paired t Test on Concentration Means (p value)	0.95	1.00
Paired t Test on Load Means (p value)	0.83	0.54
Difference in Slope, Load vs. Flow	-9.73%	-24.22%

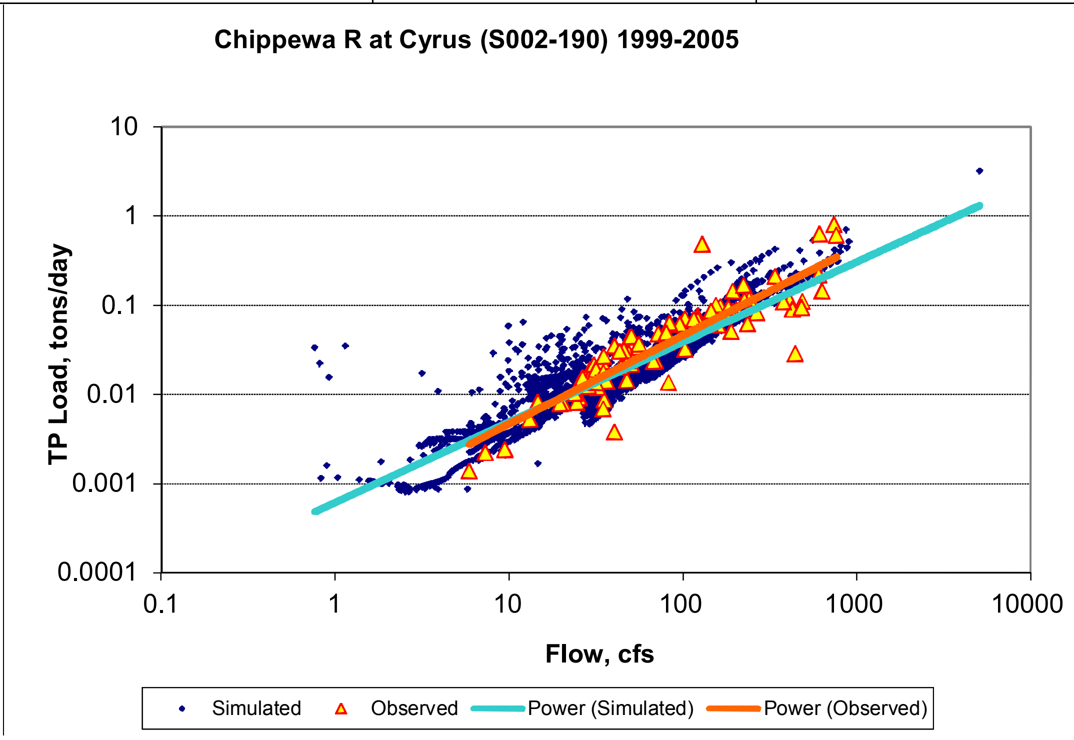


Figure 9. Total P Load Power Plot, Calibration Period, Chippewa River at Cyrus (S002-190)

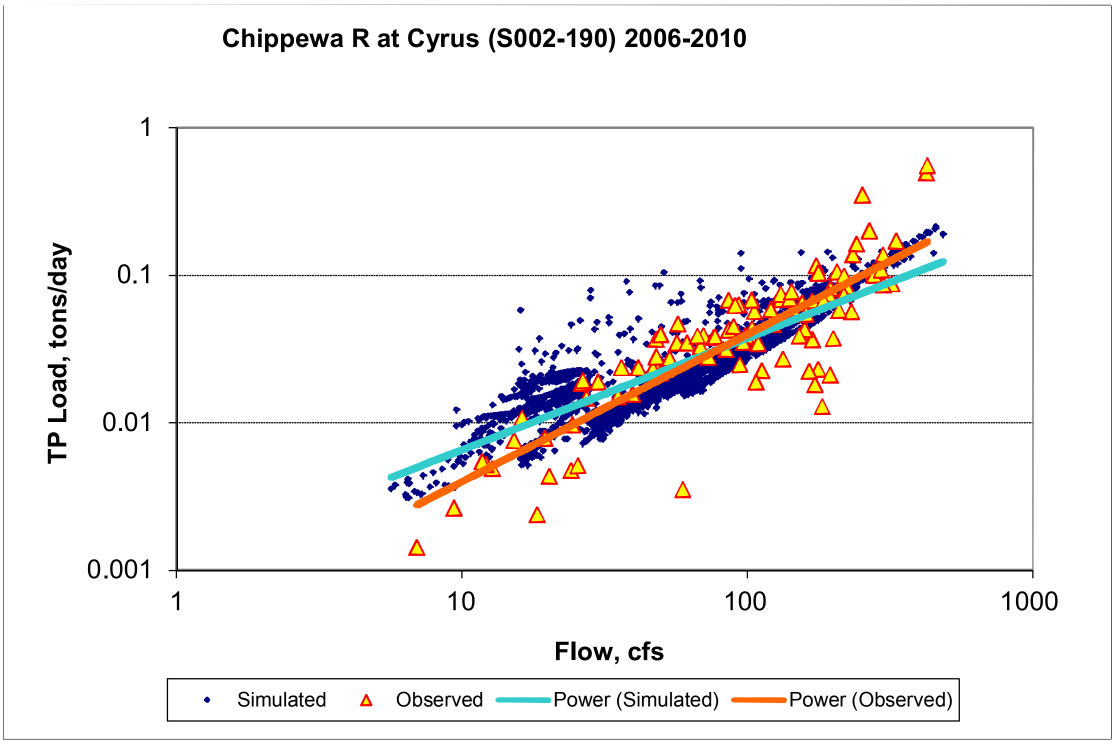


Figure 10. Total P Load Power Plot, Validation Period, Chippewa River at Cyrus (S002-190)

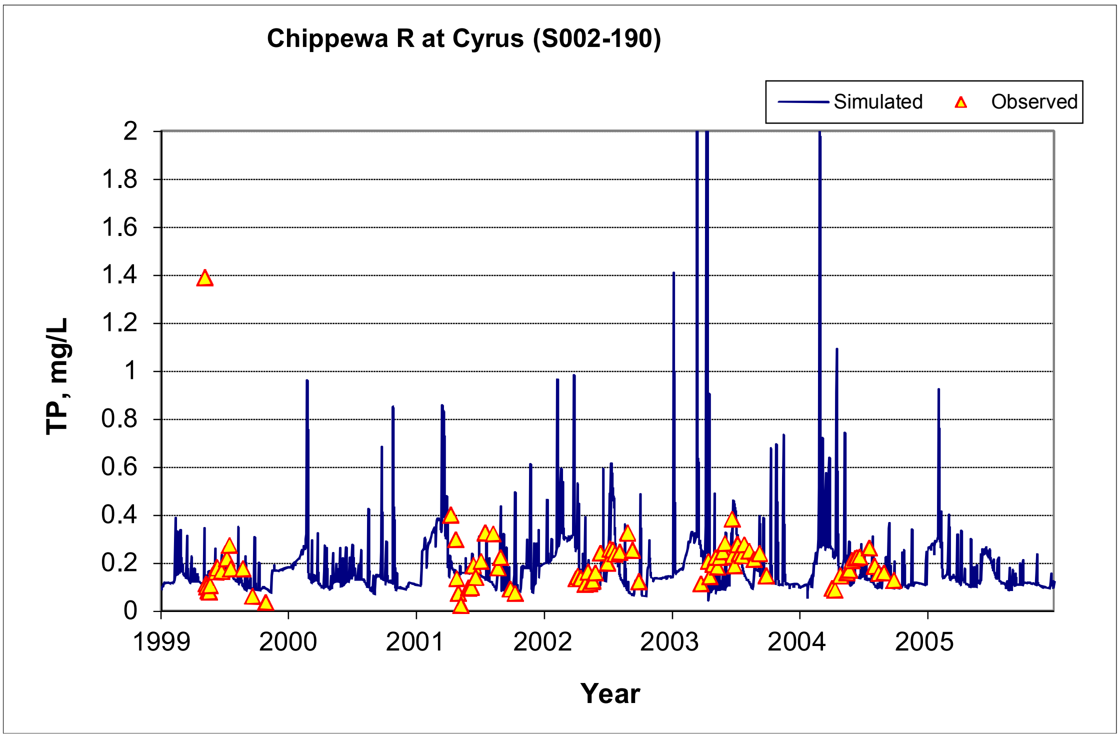


Figure 11. Total P Concentration Time Series, Calibration Period, Chippewa River at Cyrus (S002-190)

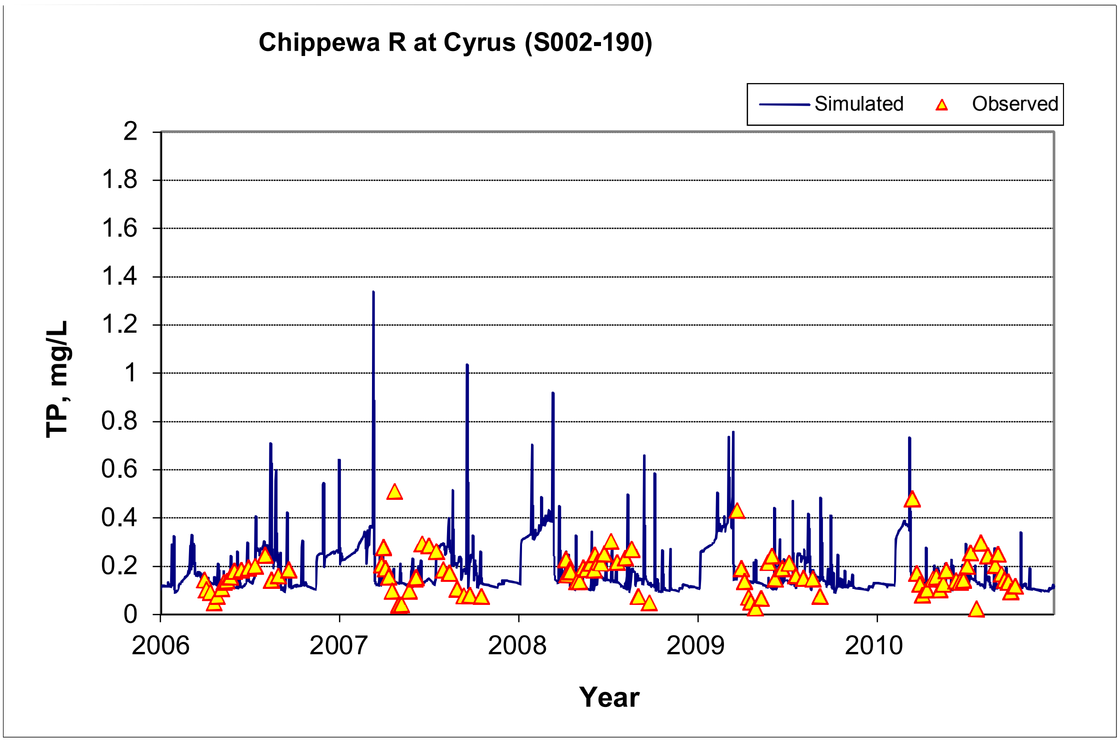


Figure 12. Total P Concentration Time Series, Validation Period, Chippewa River at Cyrus (S002-190)

Table 4. Summary Statistics, NOx-N, Chippewa River at Cyrus (S002-190)

	Calibration (1999-2005)	Validation (2006-2010)
Count	105	99
Concentration Average Error	94.50%	-22.89%
Concentration Median Error	55.96%	2.74%
Paired Load Average Error	132.26%	-41.07%
Paired Load Median Error	13.00%	1.27%
Paired t Test on Concentration Means (p value)	0.01	0.40
Paired t Test on Load Means (p value)	0.05	0.12
Difference in Slope, Load vs. Flow	-30.54%	-42.66%

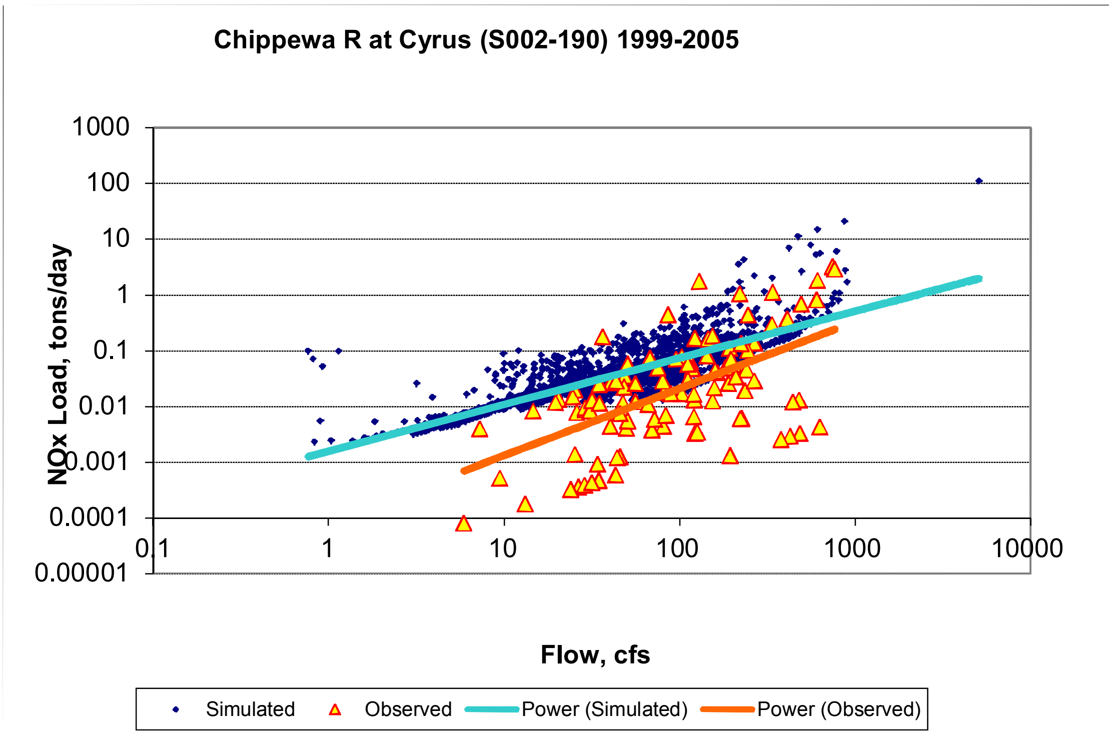


Figure 13. NOx-N Load Power Plot, Calibration Period, Chippewa River at Cyrus (S002-190)

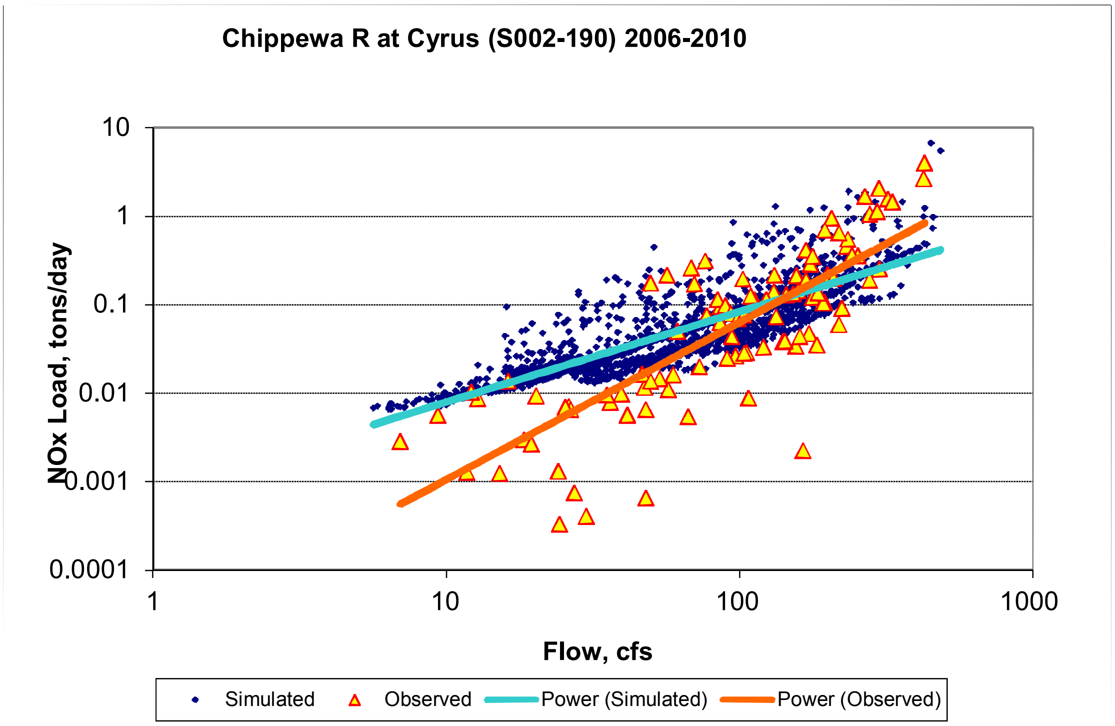


Figure 14. NOx-N Load Power Plot, Validation Period, Chippewa River at Cyrus (S002-190)

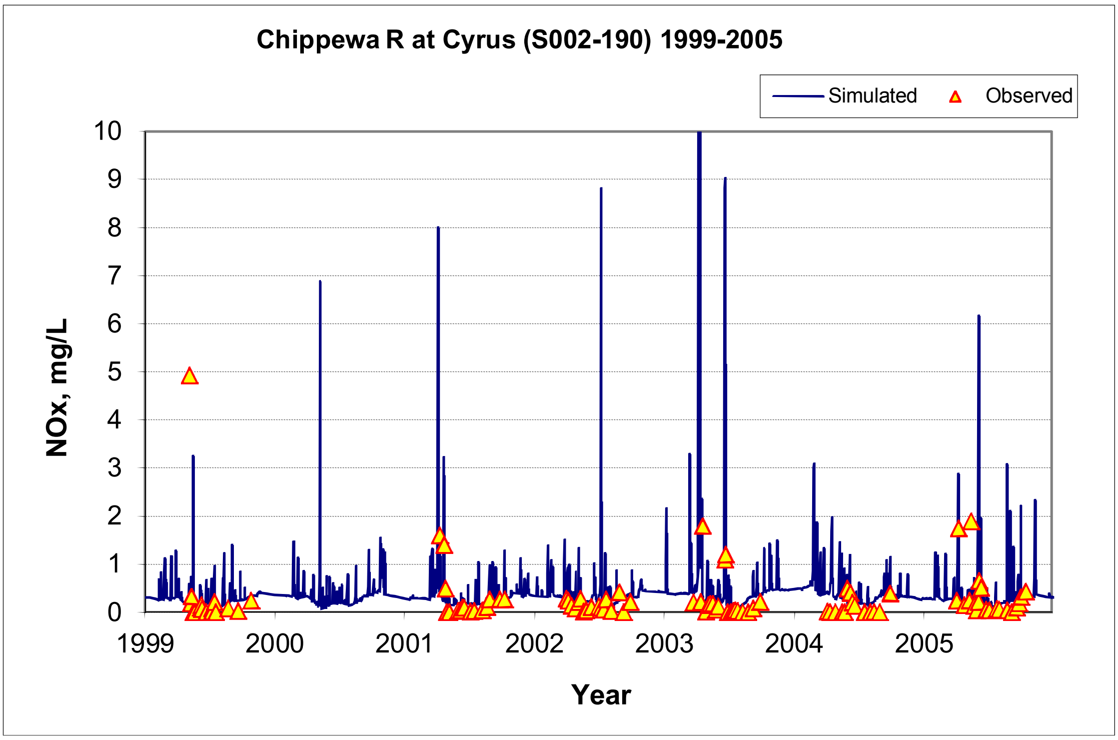


Figure 15. NOx-N Concentration Time Series, Calibration Period, Chippewa River at Cyrus (S002-190)

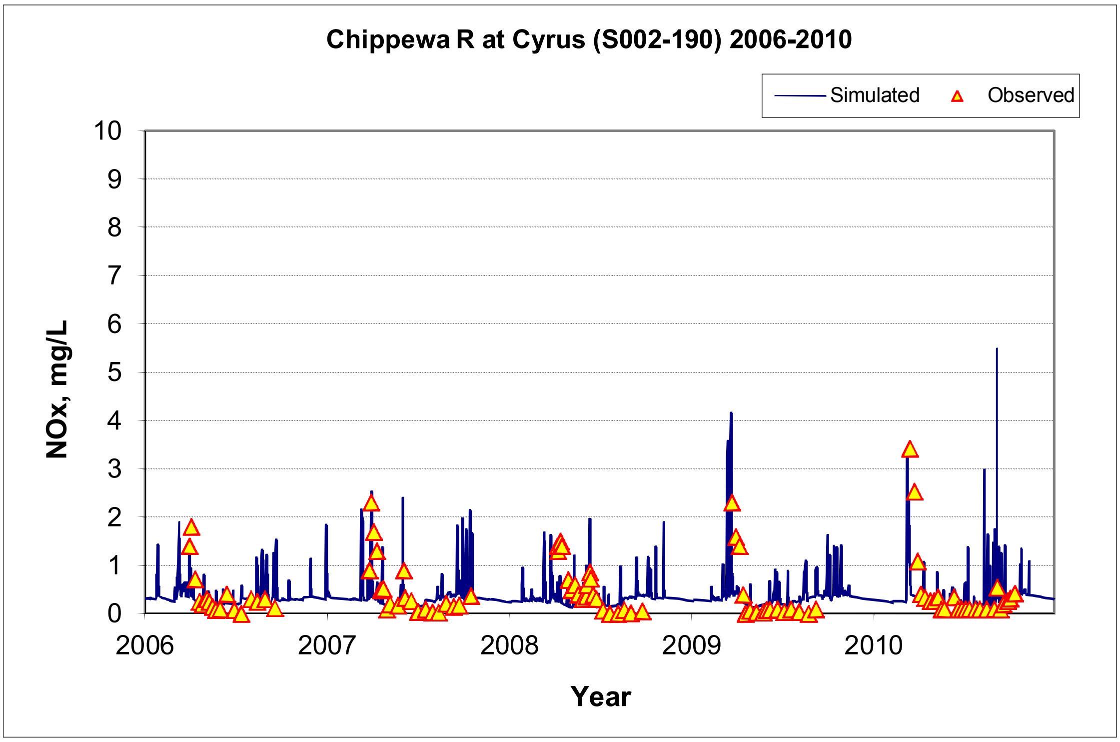


Figure 16. NOx-N Concentration Time Series, Validation Period, Chippewa River at Cyrus (S002-190)

Table 5. Summary Statistics, Total N, Chippewa River at Cyrus (S002-190)

	Calibration (1999-2005)	Validation (2006-2010)
Count	84	6
Concentration Average Error	17.03%	-10.09%
Concentration Median Error	12.67%	-8.42%
Paired Load Average Error	59.10%	-13.27%
Paired Load Median Error	6.29%	-10.70%
Paired t Test on Concentration Means (p value)	0.66	0.89
Paired t Test on Load Means (p value)	0.10	0.58
Difference in Slope, Load vs. Flow	-7.01%	-10.21%

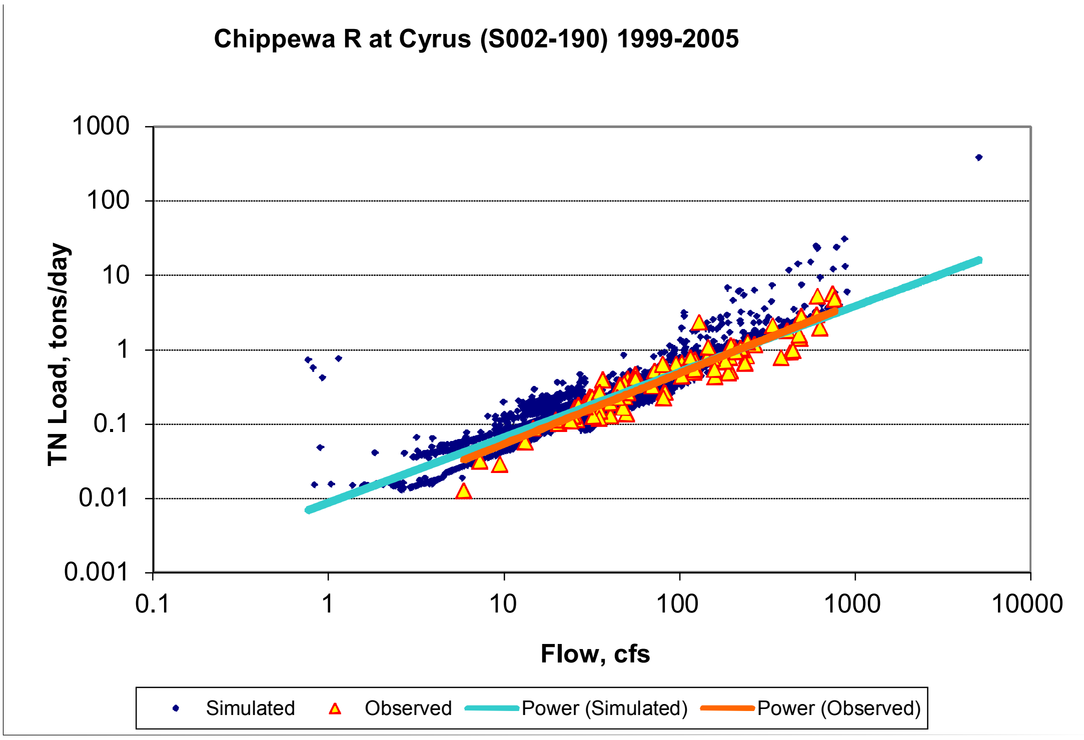


Figure 17. Total N Load Power Plot, Calibration Period, Chippewa River at Cyrus (S002-190)

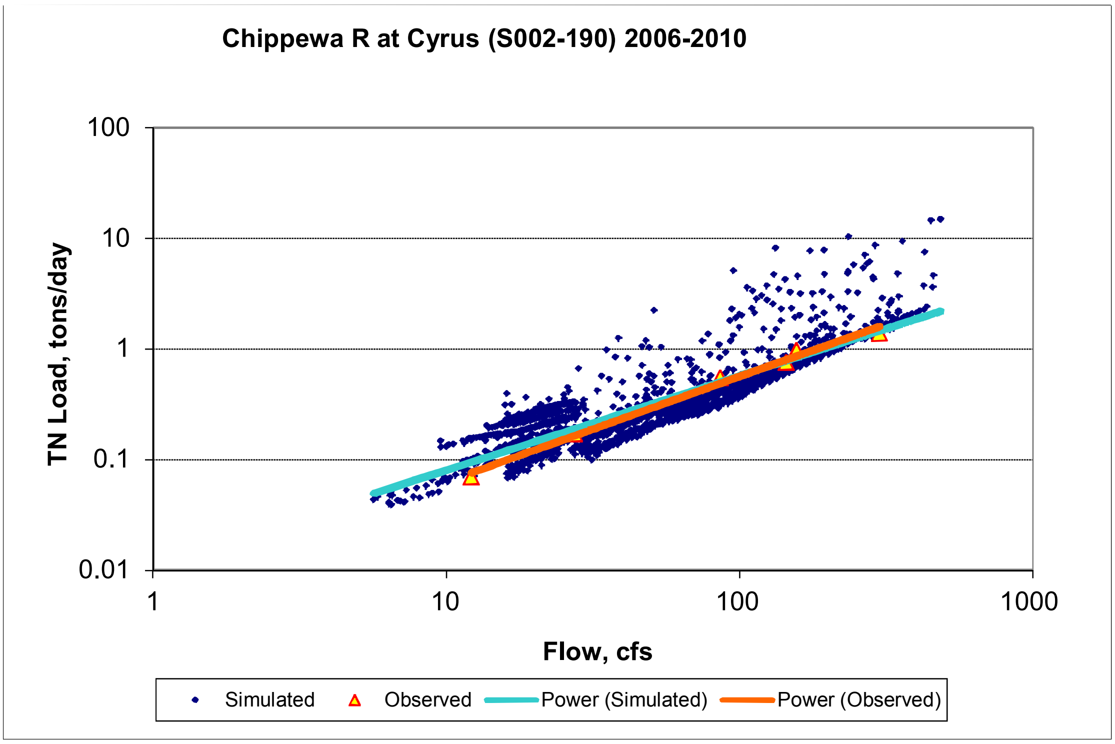


Figure 18. Total N Load Power Plot, Validation Period, Chippewa River at Cyrus (S002-190)

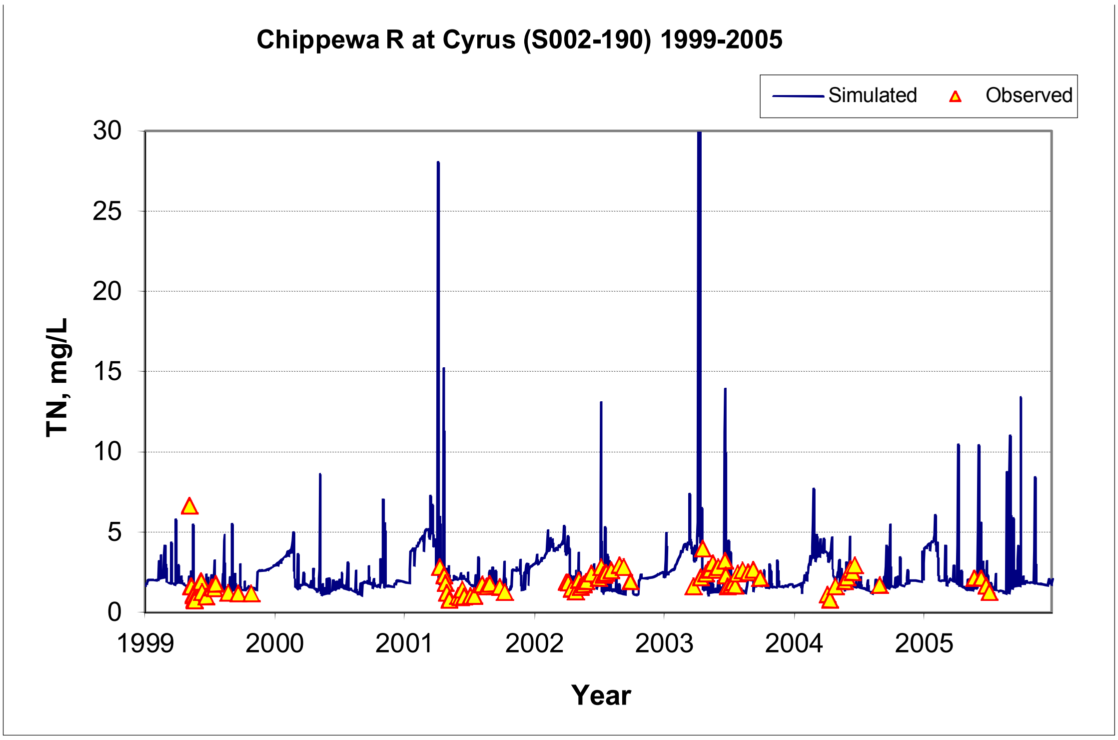


Figure 19. Total N Concentration Time Series, Calibration Period, Chippewa River at Cyrus (S002-190)

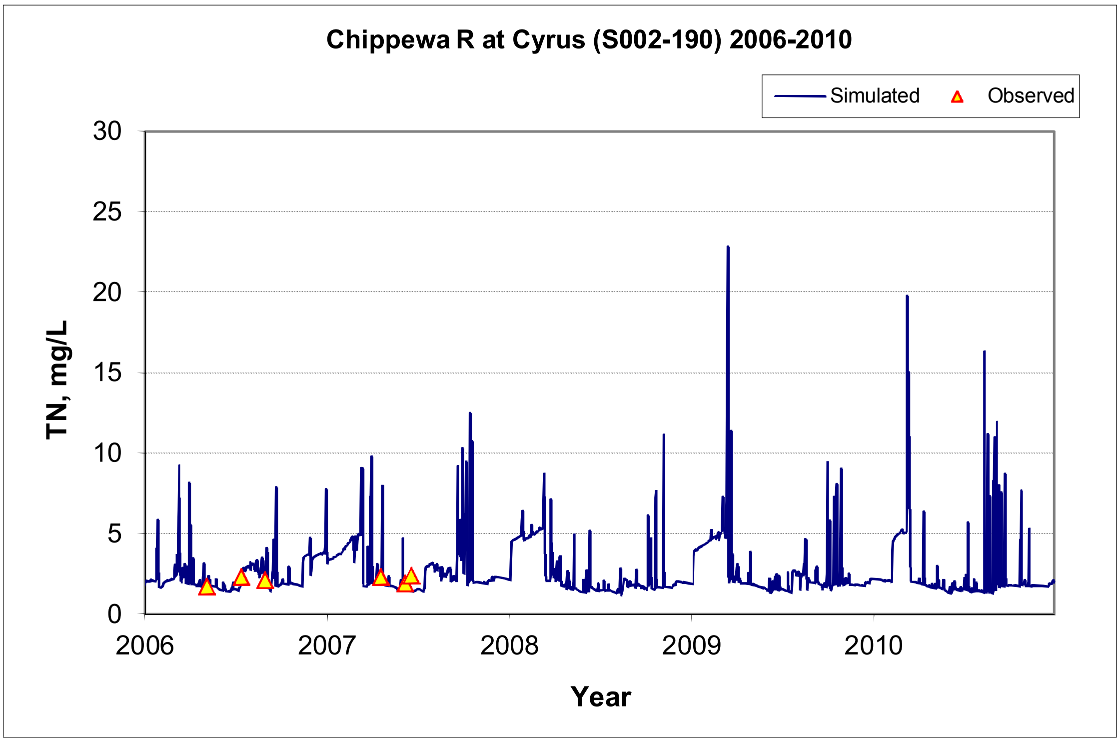


Figure 20. Total N Concentration Time Series, Validation Period, Chippewa River at Cyrus (S002-190)

2 East Branch Chippewa River (S005-364)

Table 6. Summary Statistics, TSS, East Branch Chippewa River (S005-364)

	Calibration (1999-2005)	Validation (2006-2010)
Count	131	115
Concentration Average Error	-3.98%	19.87%
Concentration Median Error	2.58%	18.19%
Paired Load Average Error	4.63%	1.82%
Paired Load Median Error	0.59%	5.12%
Paired t Test on Concentration Means (p value)	0.97	0.51
Paired t Test on Load Means (p value)	0.84	0.84
Difference in Slope, Load vs. Flow	41.88%	18.31%

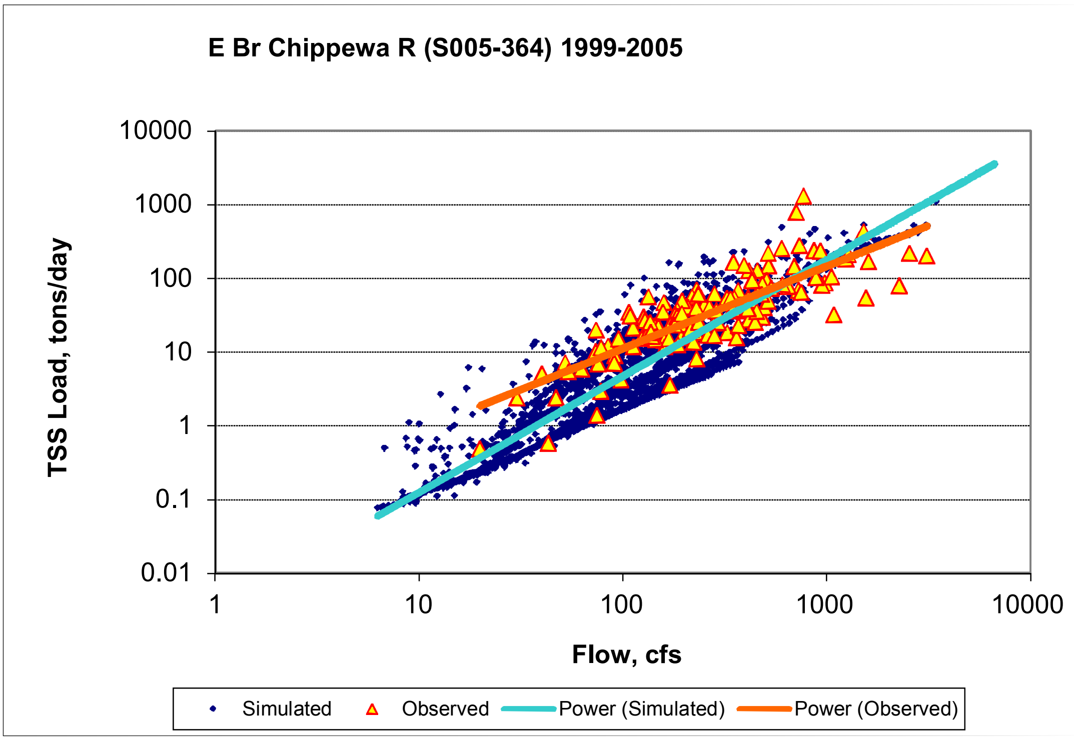


Figure 21. TSS Load Power Plot, Calibration Period, East Branch Chippewa River (S005-364)

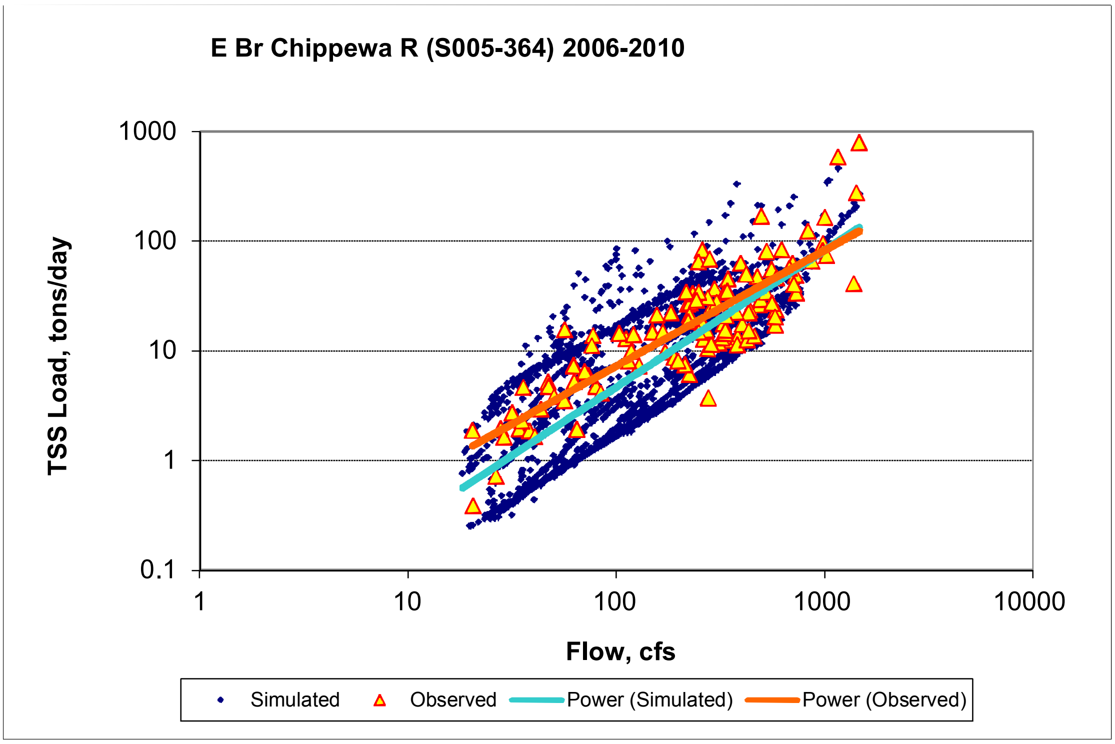


Figure 22. TSS Load Power Plot, Validation Period, East Branch Chippewa River (S005-364)

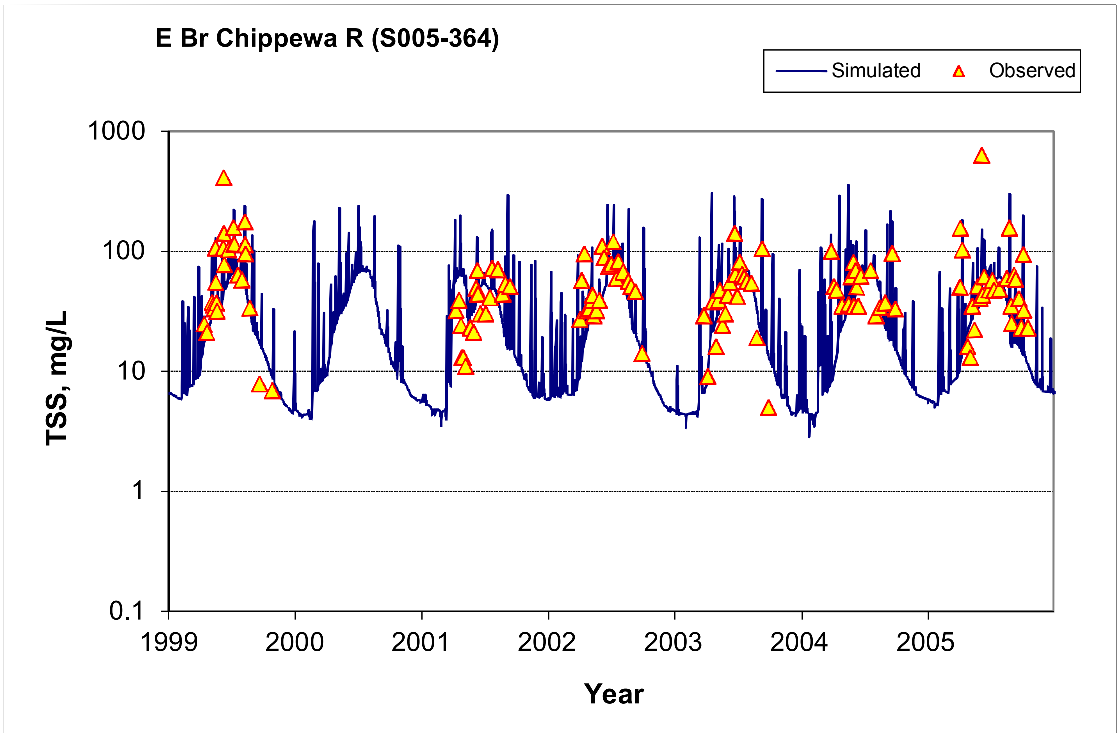


Figure 23. TSS Concentration Time Series, Calibration Period, East Branch Chippewa River (S005-364)

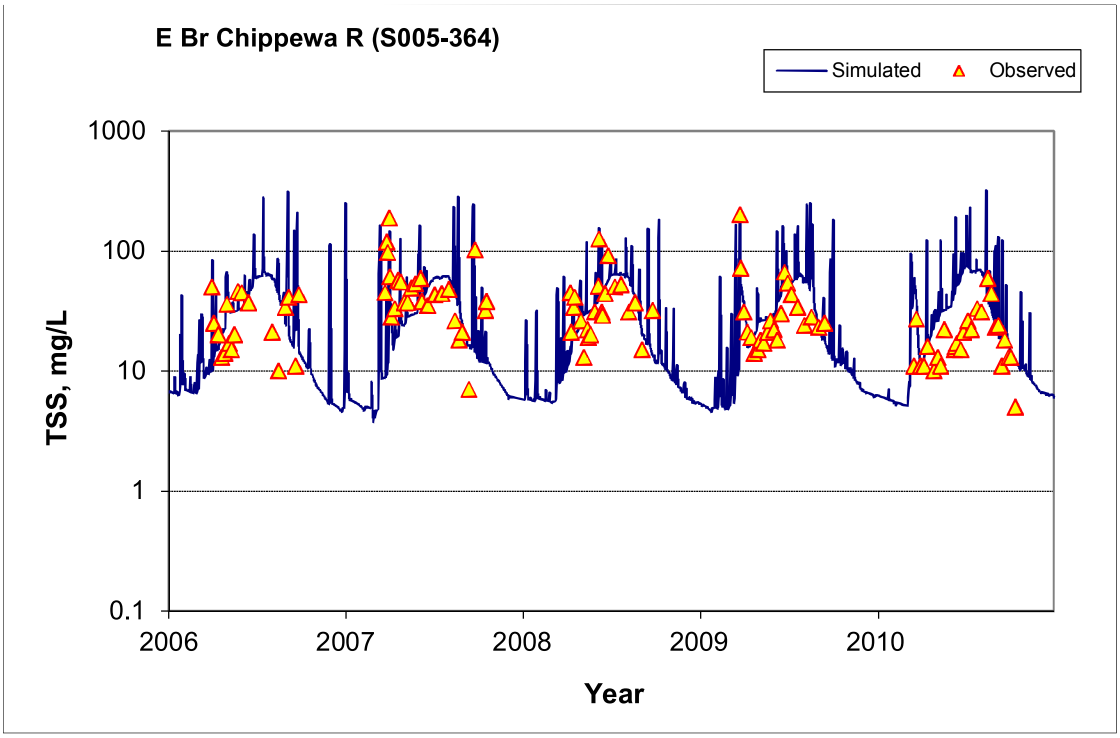


Figure 24. TSS Concentration Time Series, Validation Period, East Branch Chippewa River (S005-364)

Table 7. Summary Statistics, Ortho P, East Branch Chippewa River (S005-364)

	Calibration (1999-2005)	Validation (2006-2010)
Count	128	90
Concentration Average Error	5.10%	10.55%
Concentration Median Error	8.03%	5.48%
Paired Load Average Error	-5.20%	9.05%
Paired Load Median Error	1.64%	1.86%
Paired t Test on Concentration Means (p value)	0.99	0.84
Paired t Test on Load Means (p value)	0.81	0.68
Difference in Slope, Load vs. Flow	-20.56%	0.05%

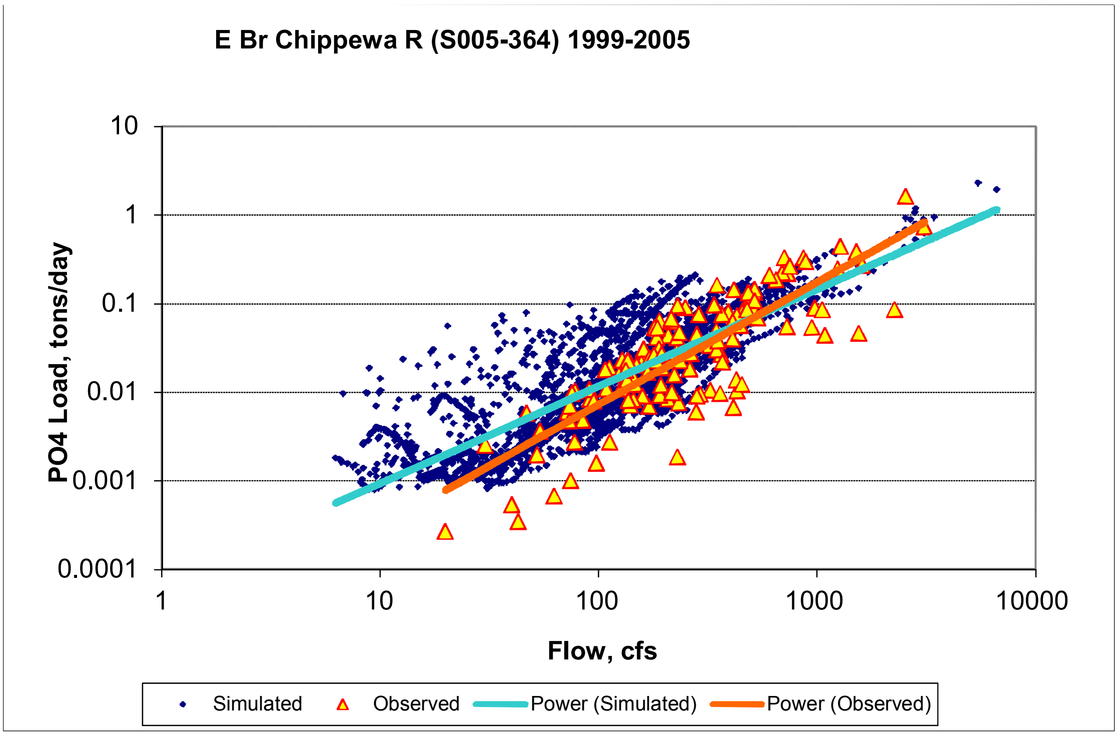


Figure 25. Ortho P Load Power Plot, Calibration Period, East Branch Chippewa River (S005-364)

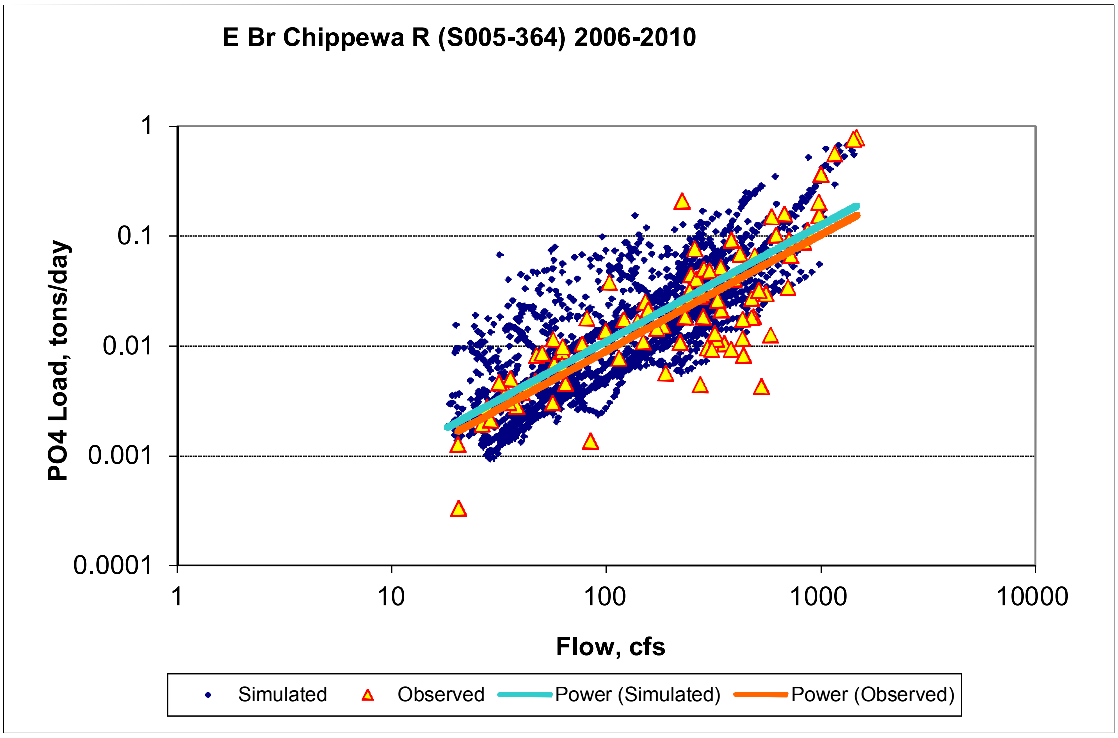


Figure 26. Ortho P Load Power Plot, Validation Period, East Branch Chippewa River (S005-364)

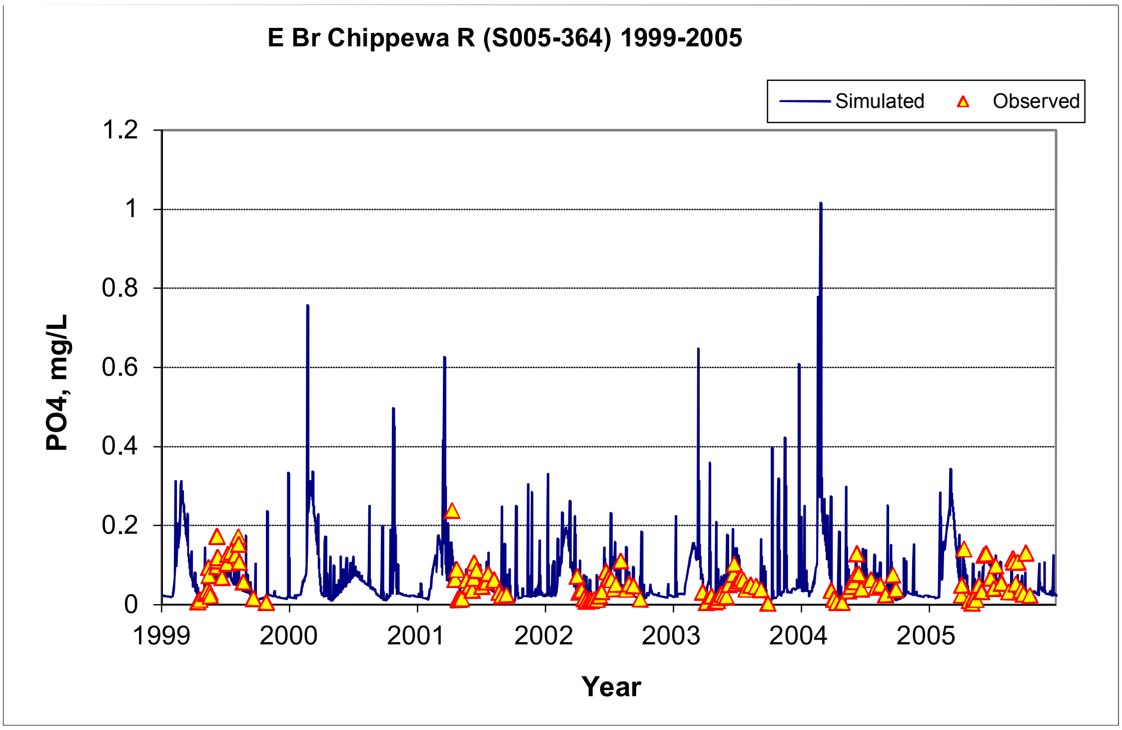


Figure 27. Ortho P Concentration Time Series, Calibration Period, East Branch Chippewa River (S005-364)

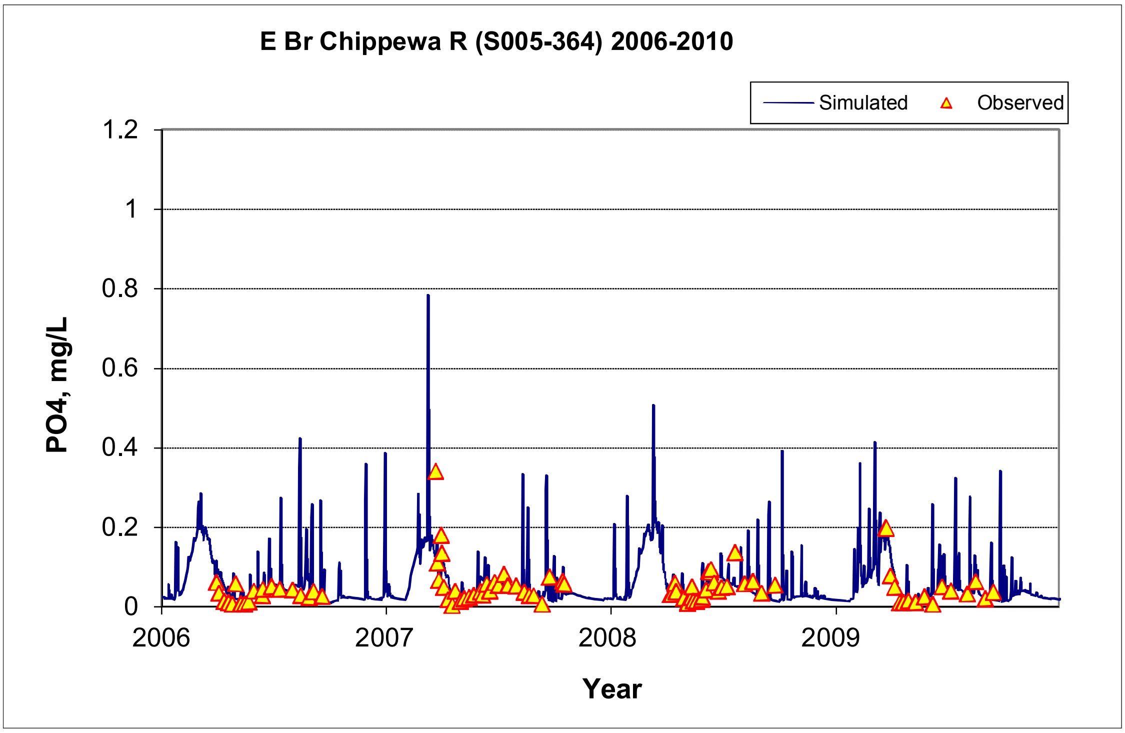


Figure 28. Ortho P Concentration Time Series, Validation Period, East Branch Chippewa River (S005-364)

Table 8. Summary Statistics, Total P, East Branch Chippewa River (S005-364)

	Calibration (1999-2005)	Validation (2006-2010)
Count	103	126
Concentration Average Error	3.18%	14.18%
Concentration Median Error	11.18%	24.96%
Paired Load Average Error	-9.19%	-12.55%
Paired Load Median Error	3.21%	7.56%
Paired t Test on Concentration Means (p value)	1.00	0.86
Paired t Test on Load Means (p value)	0.75	0.67
Difference in Slope, Load vs. Flow	-14.71%	-10.52%

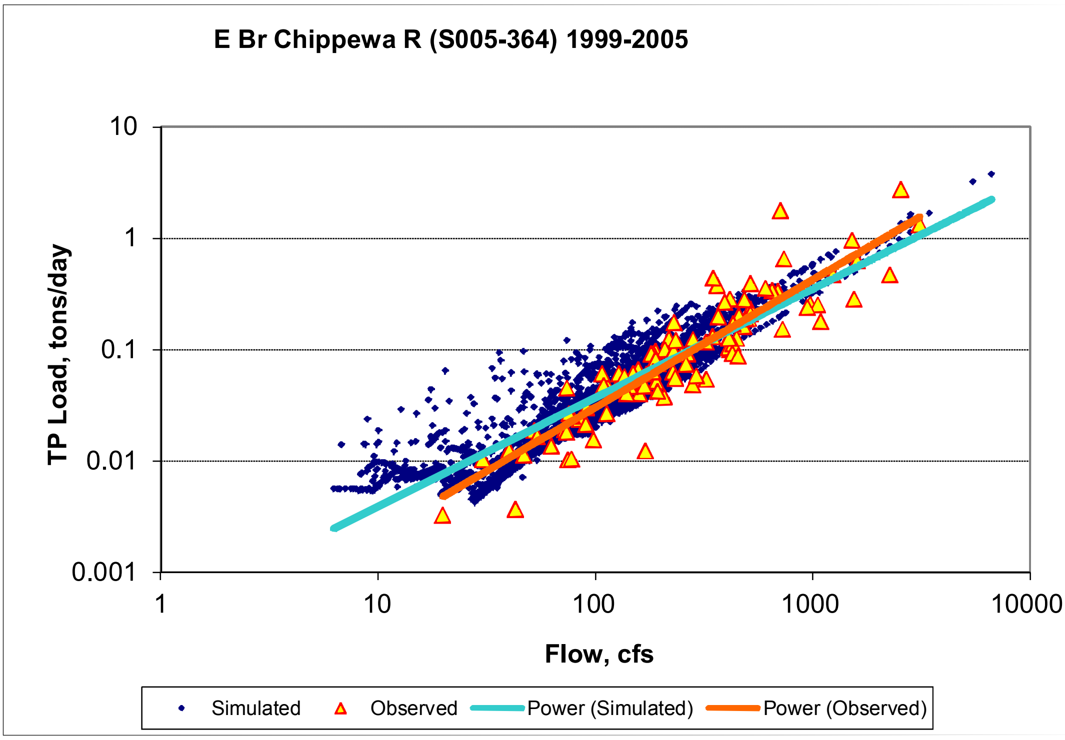


Figure 29. Total P Load Power Plot, Calibration Period, East Branch Chippewa River (S005-364)

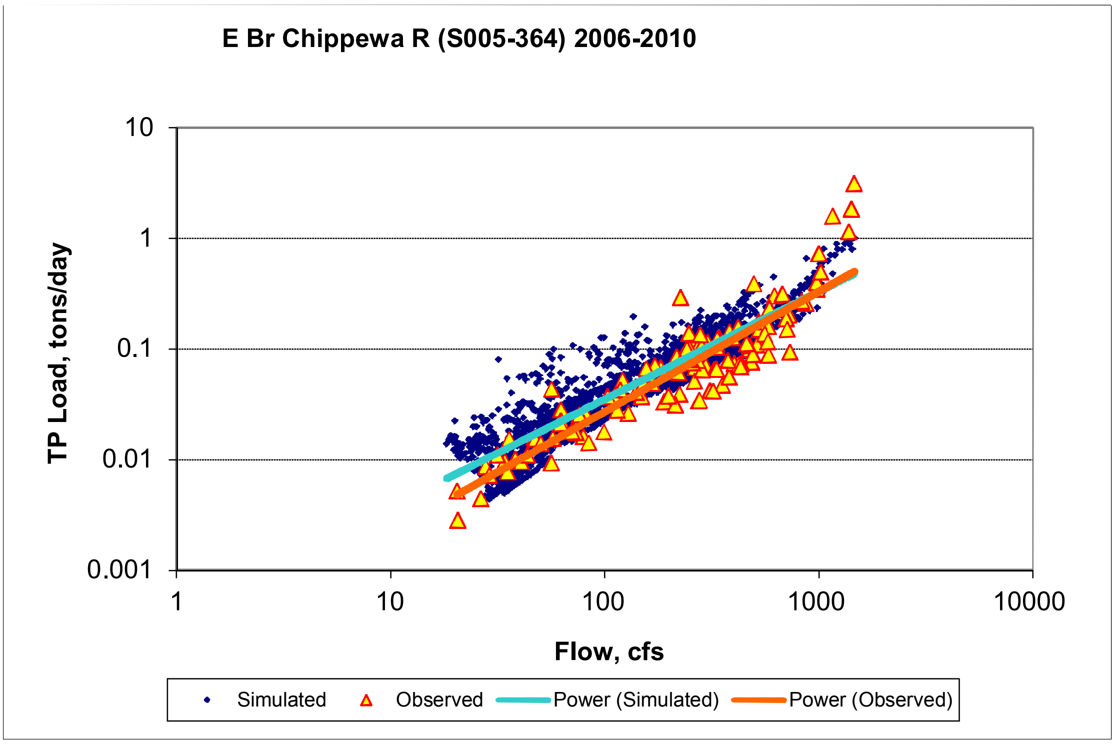


Figure 30. Total P Load Power Plot, Validation Period, East Branch Chippewa River (S005-364)

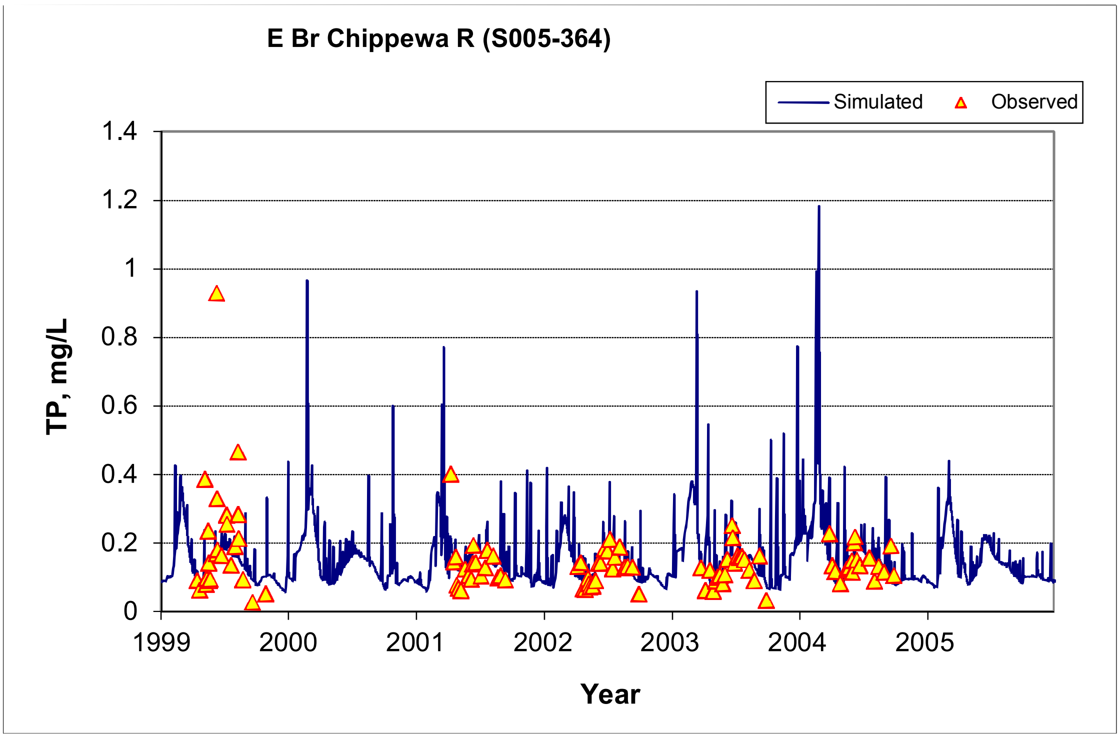


Figure 31. Total P Concentration Time Series, Calibration Period, East Branch Chippewa River (S005-364)

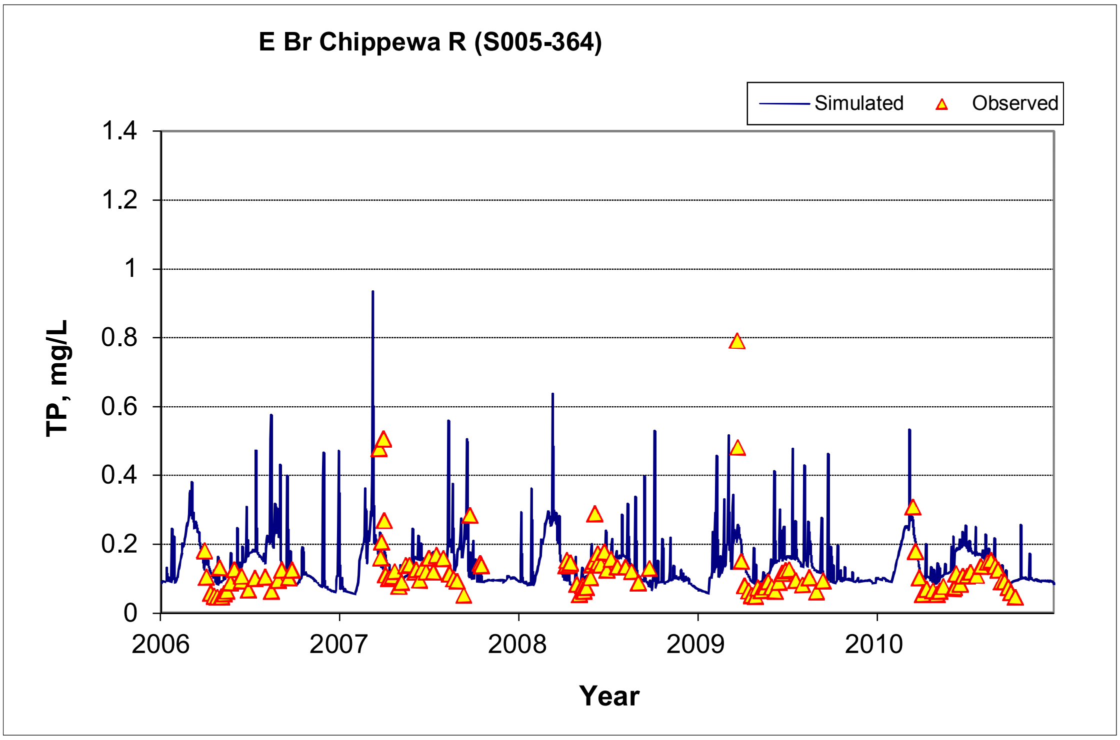


Figure 32. Total P Concentration Time Series, Validation Period, East Branch Chippewa River (S005-364)

Table 9. Summary Statistics, NOx-N, East Branch Chippewa River (S005-364)

	Calibration (1999-2005)	Validation (2006-2010)
Count	131	125
Concentration Average Error	-0.52%	-3.91%
Concentration Median Error	-3.17%	3.65%
Paired Load Average Error	31.68%	-20.65%
Paired Load Median Error	-0.50%	0.39%
Paired t Test on Concentration Means (p value)	0.98	0.97
Paired t Test on Load Means (p value)	0.29	0.48
Difference in Slope, Load vs. Flow	-32.17%	-28.03%

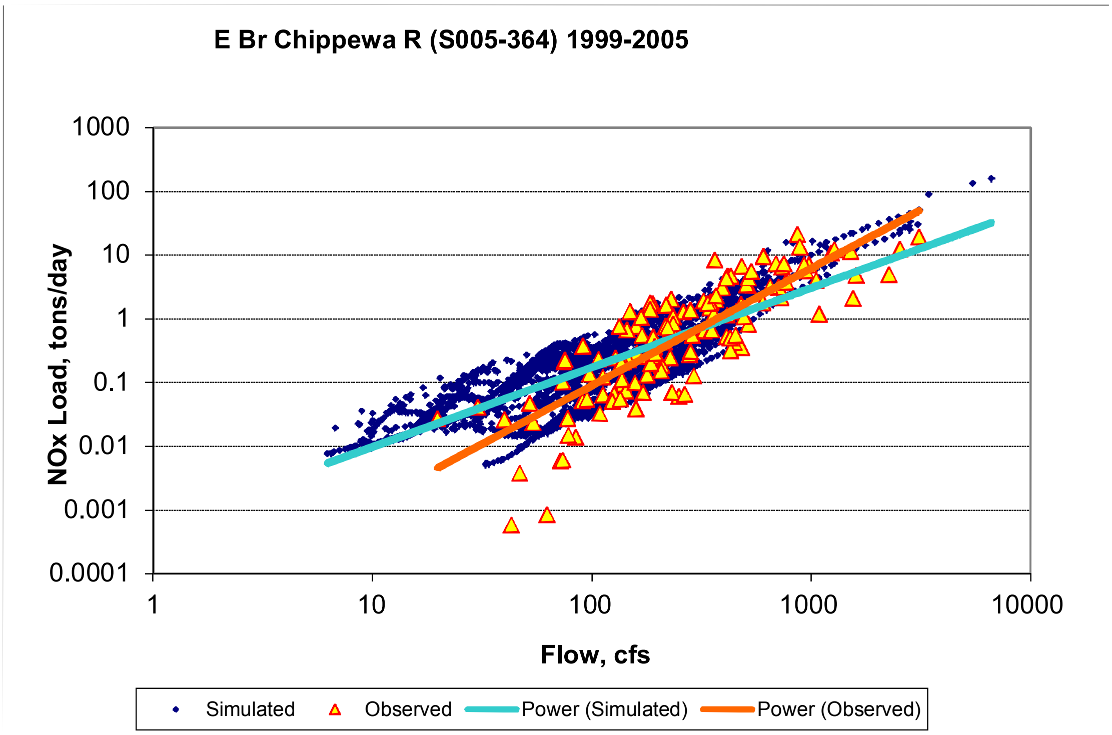


Figure 33. NOx-N Load Power Plot, Calibration Period, East Branch Chippewa River (S005-364)

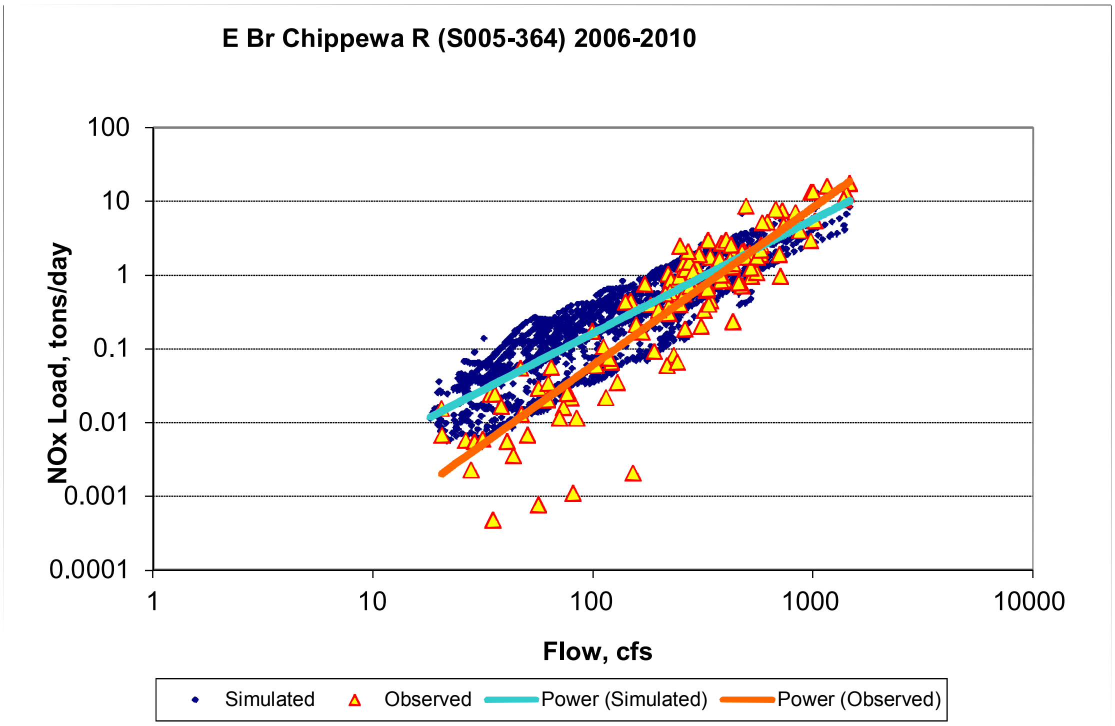


Figure 34. NOx-N Load Power Plot, Validation Period, East Branch Chippewa River (S005-364)

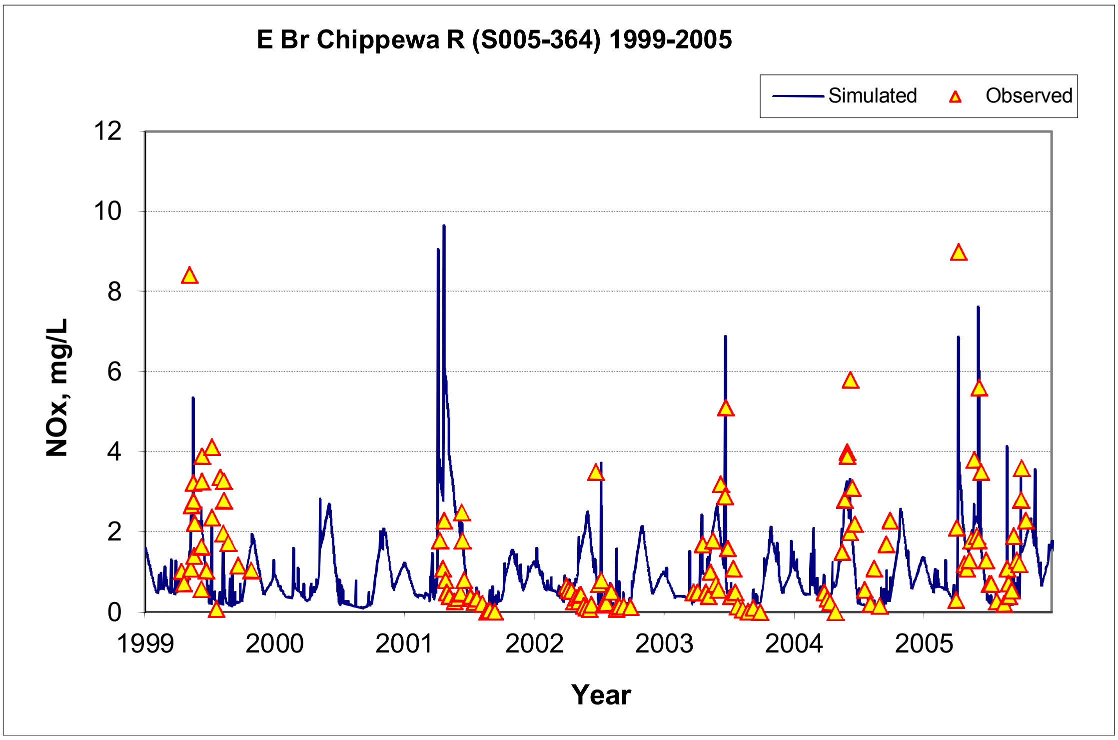


Figure 35. NOx-N Concentration Time Series, Calibration Period, East Branch Chippewa River (S005-364)

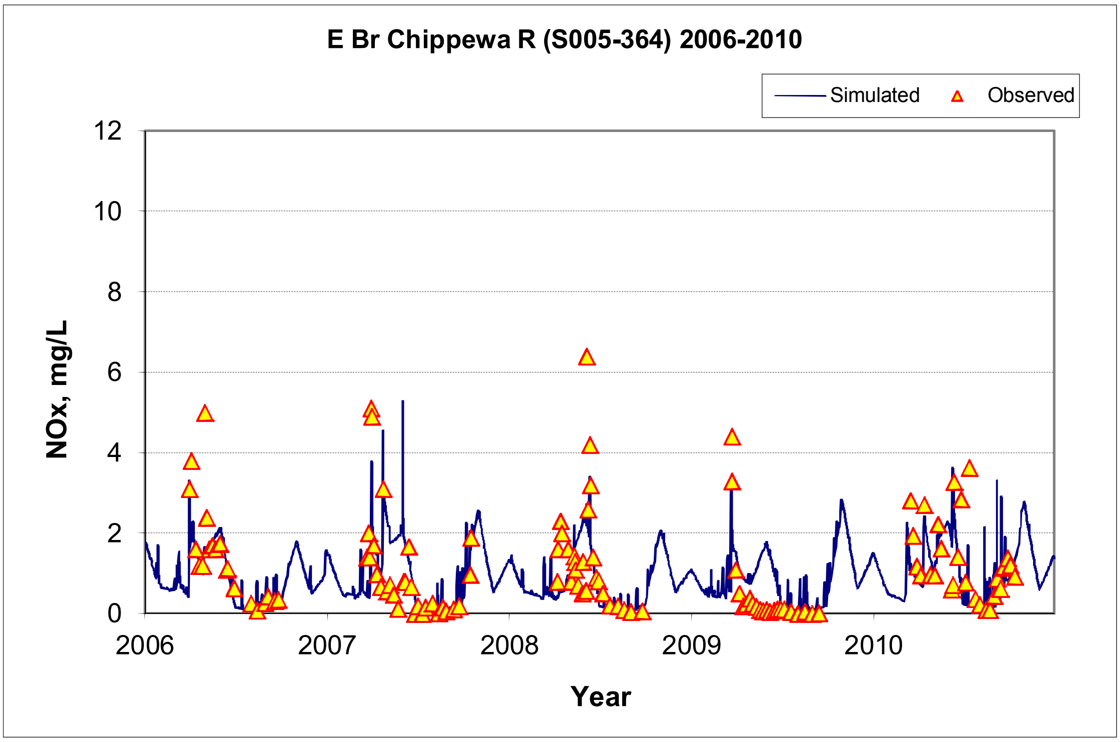


Figure 36. NOx-N Concentration Time Series, Validation Period, East Branch Chippewa River (S005-364)

Table 10. Summary Statistics, Total N, East Branch Chippewa River (S005-364)

	Calibration (1999-2005)	Validation (2006-2010)
Count	107	17
Concentration Average Error	-1.64%	57.17%
Concentration Median Error	6.54%	59.15%
Paired Load Average Error	20.42%	10.02%
Paired Load Median Error	1.48%	12.31%
Paired t Test on Concentration Means (p value)	1.00	0.00
Paired t Test on Load Means (p value)	0.49	0.61
Difference in Slope, Load vs. Flow	-22.24%	-18.80%

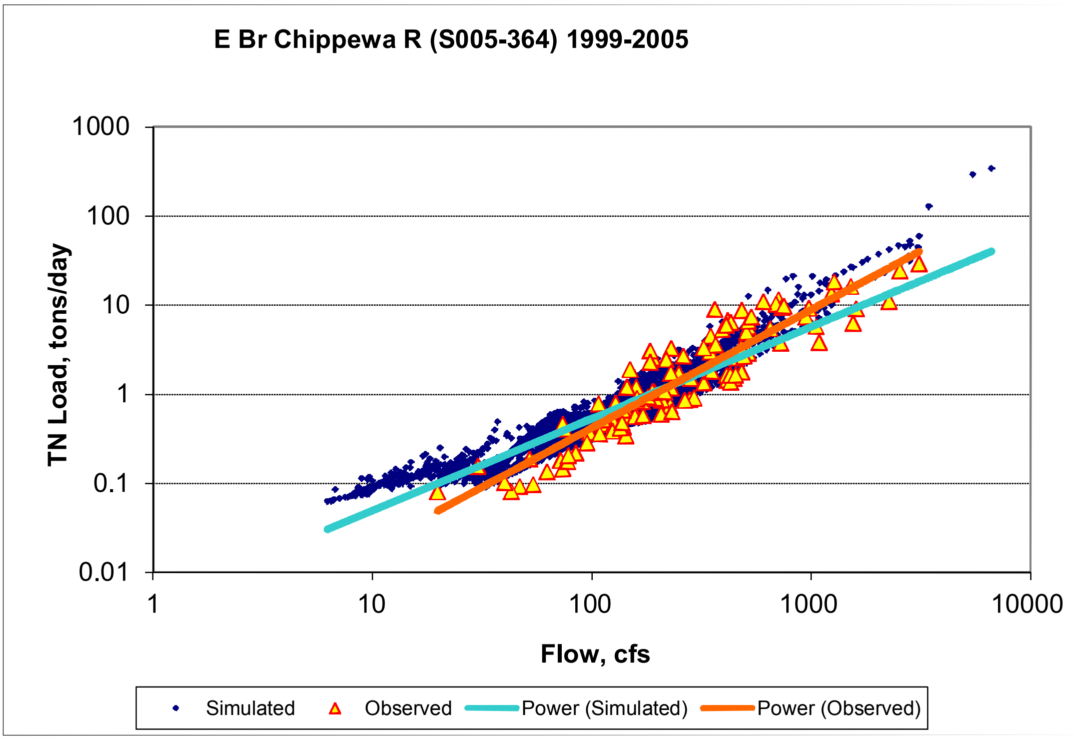


Figure 37. Total N Load Power Plot, Calibration Period, East Branch Chippewa River (S005-364)

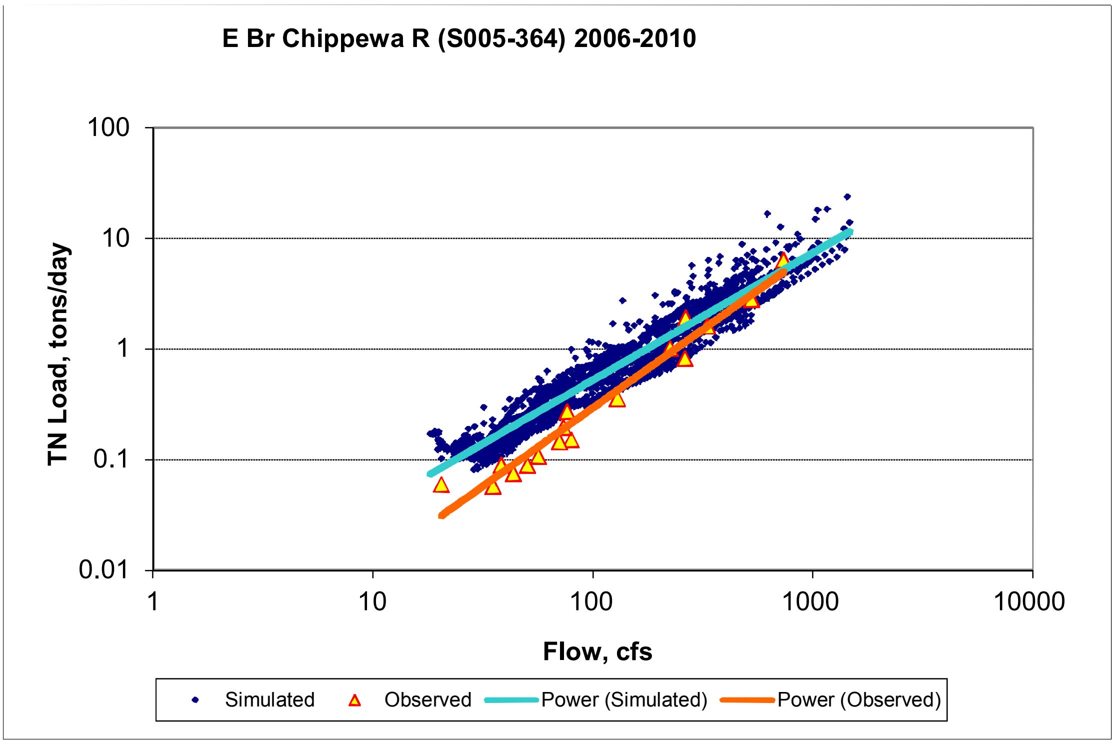


Figure 38. Total N Load Power Plot, Validation Period, East Branch Chippewa River (S005-364)

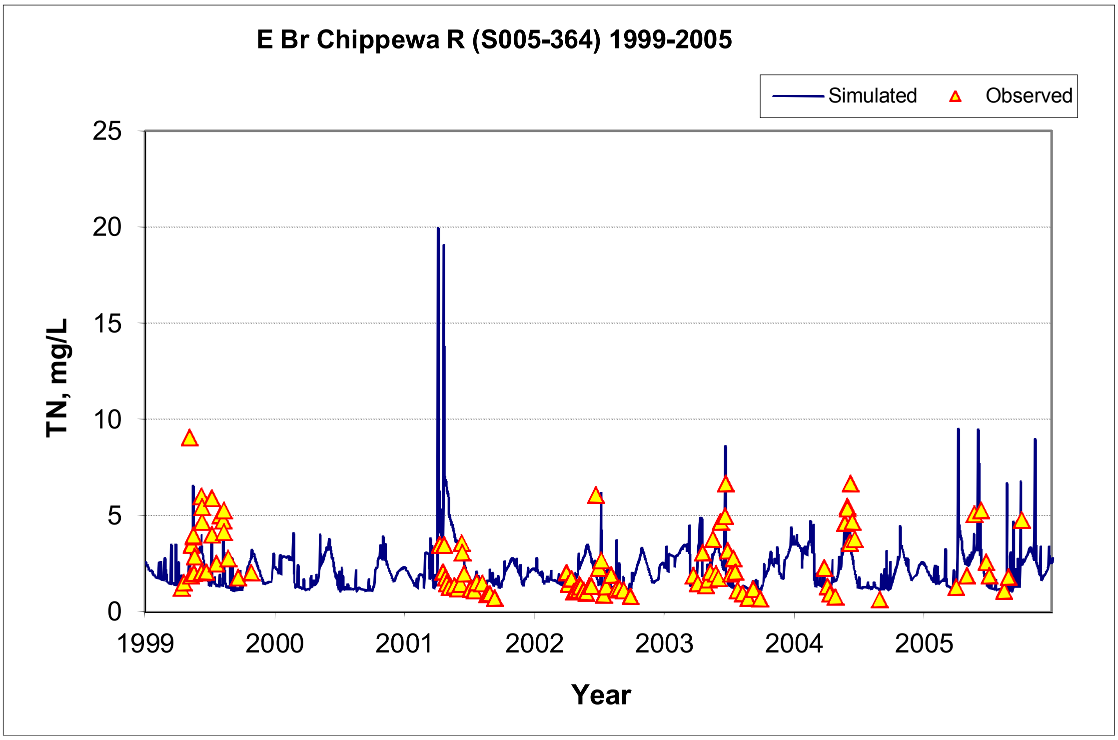


Figure 39. Total N Concentration Time Series, Calibration Period, East Branch Chippewa River (S005-364)

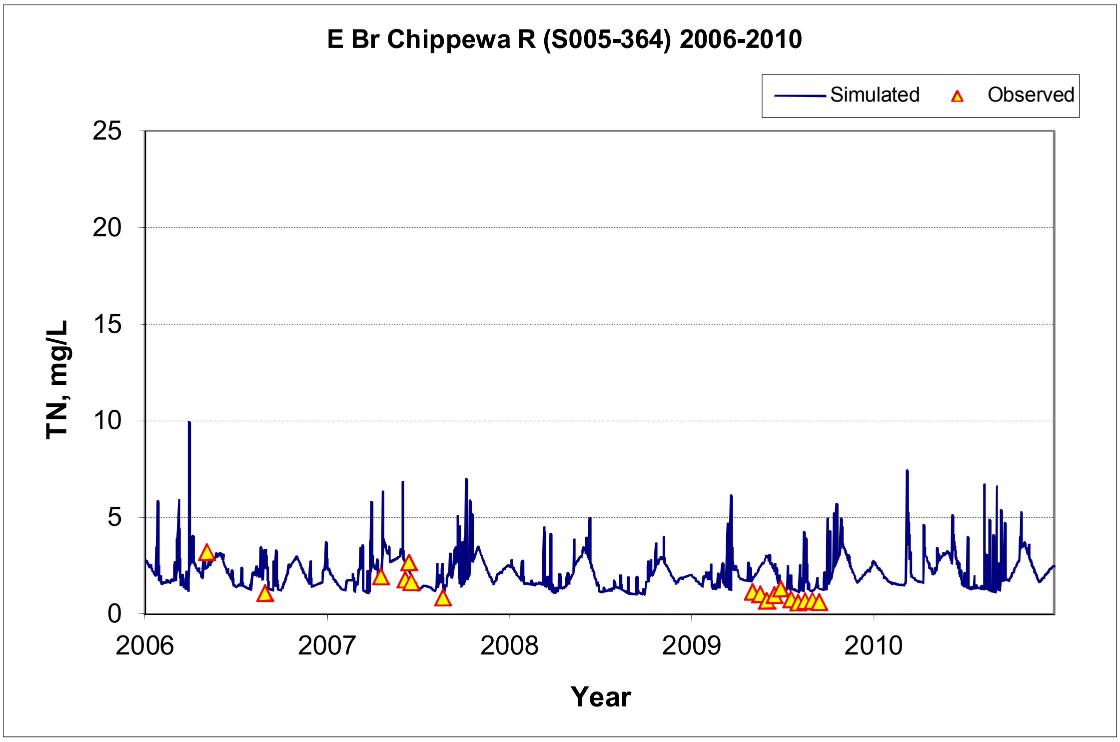


Figure 40. Total N Concentration Time Series, Validation Period, East Branch Chippewa River (S005-364)

3 Shakopee Creek near Benson (S002-201)

Table 11. Summary Statistics, TSS, Shakopee Crk near Benson (S002-201)

	Calibration (1999-2005)	Validation (2006-2010)
Count	133	118
Concentration Average Error	-21.50%	-1.82%
Concentration Median Error	0.78%	14.71%
Paired Load Average Error	6.07%	18.20%
Paired Load Median Error	0.16%	7.18%
Paired t Test on Concentration Means (p value)	0.40	1.00
Paired t Test on Load Means (p value)	0.86	0.55
Difference in Slope, Load vs. Flow	26.33%	33.91%

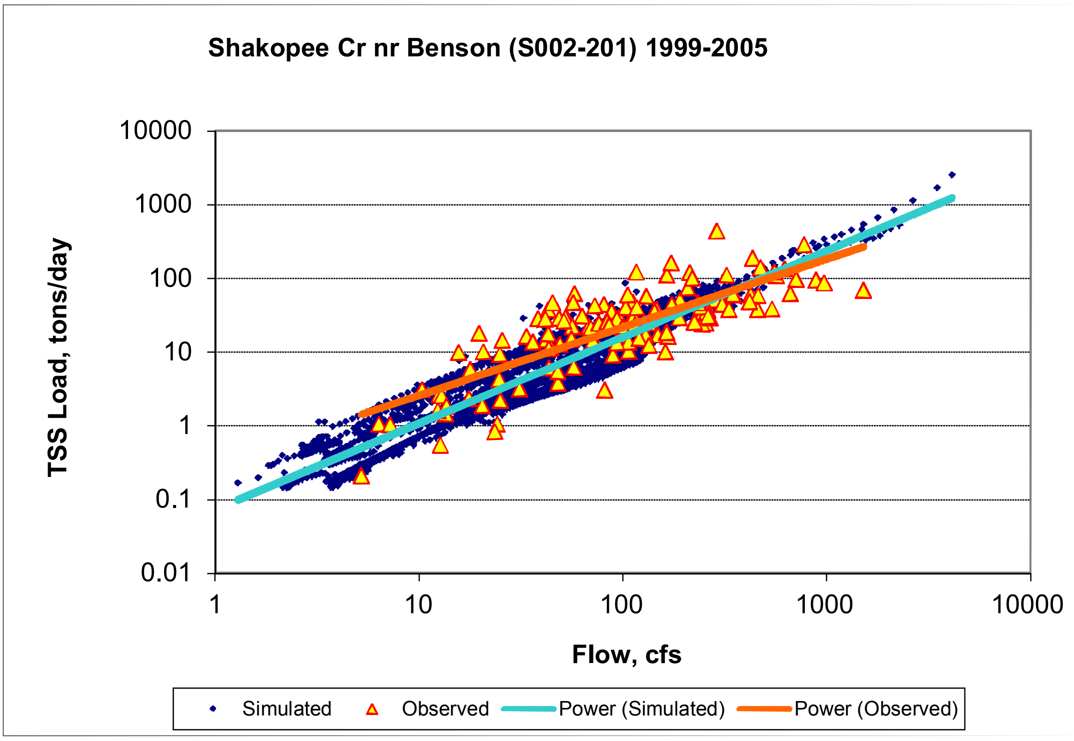


Figure 41. TSS Load Power Plot, Calibration Period, Shakopee Crk near Benson (S002-201)

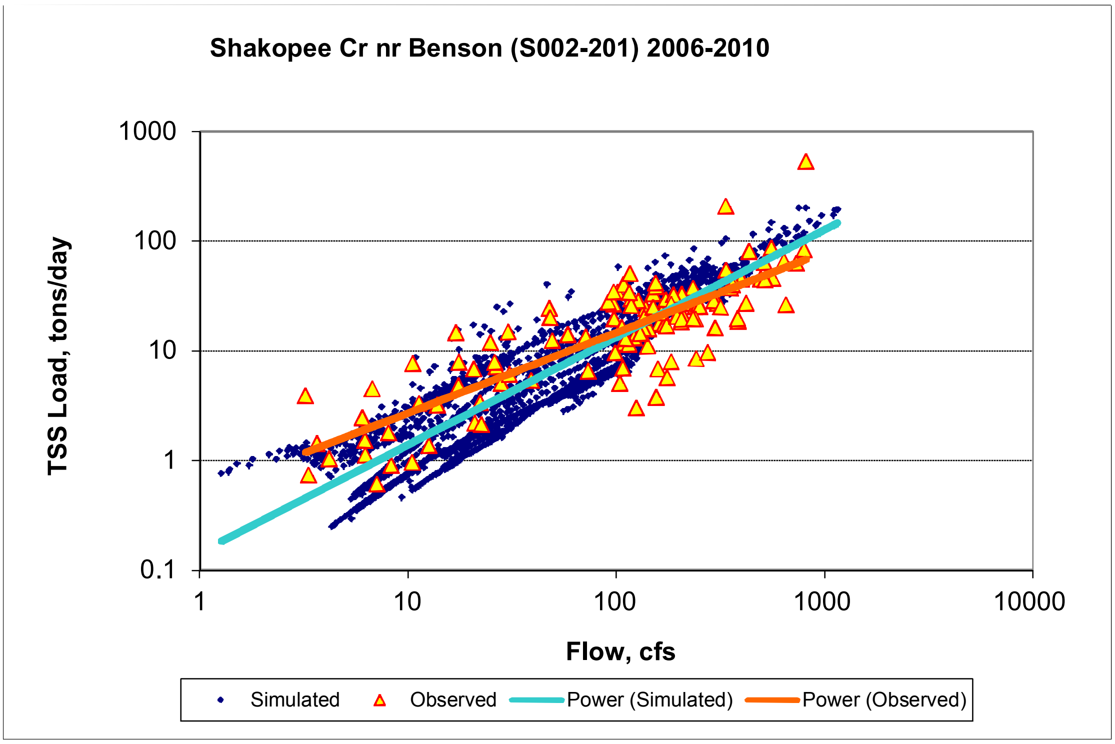


Figure 42. TSS Load Power Plot, Validation Period, Shakopee Crk near Benson (S002-201)

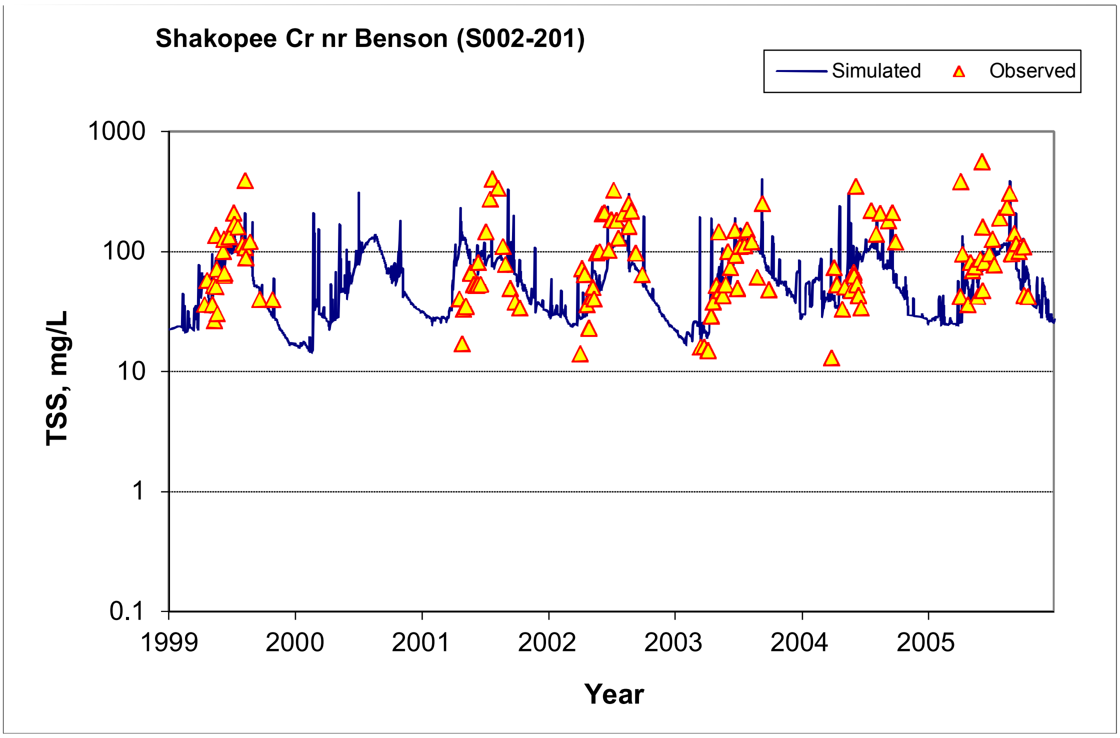


Figure 43. TSS Concentration Time Series, Calibration Period, Shakopee Crk near Benson (S002-201)

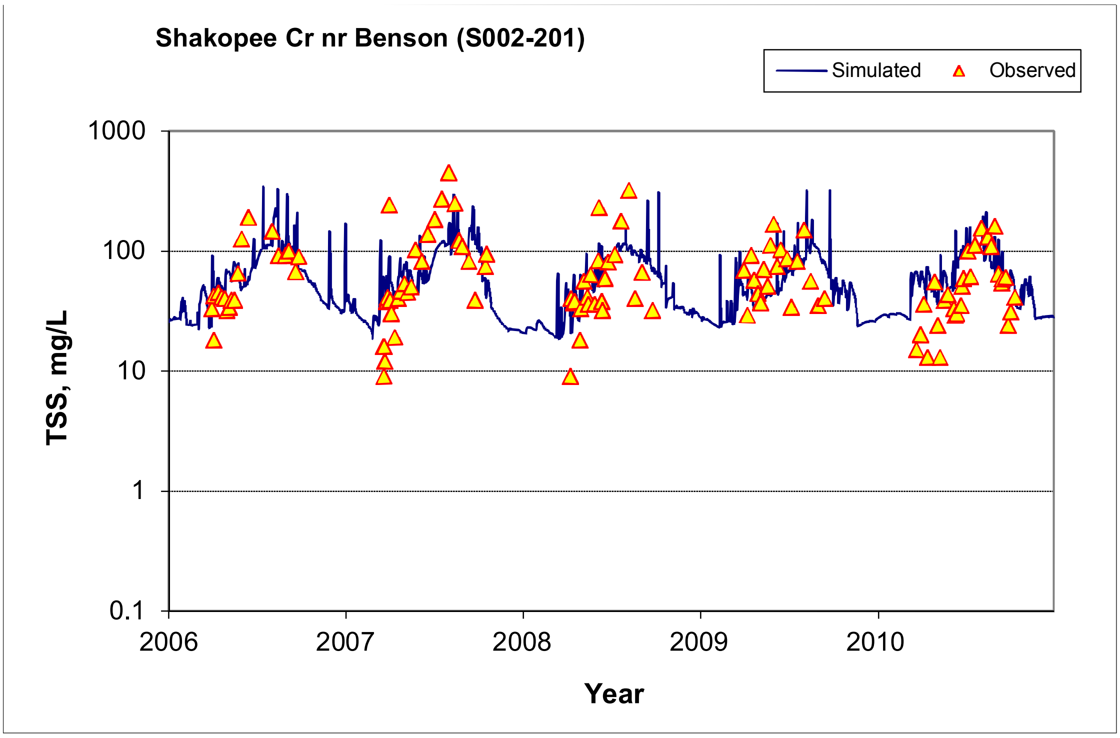


Figure 44. TSS Concentration Time Series, Validation Period, Shakopee Crk near Benson (S002-201)

Table 12. Summary Statistics, Ortho P, Shakopee Crk near Benson (S002-201)

	Calibration (1999-2005)	Validation (2006-2010)
Count	130	90
Concentration Average Error	10.62%	-24.61%
Concentration Median Error	33.21%	14.67%
Paired Load Average Error	-20.52%	-20.25%
Paired Load Median Error	4.23%	3.82%
Paired t Test on Concentration Means (p value)	0.86	0.35
Paired t Test on Load Means (p value)	0.49	0.50
Difference in Slope, Load vs. Flow	-3.97%	53.44%

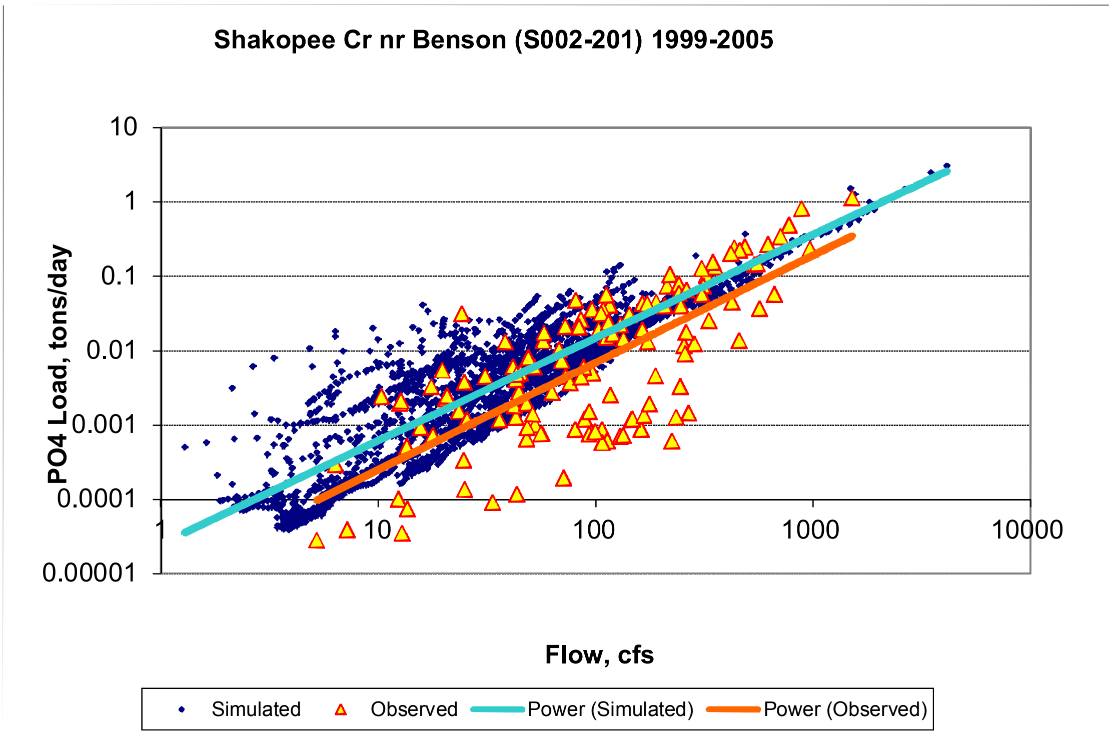


Figure 45. Ortho P Load Power Plot, Calibration Period, Shakopee Crk near Benson (S002-201)

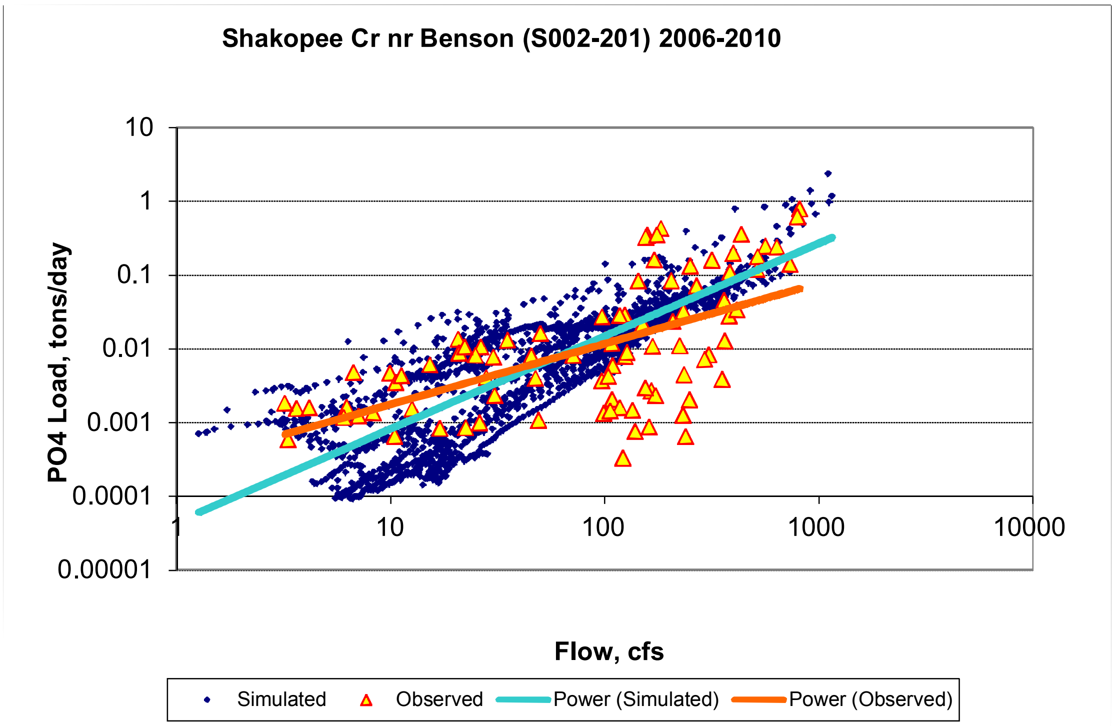


Figure 46. Ortho P Load Power Plot, Validation Period, Shakopee Crk near Benson (S002-201)

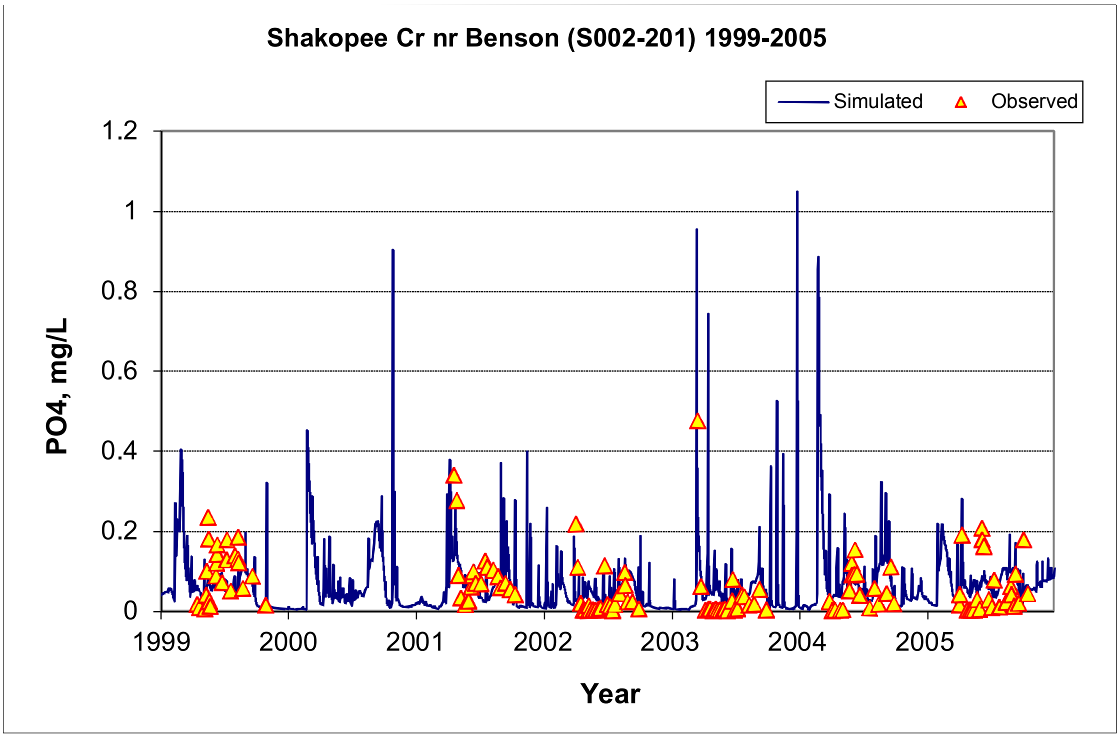


Figure 47. Ortho P Concentration Time Series, Calibration Period, Shakopee Crk near Benson (S002-201)

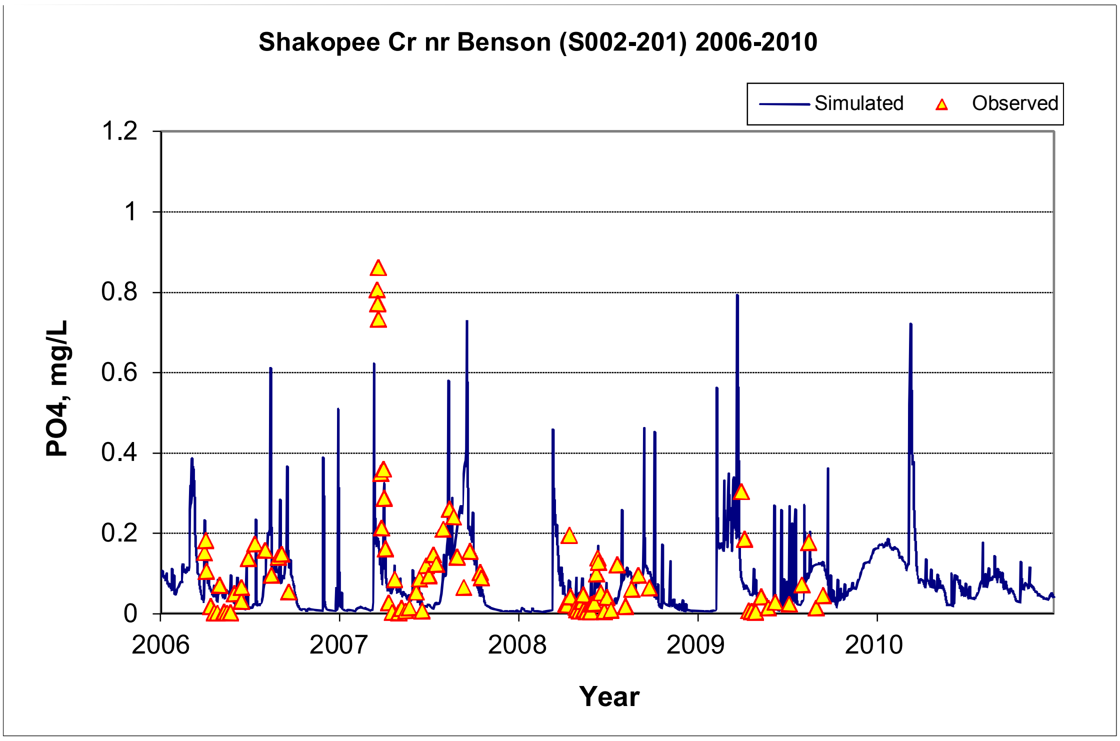


Figure 48. Ortho P Concentration Time Series, Validation Period, Shakopee Crk near Benson (S002-201)

Table 13. Summary Statistics, Total P, Shakopee Crk near Benson (S002-201)

	Calibration (1999-2005)	Validation (2006-2010)
Count	107	128
Concentration Average Error	8.25%	-0.65%
Concentration Median Error	11.83%	16.54%
Paired Load Average Error	12.26%	0.63%
Paired Load Median Error	3.15%	9.14%
Paired t Test on Concentration Means (p value)	1.00	1.00
Paired t Test on Load Means (p value)	0.68	0.94
Difference in Slope, Load vs. Flow	18.01%	23.92%

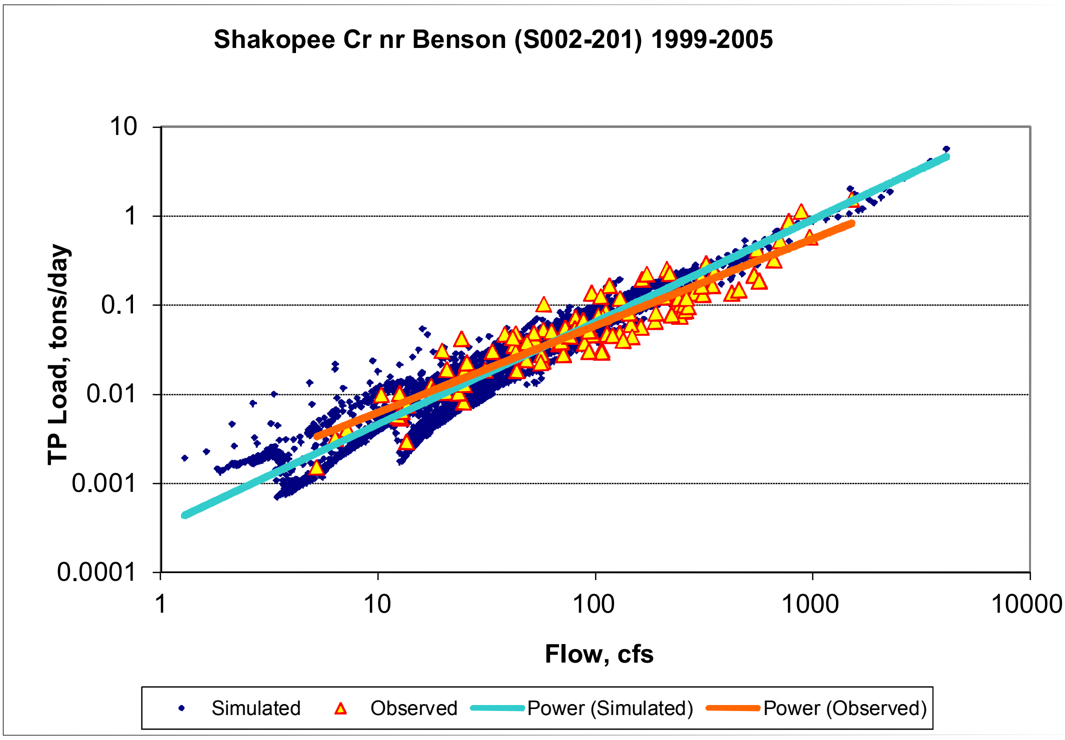


Figure 49. Total P Load Power Plot, Calibration Period, Shakopee Crk near Benson (S002-201)

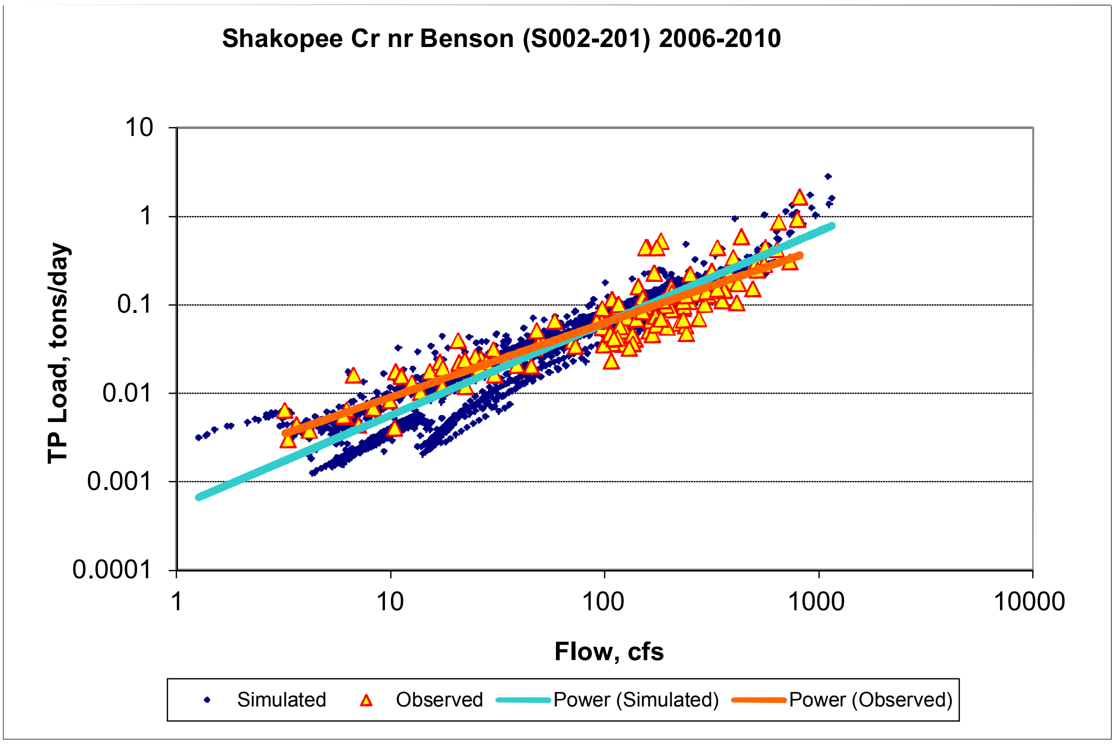


Figure 50. Total P Load Power Plot, Validation Period, Shakopee Crk near Benson (S002-201)

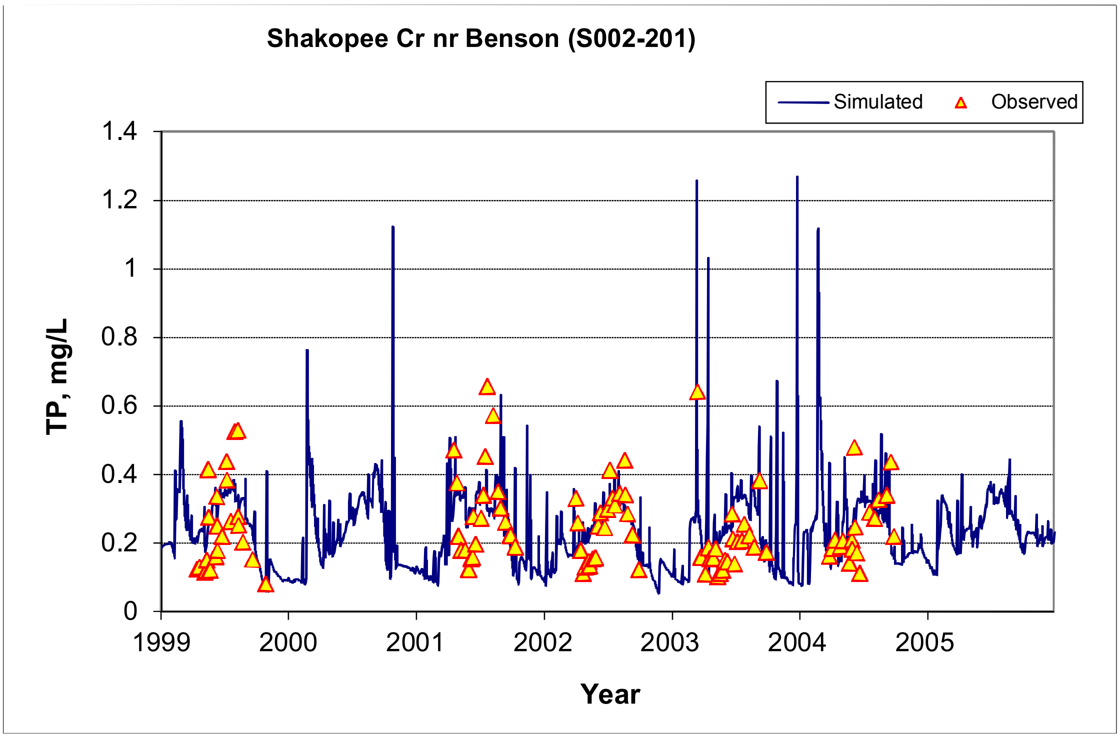


Figure 51. Total P Concentration Time Series, Calibration Period, Shakopee Crk near Benson (S002-201)

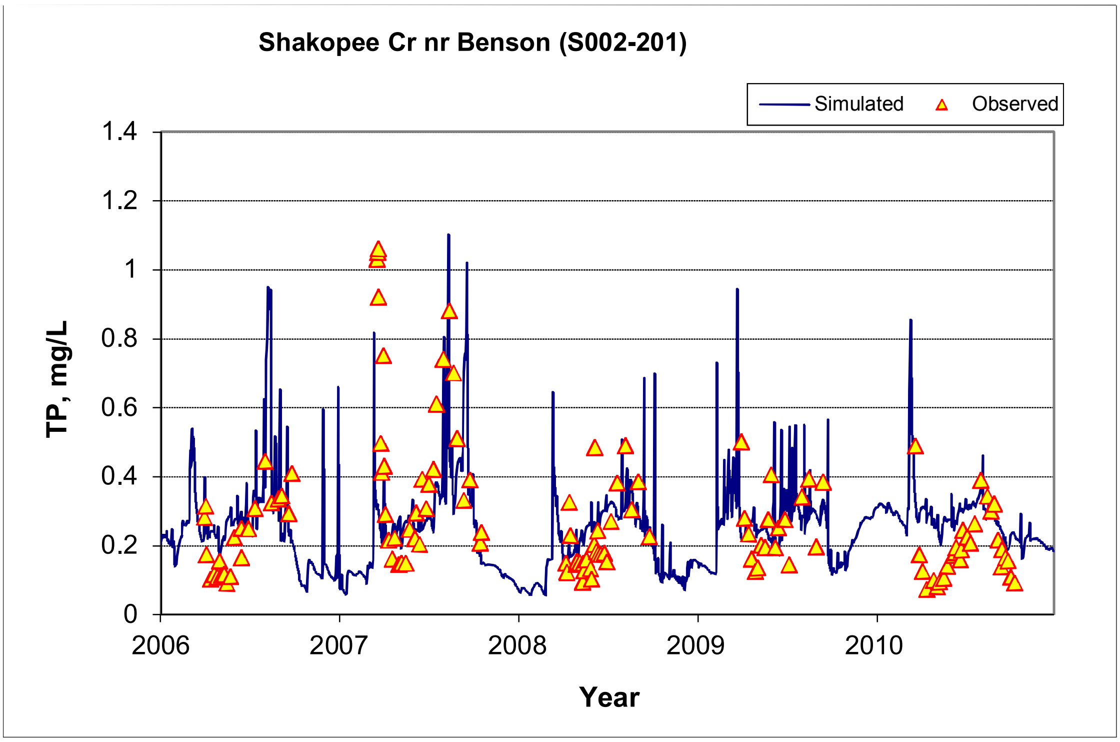


Figure 52. Total P Concentration Time Series, Validation Period, Shakopee Crk near Benson (S002-201)

Table 14. Summary Statistics, NOx-N, Shakopee Crk near Benson (S002-201)

	Calibration (1999-2005)	Validation (2006-2010)
Count	134	127
Concentration Average Error	-12.33%	-27.53%
Concentration Median Error	-1.04%	-4.41%
Paired Load Average Error	-21.87%	-23.18%
Paired Load Median Error	-0.08%	-0.56%
Paired t Test on Concentration Means (p value)	0.83	0.15
Paired t Test on Load Means (p value)	0.45	0.41
Difference in Slope, Load vs. Flow	-70.20%	-48.48%

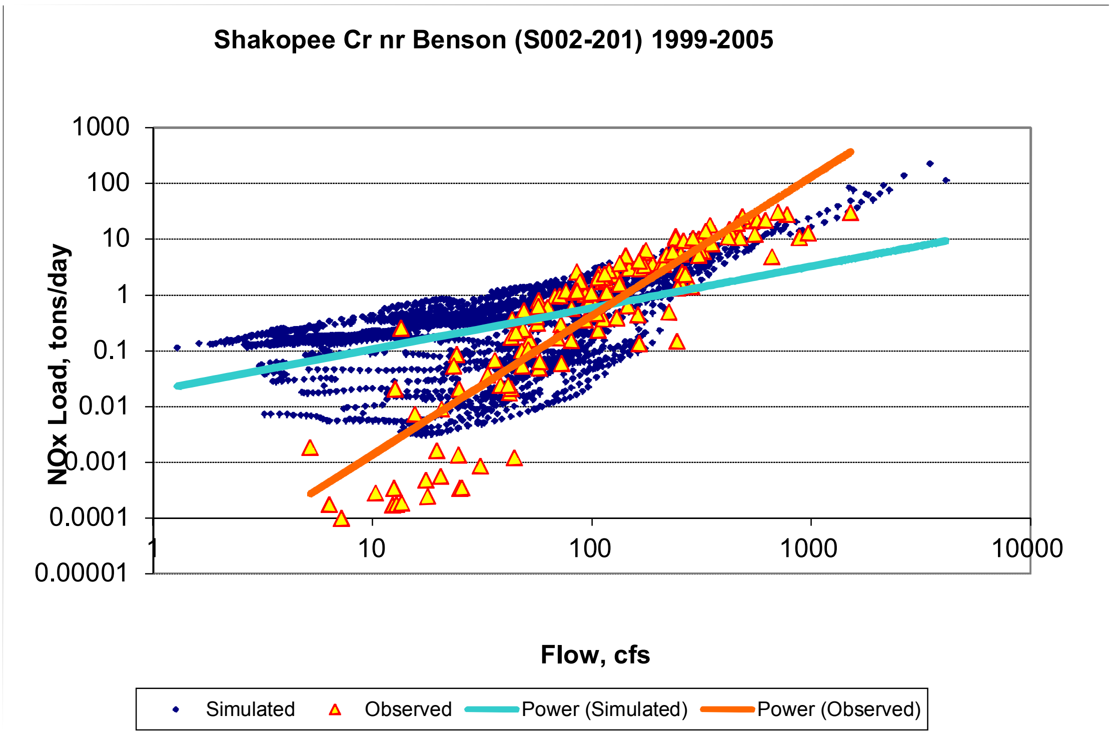


Figure 53. NOx-N Load Power Plot, Calibration Period, Shakopee Crk near Benson (S002-201)

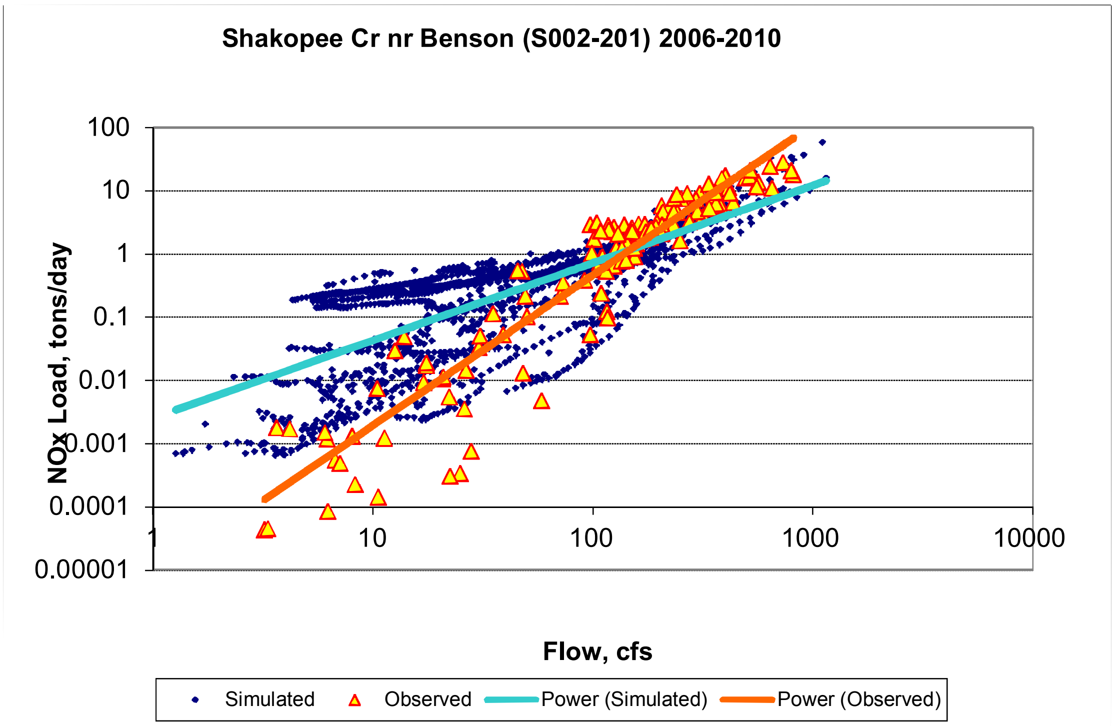


Figure 54. NOx-N Load Power Plot, Validation Period, Shakopee Crk near Benson (S002-201)

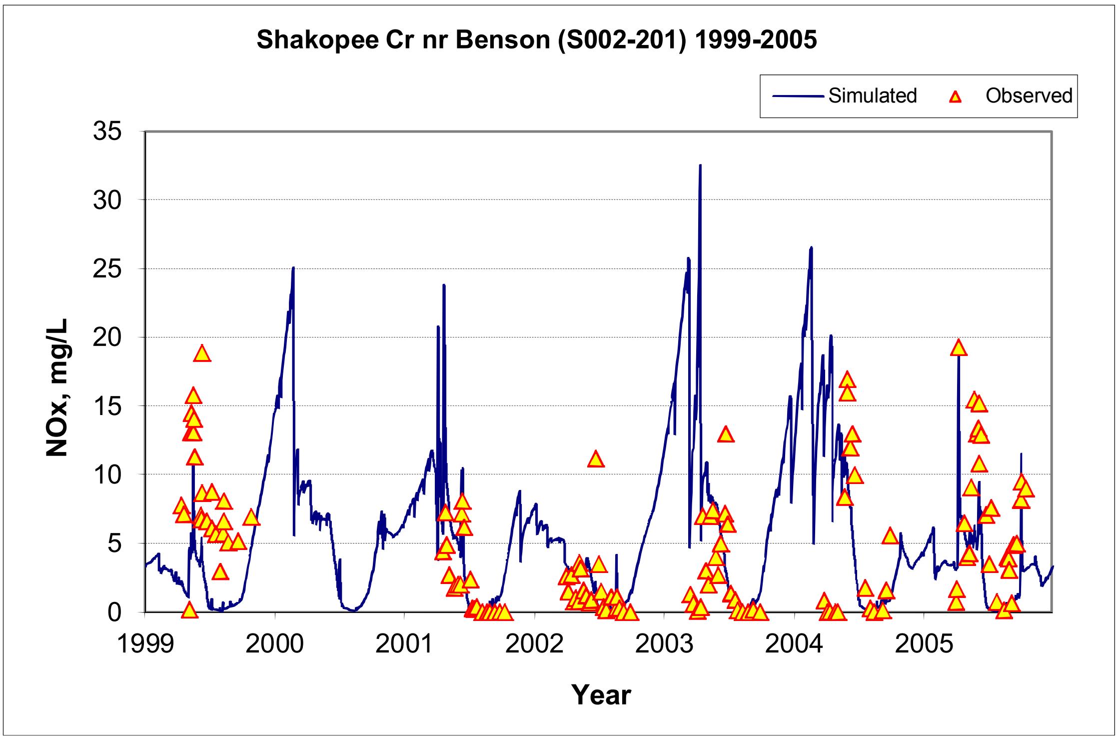


Figure 55. NOx-N Concentration Time Series, Calibration Period, Shakopee Crk near Benson (S002-201)

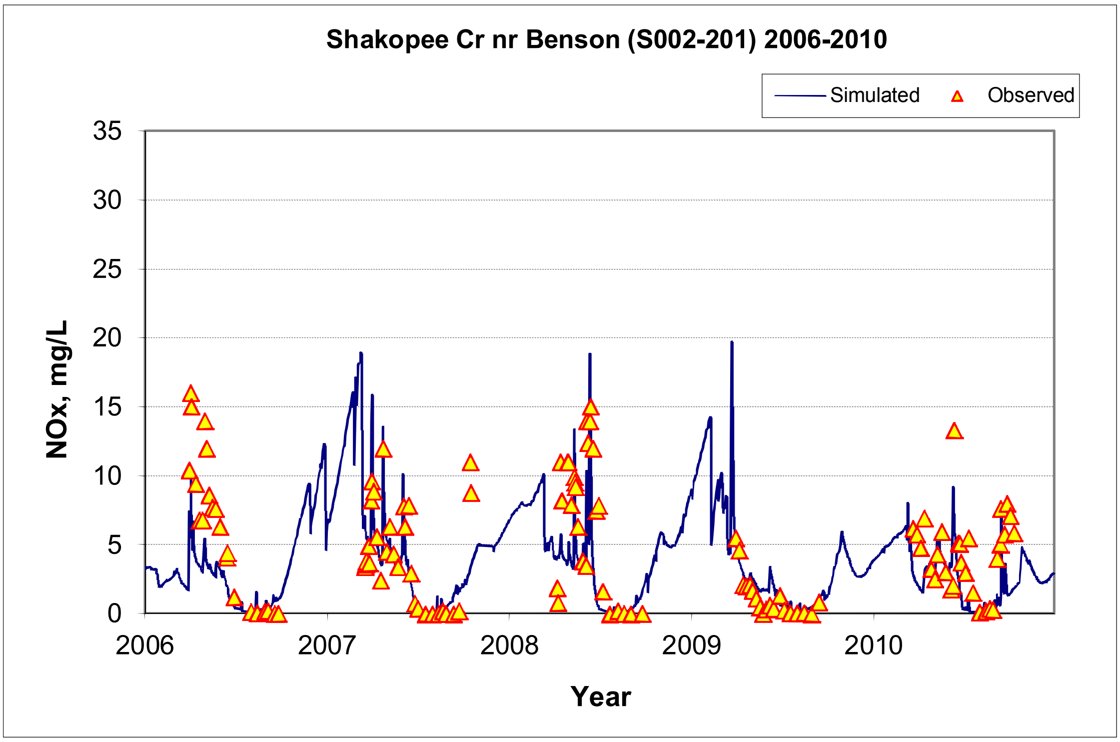


Figure 56. NOx-N Concentration Time Series, Validation Period, Shakopee Crk near Benson (S002-201)

Table 15. Summary Statistics, Total N, Shakopee Crk near Benson (S002-201)

	Calibration (1999-2005)	Validation (2006-2010)
Count	110	20
Concentration Average Error	7.98%	10.63%
Concentration Median Error	9.81%	19.73%
Paired Load Average Error	-8.59%	-14.53%
Paired Load Median Error	1.13%	2.19%
Paired t Test on Concentration Means (p value)	0.96	0.77
Paired t Test on Load Means (p value)	0.77	0.56
Difference in Slope, Load vs. Flow	-46.87%	-26.54%

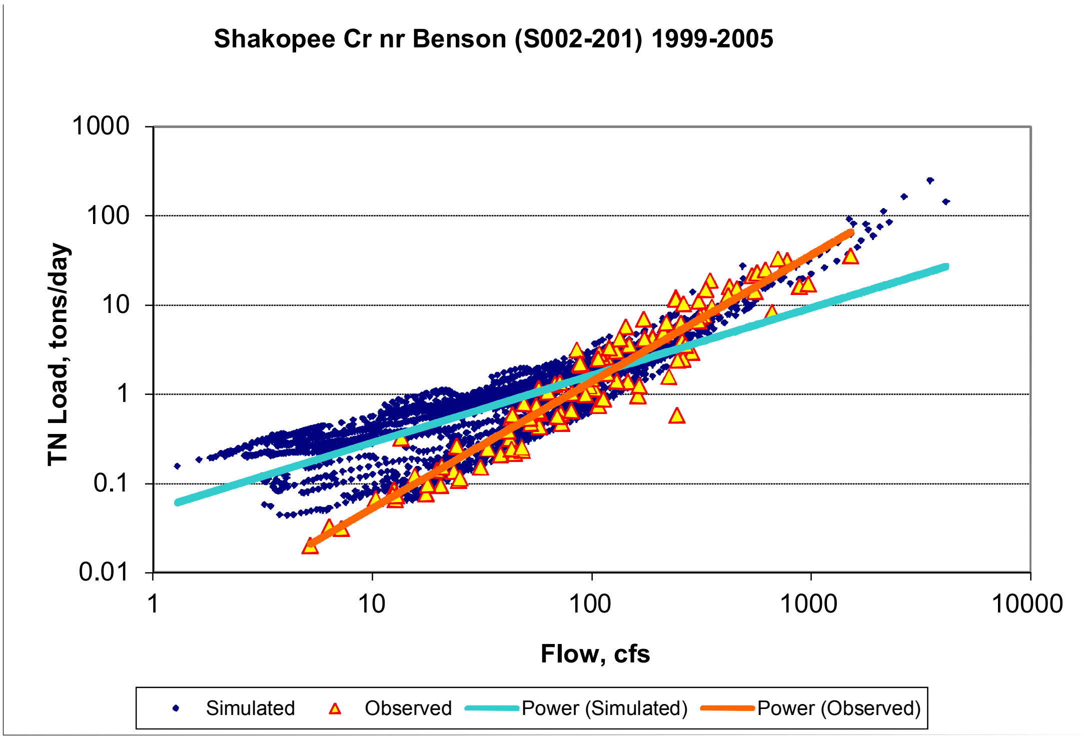


Figure 57. Total N Load Power Plot, Calibration Period, Shakopee Crk near Benson (S002-201)

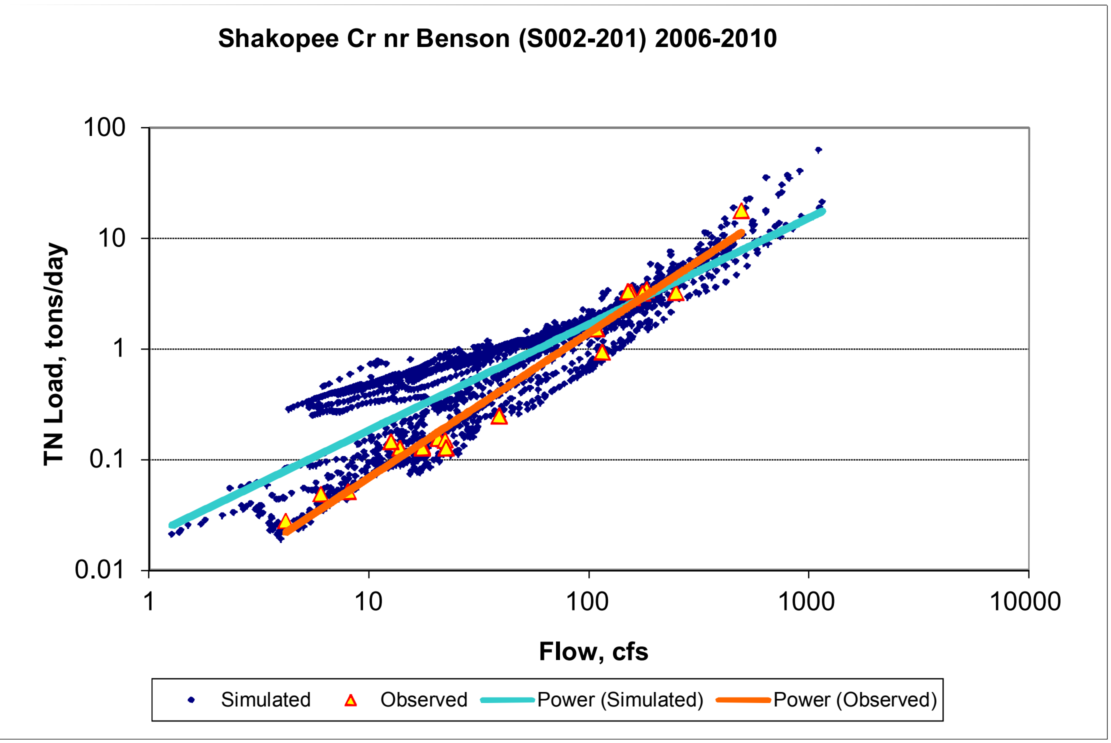


Figure 58. Total N Load Power Plot, Validation Period, Shakopee Crk near Benson (S002-201)

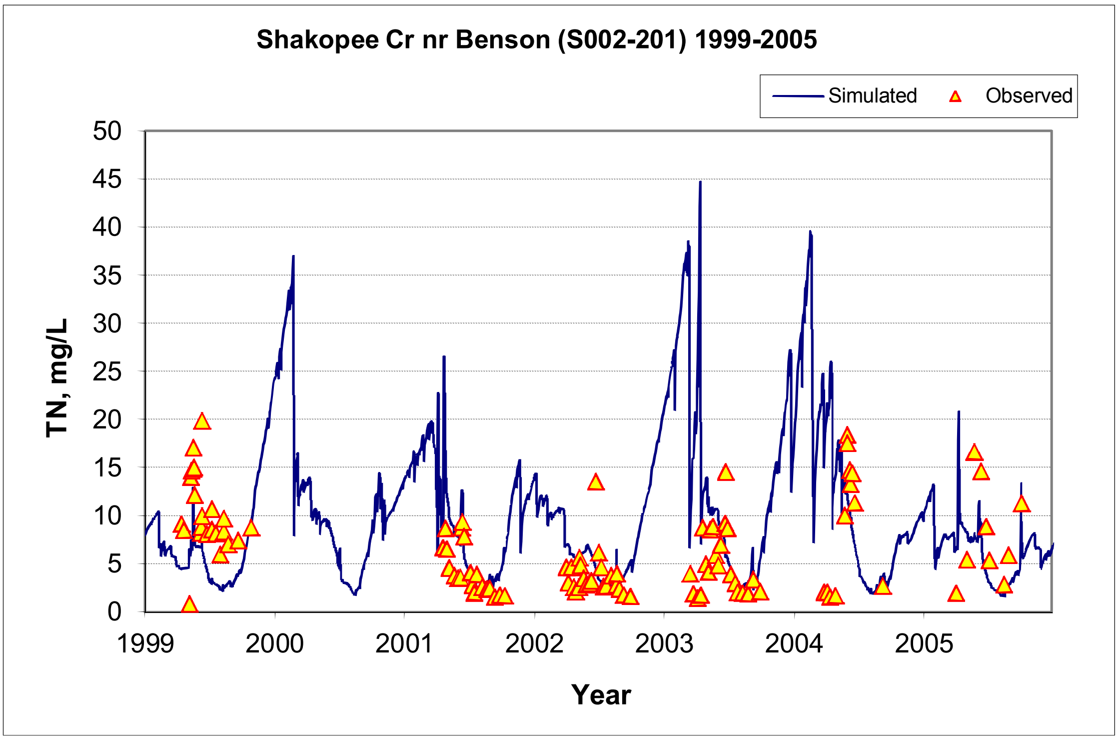


Figure 59. Total N Concentration Time Series, Calibration Period, Shakopee Crk near Benson (S002-201)

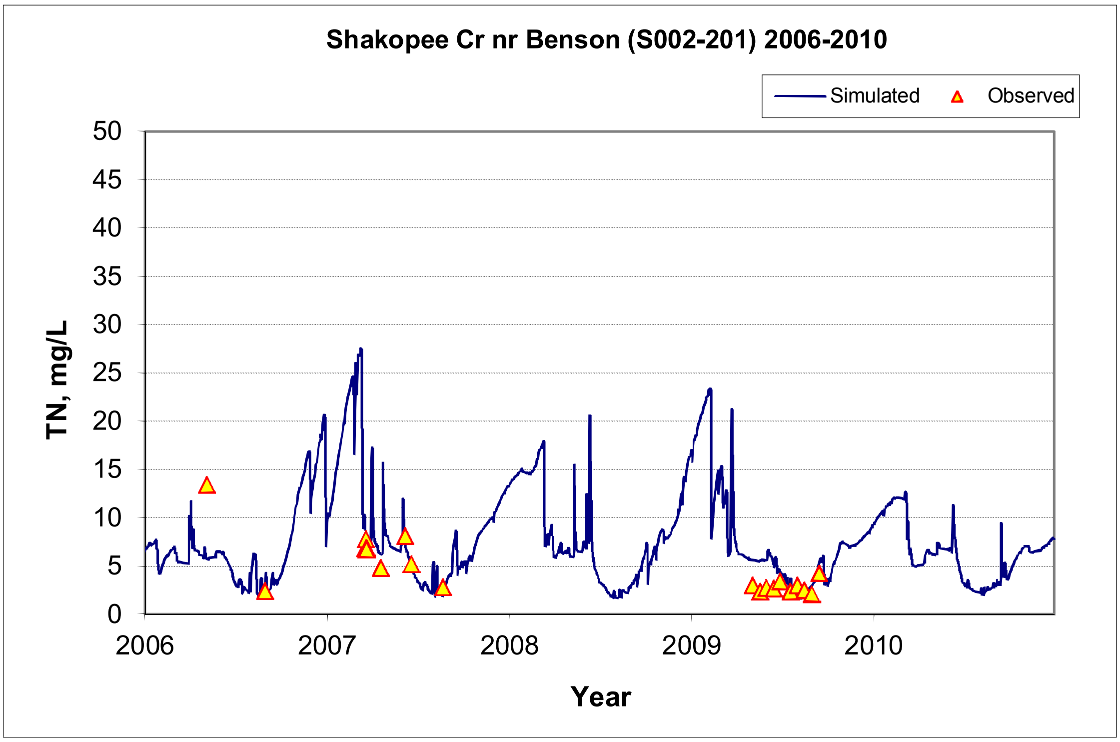


Figure 60. Total N Concentration Time Series, Validation Period, Shakopee Crk near Benson (S002-201)

4 Chippewa River at Milan (S002-203)

Table 16Summary Statistics, TSS, Chippewa River at Milan (S002-203)

	Calibration (1998-2005)	Validation (2006-2010)
Count	157	147
Concentration Average Error	-12.43%	11.36%
Concentration Median Error	-12.27%	17.57%
Paired Load Average Error	1.82%	-17.06%
Paired Load Median Error	-2.96%	4.20%
Paired t Test on Concentration Means (p value)	0.91	0.87
Paired t Test on Load Means (p value)	0.95	0.57
Difference in Slope, Load vs. Flow	21.87%	-7.42%

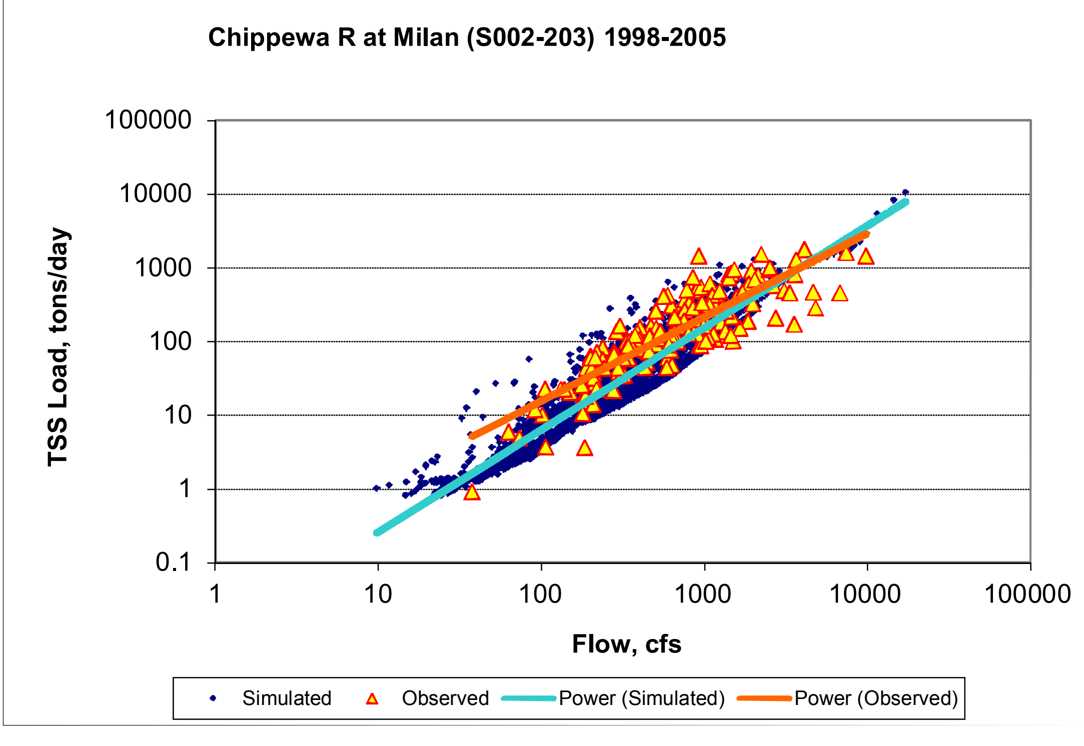


Figure 61. TSS Load Power Plot, Calibration Period, Chippewa River at Milan (S002-203)

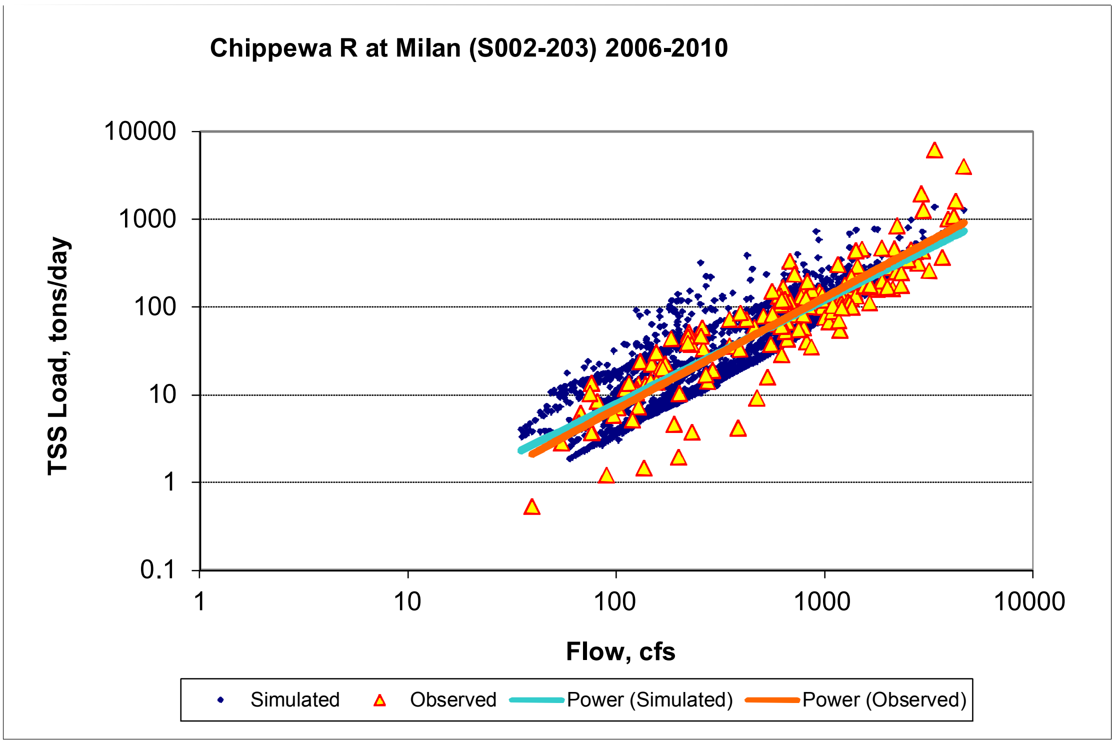


Figure 62. TSS Load Power Plot, Validation Period, Chippewa River at Milan (S002-203)

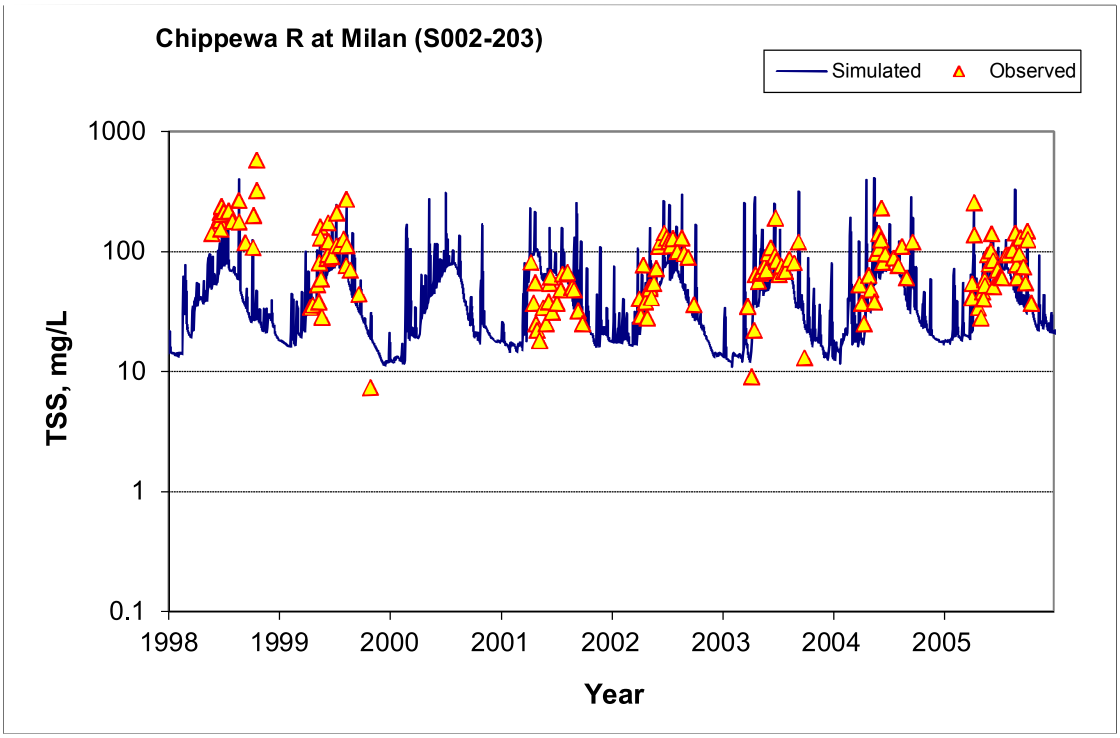


Figure 63. TSS Concentration Time Series, Calibration Period, Chippewa River at Milan (S002-203)

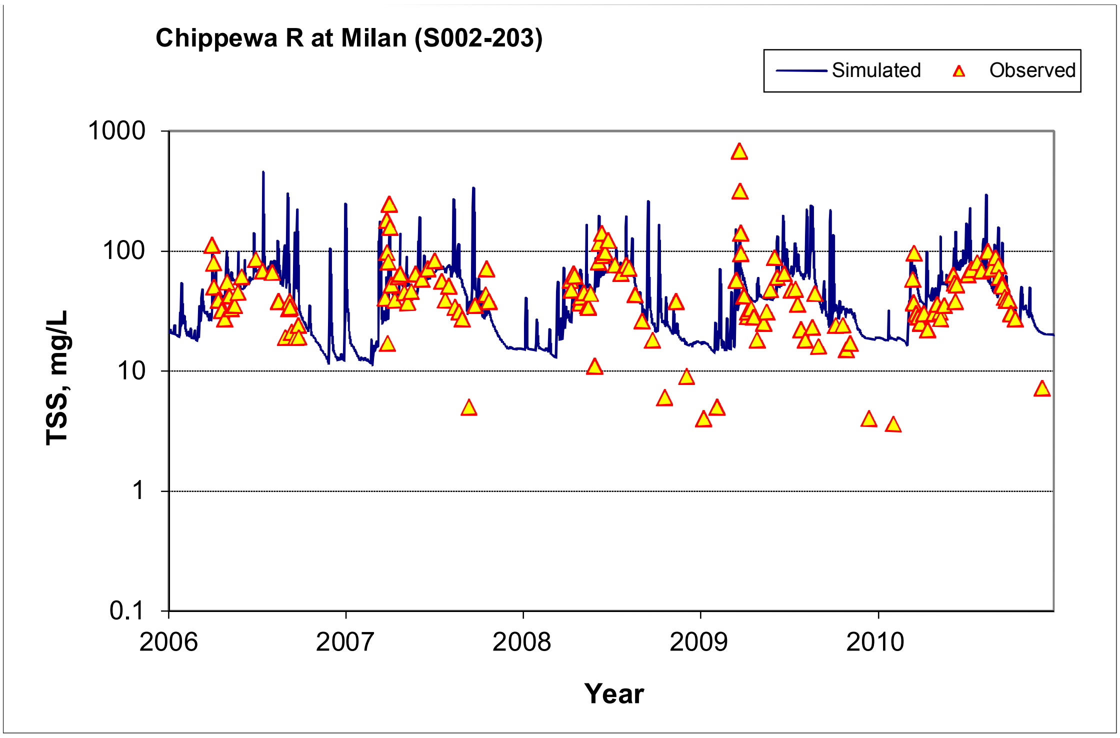


Figure 64. TSS Concentration Time Series, Validation Period, Chippewa River at Milan (S002-203)

Table 17. Summary Statistics, Ortho P, Chippewa River at Milan (S002-203)

	Calibration (1998-2005)	Validation (2006-2010)
Count	152	124
Concentration Average Error	10.04%	18.88%
Concentration Median Error	16.61%	21.19%
Paired Load Average Error	-6.98%	6.23%
Paired Load Median Error	3.62%	2.79%
Paired t Test on Concentration Means (p value)	0.93	0.54
Paired t Test on Load Means (p value)	0.75	0.73
Difference in Slope, Load vs. Flow	-36.82%	-33.50%

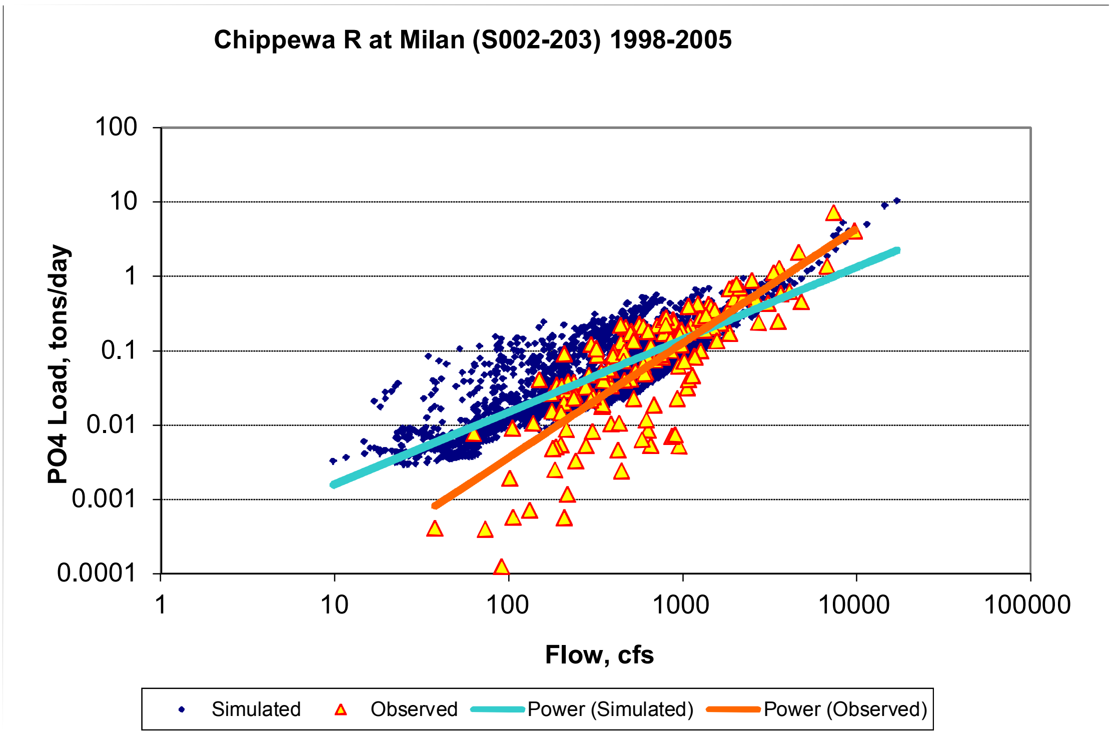


Figure 65. Ortho P Load Power Plot, Calibration Period, Chippewa River at Milan (S002-203)

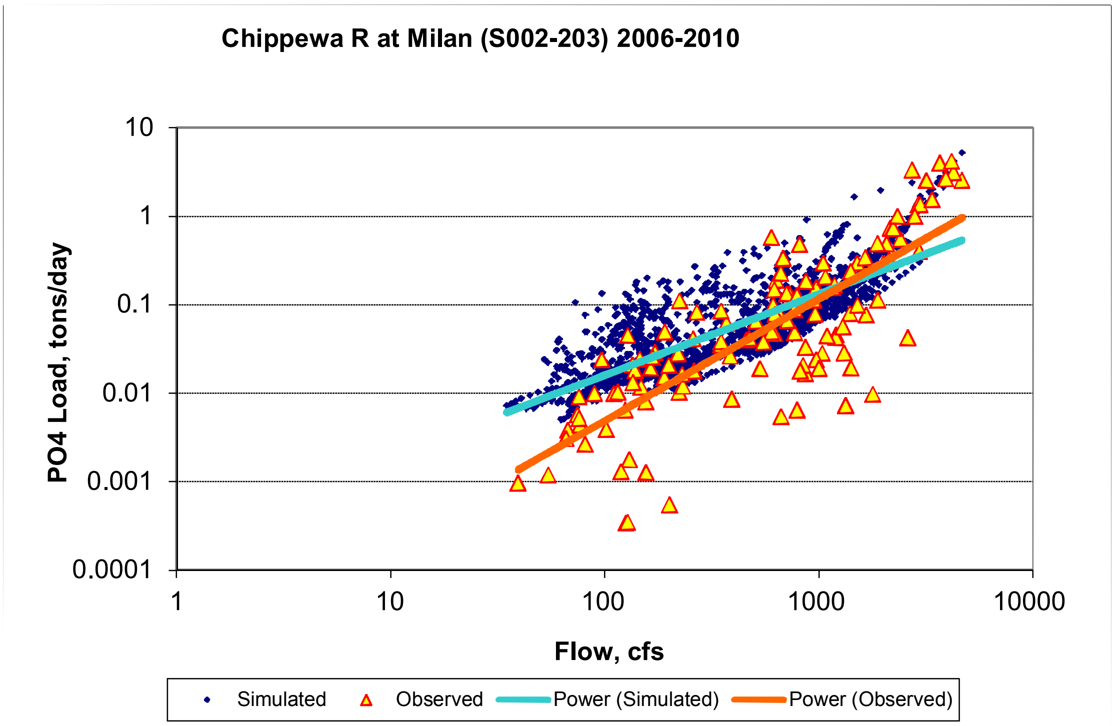


Figure 66. Ortho P Load Power Plot, Validation Period, Chippewa River at Milan (S002-203)

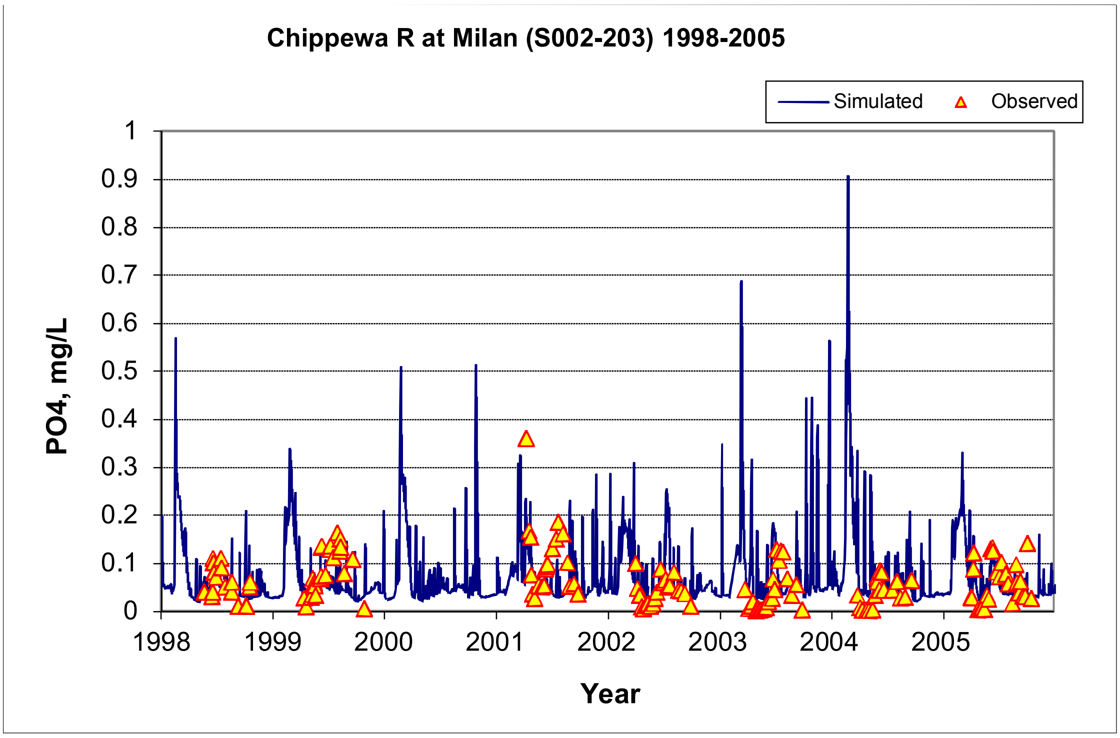


Figure 67. Ortho P Concentration Time Series, Calibration Period, Chippewa River at Milan (S002-203)

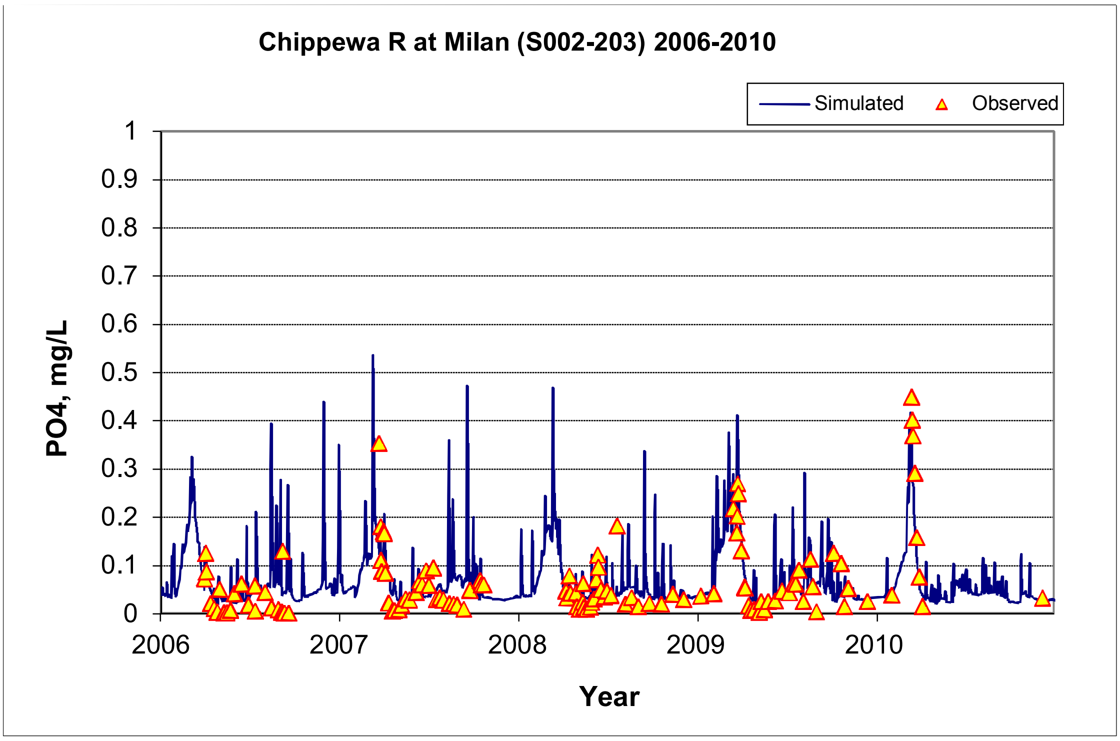


Figure 68. Ortho P Concentration Time Series, Validation Period, Chippewa River at Milan (S002-203)

Table 18. Summary Statistics, Total P, Chippewa River at Milan (S002-203)

	Calibration (1998-2005)	Validation (2006-2010)
Count	124	158
Concentration Average Error	-18.59%	-0.79%
Concentration Median Error	-12.10%	4.60%
Paired Load Average Error	-22.70%	-20.63%
Paired Load Median Error	-2.52%	1.47%
Paired t Test on Concentration Means (p value)	0.64	1.00
Paired t Test on Load Means (p value)	0.43	0.48
Difference in Slope, Load vs. Flow	-14.98%	-25.72%

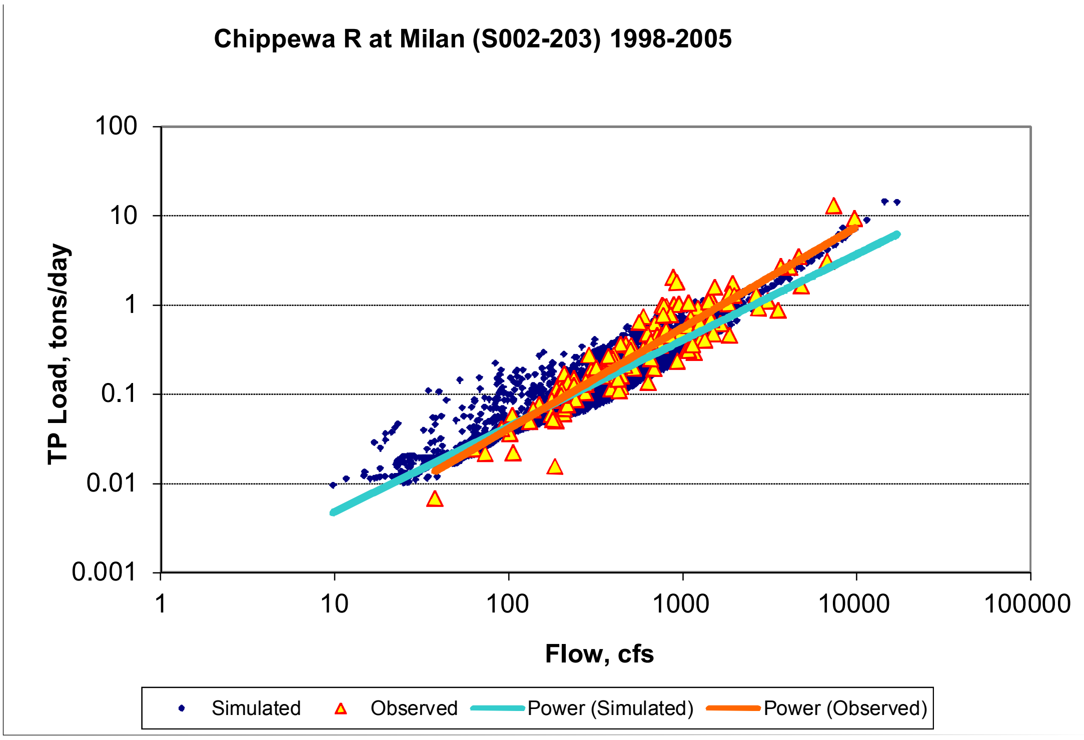


Figure 69. Total P Load Power Plot, Calibration Period, Chippewa River at Milan (S002-203)

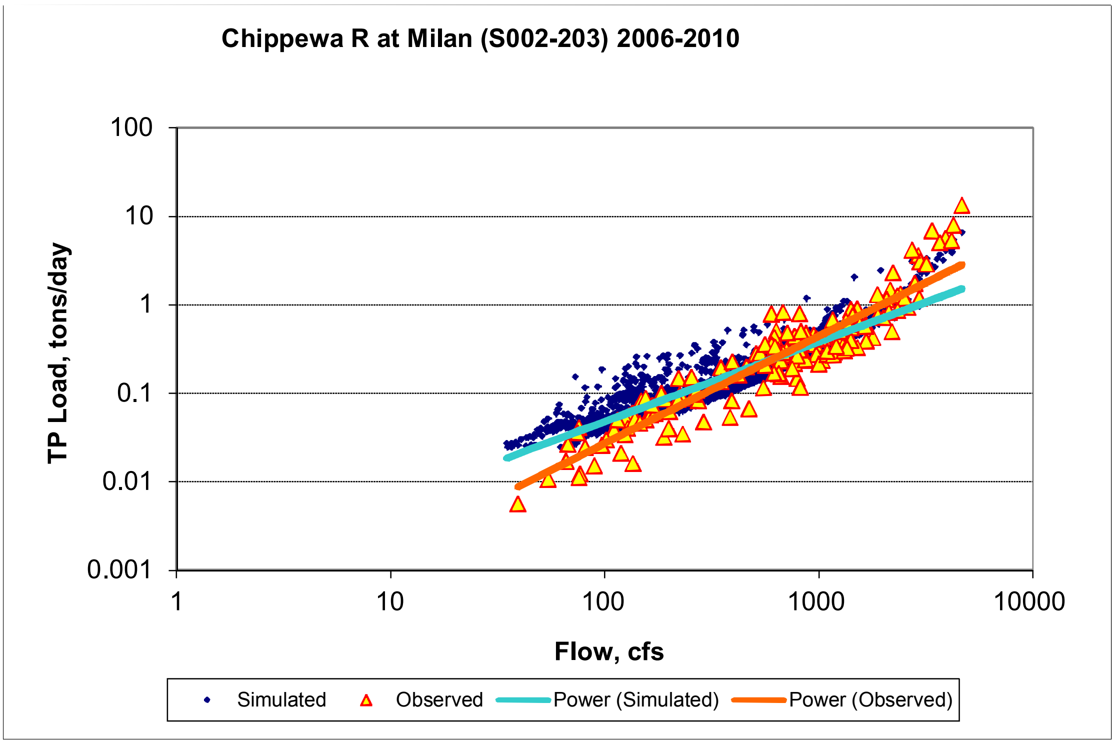


Figure 70. Total P Load Power Plot, Validation Period, Chippewa River at Milan (S002-203)

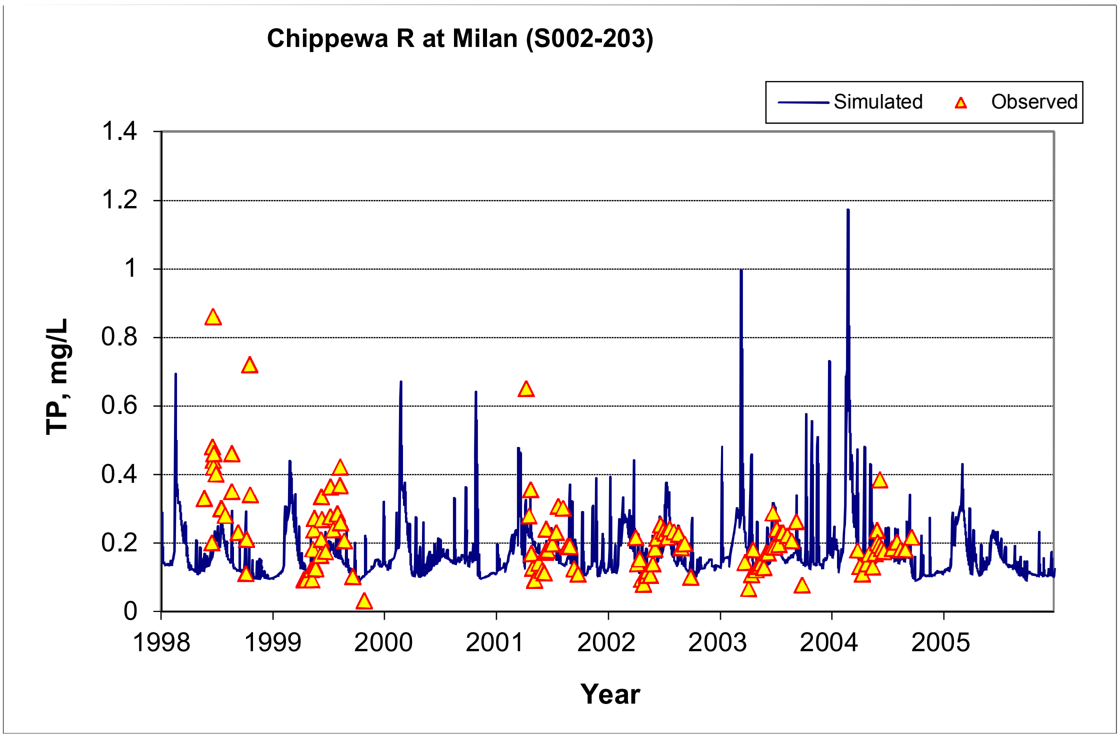


Figure 71. Total P Concentration Time Series, Calibration Period, Chippewa River at Milan (S002-203)

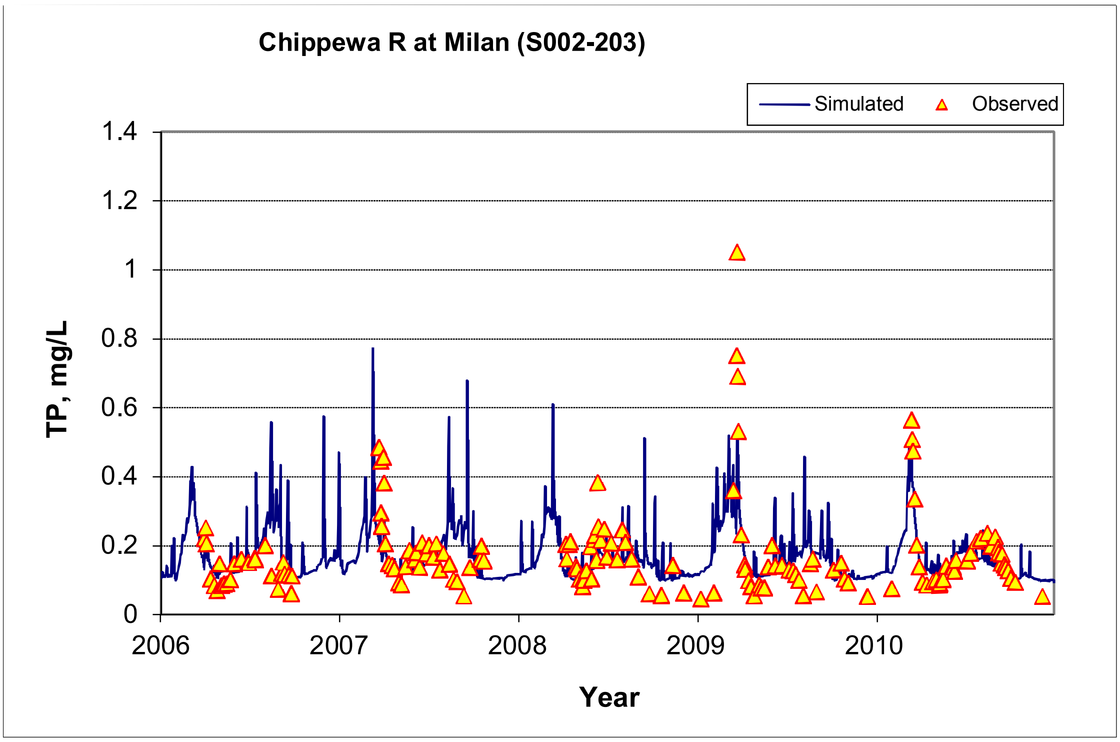


Figure 72. Total P Concentration Time Series, Validation Period, Chippewa River at Milan (S002-203)

Table 19. Summary Statistics, NOx-N, Chippewa River at Milan (S002-203)

	Calibration (1998-2005)	Validation (2006-2010)
Count	157	158
Concentration Average Error	16.53%	3.19%
Concentration Median Error	2.17%	2.61%
Paired Load Average Error	51.67%	12.73%
Paired Load Median Error	0.49%	0.29%
Paired t Test on Concentration Means (p value)	0.66	0.99
Paired t Test on Load Means (p value)	0.12	0.69
Difference in Slope, Load vs. Flow	-47.50%	-26.25%

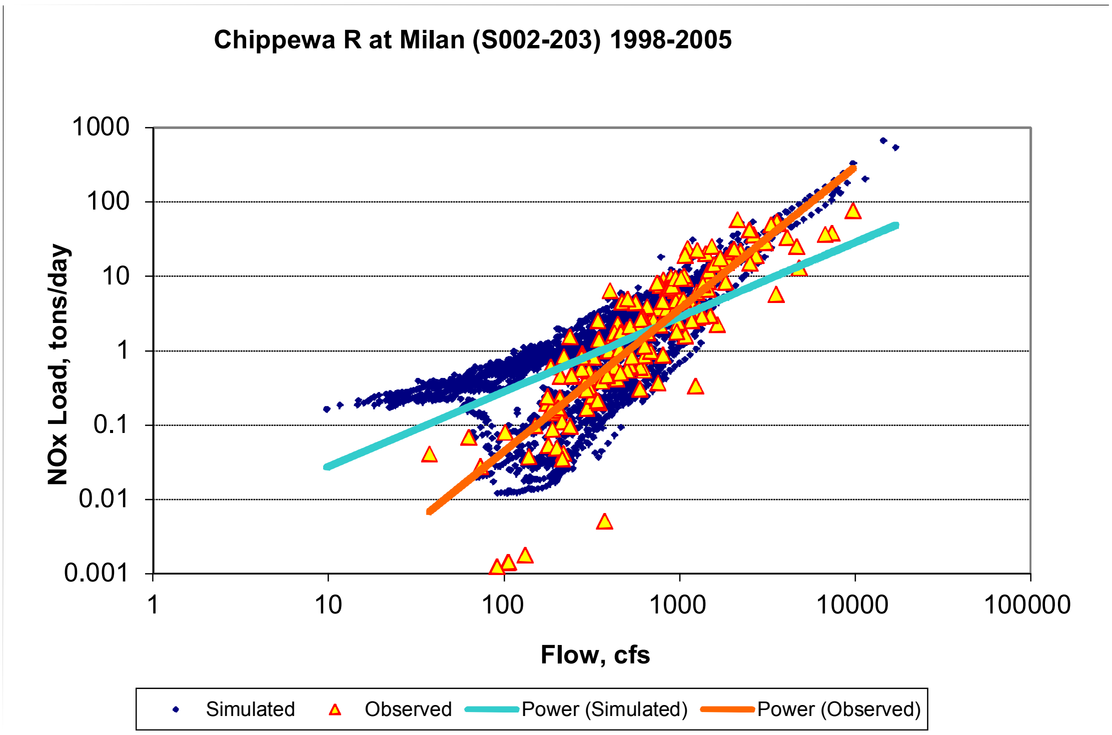


Figure 73. NOx-N Load Power Plot, Calibration Period, Chippewa River at Milan (S002-203)

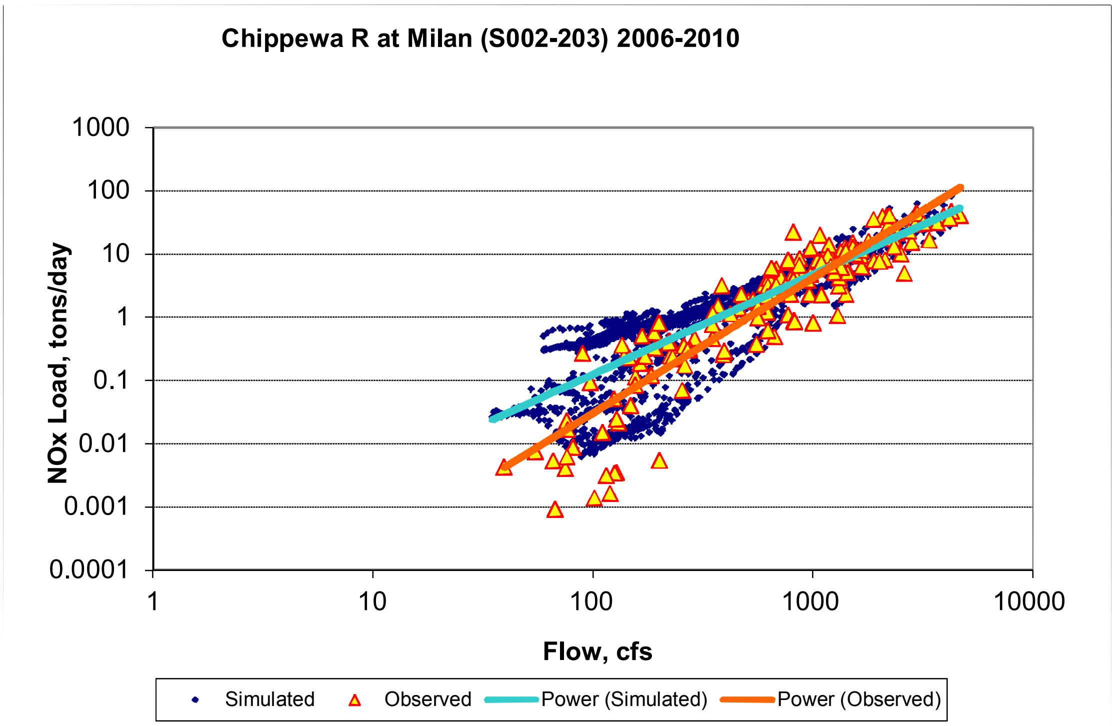


Figure 74. NOx-N Load Power Plot, Validation Period, Chippewa River at Milan (S002-203)

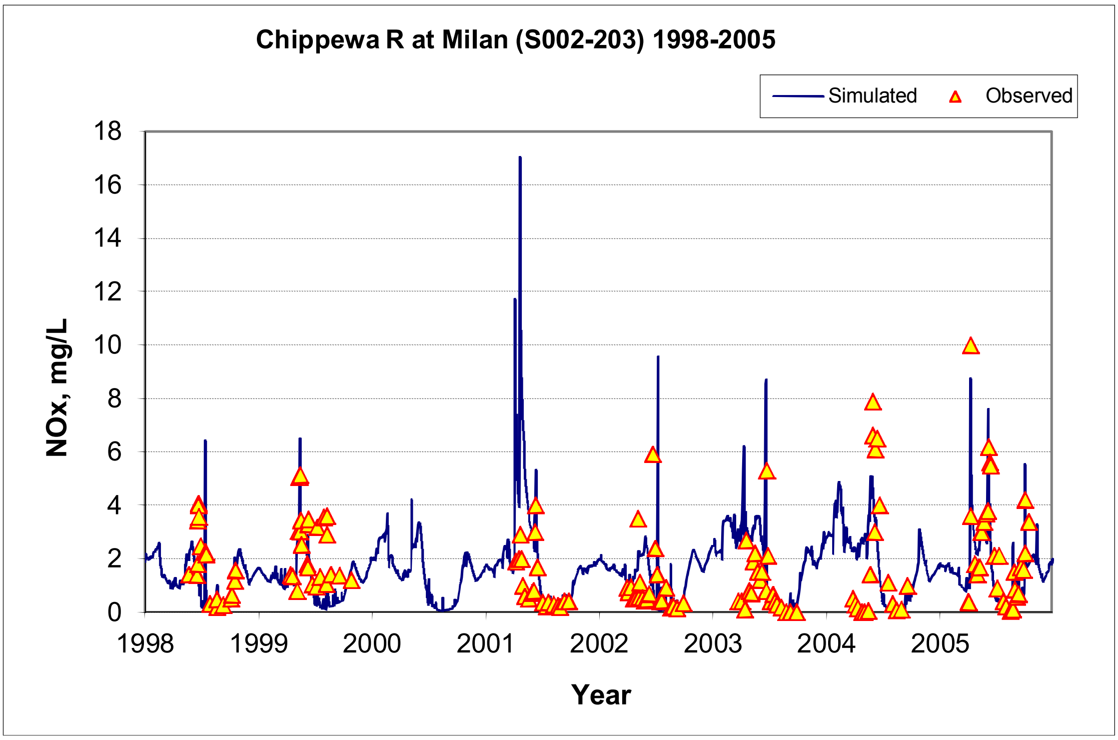


Figure 75. NOx-N Concentration Time Series, Calibration Period, Chippewa River at Milan (S002-203)

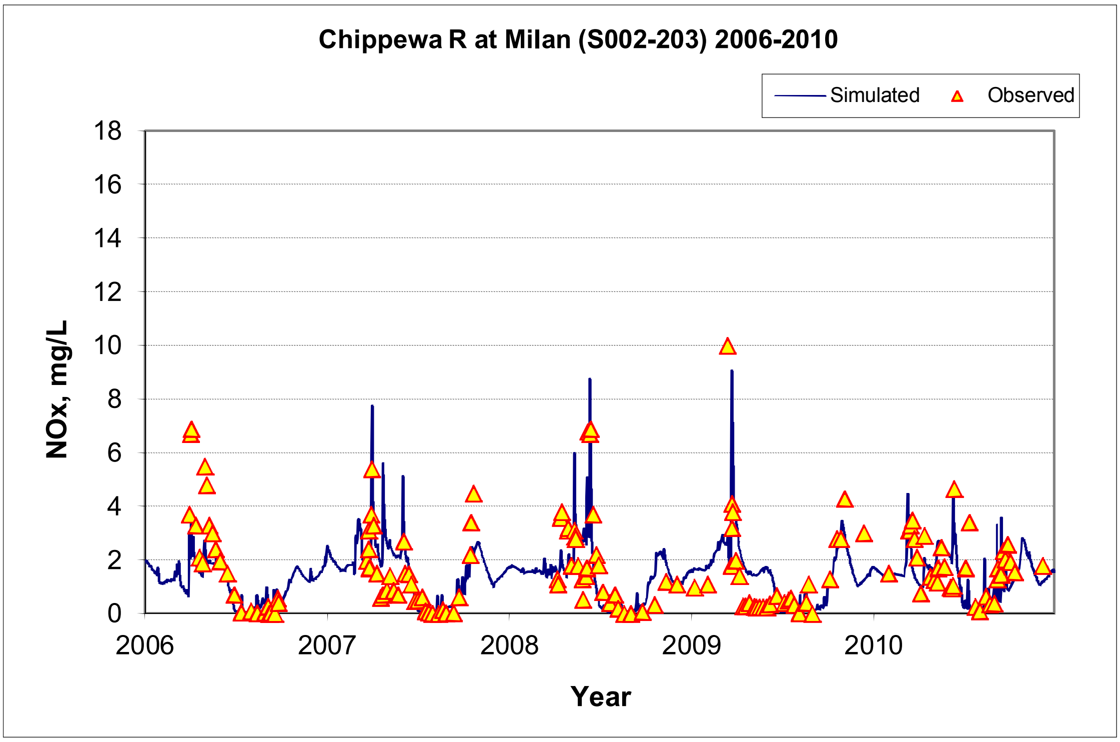


Figure 76. NOx-N Concentration Time Series, Validation Period, Chippewa River at Milan (S002-203)

Table 20. Summary Statistics, Total N, Chippewa River at Milan (S002-203)

	Calibration (1998-2005)	Validation (2006-2010)
Count	129	79
Concentration Average Error	4.04%	11.63%
Concentration Median Error	-0.10%	21.06%
Paired Load Average Error	37.00%	12.12%
Paired Load Median Error	-0.04%	3.40%
Paired t Test on Concentration Means (p value)	1.00	0.88
Paired t Test on Load Means (p value)	0.25	0.66
Difference in Slope, Load vs. Flow	-28.01%	-16.25%

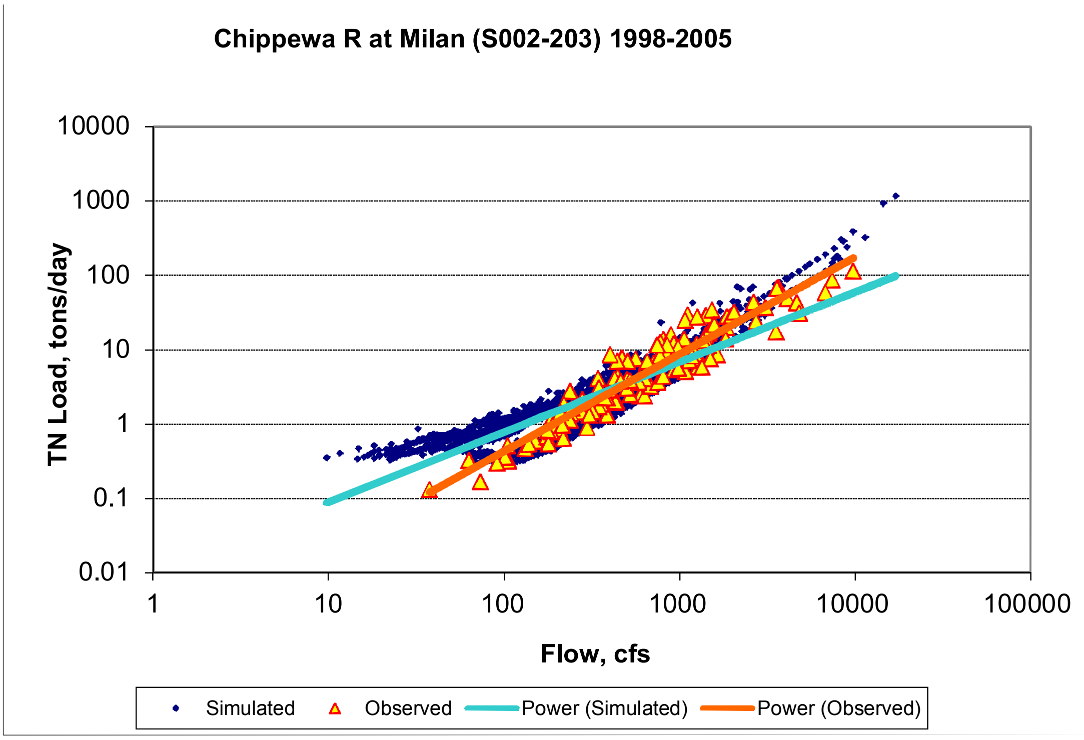


Figure 77. Total N Load Power Plot, Calibration Period, Chippewa River at Milan (S002-203)

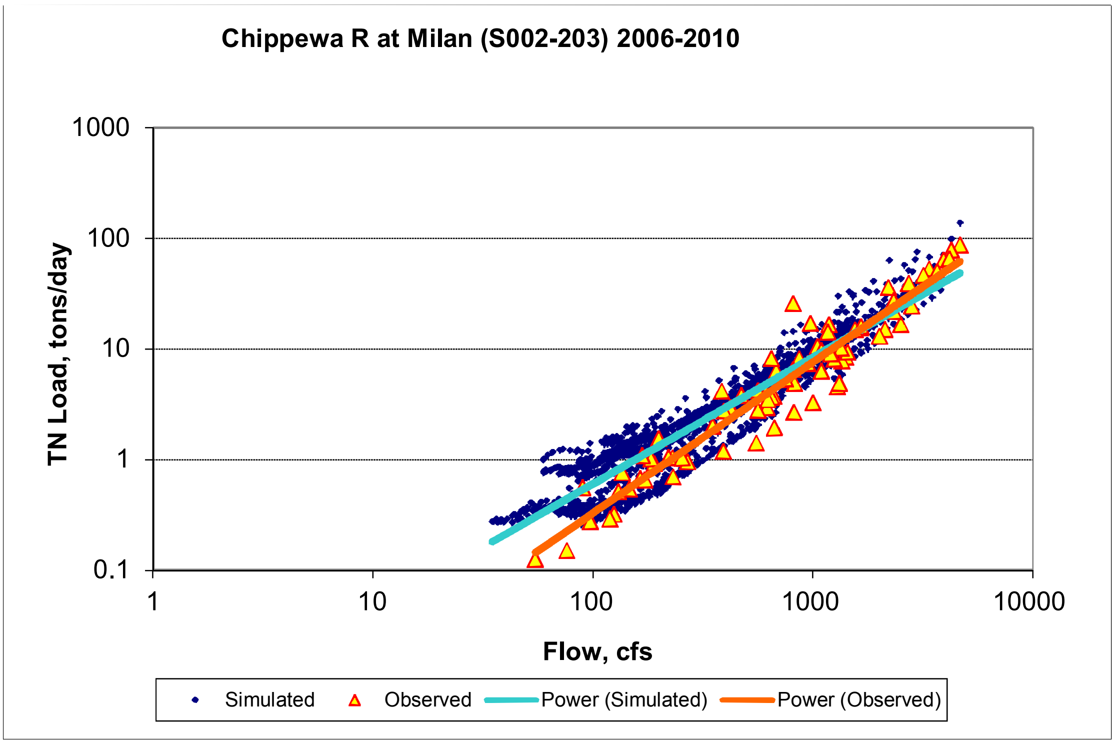


Figure 78. Total N Load Power Plot, Validation Period, Chippewa River at Milan (S002-203)

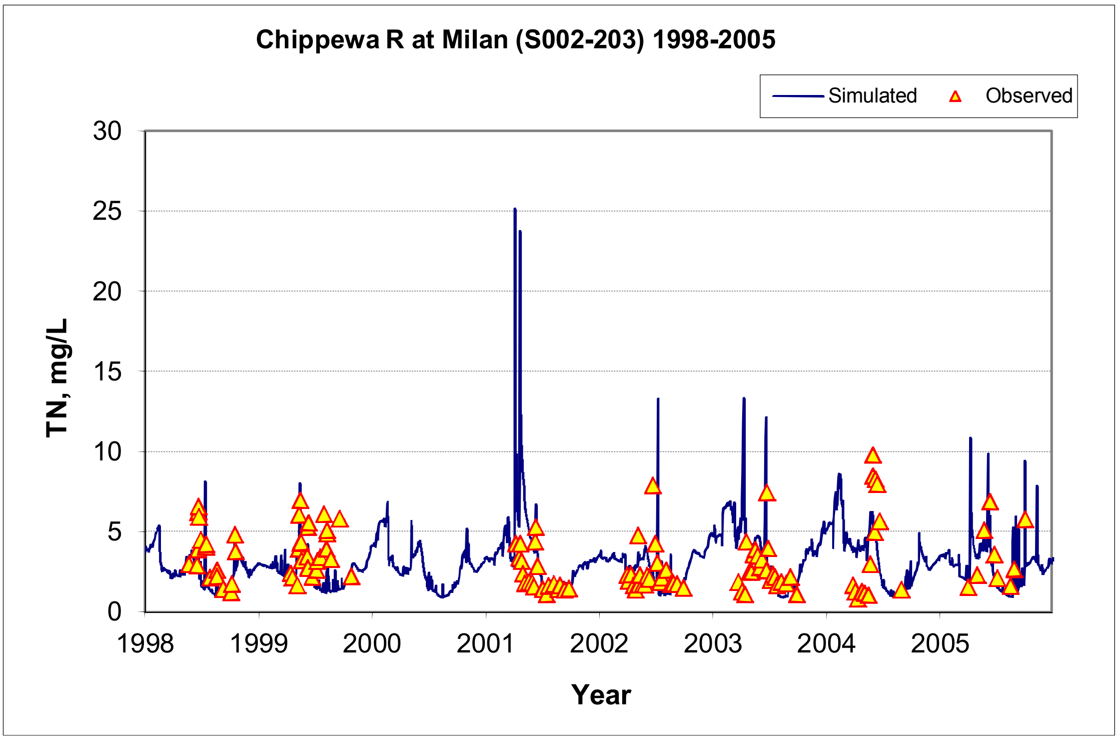


Figure 79. Total N Concentration Time Series, Calibration Period, Chippewa River at Milan (S002-203)

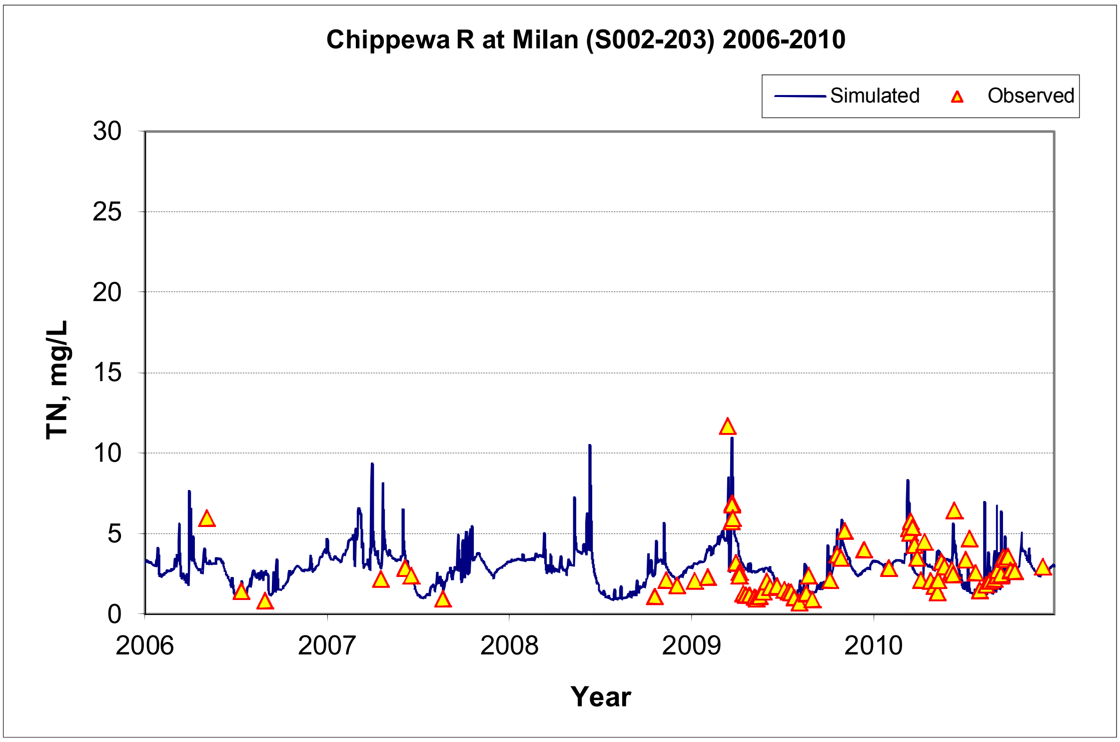


Figure 80. Total N Concentration Time Series, Validation Period, Chippewa River at Milan (S002-203)

5 Dry Weather Creek (S002-204)

Table 21. Summary Statistics, TSS, Dry Weather Creek (S002-204)

	Calibration (1999-2005)	Validation (2006-2010)
Count	143	124
Concentration Average Error	-7.59%	27.34%
Concentration Median Error	7.11%	17.27%
Paired Load Average Error	-21.71%	-5.60%
Paired Load Median Error	0.25%	0.75%
Paired t Test on Concentration Means (p value)	0.76	0.32
Paired t Test on Load Means (p value)	0.47	0.70
Difference in Slope, Load vs. Flow	10.86%	19.83%

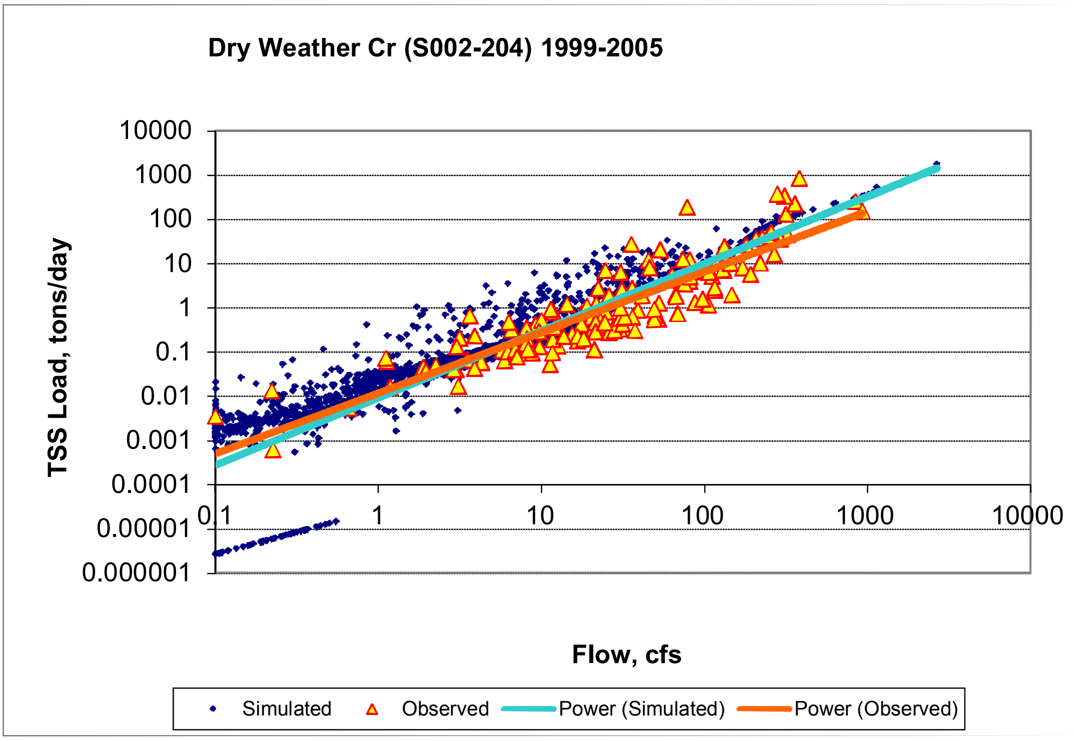


Figure 81. TSS Load Power Plot, Calibration Period, Dry Weather Creek (S002-204)

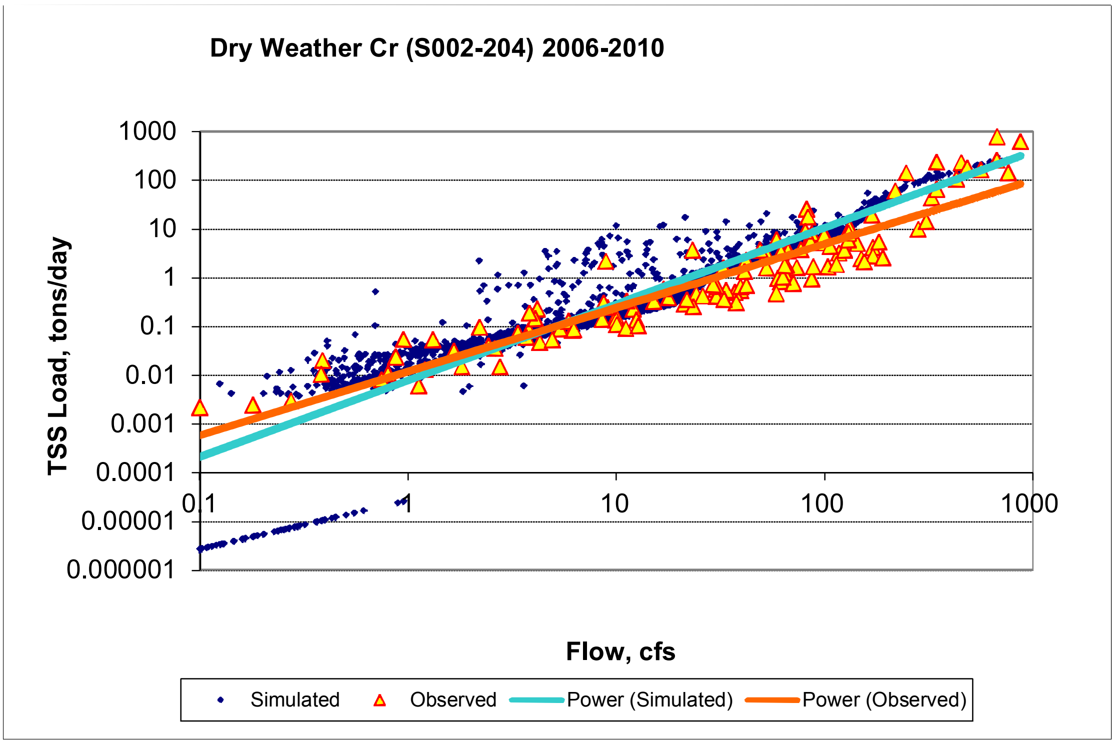


Figure 82. TSS Load Power Plot, Validation Period, Dry Weather Creek (S002-204)

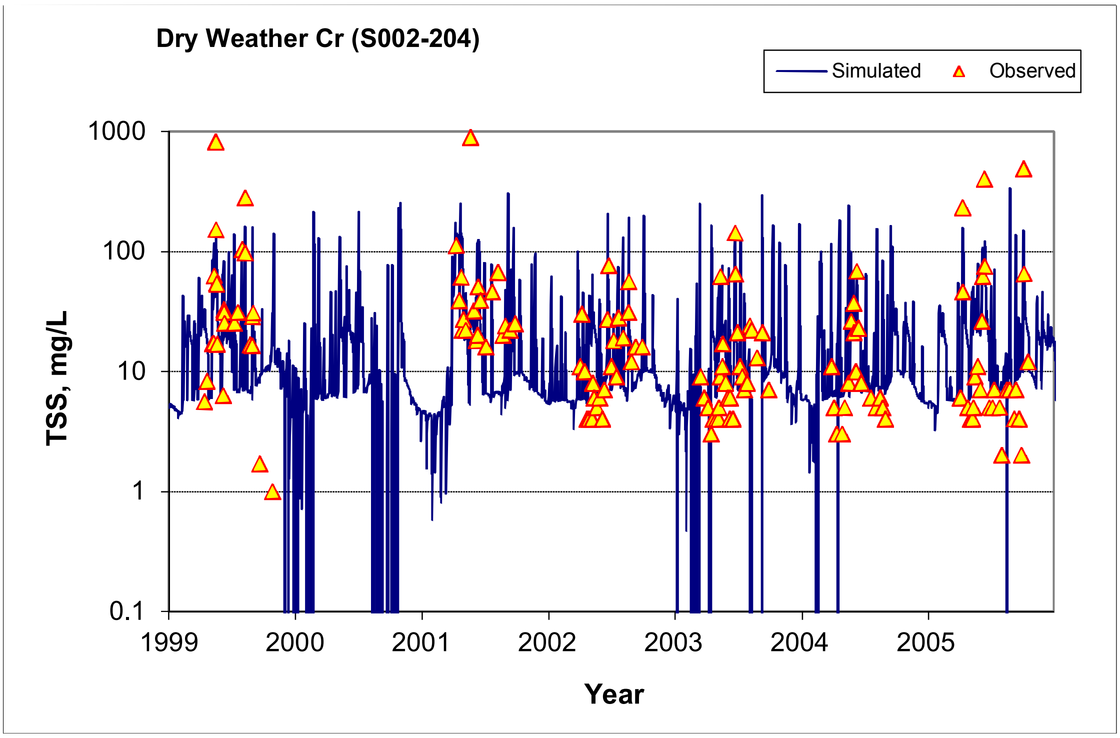


Figure 83. TSS Concentration Time Series, Calibration Period, Dry Weather Creek (S002-204)

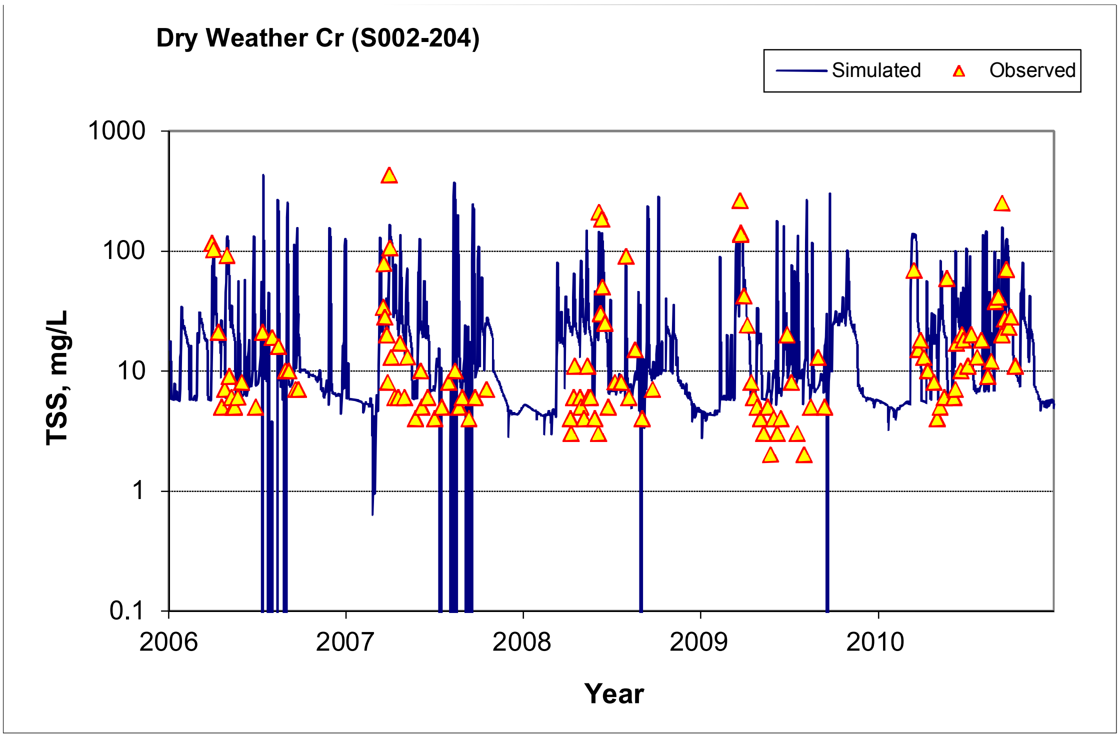


Figure 84. TSS Concentration Time Series, Validation Period, Dry Weather Creek (S002-204)

Table 22. Summary Statistics, Ortho P, Dry Weather Creek (S002-204)

	Calibration (1999-2005)	Validation (2006-2010)
Count	132	82
Concentration Average Error	-12.10%	-6.73%
Concentration Median Error	-0.49%	1.76%
Paired Load Average Error	-24.13%	47.15%
Paired Load Median Error	0.02%	0.02%
Paired t Test on Concentration Means (p value)	0.78	0.80
Paired t Test on Load Means (p value)	0.44	0.27
Difference in Slope, Load vs. Flow	11.99%	29.63%

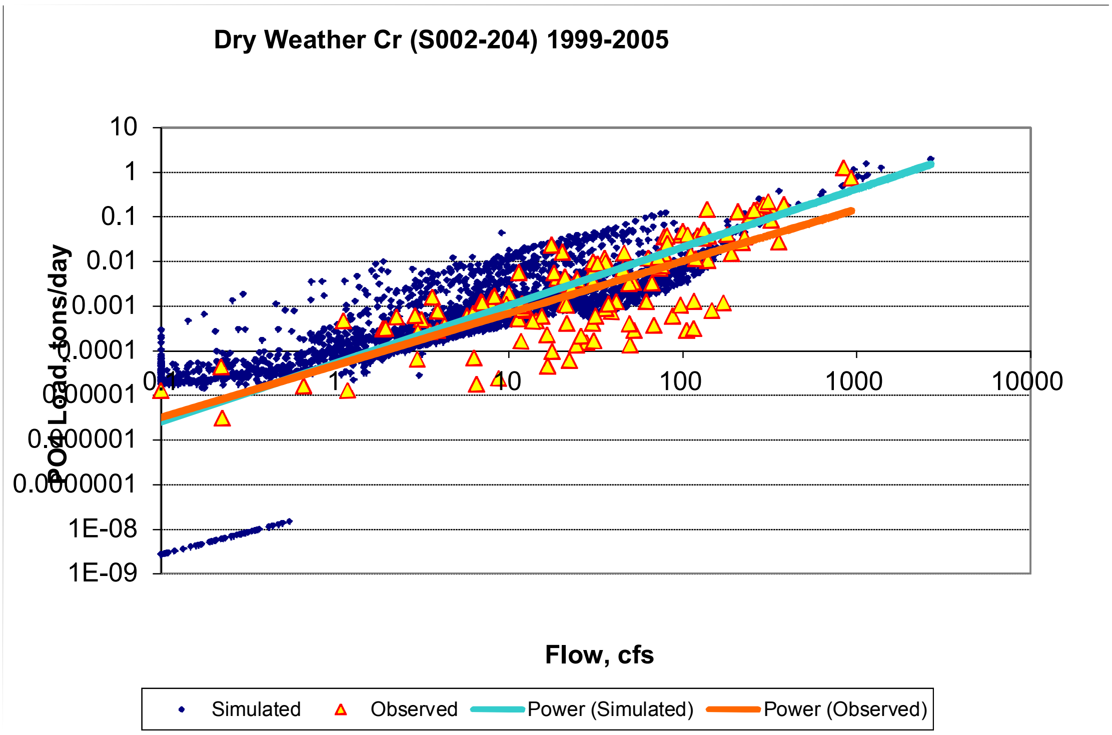


Figure 85. Ortho P Load Power Plot, Calibration Period, Dry Weather Creek (S002-204)

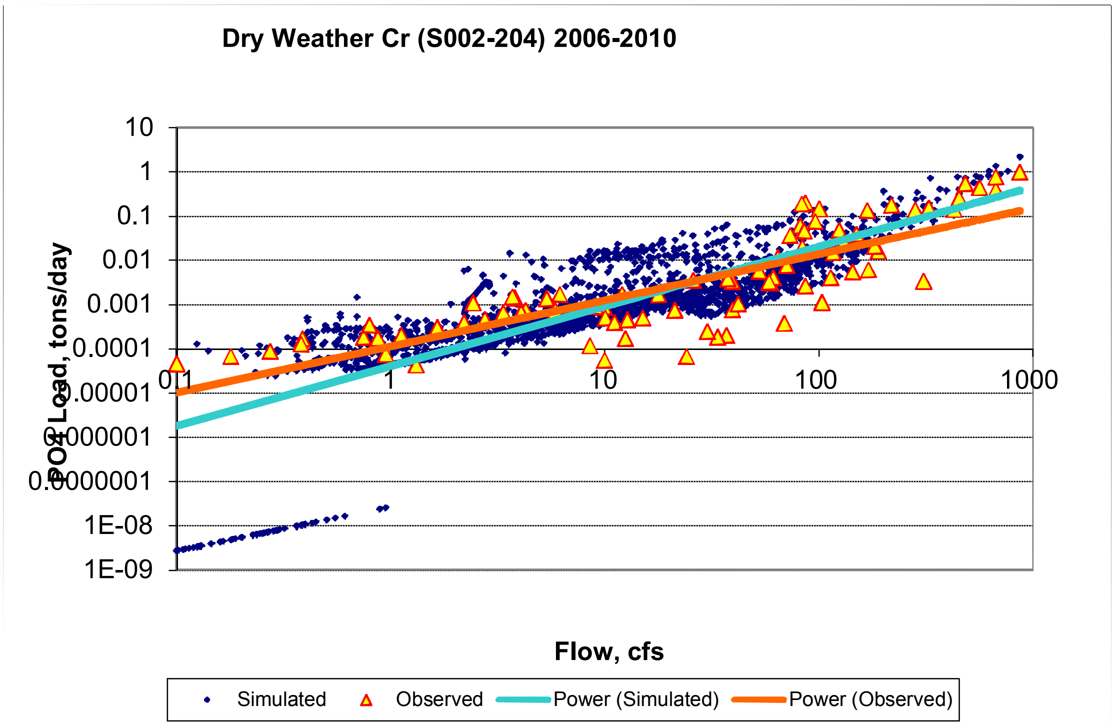


Figure 86. Ortho P Load Power Plot, Validation Period, Dry Weather Creek (S002-204)

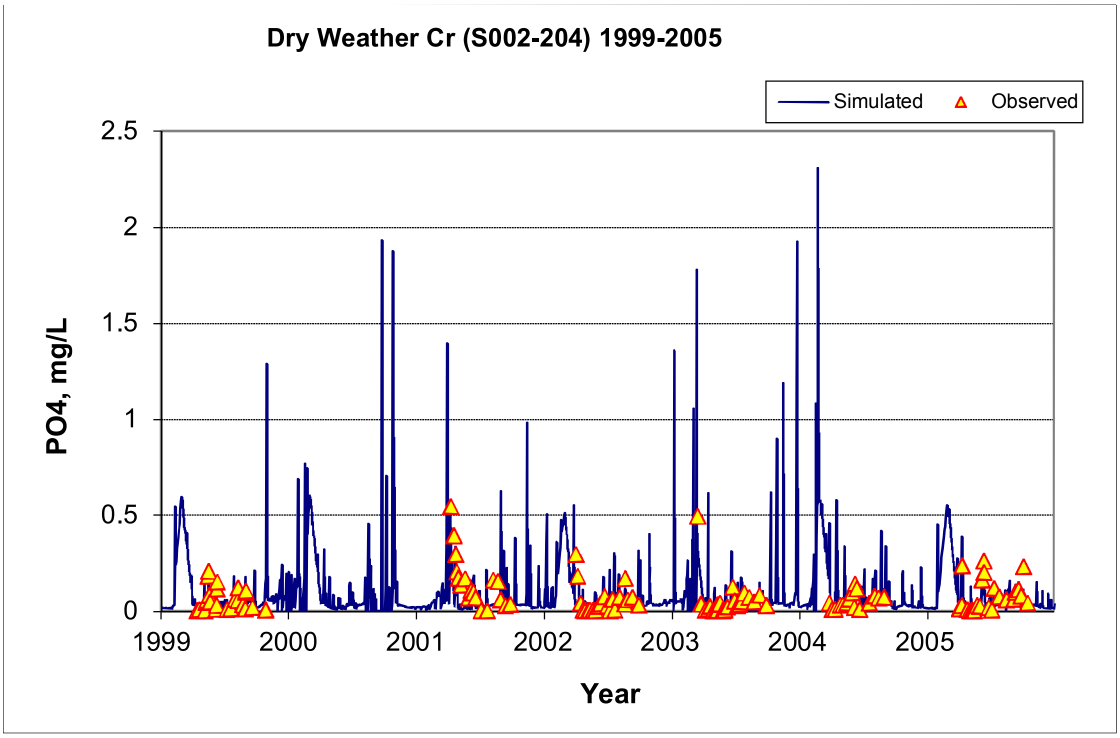


Figure 87. Ortho P Concentration Time Series, Calibration Period, Dry Weather Creek (S002-204)

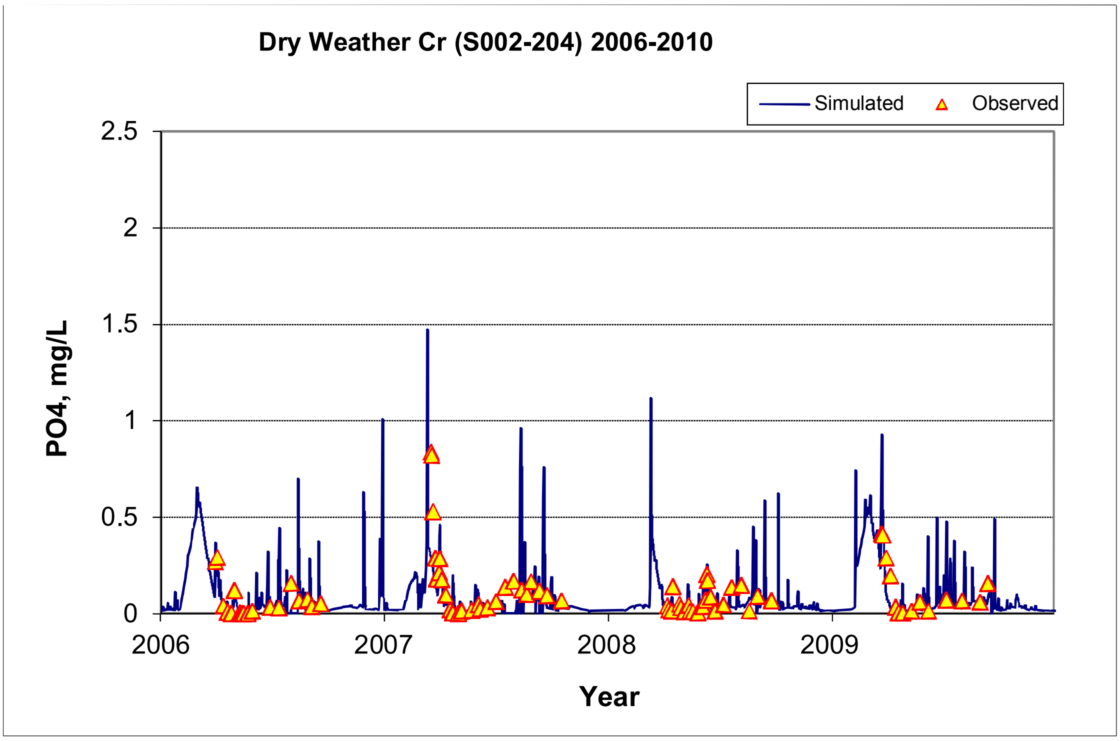


Figure 88. Ortho P Concentration Time Series, Validation Period, Dry Weather Creek (S002-204)

Table 23. Summary Statistics, Total P, Dry Weather Creek (S002-204)

	Calibration (1999-2005)	Validation (2006-2010)
Count	108	123
Concentration Average Error	0.15%	7.88%
Concentration Median Error	15.91%	19.25%
Paired Load Average Error	-38.55%	-7.30%
Paired Load Median Error	0.98%	0.83%
Paired t Test on Concentration Means (p value)	0.98	0.90
Paired t Test on Load Means (p value)	0.25	0.68
Difference in Slope, Load vs. Flow	-8.20%	-8.06%

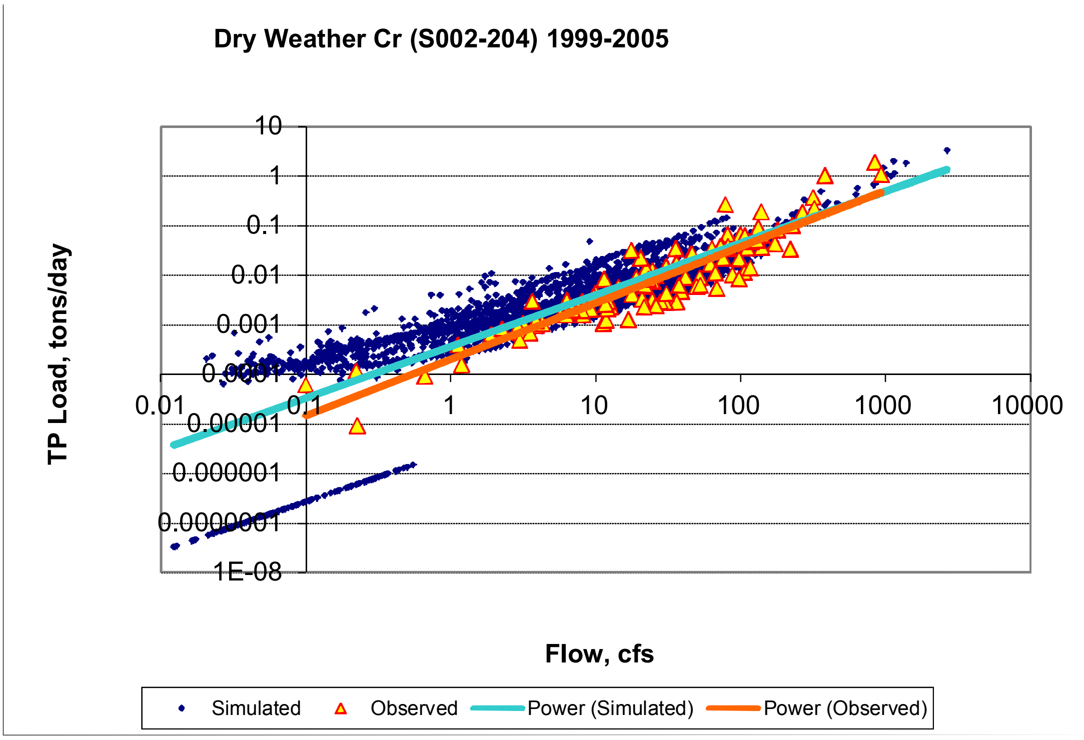


Figure 89. Total P Load Power Plot, Calibration Period, Dry Weather Creek (S002-204)

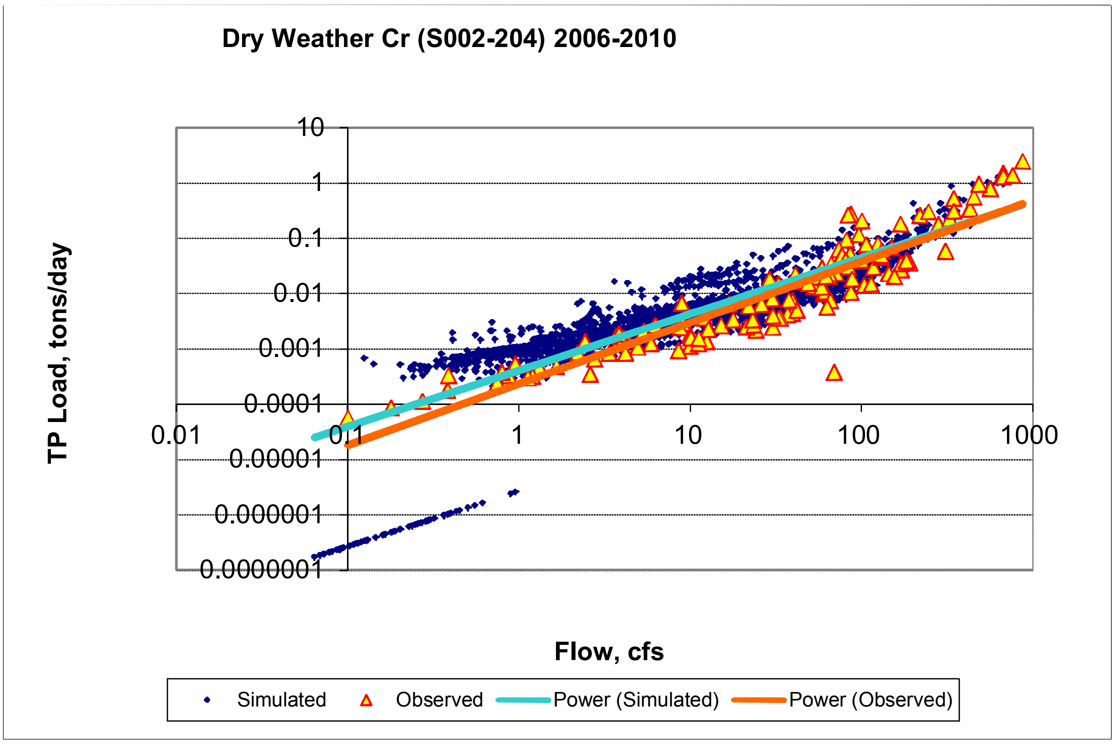


Figure 90. Total P Load Power Plot, Validation Period, Dry Weather Creek (S002-204)

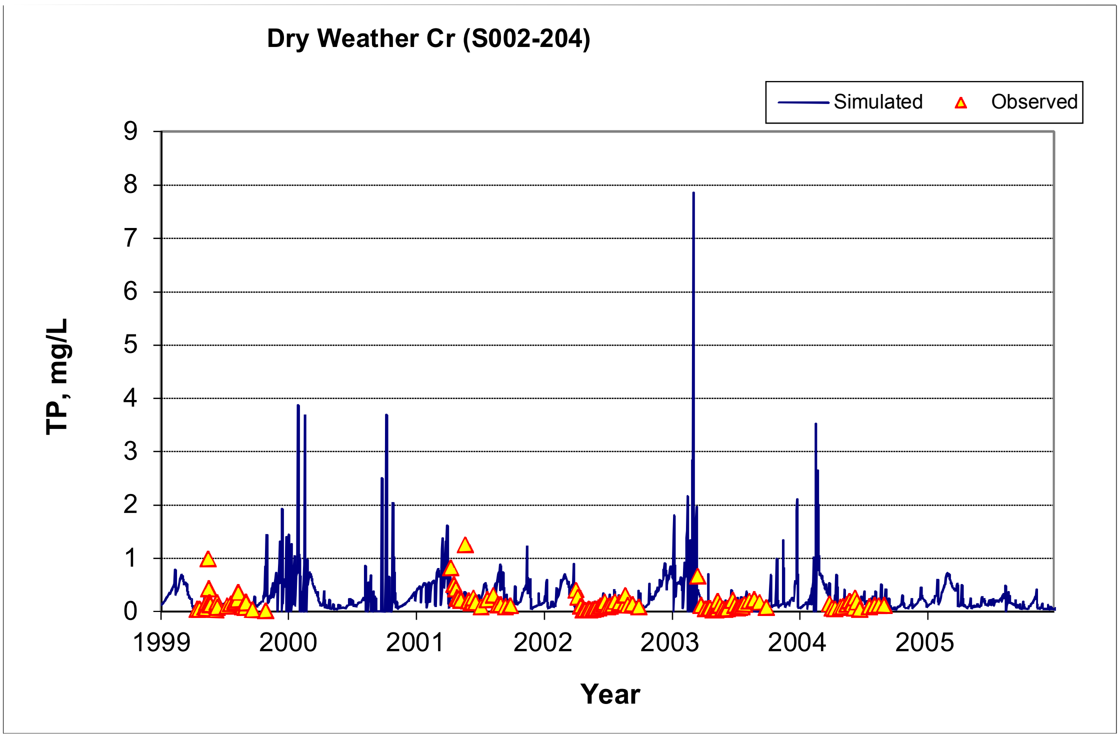


Figure 91. Total P Concentration Time Series, Calibration Period, Dry Weather Creek (S002-204)

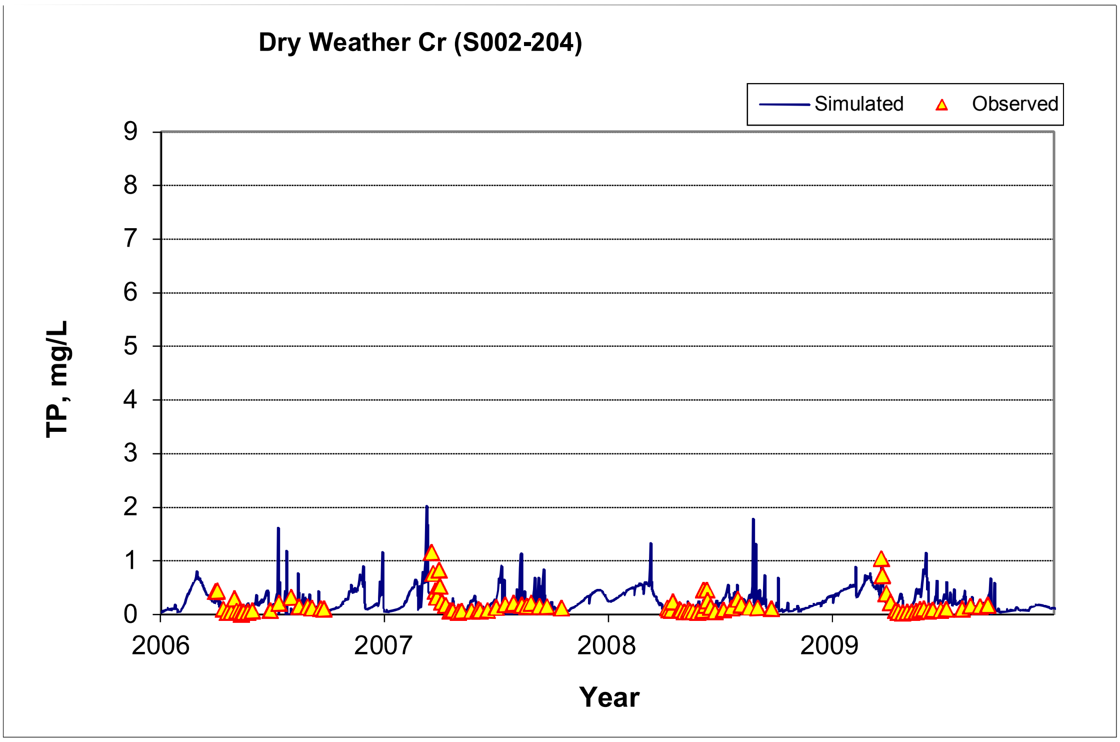


Figure 92. Total P Concentration Time Series, Validation Period, Dry Weather Creek (S002-204)

Table 24. Summary Statistics, NOx-N, Dry Weather Creek (S002-204)

	Calibration (1999-2005)	Validation (2006-2010)
Count	136	124
Concentration Average Error	-5.50%	-11.88%
Concentration Median Error	0.18%	-4.18%
Paired Load Average Error	43.40%	38.46%
Paired Load Median Error	0.01%	-0.14%
Paired t Test on Concentration Means (p value)	0.96	0.85
Paired t Test on Load Means (p value)	0.21	0.23
Difference in Slope, Load vs. Flow	-25.12%	-14.86%

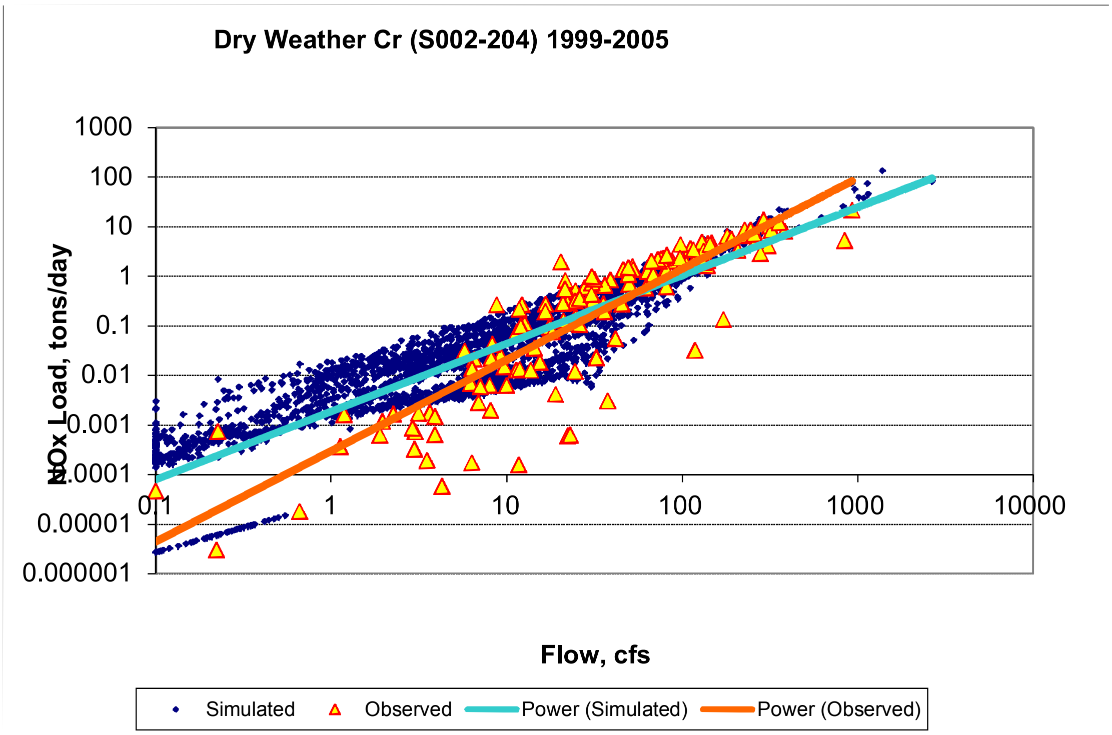


Figure 93. NOx-N Load Power Plot, Calibration Period, Dry Weather Creek (S002-204)

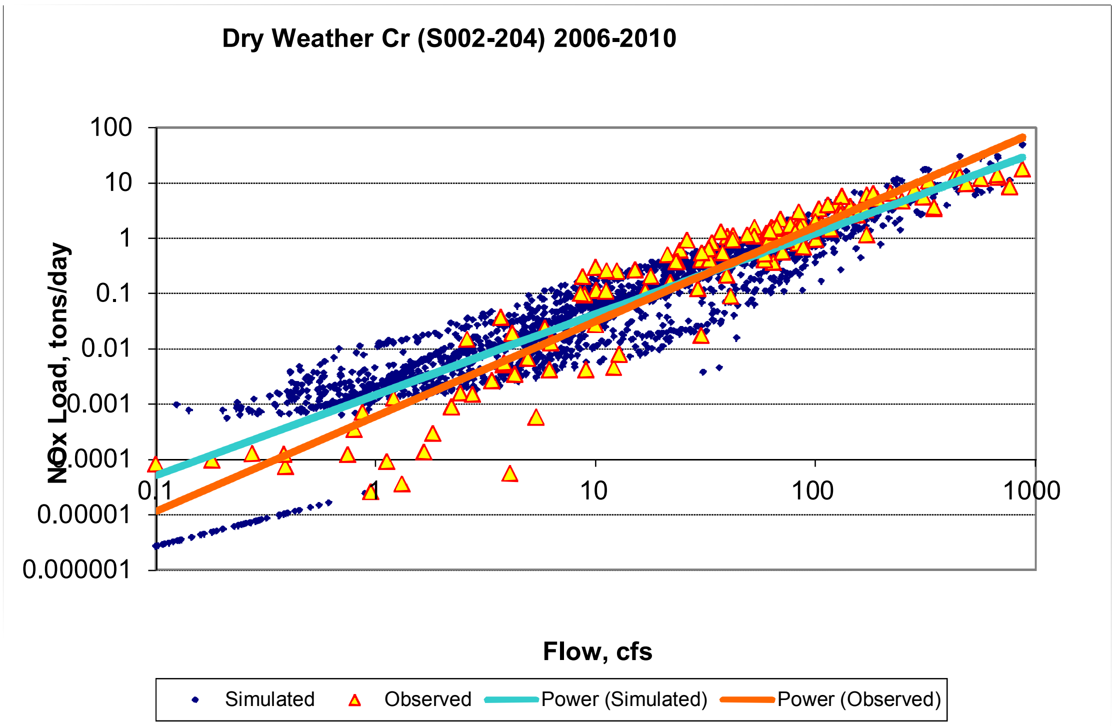


Figure 94. NOx-N Load Power Plot, Validation Period, Dry Weather Creek (S002-204)

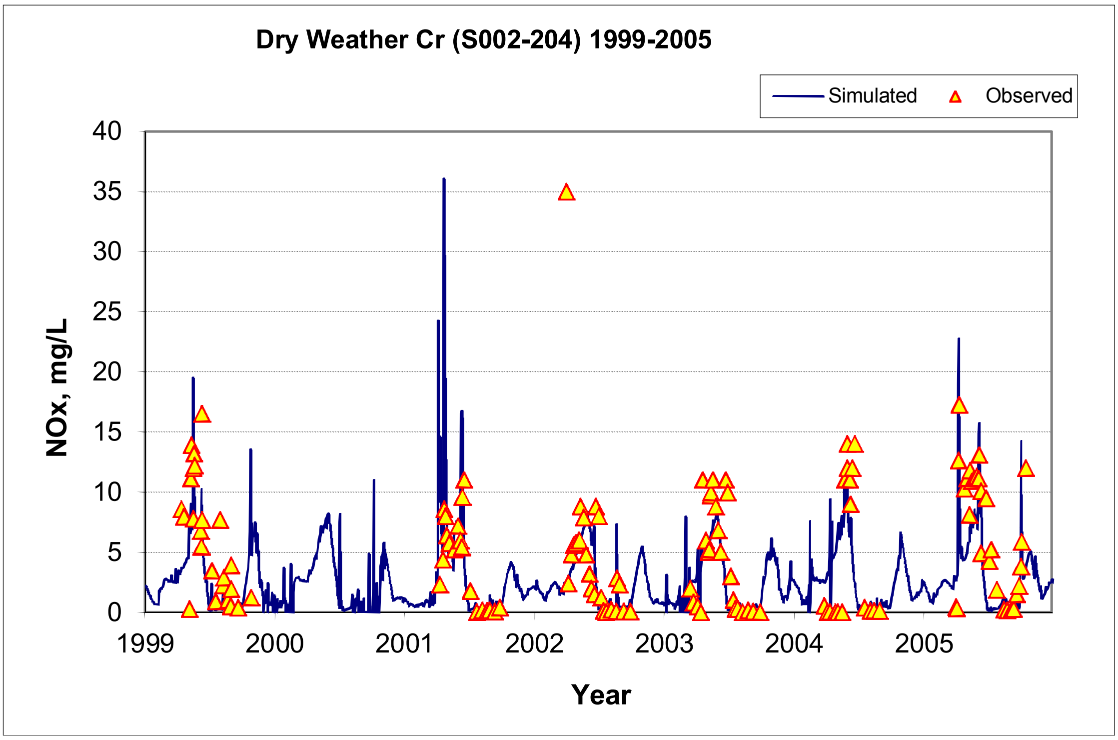


Figure 95. NOx-N Concentration Time Series, Calibration Period, Dry Weather Creek (S002-204)

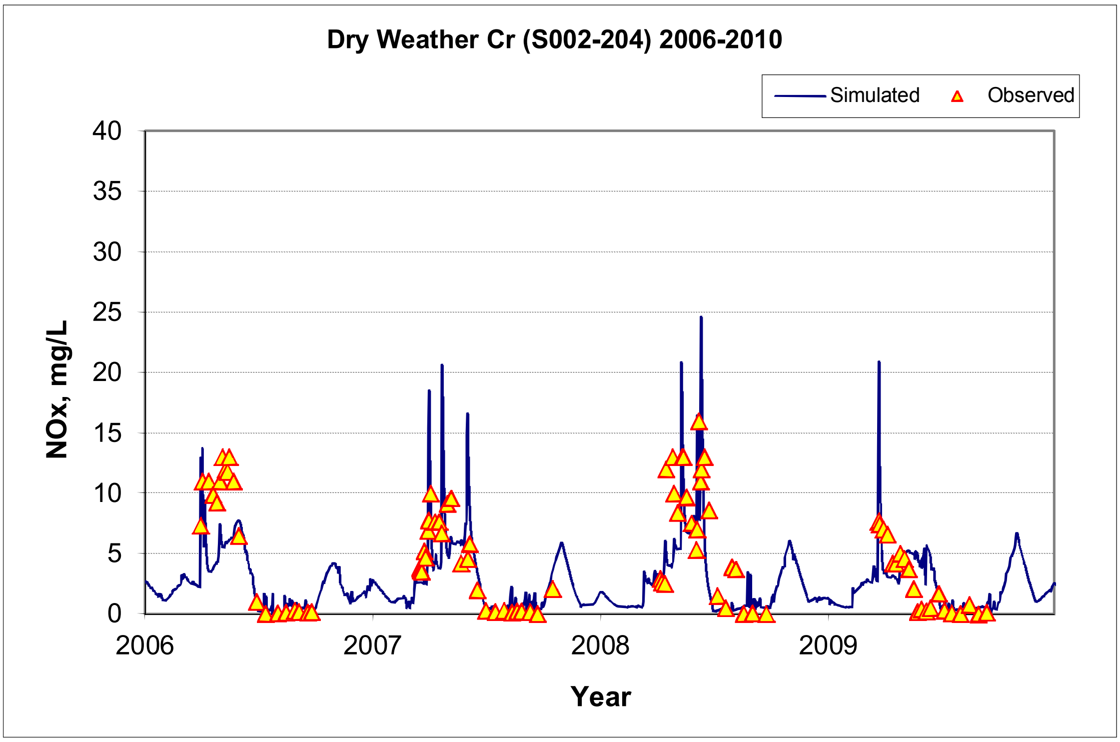


Figure 96. NOx-N Concentration Time Series, Validation Period, Dry Weather Creek (S002-204)

Table 25. Summary Statistics, Total N, Dry Weather Creek (S002-204)

	Calibration (1999-2005)	Validation (2006-2010)
Count	113	20
Concentration Average Error	-2.13%	22.69%
Concentration Median Error	-3.13%	24.28%
Paired Load Average Error	36.62%	-40.91%
Paired Load Median Error	-0.49%	1.09%
Paired t Test on Concentration Means (p value)	0.99	0.45
Paired t Test on Load Means (p value)	0.30	0.28
Difference in Slope, Load vs. Flow	-18.30%	-19.43%

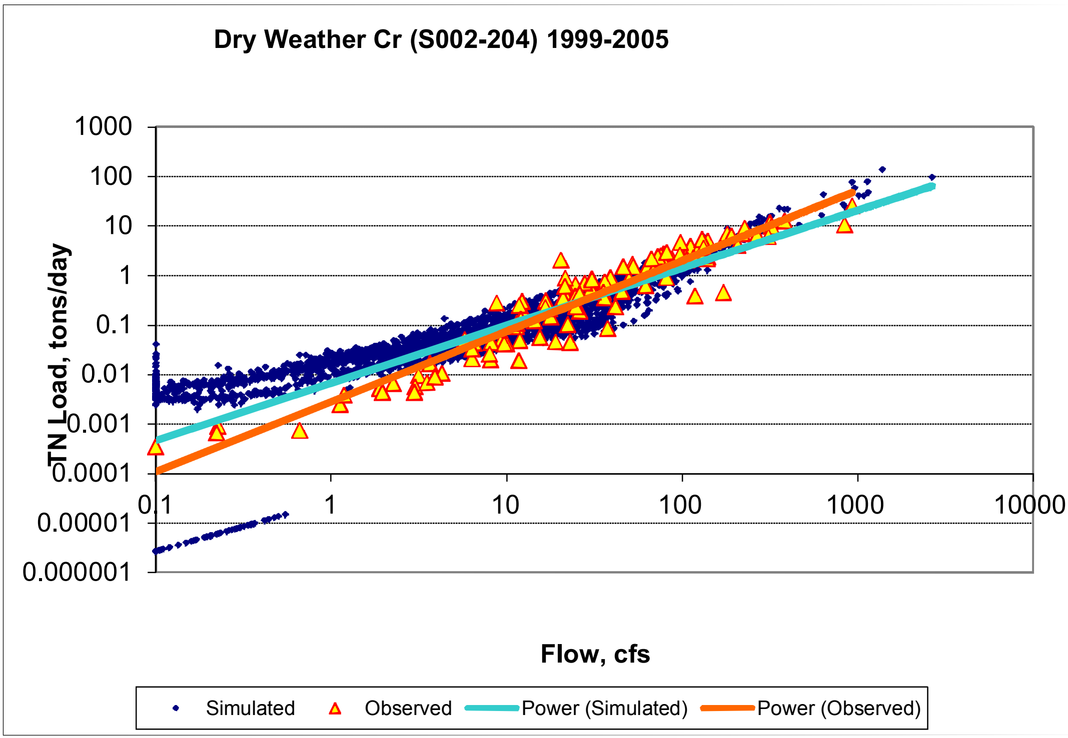


Figure 97. Total N Load Power Plot, Calibration Period, Dry Weather Creek (S002-204)

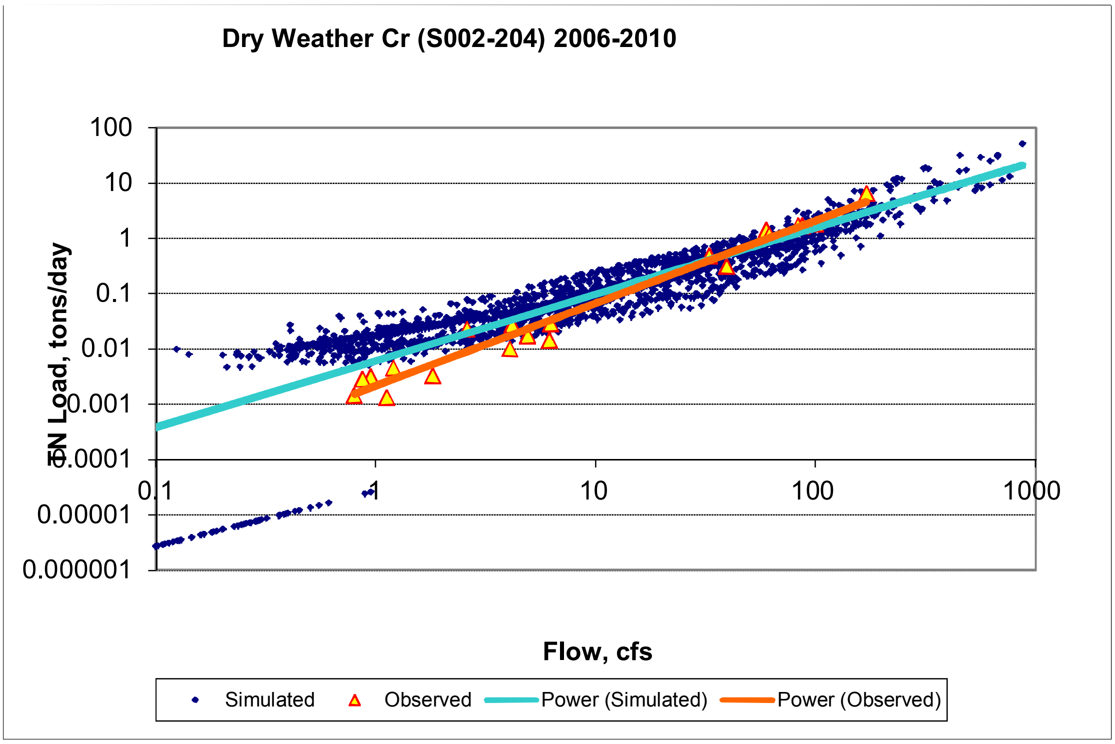


Figure 98. Total N Load Power Plot, Validation Period, Dry Weather Creek (S002-204)

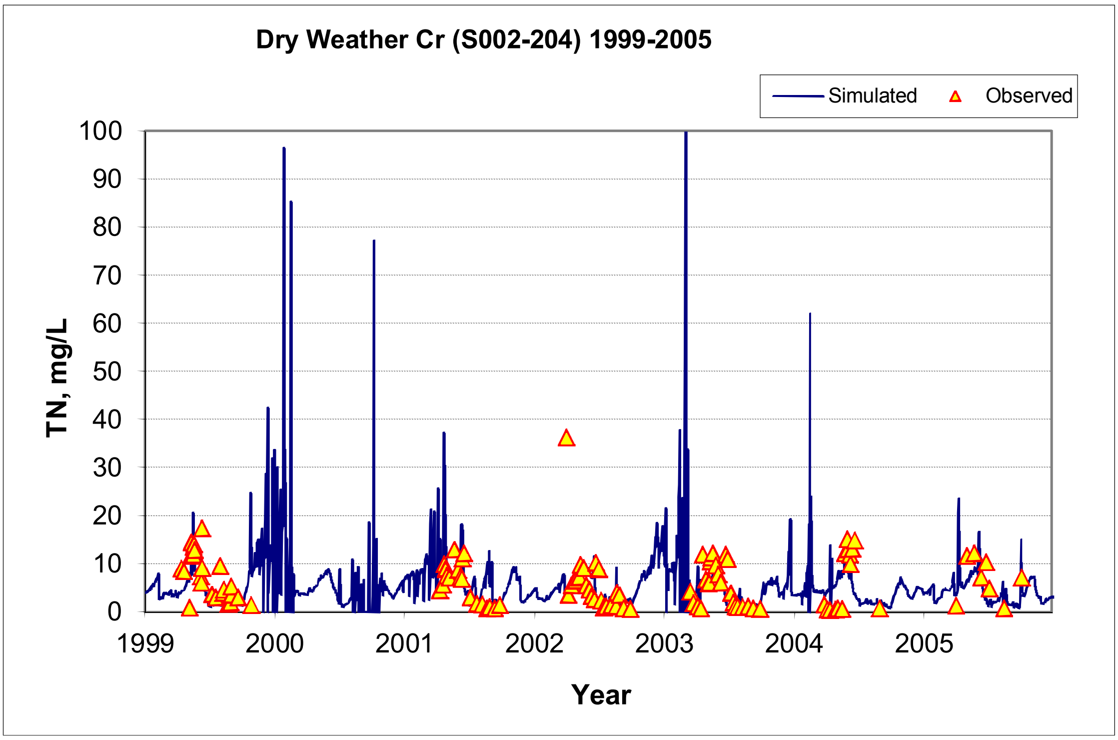


Figure 99. Total N Concentration Time Series, Calibration Period, Dry Weather Creek (S002-204)

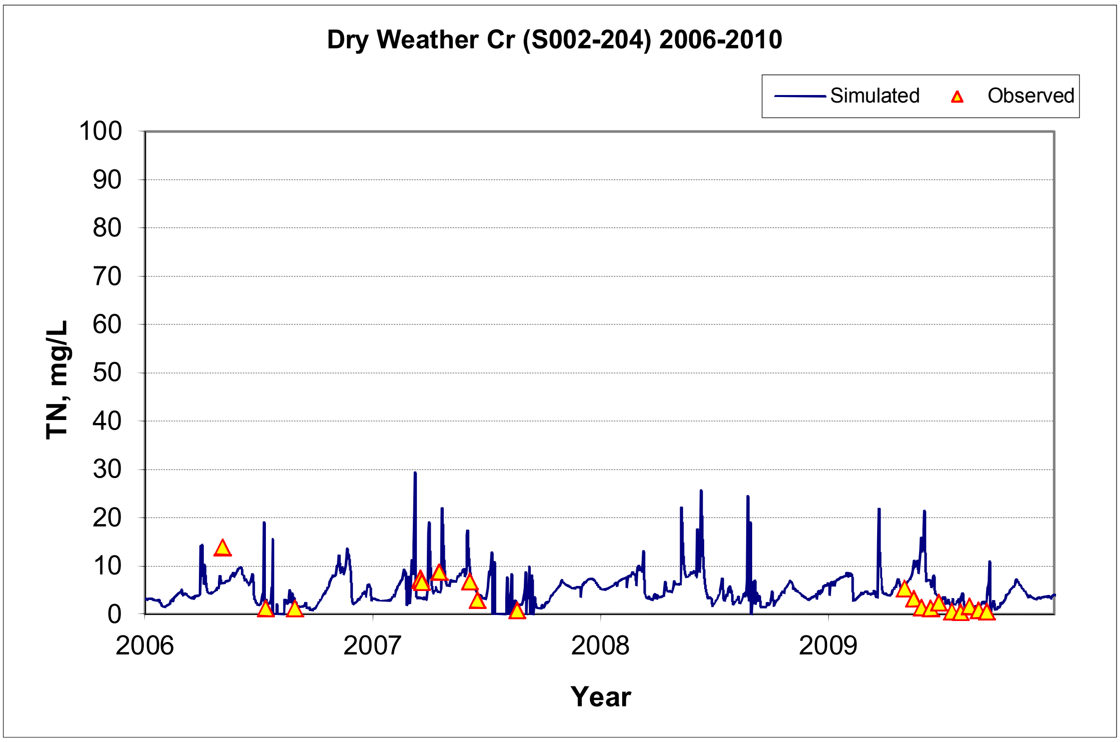


Figure 100. Total N Concentration Time Series, Validation Period, Dry Weather Creek (S002-204)

6 Chippewa River at Montevideo (S002-175)

Table 26. Summary Statistics, TSS, Chippewa River at Montevideo (S002-175)

	Calibration (1993-2005)	Validation (2006-2010)
Count	22	ND
Concentration Average Error	-19.07%	ND
Concentration Median Error	-3.83%	ND
Paired Load Average Error	6.76%	ND
Paired Load Median Error	-3.49%	ND
Paired t Test on Concentration Means (p value)	0.53	ND
Paired t Test on Load Means (p value)	0.71	ND
Difference in Slope, Load vs. Flow	-13.47%	ND

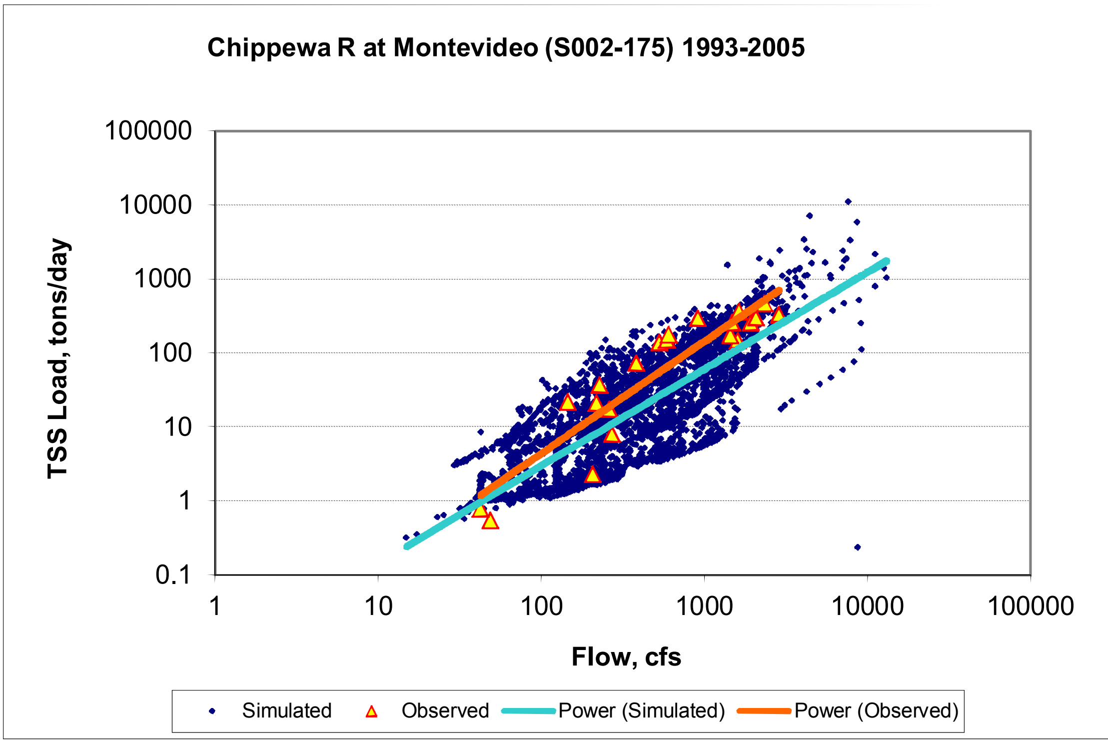


Figure 101. TSS Load Power Plot, Calibration Period, Chippewa River at Montevideo (S002-175)

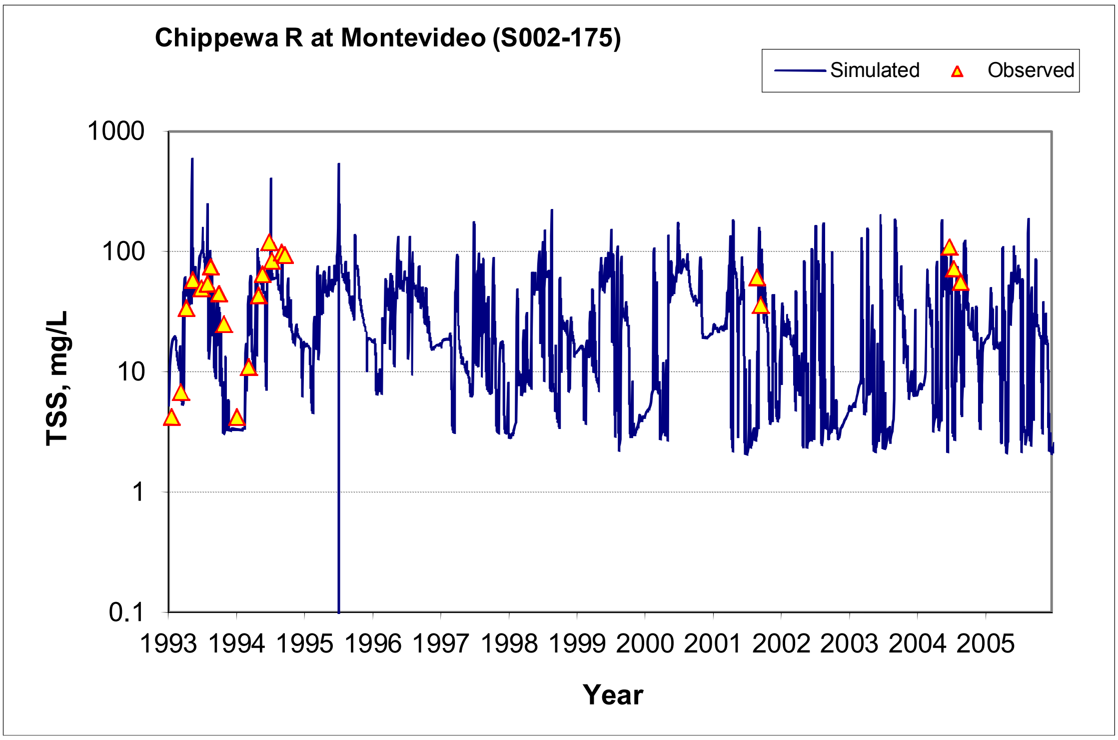


Figure 102. TSS Concentration Time Series, Calibration Period, Chippewa River at Montevideo (S002-175)

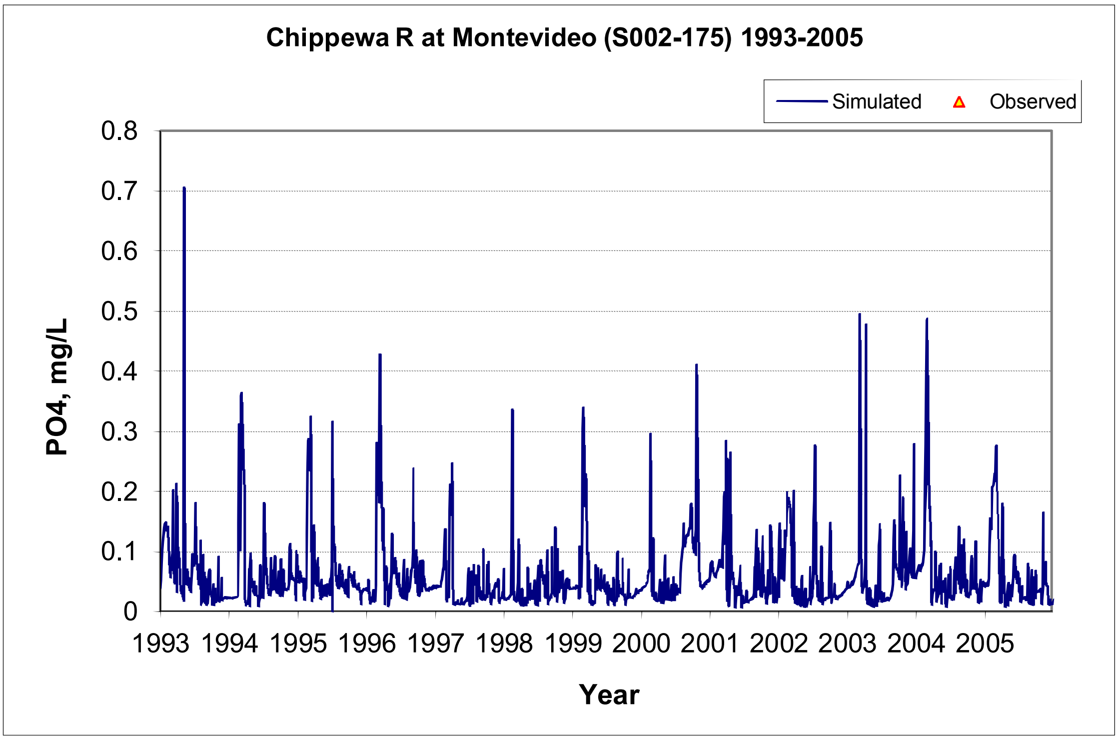


Figure 103. Ortho P Concentration Time Series, Calibration Period, Chippewa River at Montevideo (S002-175)

Table 27. Summary Statistics, Total P, Chippewa River at Montevideo (S002-175)

	Calibration (1993-2005)	Validation (2006-2010)
Count	22	ND
Concentration Average Error	50.33%	ND
Concentration Median Error	16.33%	ND
Paired Load Average Error	26.82%	ND
Paired Load Median Error	9.10%	ND
Paired t Test on Concentration Means (p value)	0.04	ND
Paired t Test on Load Means (p value)	0.34	ND
Difference in Slope, Load vs. Flow	9.61%	ND

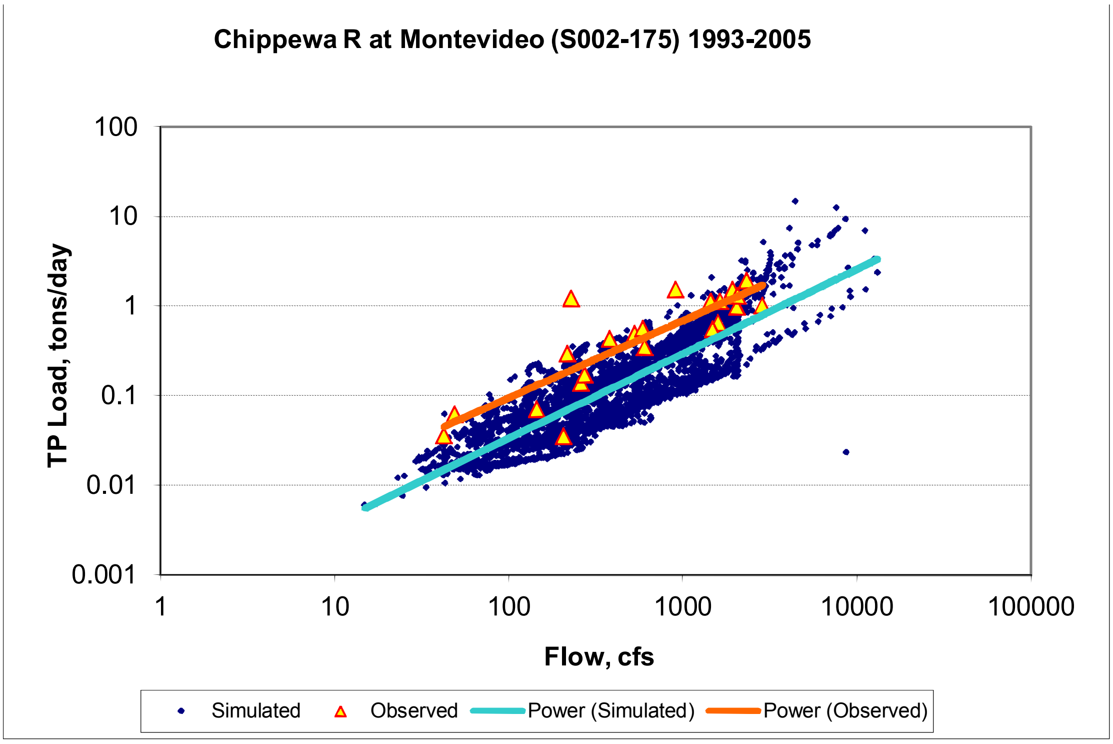


Figure 104. Total P Load Power Plot, Calibration Period, Chippewa River at Montevideo (S002-175)

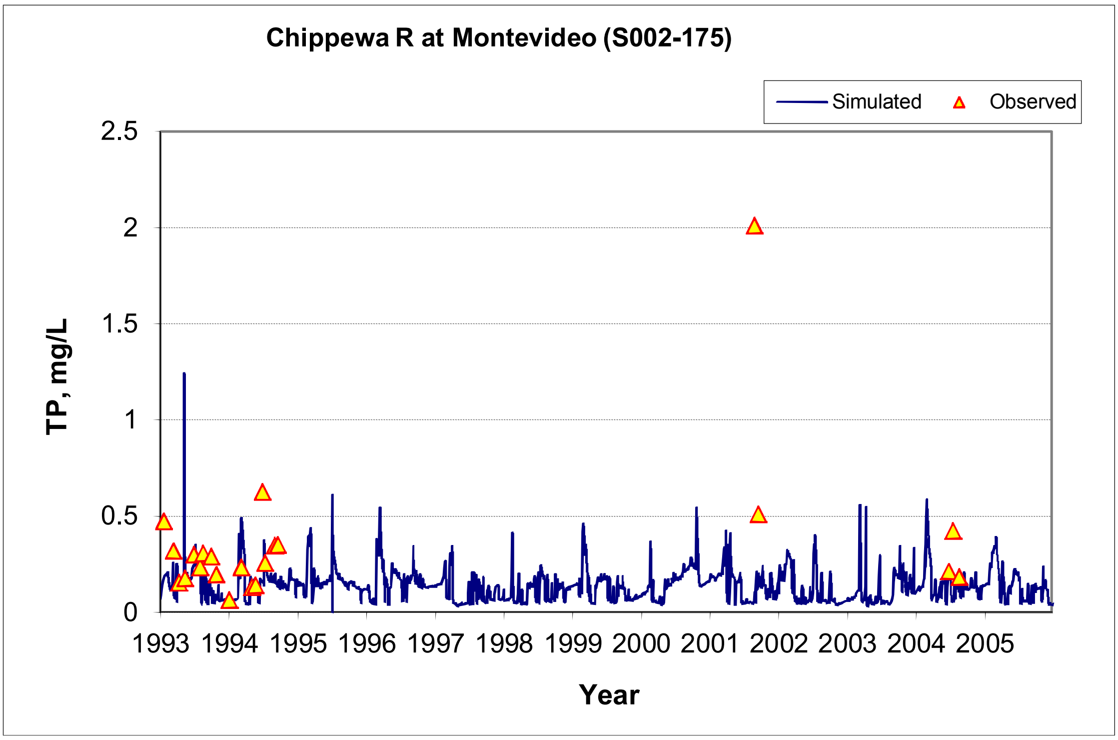


Figure 105. Total P Concentration Time Series, Calibration Period, Chippewa River at Montevideo (S002-175)

Table 28. Summary Statistics, NOx-N, Chippewa River at Montevideo (S002-175)

	Calibration (1993-2005)	Validation (2006-2010)
Count	23	ND
Concentration Average Error	3.69%	ND
Concentration Median Error	1.37%	ND
Paired Load Average Error	-30.50%	ND
Paired Load Median Error	1.91%	ND
Paired t Test on Concentration Means (p value)	0.74	ND
Paired t Test on Load Means (p value)	0.40	ND
Difference in Slope, Load vs. Flow	-5.04%	ND

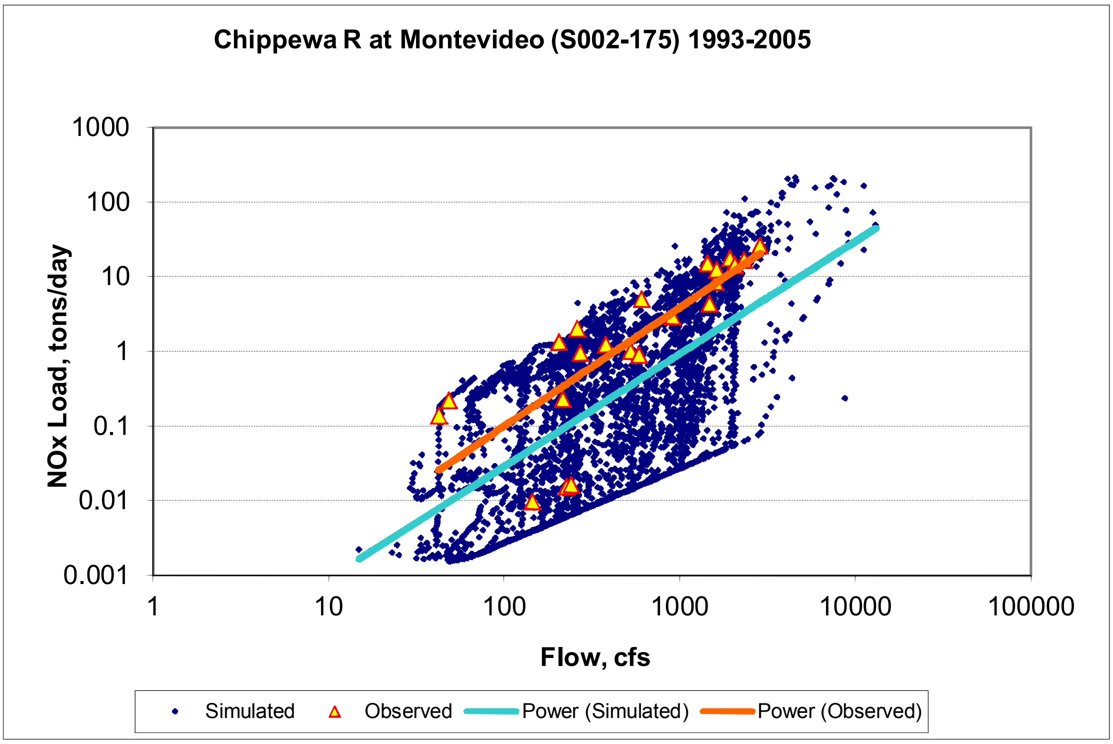


Figure 106. NOx-N Load Power Plot, Calibration Period, Chippewa River at Montevideo (S002-175)

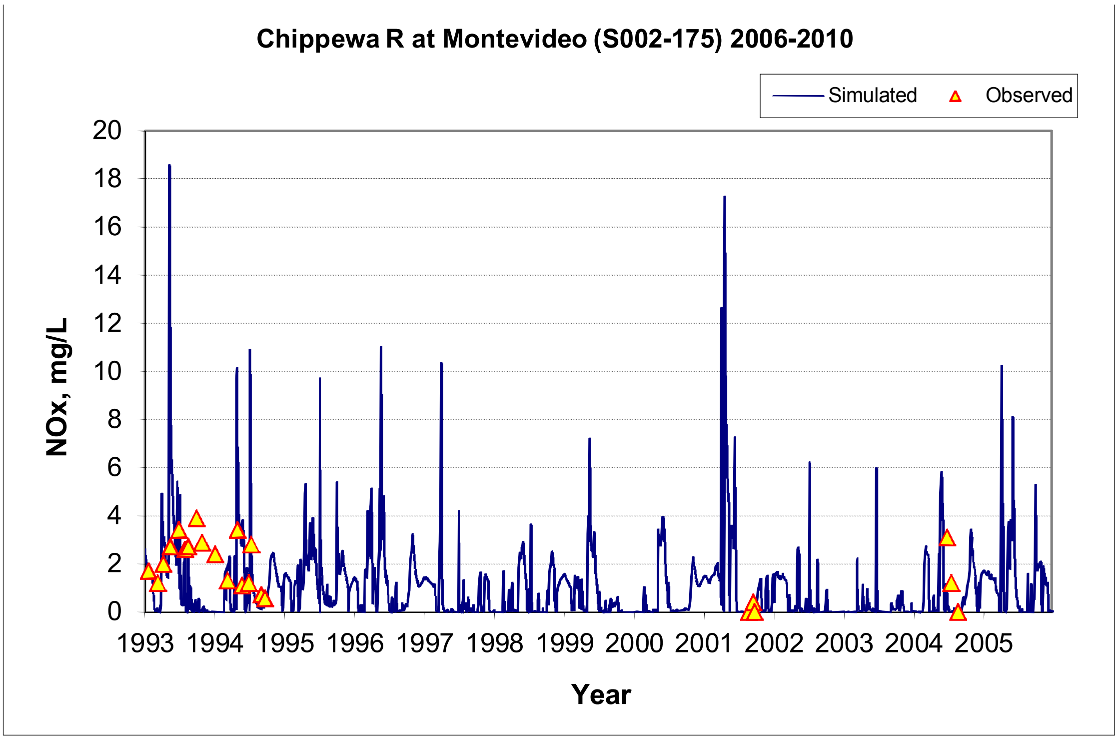


Figure 107. NOx-N Concentration Time Series, Calibration Period, Chippewa River at Montevideo (S002-175)

Table 29. Summary Statistics, Total N, Chippewa River at Montevideo (S002-175)

	Calibration (1993-2005)	Validation (2006-2010)
Count	18	ND
Concentration Average Error	13.49%	ND
Concentration Median Error	28.44%	ND
Paired Load Average Error	-16.07%	ND
Paired Load Median Error	2.68%	ND
Paired t Test on Concentration Means (p value)	0.67	ND
Paired t Test on Load Means (p value)	0.55	ND
Difference in Slope, Load vs. Flow	11.45%	ND

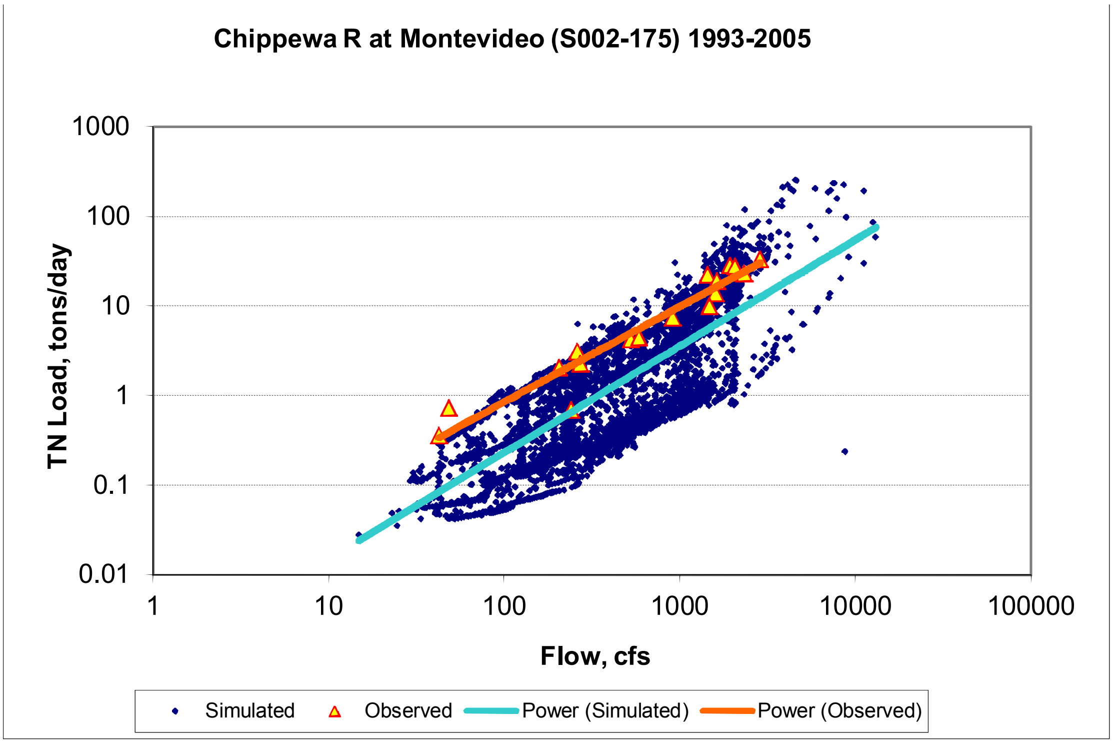


Figure 108. Total N Load Power Plot, Calibration Period, Chippewa River at Montevideo (S002-175)

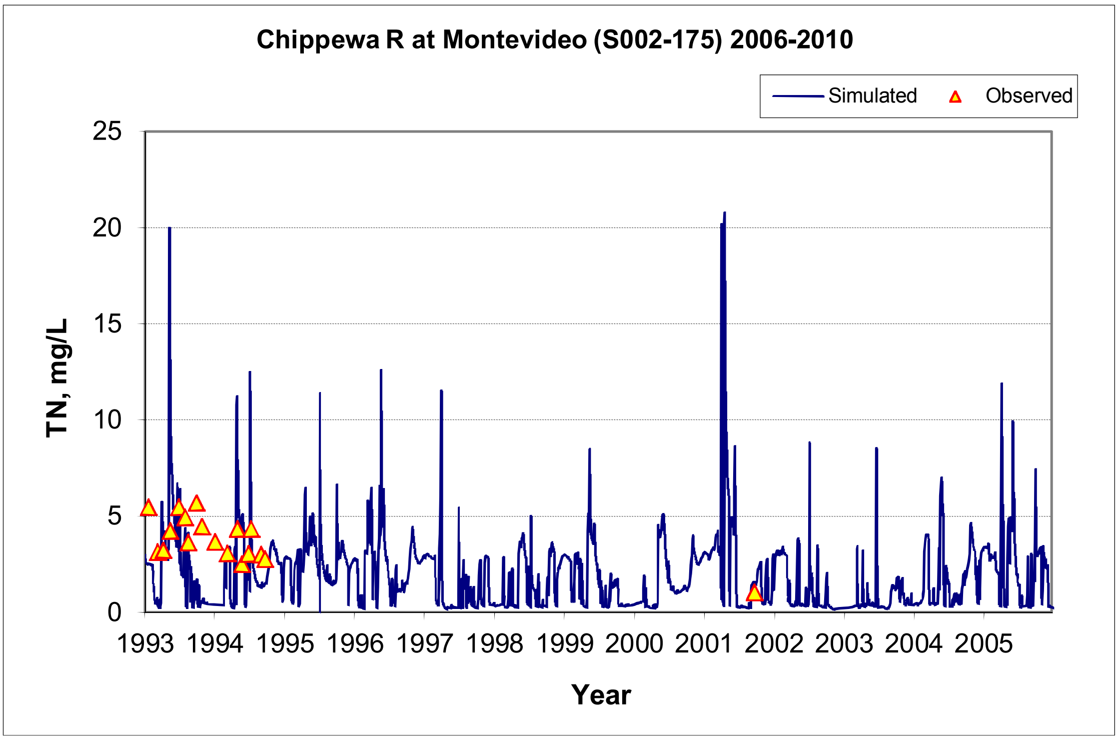


Figure 109. Total N Concentration Time Series, Calibration Period, Chippewa River at Montevideo (S002-175)