St. Joseph River Watershed
Indiana TMDLs

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Prepared for
U.S. Environmental Protection Agency, Region 5
Indiana Department of Environmental Management

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Abbreviations and Acronyms

AFG	allocation for future growth
ALU	aquatic life use
ARS	Agricultural Research Service (U.S. Department of Agriculture)
CSO	combined sewer overflow
BHSJ	Branch-Hillsdale-St. Joseph Community Health Agency (Michigan)
CAFO	concentrated animal feeding operation
CFO	confined feeding operation
CSS	combined sewer system
CWA	Clean Water Act
EBSJR	East Branch St. Joseph River
EFWBSJR	East Fork West Branch St. Joseph River
FDC	flow duration curve
HSTS	home sewage treatment system
HU	hydrologic unit
HUC	hydrologic unit code
IBC	impaired biotic communities
IDEM	Indiana Department of Environmental Management
Lake Erie LaMP	Lake Erie Lake Management Plan
LA	load allocation
LDC	load duration curve
Michigan DEQ	Michigan Department of Environmental Quality
MOS	margin of safety
NBEC	North Branch Eagle Creek
NPS	nonpoint source
NRCS	Natural Resources Conservation Service (U.S. Department of Agriculture)
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
OIALW	other indigenous aquatic life and wildlife
OWTS	on-site wastewater treatment system
RM	river mile
RU	recreation use (in Ohio and Michigan) or recreational use (in Indiana)
SJR	St. Joseph River
SJRW	St. Joseph River Watershed
SJRWI	St. Joseph River Watershed Initiative
SRF	state revolving fund
SSO	sanitary sewer overflow
STP	sewage treatment plant
SWAT	Soil and Water Assessment Tool
SWCD	soil and water conservation district
USDA	United States Department of Agriculture)
U.S. EPA	United States Environmental Protection Agency
U.S. FWS	United States Fish and Wildlife Service (U.S. Department of the Interior)
USGS	United States Geological Survey (U.S. Department of the Interior)
WBSJR	West Branch St. Joseph River
WFWBSJR	West Fork West Branch St. Joseph River
WLA	wasteload allocation
WMP	watershed management plan
WQS	water quality standards

WWH	warmwater habitat
WWSL	wastewater stabilization lagoon
WWTP	wastewater treatment plant
WY	water year

Units of Measure

c/d	counts per day
counts/100 mL	counts per 100 milliliters
gpd	gallons per day
mgd	million gallons per day
mg/L	milligrams per liter

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- Indiana Department of Environmental Management (IDEM)
- Michigan Department of Environmental Quality (Michigan DEQ)
- Ohio Environmental Protection Agency (Ohio EPA)
- Ohio Department of Natural Resources
- St. Joseph River Watershed Initiative
- Tetra Tech, Inc.
- U.S. EPA, Regions 5

Executive Summary

The St. Joseph River (SJR) watershed is in northwestern Ohio, south central Michigan, and northeast Indiana and drains to the Maumee River, encompassing approximately 1,085 square miles. In Ohio and Indiana, the SJR and its tributaries are impaired for their designated recreation uses by *Escherichia coli* (*E. coli*); are impaired for their aquatic life uses (ALU) by nutrients, sediment, and non-pollutants (e.g., direct habitat alteration); and are impaired for human health due to the presence of polychlorinated biphenyls in fish tissue. ALU impairments from non-pollutants and human health impairments are not addressed herein.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters that the states list as impaired on their section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads.

U.S. EPA's original goals for the St. Joseph River Watershed (SJRW) TMDL project were to assist the Ohio Environmental Protect Agency (Ohio EPA), the Indiana Department of Environmental Management (IDEM), and the Michigan Department of Environment Quality (MDEQ) in the development of multi-state TMDLs for impaired waterbodies of the SJRW. These goals were modified due to an Ohio Supreme Court ruling in March 2015. In *Fairfield County Board of Commissioners v. Nally* (March 2015), the Ohio Supreme Court determined that a TMDL is a rule and that a TMDL in Ohio must be promulgated before it can be submitted to U.S. EPA for approval. This ruling has affected Ohio EPA's ability to finalize and submit TMDLs to U.S. EPA given that Ohio EPA currently does not have TMDL promulgation processes in place.

The implications and timing of this ruling have impacted the SJRW TMDL project. Originally, U.S. EPA planned to develop a single TMDL report for the entire watershed, addressing impaired segments in Indiana and impaired watershed assessment units (WAUs) in Ohio. But due to the Ohio Supreme Court ruling, U.S. EPA has revised its approach to present the TMDLs in two different reports: one with the TMDLs for impaired segments in the SJRW within the boundaries of the state of Indiana, and a second report with the TMDLs for impaired WAUs in the SJRW within the boundaries of the state of Ohio. The TMDLs in the SJRW for Indiana are presented in this report. TMDLs for the impaired waters in the SJRW in Ohio will be presented in a report at a later date.

This document presents the results of a TMDL study for the Indiana-portion of the SJRW. The watershed characterization and source assessment are presented for the entire SJRW and rely, in part, on valuable background information provided in watershed improvement plans, state agency issued water quality reports, and many additional existing studies. The linkage analyses, TMDLs, allocations, and implementation plan framework are specific to the Indiana-portion of the SJRW.

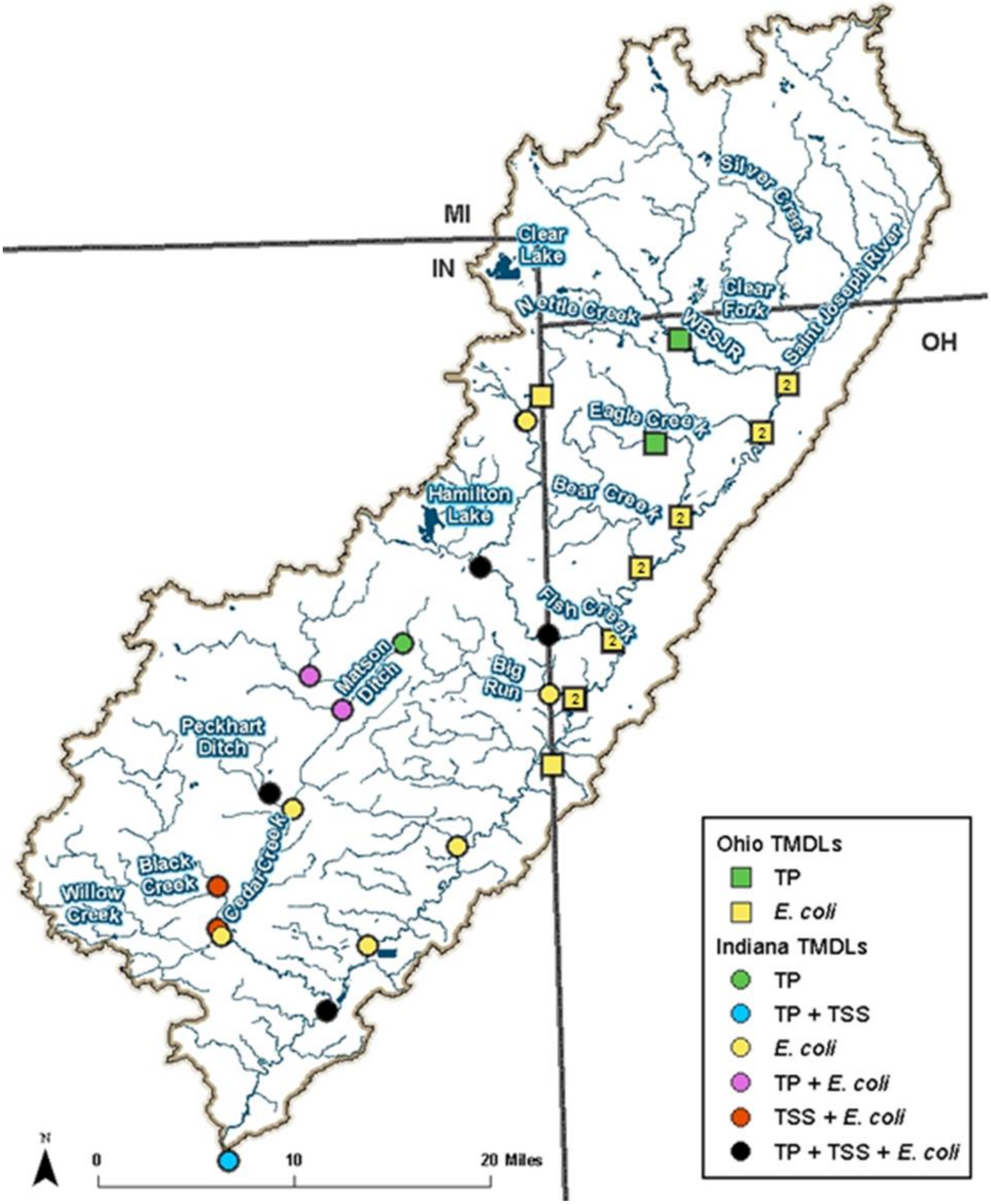
TMDLs in Indiana were developed using a load duration curve (LDC) approach using flow simulated from a watershed-scale model. TP and TSS targets in Indiana were set to 0.30 milligrams per liter (mg/L) for TP and 30 mg/L for TSS, while *E. coli* targets were selected from Indiana's recreational use criteria (125 counts per 100 milliliters).

The following TMDLs were developed in Indiana (Notes
TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.
Ohio *E. coli* TMDL symbols along the SJR overlap Ohio *E. coli* TMDL symbols at the mouths of tributaries to the SJR.
Figure 1):

- *E. coli* TMDLs were developed at 17 sites in the watershed to address 60 impaired segments
- TSS TMDLs were developed at 7 sites to address 7 segments with impaired biotic communities (IBC)
- TP TMDLs were developed at 8 sites to address 7 segments impaired by nutrients, 18 segments with IBCs, and 2 segments impaired by low dissolved oxygen

Reductions of current loads are necessary to achieve the loads specified within the TMDLs. When reductions were necessary, the reductions in the SJR mainstem in Indiana ranged from 1 to 90 percent for *E. coli*; 4 to 66 percent for TP; and 14 to 95 percent for TSS. Reductions for the tributaries of the SJR in Indiana ranged from 14 percent to >99 percent for *E. coli*; 3 to 84 percent for TP; and 17 to 94 percent for TSS.

Implementation of the TMDLs will be accomplished through the National Pollutant Discharge Elimination System (NPDES) program for permitted point sources and through application of best management practices (BMPs) to address agricultural and urban runoff.



Notes
TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.
Ohio *E. coli* TMDL symbols along the SJR overlap Ohio *E. coli* TMDL symbols at the mouths of tributaries to the SJR.

Figure 1. TMDLs in the SJRW.

1 Introduction

The St. Joseph River watershed (SJRW) is in northwestern Ohio, south central Michigan, and northeast Indiana. The watershed encompasses approximately 1,085 square miles and drains to the Maumee River. The SJRW consists of one 8-digit hydrologic unit (hydrologic unit code [HUC] 04100003) that is further subdivided into eight 10-digit hydrologic units (HUs) and 45 12-digit HUs (Figure 2 and Table A-1 in Appendix A).

In 2005, the Michigan Department of Environmental Quality (Michigan DEQ) conducted surveys of the East Branch St. Joseph River (EBSJR) and West Branch of the St. Joseph River (WBSJR). Macroinvertebrate community health was typically good to excellent and therefore met the other indigenous aquatic life and wildlife (OIALW) designated use. Numeric chemical criteria were met in most locations, although mercury and zinc exceeded criteria in a few samples and nutrients were sometimes detected at levels above expected ranges. No impairments are contained in Michigan's draft 2016 Integrated Report.

In 2013, the Ohio Environmental Protection Agency (Ohio EPA) evaluated the biological health and water quality of its portion of the SJRW (Ohio EPA 2015a). The results indicated that the watershed assessment units (WAUs; equivalent to 12-digit hydrologic units) that are composed of the tributaries to the St. Joseph River (SJR) were impaired for their designated aquatic life uses (ALUs) and recreation uses (RUs). Ohio EPA also found the SJR mainstem to be impaired for its recreation use (RU). The impaired WAUs and mainstem are listed in Ohio's draft 2016 Integrated Report.

Fixed water quality monitoring sites are sampled for nutrients and total suspended solids (TSS) a few times per year in Indiana, including most recently in 2014. Indiana Department of Environmental Management (IDEM) listed six segments of Cedar Creek and one segment of Dosch Ditch for nutrient impairments, 18 segments for impaired biotic communities (IBC), and one segment each on Fish Creek and Peckhart Ditch for dissolved oxygen in Indiana's draft Clean Water Act (CWA) 303(d) list (IDEM 2014c). IDEM also found two segments of the mainstem SJR and 57 segments in the SJRW to be impaired for RUs. Eight segments of the Cedarville Reservoir are also impaired for their RUs, but IDEM will address the Cedarvillle Reservoir impairments at a later date. Segments of the SJR, Cedar Creek, and Davis Ditch are impaired by polychlorinated biphenyls but these human health use impairments were not addressed in this TMDL project.

The CWA and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop TMDLs for waters on the section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, allocation of loads, and prioritization of implementation activities. TMDL targets and allocations are derived from the water quality standards (designated uses, narrative and numeric criteria). The TMDL allocations are separated into wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources.

The TMDL project area for this study is defined as the entire 8-digit HU, including the mainstem and tributary subwatersheds. While Lake Erie is not within the project area, TMDL implementation within the project area is anticipated to help improve water quality in the Maumee River and eventually in Lake Erie's Western Basin. TMDLs for aquatic life and recreation uses were developed. The overall goals and objectives in developing the TMDLs for this project area are as follows:

- Assess the water quality within the project area and identify key issues associated with the impairments and potential pollutant sources.

- Use the available research and data to identify the water quality conditions that will result in all streams fully supporting their designated uses.
- Prepare a final TMDL report for the Indiana portion of the SJRW that meets the requirements of the CWA and provides information to the stakeholders that can be used to facilitate implementation activities and improve water quality.
- Provide a framework implementation plan to address the necessary load reductions that is consistent with the existing watershed management plans.

The results of the TMDL process are documented in this report.

Water quality data and information that supported TMDL development were provided the St. Joseph River Watershed Imitative (SJRWI). The SJRWI (http://www.sjrwi.org/) is a non-profit organization that seeks to improve water quality in the SJRW. The organization actively monitors water quality the SJR and its tributaries. SJRWI has worked with local government agencies to develop watershed management plans to address water quality impairment throughout the SJRW.

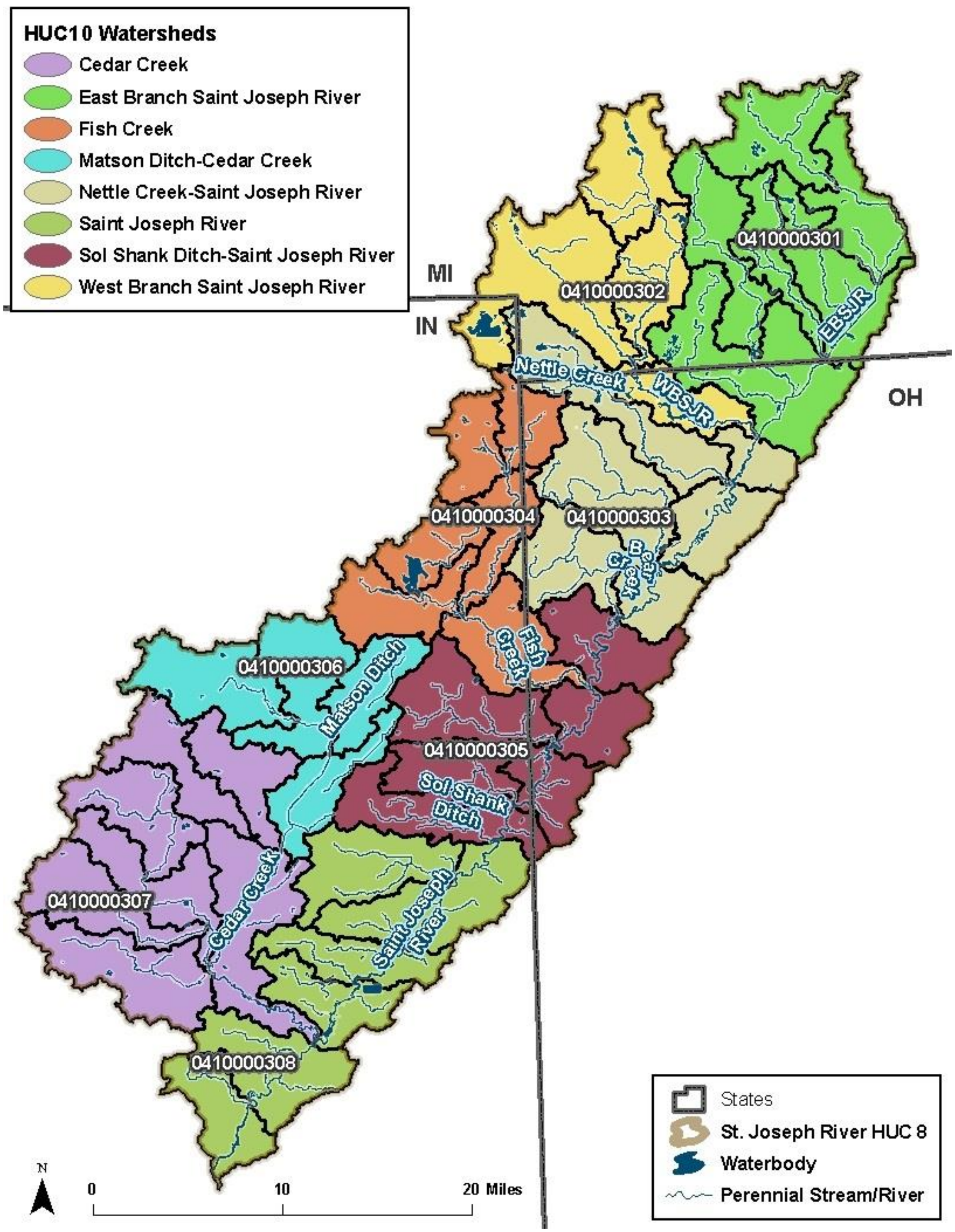


Figure 2. 10-digit hydrologic units in the SJRW.

2 Water Quality Standards and Impairments

This section summarizes the applicable water quality standards (WQS) for waters in the TMDL project area (Table 1) and provides information on the waterbody impairments. The WQS for the states are promulgated in each state's administrative codes:

- Michigan Administrative Rules, *Part 4. Water Quality Standards* (R 323.1041 - 323.1117)[1]
- Ohio Administrative Code (OAC) chapter *3745-1*[2]
- Indiana Administrative Code (IAC) chapter 327 article 2[3]

Table 1. State water quality standards

Component	Description
Designated Use	Designated use reflects how the water could be used by humans and how well it supports a biological community. Every water has a designated use or uses; however, not all uses apply to all waters (i.e., they are waterbody specific).
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated uses of the waterbody. Biological criteria indicate the health of the in-stream biological community by using indices that measure aquatic species community health.
Narrative Criteria	These are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that can cause algal blooms.
Antidegradation Policy	This policy establishes situations under which state agencies may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need.

TMDLs presented in this report were only developed to address impairments in Indiana; Michigan and Ohio WQS are also presented because waters in those states drain to Indiana. U.S. EPA draft guidance on multijurisdictional TMDLs (U.S. EPA 2012b), explains that *the central goal of the CWA and EPA's implementing regulations is to ensure that downstream States/Tribes are not subjected to pollutant loads from upstream or adjacent jurisdictions that cause or contribute to the impairment of downstream waters.* U.S. EPA encourages upstream or adjacent states to calculate loading contributions that may be impacting downstream impaired waters. These calculations should be represented as separate loads within TMDLs addressing downstream impaired waters (e.g., refer to Table H-4 in Appendix H for an *Ohio upstream allocation*).

2.1 Designated Uses

Beneficial use designations define the existing and potential uses of a waterbody. The designated uses consider human health, recreation, aquatic life, water supplies (agricultural, drinking, and industrial), and navigation (Table 2). In Michigan, designated uses for tributaries to the SJR are either, coldwater fisheries, warmwater fisheries, and OIALW. In Ohio, designated uses for the SJRW were promulgated into *OAC-3745-1-11*, which contains designated uses in the Maumee River watershed; most waterbodies are designated as warmwater habitat (WWH) and primary contact recreation (PCR) (Table A-2 in

[1] R 323.1041 - 323.1117 is available at http://www.michigan.gov/documents/deq/wb-swas-rules-part4_254149_7.pdf (accessed October 31, 2014)
[2] OAC-3745-1 is available at http://epa.ohio.gov/dsw/rules/3745_1.aspx (accessed October 31, 2014)
[3] 327 IAC 2 is available at http://www.in.gov/legislative/iac/T03270/A00020.PDF (accessed October 31, 2014).

Appendix A). Indiana waters are designated for aquatic life use and, in Indiana, all waters are designated for full body contact recreation use, unless specifically designated otherwise.

Table 2. Designated uses in Indiana, Michigan, and Ohio

Indiana	Michigan	Ohio
All designated uses per state		
▪ Agricultural use ▪ Aquatic life ▪ Exceptional use ▪ Fish consumption ▪ Full body contact [recreation] ▪ Industrial water supply ▪ Limited use ▪ Public water supply	▪ Agriculture ▪ Coldwater fishery ▪ Fish consumption ▪ Full body contact recreation ▪ Industrial water supply ▪ Navigation ▪ Other indigenous aquatic life and wildlife ▪ Partial body contact recreation ▪ Warmwater fishery	▪ Agricultural water supply ▪ Aquatic life [a] ▪ Human health (fish tissue) ▪ Industrial water supply ▪ Public water supply ▪ Recreation [b]
Designated uses addressed by TMDLs		
▪ Aquatic life ▪ Full body contact [recreation]	(no TMDLs were developed in Michigan)	▪ Aquatic life ▪ Recreation

Sources: Appendix A of Indiana's draft 2014 Integrated Report (IDEM 2014c), Appendix B2 of Michigan's 2014 Integrated Report (Michigan DEQ 2014b), and *OAC-3745-1-07.*
Notes
a. Ohio's aquatic life use is delineated into coldwater habitat, exceptional warmwater habitat, limited resources water, modified warmwater habitat (with three sub-delineations), seasonal salmonid habitat, and warmwater habitat.
b. Ohio's recreation use is delineated into bathing waters, primary contact, and secondary contact.

2.2 Numeric Criteria

Numeric criteria are typically based on concentrations of pollutants and degree of aquatic life toxicity allowable in a waterbody without adversely affecting its beneficial uses. They consist of biological criteria, chemical criteria, and whole effluent toxicity levels. In the case of biological criteria, the numeric criteria are the biological community index scores that represent conditions where the designated use is met. The criteria applicable to the project area that are pertinent to the TMDL project are presented in the following sections.

2.2.1 Biological Criteria

Biological criteria[4] (also referred to as biocriteria) "are narrative descriptions or numerical values of the structure and function of aquatic communities in a waterbody necessary to protect the designated aquatic life use, implement in, or through water quality standards" (Flotemersch et al. 2006, p. G-2). Biological criteria are typically set using biological indices[5]; for example, the Index of Biological Integrity (IBI) measures fish community health.

[4] The scientific definition varies from the regulatory definition, which is that biological criteria "are quantified values representing the biological condition of a waterbody as measured by structure and function of the aquatic communities typically at reference conditions" (Flotemersch et al. 2006, p. G-2).

[5] Biological indices are "a set of metrics collected into a single score calibrated to reference conditions and used as a measure of biological condition" (Flotemersch et al. 2006, p. G-2).

2.2.1.1 Ohio

The biological criteria in Ohio are numeric and vary by ALU designation and level III ecoregion[6]. ALU designations in Ohio include coldwater habitat (CWH), exceptional warmwater habitat, seasonal salmonid habitat, warmwater habitat (WWH), modified warmwater habitat (MWH), and limited resource waters (LRW). The ability of a waterbody to meet its ALU designation is based primarily on the scores it receives on three community indices, as applicable: the IBI, the Modified Index of well-being (MIwb), and the Invertebrate Community Index (ICI). The IBI and MIwb are based on the composition and health of the fish community, and the ICI is based on the composition of the macroinvertebrate community.

2.2.1.2 Indiana

While IDEM uses biological indices for use attainment assessment, biological criteria have not been promulgated into the WQS numeric criteria rules. The IBI and macroinvertebrate Index of Biotic Integrity (mIBI) are used for ALU support of rivers and streams in Indiana[7]. However, nutrients (total phosphorus [TP], nitrate plus nitrite [NN]), dissolved oxygen, pH, and algal condition are evaluated with the IBI and mIBI to assess ALU attainment[8].

2.2.2 Chemical Criteria

Each state uses *Escherichia coli* (*E. coli*) to assess their designated RUs; *E. coli* is an indicator species for pathogens that are harmful to human health. The numeric criteria, designated RUs, and recreation seasons vary between the states (Table 3).

[6] North America is delineated into four levels of nested ecoregions. Level I ecoregions are the largest and allow for coarse, continental analyses while level IV ecoregions are the smallest and allow for fine, localized analyses (Commission for Environmental Cooperation 1997). The SJRW is within the *Eastern Temperature Forest* level I ecoregion (#8); within the *Mixed Wood Plains* (#8.1) and *Central USA Plains* (#8.2) level II ecoregions; within the *South Michigan / Indiana Drift Plane* (#8.1.6 and #56) and *Eastern Corn Belt Plains* (#8.2.4 and #55) level III ecoregions; and within Clayey High Lime Till Plains (#55a), *Northern Indiana Lake Country* (#56a), Battle Creek/Elkhart Outwash Plain (#56b), Interlobate Dead Ice Moraines (#56h) level IV ecoregions.

[7] To be fully supporting the ALU, the IBI and mIBI must be greater than or equal to a score of 36.

[8] Total phosphorus (TP), nitrate plus nitrite (NN), dissolved oxygen, pH, and algal condition are evaluated from at least three sampling events; if three or more of the five parameters exceed criteria, then the ALU is not attained. Qualitative Habitat Evaluation Index data are not directly used for determining ALU support but are used to help assess the cause(s) of impairment to aquatic community health.

Table 3. Numeric criteria for the protection of RU

Component	Indiana	Michigan [a]	Ohio [b]
Recreation season	Apr - Oct	May - Oct	May - Oct
Indicator	*E. coli*	*E. coli*	*E. coli*
Maximum criteria (count per 100 mL)	Single sample	Daily (geometric mean of sample event) [c]	Single sample
	235 [f]	TBCR: 300 PBCR: 1,000 [d]	Bathing water: 410 PCR: 410 SCR: 1,030
Geometric mean criteria (count per 100 mL)	5 equally spaced samples over 30-days	5 or more individual sample events over a 30-day period	90-day
	FBC: 125	TBCR: 130	Bathing water: 126 [e] PCR: 126 [e] SCR: 1,030
Promulgated rules	*327 IAC 2-1.5-8(e)*	*R 323.1062* *R 323.1100*	*OAC 3745-1-37, Table 37-2*

Notes

FBC = full body contact; IAC = Indiana Administrative Code; mL = milliliter; MPN = most probable number; OAC = Ohio Administrative Code; PBCR = partial body contact recreation; PCR = primary contact recreation; SCR = secondary contact recreation; TBCR = total body contact recreation.

a. Michigan defines a sample event as 3 or more individual samples at representative locations within a defined sample area.

b. Ohio criteria apply inside and outside of mixing zones. Single sample criteria may not be exceeded in more than 10 percent of samples.

c. Compliance is based upon the geometric mean of the individual samples collected during a *sample event*, as defined in footnote 'a' above

d. Michigan's partial body contact recreation criterion is applicable year round.

e. The St. Joseph River is designated PCR and J. Lattener Ditch is designated SCR; all other waterbodies are designated PCR. Any discharger within 5 miles of a more stringent downstream designated use must discharge to protect that downstream use.

f. If five equally spaced samples were not collected over a 30-day period, then the single sample maximum criteria may be used to determine attainment. Additionally, the single sample maximum criteria is used for making beach notification and closure decisions, according to 327 IAC 2-1.6(d).

2.3 Narrative Criteria and Guidance

Narrative criteria are the general water quality criteria that apply to all surface waters. Those criteria, promulgated in *327 IAC 2-1-5-8(b)(1)(A) through (D) for the Great Lakes system*, *R 323.1050*, and *OAC-3745-1-04*, generally state that all waters must be free from sludge, floating debris, foam oil and scum, color- and odor-producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that can cause nuisance aquatic plant growth or algal blooms.

2.3.1 Nutrients

Indiana, Michigan, and Ohio do not have numeric criteria for aquatic life use impairments caused by nutrients or sediment. Each state uses different nutrient and sediment targets based upon different methodologies.

2.3.1.1 Michigan

Michigan DEQ uses a site-specific approach to identify nutrient TMDL targets based on Michigan's narrative criteria. This methodology includes an evaluation of relevant data that describe the relationship between designated uses and nutrients. Michigan DEQ implements site-specific targets through NPDES permits and TMDLs.

2.3.1.2 Ohio

In Ohio, TMDL targets are selected on the basis of evaluating reference stream data published in a technical report titled *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and*

Streams (Ohio EPA 1999; referred to throughout as the *Associations* document). The document identifies ranges of concentrations for NN and TP on the basis of observed concentrations at all sampled ecoregional reference sites. Those reference stream concentrations were used as TMDL targets and are shown in Table 4. While nutrient targets are not codified in Ohio's water quality standards, Ohio EPA's methodology is very rigorous and the linkage of the targets to the health of the aquatic community is well established in the *Associations* document. Targets from the *Associations* documents have been used in numerous recent TMDLs approved by U.S. EPA[9].

Table 4. Ohio's statewide-suggested TP targets (mg/L) for the protection of aquatic life

Stream class	Stream size (square miles)	Beneficial use		
		EWH	WWH	MWH
Headwaters	< 20	0.05	0.08	0.34
Wading	20 - 200	0.05	0.10	0.28
Small river	200 - 1,000	0.10	0.17	0.25
Large river	> 1,000	0.15 [a]	0.30	0.32

Source: Ohio EPA 1999
Notes:
EWH = exceptional warmwater habitat; mg/L = milligrams per liter; MWH = modified warmwater habitat; WWH = warmwater habitat.
Statewide total phosphorus recommendations were generated by Ohio EPA (1999) with ANOVA analyses of statewide pooled data.
a. Assumes a nitrogen:phosphorus ratio that is greater than or equal to10:1.

2.3.1.3 Indiana

In Indiana, the nutrient TMDL target is typically 0.30 milligrams per liter (mg/L) TP. IDEM uses the TP target values, along with pH, dissolved oxygen, and algal information, to determine ALU support for rivers and streams. Typically, if two or more of the targets are exceeded, then the ALU is impaired and nutrients are considered a cause of impairment.

Indiana TP TMDLs in the SJRW were set to a target concentration of 0.30 mg/L. This target was used for TP TMDLs that address segments listed for nutrients and for segments listed for IBC when any TP concentrations in such a segment exceed the target of 0.30 mg/L.

2.3.2 Habitat

IDEM and Ohio use the Qualitative Habitat Evaluation Index (QHEI) to evaluate ALU attainment and identify the potential causes and sources of ALU impairment. The QHEI is a quantitative expression of a qualitative, visual assessment of habitat in free-flowing streams and was developed by Ohio EPA to assess available habitat for fish communities (Rankin 1989, 1995). The QHEI is a composite score of six physical habitat categories:

- Substrate
- In-stream cover
- Channel morphology
- Riparian zone and bank erosion
- Pool/glide and riffle/run quality
- Gradient

[9] The following are examples of recent Ohio TMDLs that used targets from the *Associations* document (Ohio EPA 1999) and were approved by U.S. EPA Region 5: *Maumee River (Lower) Tributaries and Lake Erie Tributaries TMDL Report* (Ohio EPA 2012b), *Total Maximum Daily Loads for the Grand River (Lower) Watershed* (Ohio EPA 2012a), *Total Maximum Daily Loads for the Sandusky River (lower) and Bay Tributaries Watershed* (Ohio EPA 2014b), *Total Maximum Daily Loads for the White Oak Creek Watershed* (Ohio EPA 2009b), *Total Maximum Daily Loads for the Swan Creek Watershed* (Ohio EPA 2009a).

Each of those categories is subdivided into specific attributes that are assigned a point value reflective of the attribute's effect on the aquatic life. Highest scores are assigned to the attributes correlated to streams with high biological diversity and integrity and lower scores are progressively assigned to less desirable habitat features. A QHEI evaluation form[10] is used by a trained evaluator while at the sampling location. Each of the components is evaluated on-site, recorded on the form, the score totaled, and the data later analyzed in an electronic database.

The QHEI is a macro-scale approach that measures the emergent properties of habitat (sinuosity, pool/riffle development) rather than the individual factors that influence the properties (current velocity, depth, substrate size). The QHEI is used to evaluate the characteristics of a short stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites could have poorer physical habitat because of a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. However, QHEI evaluations are segment specific and do not give a strong indication of the quality of the habitat in other stream segments.

QHEI scores can range from 12 to 100. Ohio EPA (2006) has determined appropriate QHEI target scores through statistical analysis of Ohio's statewide database of paired QHEI and IBI scores. Simple linear and exponential regressions and frequency analyses of combined and individual components of QHEI metrics in relation to the IBI were examined. The regressions indicate that the QHEI is significantly correlated with the IBI. QHEI scores of more than 75 generally indicate excellent stream habitat, scores between 60 and 75 indicate good habitat quality, and scores of less than 45 demonstrate habitat that is not conducive to WWH. Scores between 45 and 60 need separate evaluation by trained field staff to determine the stream's ALU potential.

In Indiana, the QHEI scores are used with IBC listings to determine if habitat is the primary stressor affecting the IBC or if multiple stressors are causing the IBC. IDEM considers QHEI scores less than 51 to indicate poor habitat.

2.3.3 Sediment

Using TSS as an indicator of sediment in the water column is fairly common and has been used in numerous TMDL reports; however, TSS concentrations can be an underestimation of sediment loads because they account only for particles small enough to remain suspended in the water column. Larger particles, such as sand and coarser particles, that could have the most influence on aquatic life and stream substrates are often not included in TSS concentrations because they usually settle out of the water column. Several of the QHEI metrics are also useful for assessing sedimentation and siltation.

2.3.3.1 Michigan

Michigan DEQ uses a site-specific approach to identify TSS TMDL targets using Michigan's narrative WQSs. This methodology includes an evaluation of relevant data that describe the relationship between designated uses and sedimentation/siltation. Michigan DEQ implements site-specific targets through NPDES permits and TMDLs.

2.3.3.2 Ohio

In Ohio, TSS TMDL targets are typically selected from the *Associations* document (Ohio EPA 1999), as discussed in Section 2.3.1.2. The document identifies ranges of concentrations TSS on the basis of observed concentrations at all sampled ecoregional reference sites. One of the methods that U.S. EPA recommends is basing nutrient criteria on the 75th percentile of the frequency distribution of reference streams (U.S. EPA 2000).

[10] The evaluation form is available at http://www.epa.ohio.gov/portals/35/documents/QHEIFieldSheet061606.pdf.

No Ohio WAU is impaired by sedimentation/siltation; thus, no TSS TMDLs were developed. TSS targets based upon the *Associations* document (Ohio EPA 1999) are presented in this report for reference since Ohio streams drain to some Indiana impairments that were addressed through TSS TMDLs.

2.3.3.3 Indiana

In Indiana, sediment TMDL targets are typically 30 mg/L TSS. TSS is a surrogate pollutant used to address impairments caused by sedimentation and siltation, which can include IBC listings.

Indiana TSS TMDLs in the SJRW were set to a target concentration of 30 mg/L. This target was used for TSS TMDLs that address segments listed for IBC when any TSS concentrations in such a segment exceed the target of 30 mg/L.

2.4 Impairments

Portions of the mainstem of the SJR and certain tributaries within the SJRW are not meeting WQS and targets. The SJR is not meeting its designated ALU in Indiana and its designated RUs in Ohio and Indiana; its tributaries are not meeting the designated ALUs and RUs in Ohio and Indiana. The scope of this project is limited to anthropogenic impairments to designated ALUs and RUs; impairments due to polychlorinated biphenyls in fish tissue in Indiana were not addressed in this TMDL document. IDEM will revisit the PCB impairments in the SJRW at a later date. No other designated uses were identified as impaired by the state agencies.

2.4.1 Aquatic Life Uses

Tributaries in the SJRW (HUC 04100003) are not attaining their designated ALUs due to excessive nutrients and sediment.

2.4.1.1 Michigan

According to the Michigan 2014 Integrated Report (Michigan DEQ 2014b), the ALU assessments in the SJRW were either fully supporting WQS or were not assessed. Therefore, TMDLs which would have addressed ALU impairments will not be developed in Michigan for the SJRW TMDL effort.

2.4.1.2 Ohio

Ohio lists impairments by watershed assessment unit (WAU)[11]. ALU impairments evaluated in this TMDL project are based upon 2013 and 2014 monitoring data. These samples were not evaluated and impairments were not determined before the publication of Ohio's CWA 303(d) list in its 2014 Integrated Report (Ohio EPA 2014a). The 2013 and 2014 monitoring data will be used to develop Ohio's 2016 303(d) list[12]. The impairments are summarized in Figure 3 and presented in Table A-3 in Appendix A.

TMDLs developed for Ohio will be published in a future TMDL document. Nutrient TMDLs will be developed for the West Branch St. Joseph River (HUC 04100003 02 04) and Eagle Creek (*03 03). TMDLs will not be developed for Clear Fork (*04 06; natural conditions), Eagle Creek (04100003 03 03; direct habitat alterations), or Nettle Creek (*03 01; direct habitat alterations).

[11] Ohio EPA samples representative monitoring sites in each WAU. Ohio EPA's monitoring sites are presented in Table A-8 and Table A-9 in Appendix A.

[12] Angela Defenbaugh & Cathy Alexander, Ohio EPA, personal communication (via electronic mail), December 17, 2014.

2.4.1.3 Indiana

Indiana lists impairments by stream segment[13] and the ALU impairments are presented in Indiana's draft 2014 303(d) list (IDEM 2014c). The impairments are summarized in Figure 4 and presented in Table A-5 in Appendix A. Seven segments across three 12-digit HUs are impaired by nutrients and TP TMDLs were developed. Eighteen segments across eleven 12-digit HUs are listed for IBC. Six TP TMDLs were developed to address the IBC-impaired segments with elevated levels of TP and seven TSS TMDLs were developed to address the IBC-impaired segments with elevated levels of TSS[14]. Two TP TMDLs may also help to address dissolved oxygen impairments.

[13] IDEM monitoring sites that were used to assess attainment are presented in Table A-10 and Table A-11 in Appendix A.

[14] IDEM did not identify causes or sources of impairment for segments listed for IBC (IDEM 2014c). Only those impaired segments that also have elevated levels of total phosphorus and TSS were addressed through TP and TSS TMDLs. The remaining IBC-impaired segments were not addressed in this TMDL project.

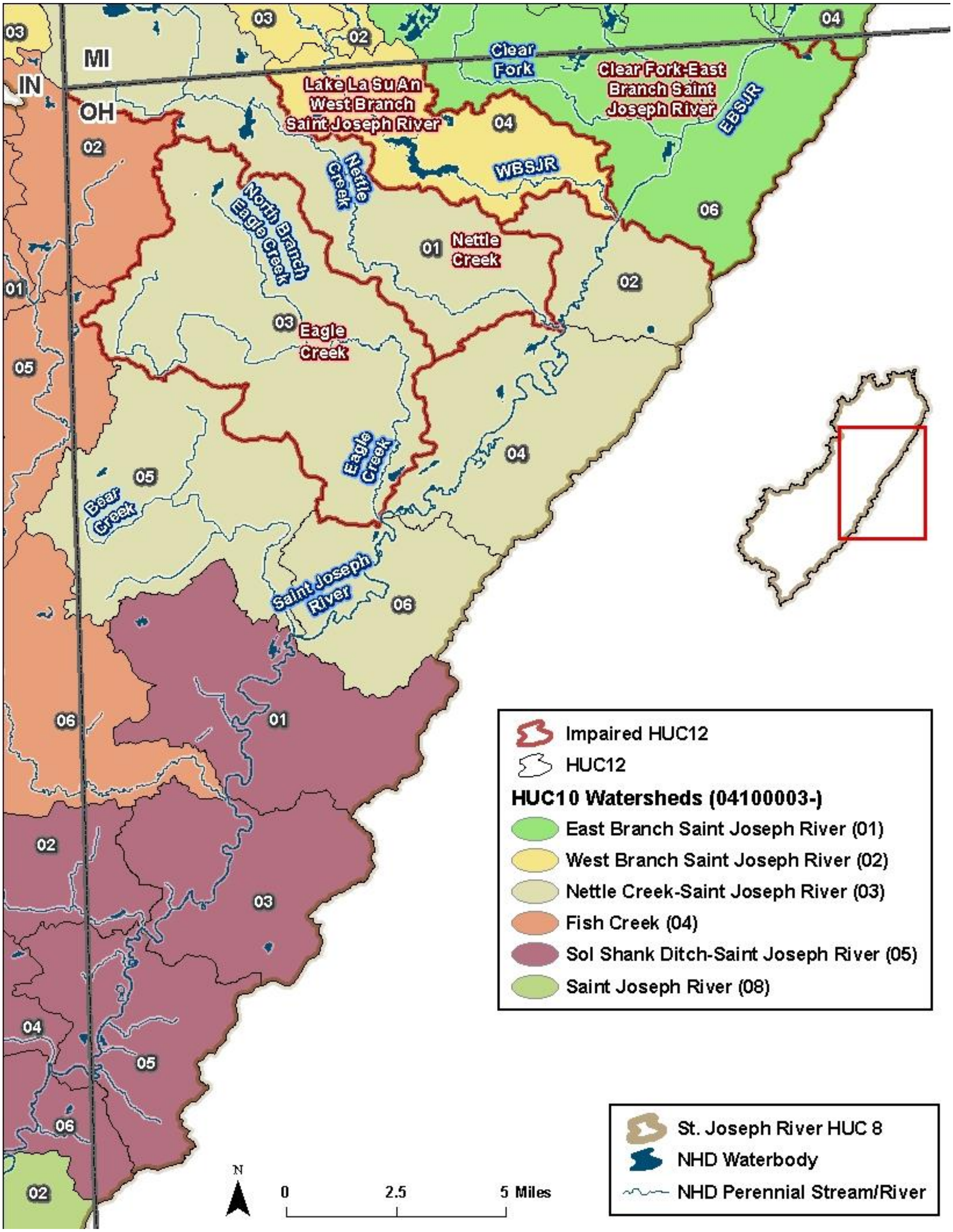


Figure 3. ALU impairments in Ohio's portion of the SJRW.

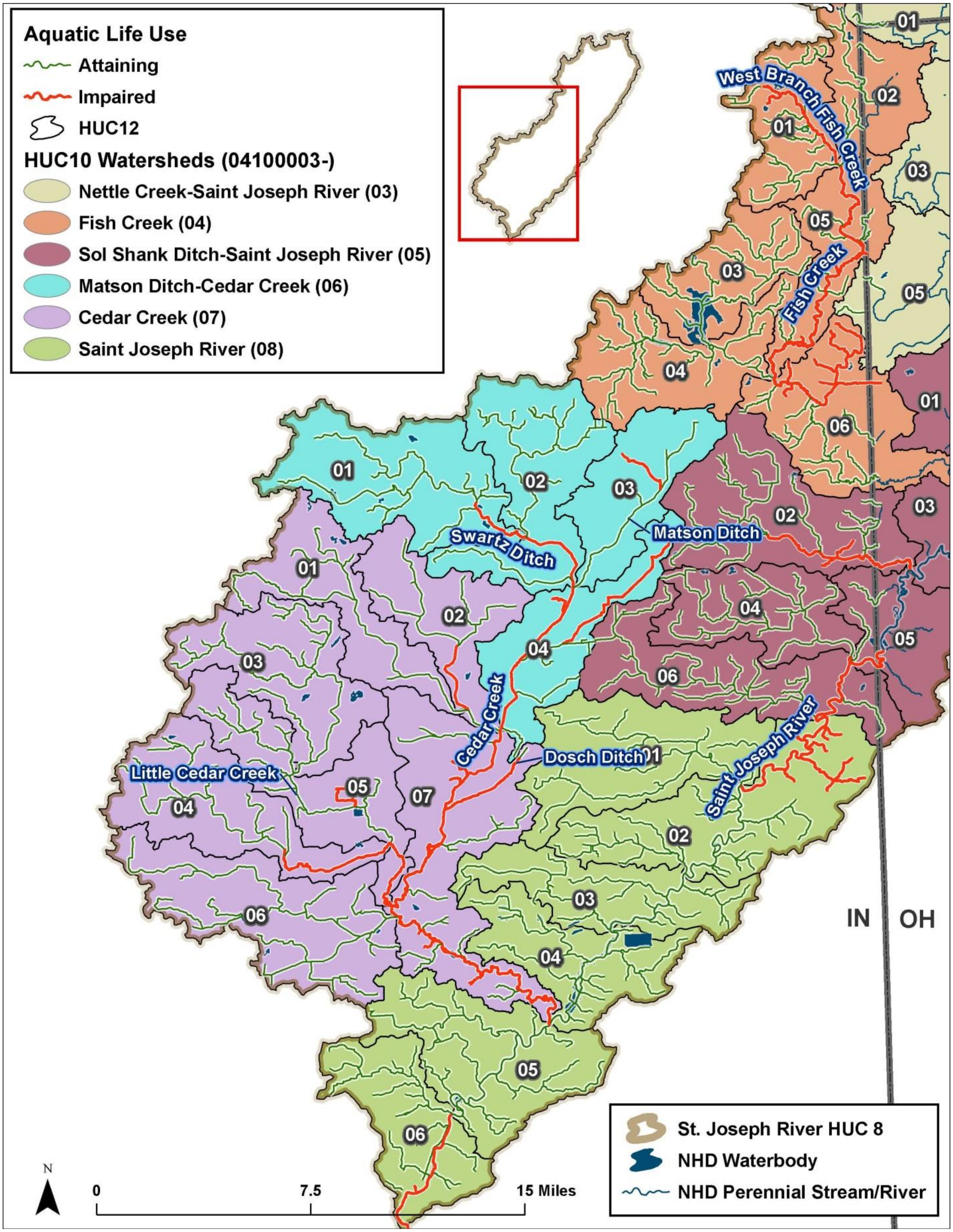


Figure 4. ALU impairments in Indiana's portion of the SJRW.

2.4.2 Recreation Uses

The SJR and its tributaries are not meeting their designated RUs[15] due to excessive levels of *E. coli*.

2.4.2.1 Michigan

No RU impairments were identified by Michigan DEQ or included in Michigan's CWA 303(d) list in the 2014 Integrated Report (Michigan DEQ 2014b). No TMDLs will therefore be developed.

2.4.2.2 Ohio

As with ALU impairments, RU impairments evaluated in this TMDL project are based upon 2013 and 2014 monitoring data. These samples were not evaluated and impairments were not determined before the publication of Ohio's CWA 303(d) list in its draft 2014 Integrated Report (Ohio EPA 2014a)[16]. All fourteen sampled WAUs are impaired by *E. coli* (Figure 5; Table A-4 in Appendix A).

2.4.2.3 Indiana

The RU impairments are presented in Indiana's CWA (303(d) list (IDEM 2014c): two segments of the lower SJR (in HUC 04100003 08 02 and *08 03) and 59 segments across 16 12-digit HUs are impaired (Figure 6; Table A-6 in Appendix A).

[15] In Michigan and Ohio, the designated uses are "recreation" uses, while in Indiana they are "recreational" uses. The term "recreational" is only used when referring to Indiana's designated uses.
[16] Two 12-digit HUs were listed as category 5 for recreation use attainment in Ohio's 2014 303(d) list (Ohio EPA 2014a).

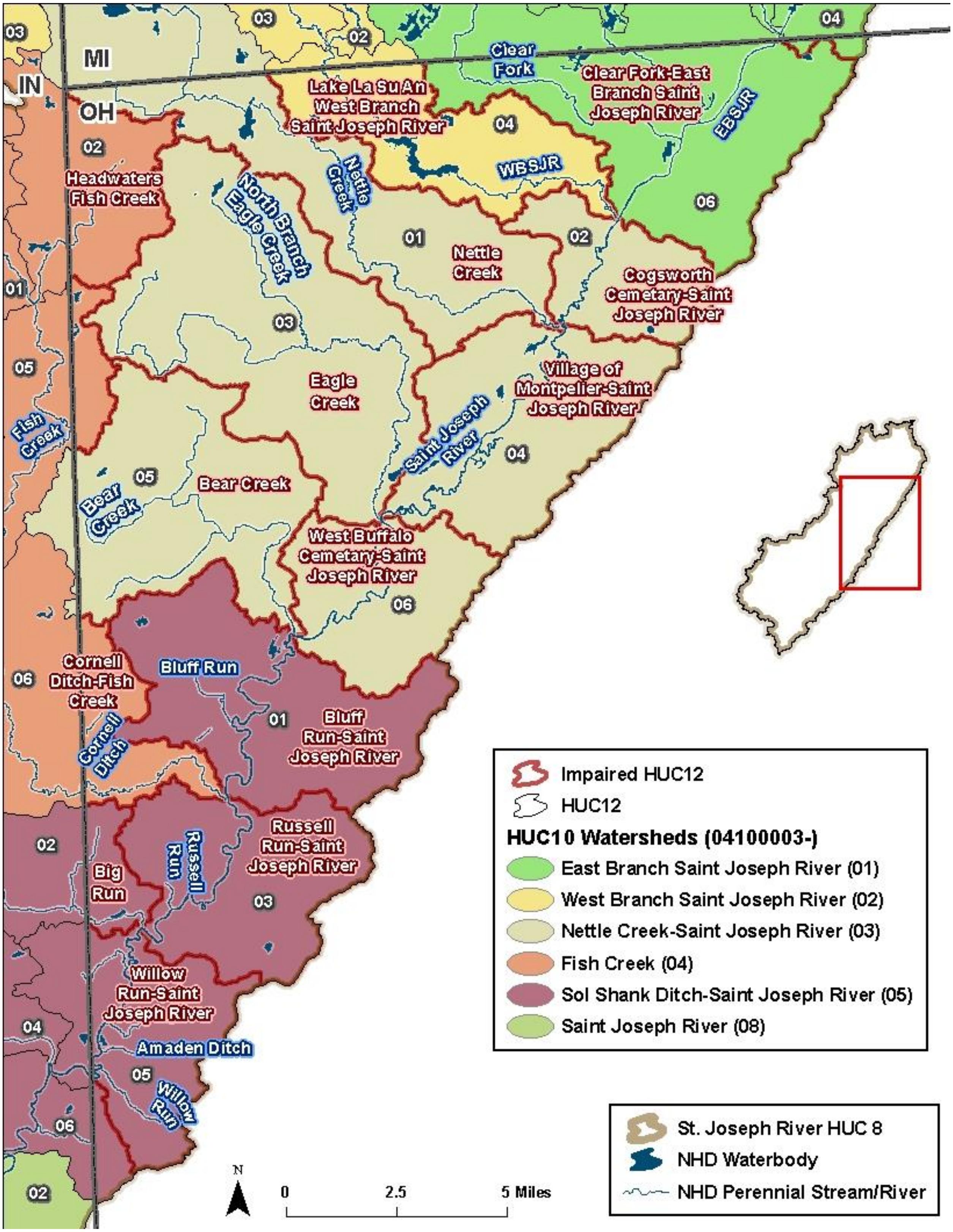


Figure 5. Recreation use impairments in Ohio's portion of the SJRW.

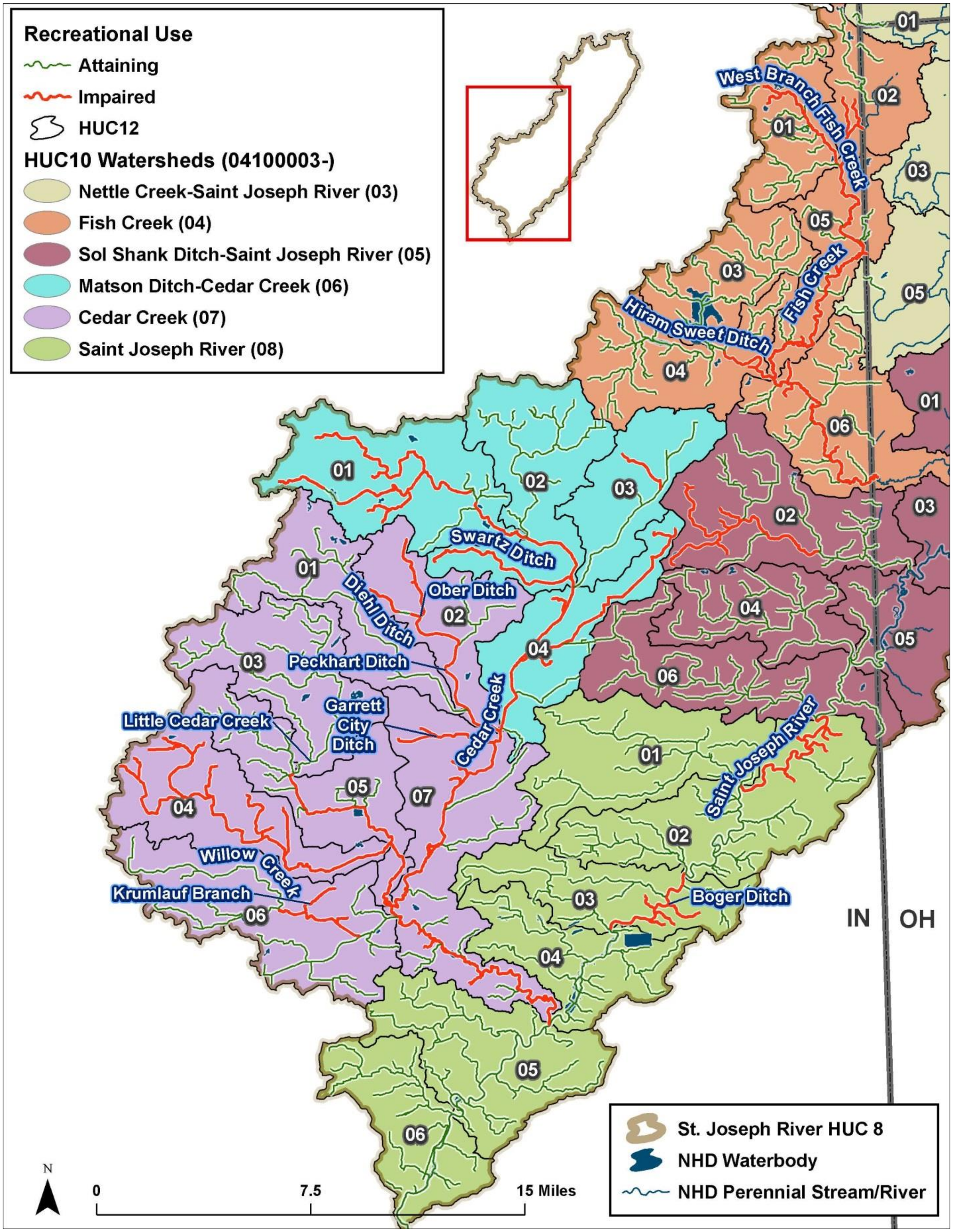


Figure 6. RU impairments in Indiana's portion of the SJRW.

3 Watershed Characterization

This section characterizes the SJRW and includes summaries of previous studies in the SJRW. A brief description of the Lake Erie Western Basin is also included because the SJR is a headwaters tributary to the Maumee River that discharges to Lake Erie in Toledo.

3.1 Lake Erie Western Basin

Lake Erie is the smallest, by volume, and shallowest of the Great Lakes. The Lake Erie basin is the most populated of the Great Lakes basins, with about one-third of the total Great Lakes basin population (Lake Erie LaMP 2011). Seventeen large metropolitan areas, including Detroit, MI; Windsor, Ontario; Toledo, OH; Cleveland, OH; and Buffalo, NY are in the Lake Erie basin (U.S. EPA 1995; see Figure 7). The lake provides drinking water to 11 million people (Lake Erie LaMP 2011). Fertile soils are located around the lake and intensely farmed, especially in northwest Ohio and southwest Ontario (U.S. EPA 1995).

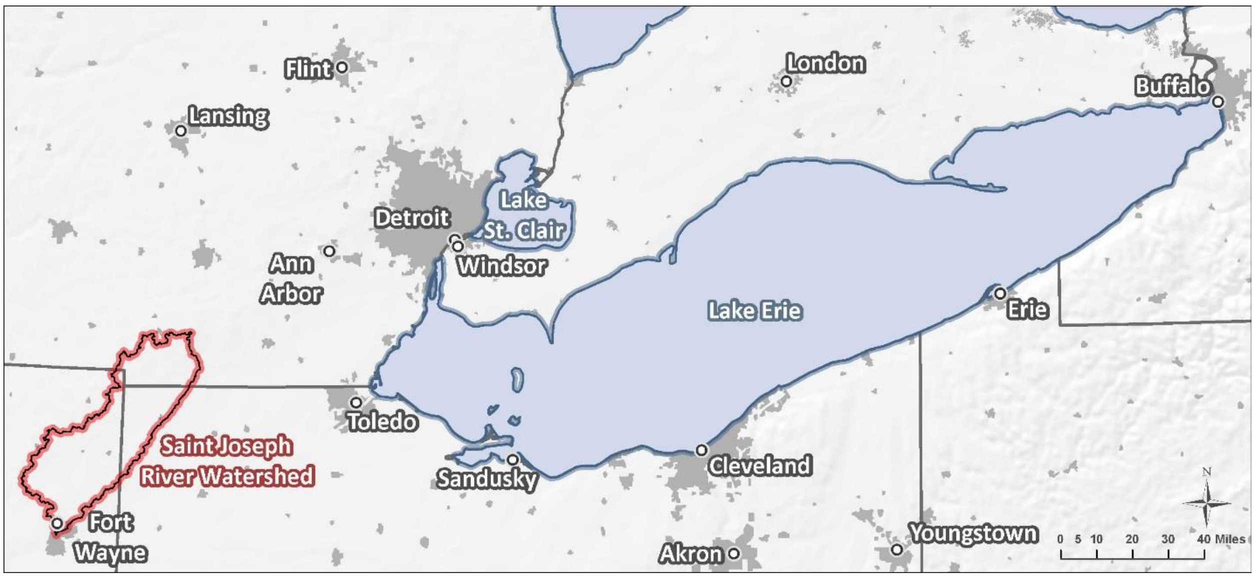


Figure 7. Lake Erie.

Lake Erie is commonly divided into three basins, which are described as follows (Lake Erie LaMP 2011):

- **Western Basin:** shallow with a mean depth of 24 feet and maximum depth of 62 feet
- **Central Basin:** average depth of 60 feet and maximum depth of 82 feet
- **Eastern Basin:** deep with an average depth of 80 feet and maximum depth of 210 feet

The water volume of the western basin is approximately one-fifth of Lake Erie (U.S.EPA 1995) but it drains about 65 percent of the Lake Erie watershed (Ohio EPA 2010c). The lake bottom of the western basin is covered with fine sediment and the western basin is turbid (Lake Erie LaMP 2011). Unlike the central and eastern basins, the western basin does not thermally stratify (Lake Erie LaMP 2011; Ohio EPA 2010c).

Ohio tributaries draining to the western basin (i.e., the Ottawa, Maumee, Toussaint, Portage, and Sandusky rivers) consist primarily of row-crop agriculture whereas tributaries draining to the central basin (i.e., the Huron, Vermillion, Black, Rocky Cuyahoga, Grand, and Ashtabula rivers) are about fairly evenly divided between row-crop agriculture, urban, and forest (Ohio EPA 2010c). The dominant land uses of the Ohio tributaries to Lake Erie is important because the majority of phosphorus loading to Lake

Erie is from "storm-pulsed runoff from the landscape into the tributaries that drain to Lake Erie" (Ohio EPA 2010c, p. 35). Ohio EPA (2013, p.5) has found that 61 percent of the total phosphorus load delivered to Lake Erie is from cultivated cropland. Causes of increased total phosphorus loading to Lake Erie from cropland are included in a summary of the sources of nutrient loading to Lake Erie that potentially cause harmful algal blooms (Smith et al. 2015).

The U.S. and Canadian governments have agreed to reduce phosphorus entering Lake Erie by 40 percent. By reaching the 40 percent targets, the two countries hope to minimize low oxygen "dead zones" in the central basin of Lake Erie, maintain healthy aquatic ecosystems, and keep algal blooms at levels that do not produce toxins that pose a threat to human or ecosystem health.

Additional characteristics of the Western Basin of Lake Erie with special focus upon nutrients, sediment, and other water quality issues is presented in the following documents:

- *Combined Coastal Management Program and Final Environmental Impact Statement for the State of Ohio* (Ohio Department of Natural Resources 2007)
- *Lake Erie Binational Nutrient Management Strategy: Protecting Lake Erie by Managing Phosphorus* (Lake Erie LaMP 2011)
- *Ohio Lake Erie Phosphorus Task Force Final Report* (Ohio EPA 2010c)
- *Ohio Lake Erie Phosphorus Task Force II Final Report* (Ohio EPA 2013)
- *Status of Nutrients in the Lake Erie Basin* (Lake Erie LaMP 2009)
- *The Great Lakes: An Environmental Atlas and Resource Book* (U.S. EPA 1995)

3.2 Previous Studies

IDEM, Michigan DEQ, Ohio EPA, SJRWI, Purdue University, and other entities have previously studied the SJRW. Section B-1 of Appendix B provides a summary of selected previous work. Additional studies regarding specific topics (e.g., SJRWI's conservation tillage study) are referenced throughout this report.

3.3 Project Setting

The SJRW (HUC 04100003) is in south central Michigan, northwest Ohio, and northeast Indiana. "Originating in Hillsdale County, Michigan, the SJR flows southwest through Williams and Defiance[c]ounties, Ohio, and DeKalb and Allen [c]ounties, in Indiana, to join with the St. Mary's River at Fort Wayne to form the Maumee River" (Ohio EPA 1994a, p. 10). The Tiffin River (HUC 04100006) watershed borders the SJRW to the east; the upper Maumee River watershed (HUC 04100005) to the southeast; the St. Mary's River watershed (HUC 04100004) to the south and the Eel River watershed (HUC 05120104; a tributary to the Wabash River) to the west. Another SJRW (HUC 04050001) that drains to Lake Michigan borders this SJRW (HUC 04100003) to the west and north. The Fort Wayne metropolitan area is within the southern end of the basin.

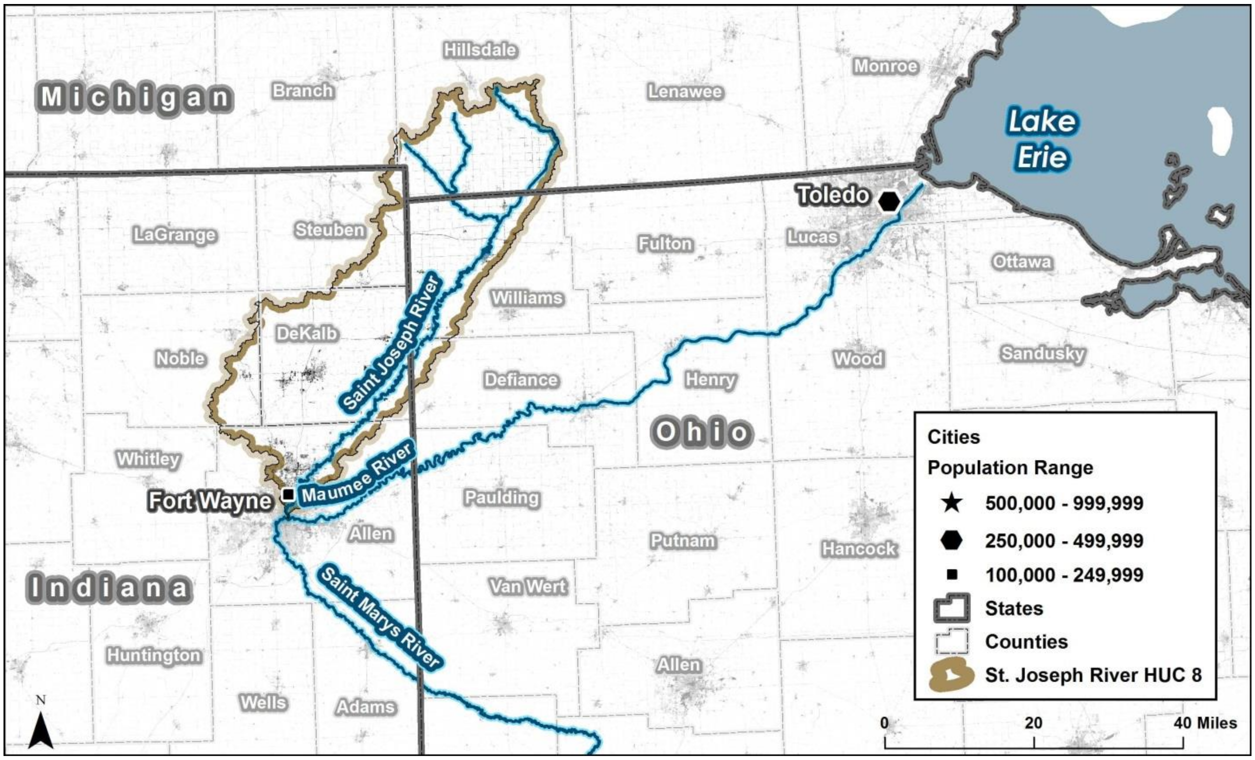


Figure 8. SJR in Lake Erie's Western Basin.

The SJRW drains about 1,085 square miles across eight counties[17] and the majority of the basin is in three counties (Hillsdale [MI], DeKalb [IN], and Williams [OH]). Fort Wayne, IN, is the largest city in the basin, followed by the cities of Auburn (IN), Garrett (IN) and the village of Montpelier (OH; Figure 9). The Ohio turnpike (Interstate 80/90) runs east-west through the northern portion of the SJRW; the major east-west U.S. routes in the watershed are U.S. routes 6 and 20. Interstate 69 runs north-south through the western portion of the watershed; the major north-south highway is U.S. route 27.

[17] The eight counties are Allen, DeKalb, Noble, and Steuben counties in Indiana; Branch and Hillsdale counties in Michigan; and Defiance and Williams counties in Ohio.

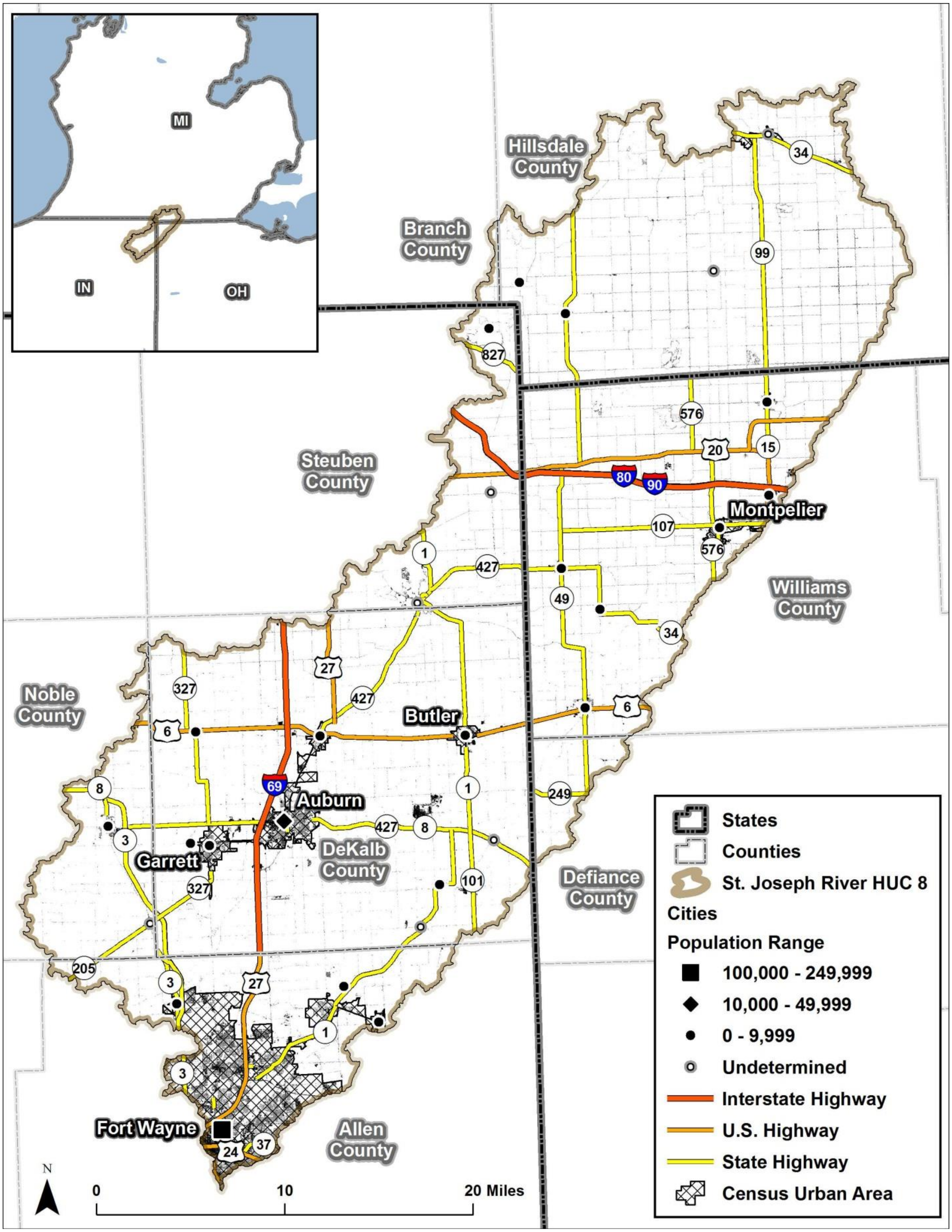


Figure 9. Major roads and population centers in the SJRW.

3.4 Land Use and Land Cover

The SJRW is primarily rural with little urban land outside of one large metropolitan area (Fort Wayne) and a few small municipalities (SJRWI 2008). Like other watersheds in northeast Indiana and northwest Ohio, the SJRW is dominated by agricultural land use, including both cultivated row crops and pastureland for livestock grazing (Table 5; Figure 10). Agricultural drain tiles are installed for row crop agriculture to drain the wetlands that existed prior to settlement (Quandt nd).

The land use is predominantly agricultural (69 percent) and includes deciduous forest (11 percent), woody wetland (7 percent), developed open space (6 percent), and developed land (5 percent). The remaining 3 percent (due to rounding) are small areas of other land uses (e.g., grasslands, open water). In 1992, about 57 percent of the land was in crop production, and 14 percent was enrolled in the Conservation Reserve Program (CRP; Ohio EPA 1994, p. 10). In addition to lands held in CRP, lands were also held in the Environmental Quality Incentives Program (EQIP) and the Wetland Reserve Program (WRP; SJRWI 2008). In addition to row crop agriculture, which is typically corn and soybeans with some grain or hay, agricultural lands are also used as pasture and for livestock production (Quandt nd, p. 24). A map of the 2013 Crop Data Layer from the USDA is presented in Figure B-1 of Appendix B.

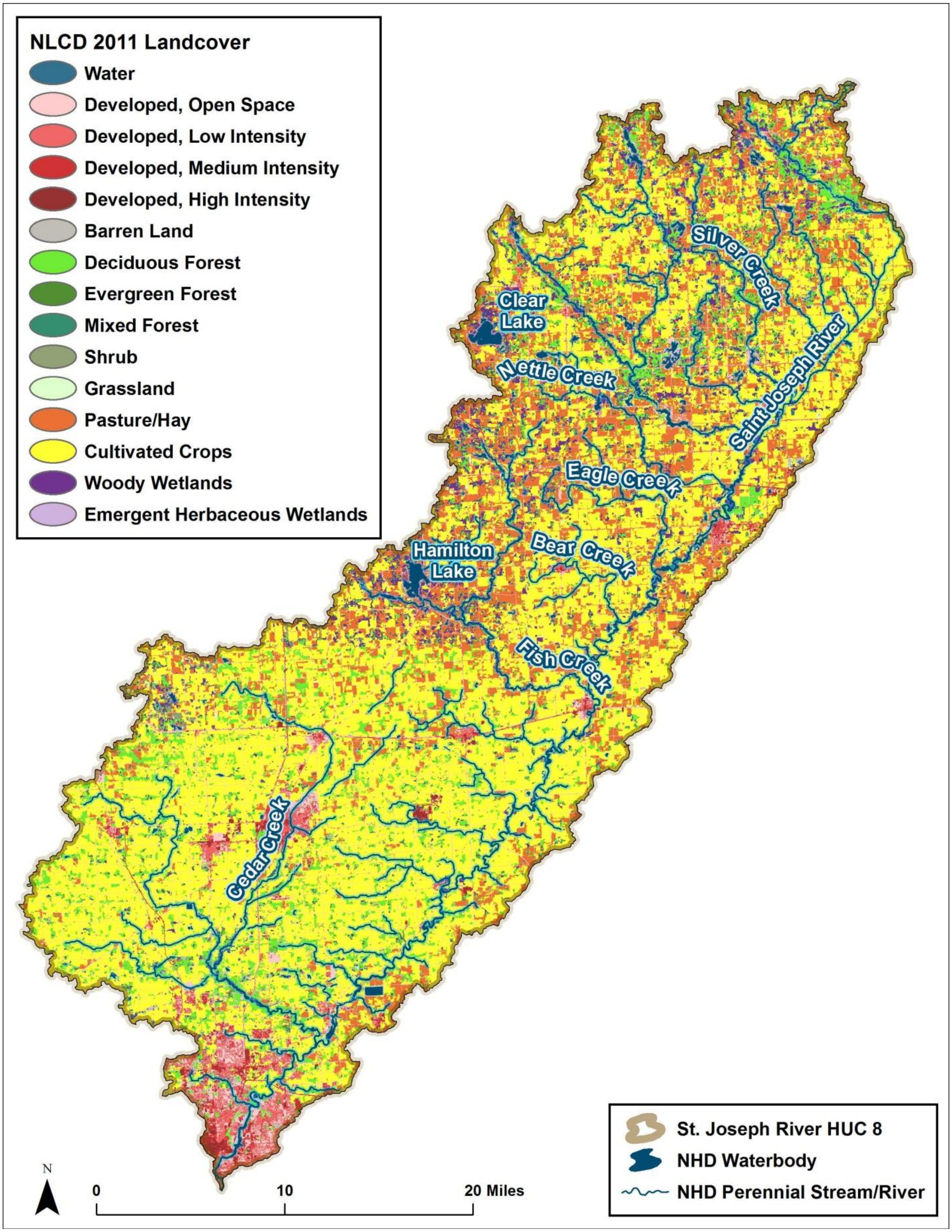
Agricultural drain tiles were installed in the SJRW to lower the water table for crop production and channels and ditches were installed to efficiently route water. Both practices significantly affect the hydrology of the region and affect the water quality of the streams due to rapid delivery of excess nutrients into the streams. Many parks, preserves, and reservations are operated by government or private entities, including three state-owned wildlife areas: Fish Creek Wildlife Area, Lake La Su An Wildlife Area, and Lost Nations State Game Park (SJRWI 2006). Several parks, a fairground, and fishing access are also protected (Ohio EPA 2015a, p. 14). These areas, which include wetlands and marshes, are protected from agricultural development.

Developed land in the project area also includes rural towns and a few urban cities. A map of impervious cover is presented in Figure B-2 in Appendix B. Both combined sewer systems and regulated Phase II municipal separate storm sewer systems (MS4s) are in the project area. Phase II MS4s serve populations of fewer than 100,000 and cover the portion of the MS4 located within the Urbanized Area, as defined by the U.S. Census or as designated by rules promulgated by IDEM, Michigan DEQ, or Ohio EPA. Combined sewer systems in the project area are discussed in Section 4.2.2.1 and regulated MS4s are discussed in Section 4.2.5.

Table 5. Land cover in the SJRW

Land cover class	Acres	Percent	Land cover class	Acres	Percent
Open Water	8,644	1%	Mixed forest	334	<½%
Developed, open space	40,810	6%	Shrub/scrub	3,751	1%
Developed, low intensity	22,621	3%	Grassland/herbaceous	2,612	<½%
Developed, medium intensity	7,712	1%	Pasture/hay	118,961	17%
Developed, high intensity	3,066	<½%	Cultivated crops	361,974	52%
Barren land	548	<½%	Woody wetlands	48,971	7%
Deciduous forest	76,503	11%	Emergent herbaceous wetlands	2,763	<½%
Evergreen forest	1,365	<½%			

Source: 2011 National Land Cover Dataset (Jin et al. 2013).
Acreages and percentages were rounded to the nearest integer.
A double dash ("--") indicates that a land cover was not present.



Source: 2011 National Land Cover Dataset (Jin et al. 2013).

Figure 10. Land cover in the SJRW.

3.5 Geology and Soils

The glacial advance and retreat of the Wisconsinian glaciation were highly influential in the topography, geology, and soils that developed in the region. In general, as glaciers advanced, existing rocks and soils were eroded repeatedly. These materials were re-deposited as sediments during several ice advance, melt, and retreat cycles. Such glacial materials were deposited as sands, gravels, silts, and clays; the melt water created large rivers, which carried and spread the deposited glacial materials throughout the region. Glacial deposits and associated land forms exerted a major effect that influences present day hydrology, soil types, and land cover.

The topography of the SJRW is rolling hills in the northern portion of the watershed, and nearly level plains in DeKalb and Allen counties in the southern portion of the watershed (SJRWI 2006). The surficial geology of the SJRW is described as

> "[D]istinguished by gently rolling glacial till plain with moraines, kames, and outwash plains. Local relief is usually less than 50 feet. Soils of the watershed reflect the glacial history, having been formed mainly in glacial till or glacial outwash." (Ohio EPA 1994a, p. 10)

3.5.1 Ecoregion Overview

The SJRW is in the Eastern Corn Belt Plains (ECBP) level III ecoregion #55 and the Southern Michigan/Northern Indiana Drift Plains (HELP) level III ecoregion #56 (Figure B-3 of Appendix B). The general physiography and geology and soils of the three corresponding level IV ecoregions are described in Table B-1 and Table B-2; Figure B-4 presents a map of the level IV ecoregions. Level IV ecoregions are at the finest ecoregional scale and are used to evaluate very localized characteristics.

3.5.2 Geology

The bedrock underling much of the SJRW is shale or black shale that was deposited during the Devonian or Mississippian ages from 300 million to 360 million years ago (Quandt 2015, p. 8). While most of the SJRW is underlain by shale, the Fort Wayne area is underlain by limestone and portions of tributaries' headwaters are underlain by sandstone (Figure B-5 in Appendix B). Quandt (2015, p. 8) also describes the unconsolidated deposits of the surficial geology as "glaciofluvial material" composed of sand and gravel or loamy till that overlies deeper clay deposits. Sediment can be more than 200 feet thick when overlying bedrock in northeast Indiana and southeast Michigan (Myers et al. 2000, p. 6).

3.5.3 Soils

The National Cooperative Soil Survey publishes soil surveys for each county in the United States. Soil surveys contain predictions of soil behavior and also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the effect of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning.

Soil surveys contain predictions of soil behavior and provide data related to different soil types, including the hydrologic soil groups (HSGs). HSG refers to the grouping of soils according to their runoff potential. Soil properties that influence HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. There are four HSGs: Groups A, B, C, and D; descriptions of the HSGs are in Table B-3 of Appendix B.

"Soils in the watershed were formed from compacted glacial till" (SJRWI 2006, p. 9). Soils in the SJRW are "moderately to somewhat poorly drained […] with moderate runoff potential" (Myers et al. 2000, p. 1). Using the soil surveys for each county in GIS, the HSGs were analyzed in GIS. Soils in the SJRW are typically D, C, and C/D (Figure 10; Table B-4) with a shallow groundwater table. Due to extensive agricultural drain tiling, much of the A/D, B/D, and C/D soils will act as A, B, or C soils, respectively.

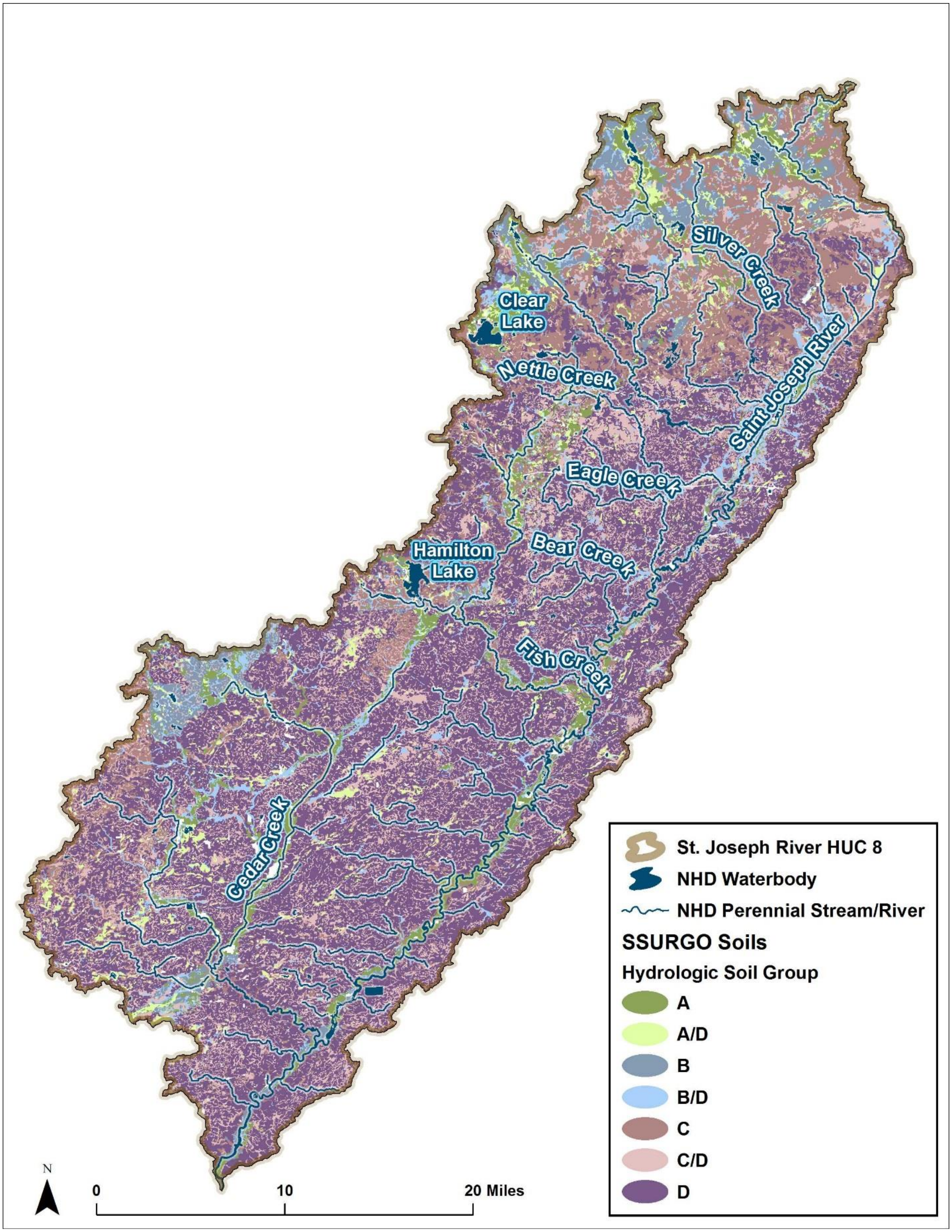


Figure 11. Hydrologic soil groups in the SJRW.

3.6 Climate

The climate of the SJRW is described as "temperate with warm summers and cold winters" (Quandt nd, p. 16). As part of the Great Lakes Region, the climate in the SJRW is determined primarily by westerly atmospheric circulation, the latitude, and the local modifying influence of nearby Lake Erie (Derecki 1976). Climate in the Great Lakes basin is further described as follows (U.S. EPA 1995, Chapter 2, Section 2)

> The weather in the Great Lakes basin is affected by three factors: air masses from other regions, the location of the basin within a large continental landmass, and the moderating influence of the lakes themselves. The prevailing movement of air is from the west. The characteristically changeable weather of the region is the result of alternating flows of warm, humid air from the Gulf of Mexico and cold, dry air from the Arctic.

These factors tend to increase humidity and can create lake effect precipitation during the cold fall and winter months. Despite that, the proximity to Lake Erie also moderates the local climate as the large waterbody acts as a heat sink or source, warming the air in cold months and cooling the air in the summer. "The average length of the growing season is about 156 days" (SJRWI 2008, p. 25).

Weather data from four gages were obtained from the Western Reserve Climate Center (WRCC 2014): Angola, IN (station 120200; 1893-2014), Fort Wayne, IN (station 14827; 1942-2014), Hillsdale, MI (station 203823; 1891-2014), and Montpelier, OH (station 335438; 1893-2014). Winter monthly average low temperatures across the four sites ranged from 15 to 22 degrees Fahrenheit while summer monthly average high temperatures ranged from 79 to 85 degrees Fahrenheit. Precipitation at the three sites ranged from 35 to 37 inches per year with 30 to 44 inches as snowfall. The data for Fort Wayne are summarized in Figure 12; similar figures for Angola, Hillsdale, and Montpelier are in Appendix B.

Examination of precipitation patterns is a key part of watershed characterization. In particular, rainfall intensity and timing affect watershed response to precipitation. This information is important in evaluating the effects of stormwater on the tributaries. Figure 13 presents one method to assess rainfall intensity; similar figures for Angola, Hillsdale, and Montpelier are presented in Appendix B. The WRCC data show that 34 to 45 percent of the precipitation events per year are less than 0.1 inches and that 5 to 7 percent are greater than 1 inch.

Table 6. Climate data summary for Fort Wayne, Indiana (station 14827)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Temperature	31.9	35.3	46.7	60.2	71.4	80.8	84.3	82.3	75.7	63.8	48.9	36.1
Low Temperature	17.0	19.4	28.5	38.8	49.2	59.2	62.8	60.8	52.9	42.1	32.5	22.0
Precipitation	2.3	2.1	2.9	3.6	4.0	4.0	3.9	3.5	2.8	2.7	2.8	2.5
Snowfall	9.0	7.4	4.8	1.2	0.0	0.0	0.0	0.0	0.0	0.2	2.6	7.4

Source: WRCC 2014.
Notes
Summary of data collected at Fort Wayne, IN National Climactic Data Center station 14827 from January 1, 1942 through October 23, 2014.
a. All four parameters are monthly averages. High and low temperatures are in degrees Fahrenheit. Average precipitation is in inches water equivalent. Average snowfall is in inches of snow.

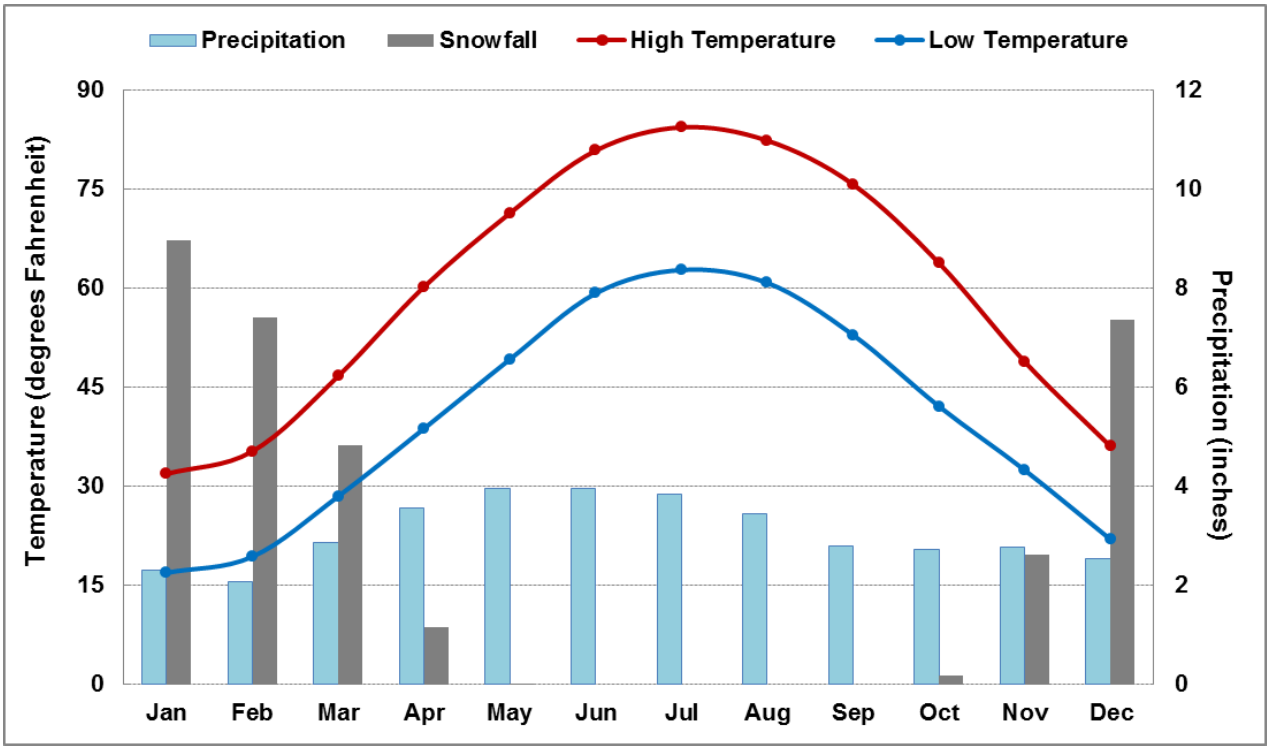


Figure 12. Temperature and precipitation summary at Fort Wayne, IN (station 14827).

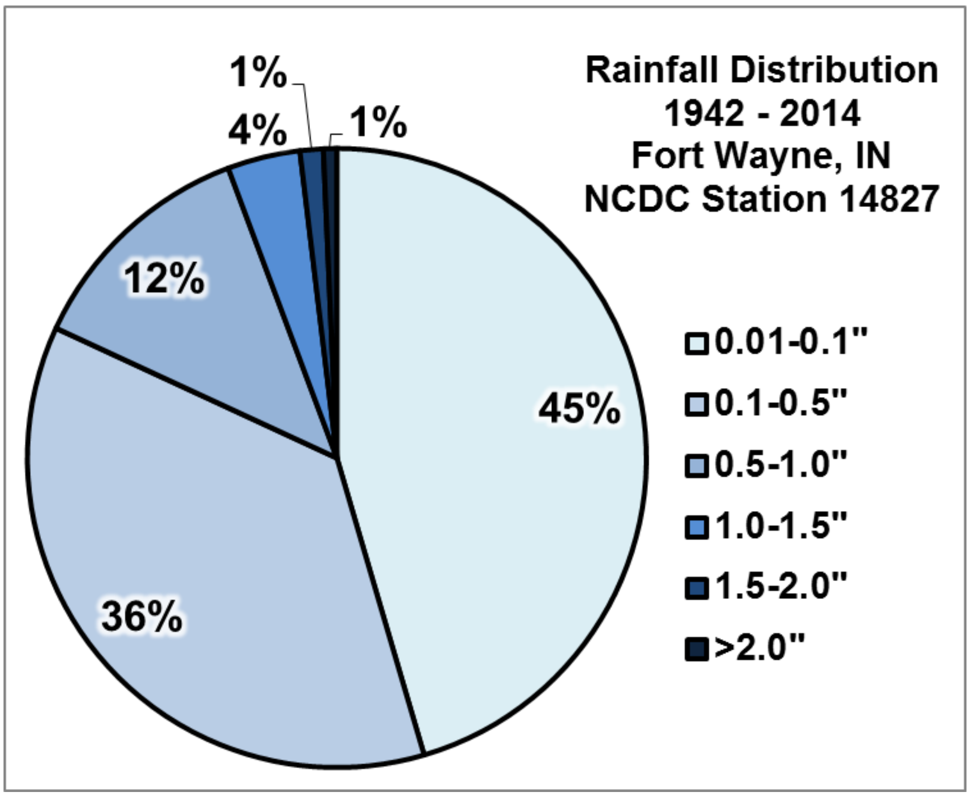


Figure 13. Precipitation intensity at Fort Wayne, IN (station 14827).

3.7 Hydrology

Hydrology plays an important role in evaluating water quality. In the project area, hydrology is primarily driven by local climate conditions. This includes situations that often result in flashy flows, where the stream responds to and recovers from precipitation events relatively quickly. Flashy flows are prominent in the East and West Branches of the St. Joseph River in Michigan (Michigan DEQ 2005). Flow regime alterations due to anthropogenic activities not only affect aquatic life but also affect humans.

"The present-day river is a wide and relatively slow-flowing stream with an average slope of 1.6 feet per mile, following the Fort Wayne moraine" (SJRWI 2006, p. 6). In Michigan, the average gradients of the East and West forks of the West Branch of the St. Joseph River are 5.5 and 7.0 feet per mile (respectively), while the average gradients in the tributaries to the East Branch range from 5 to 11 feet per mile (Michigan DEQ 2005). Generally, the headwaters tributaries in the SJRW have slopes of about 10 feet per mile (Myers et al. 2000, p. 6).

The SJR is impounded in Leo-Cedarville, at the Cedarville Dam, to create the Cedarville Reservoir (SJRWI 2008). The river is also impounded by the St. Joseph Dam in Fort Wayne near the intersection of Coliseum and North Anthony boulevards. Water withdrawn at the St. Joseph Dam is piped to Fort Wayne's Three Rivers Filtration Plant. Besides the reservoirs, small ponds to large lakes are present throughout the SJRW. SJRWI (2006, p. 10) identified 17 "sizeable inland lakes," including Cedarville Reservoir (IN), Clear Lake (IN), Hurshtown Reservoir (IN), Nettle Lake (OH), and Seneca Lake (OH)[18]. Cedarville and Hurshtown reservoirs are owned by Fort Wayne. Ohio EPA (2015, p. 40-47) discusses Ohio's inland lake monitoring, lake uses, and habitat for Barton, McKarns, and Nettle lakes.

Water is withdrawn for agricultural operations, community water systems, and NPDES permittees for industrial use. Much of the SJRW relies on groundwater for public water supply; groundwater is also used for some agricultural and industrial operations. The northeast portion of the SJRW is underlain by the Michindoh aquifer. The entire population in the middle St. Joseph River area (i.e., the *Sol Shank Ditch-St. Joseph River* HU; HUC 04100003 05) uses the Michindoh aquifer for potable water (Rice 2005), including Butler, IN, and Edgerton, OH. In Michigan, groundwater is the source of water for the community water systems and NPDES permittees in the SJRW[19]. Except for one surface water withdrawal, the Winwood Hollow Golf Course[20], all the withdrawals in Ohio are from groundwater. Indiana Department of Natural Resources (IDNR) data indicate that 142 water withdrawals are in the Indiana-portion of the SJRW (IDNR 2015a,b; Figure C-7 in Appendix C). Of these 142 withdrawals, 25 withdrawals are from surface waters, but only 8 withdrawals are from streams and rivers. The Three Rivers Filtration Plant (i.e., Fort Wayne public water supply) withdrawals from the lower SJR are the largest withdrawals (128 cfs capacity); the other seven withdrawals are considerably smaller.[21] Three Rivers Filtration Plant daily withdrawal data indicate that the WTP typically withdraws 50 cfs from the St. Joseph River (Fort Wayne 2015).

Anthropogenic activities that alter the natural flow regime in the SJRW are not limited to reservoir construction and urbanization. Hydrology is also affected by the conversion of forest land to agricultural land and the installation of subsurface tiles to improve drainage. That practice is generally referred to as *field tiling* and involves subsurface drains (e.g., corrugated plastic tile or pipe) installed below the surface that serve as conduits to collect or convey drainage water, either to a stream channel or to a surface field

[18] Refer to SJRWI (2006, p.10) for a table of lakes, locations, drainage areas, surface areas, and depths.
[19] In Michigan, agricultural water use data are confidential and cannot be disclosed to the public
[20] From 2005 through 2013, withdrawals at the Winwood Hollow Golf Course ranged from 40,000 gallons per year to 11,670,000 gallons per year (average: 3,260,000 gallons per year), excluding the years 2007 and 2010 when no surface water was withdrawn.
[21] The Willow Ridge Golf Club has withdrawal capacities of 0.4 cfs, 1.2 cfs, and 1.2 cfs from Willow Creek; Rainmaker Farms has a withdrawal capacity of 1.0 cfs from the St. Joseph River, and two private individuals have withdrawal capacities of 0.2 cfs from Yoho Branch of Sol Shank Ditch and 1.2 cfs from the St. Joseph River.

drainage ditch. While the drainage improvements increase the amount of land available for cultivation, they also influence the hydrology, aquatic habitat, and water quality of area streams. SJRWI (2006) identified many streams in the SJRW that were "channelized and straightened to improve the flow of water downstream."

The U.S. Geological Survey (USGS) maintains flow gages at several locations on the SJR (Table 7) and its tributaries (Table 8); the locations of the gages are shown on Figure 14. USGS also operates a continuously recording gage on the Maumee River below the confluences of the St. Joseph and St. Mary's rivers that form the Maumee River: Maumee River at Coliseum Boulevard at Fort Wayne, IN (gage 04182950). USGS also reports peak flow and instantaneous flow (see Table B-8 in Appendix B) at numerous additional locations throughout the watershed. Average daily mean flow data per day for the two active USGS gages from water years (WYs) 1994 through 2013 are presented in Figure B-13 and flow duration curves are presented in Figure B-14.

Table 7. USGS continuously recording stream gages on the SJR

Gage ID	Location	Area (mi.^{2})	Period of record (water years)
04177500	St Joseph River near Blakeslee OH	394	1926 - 1932
04178000	St. Joseph River near Newville, IN	610	1946 - present
04178500	St. Joseph River at Hursh, IN	734	1951 - 1953
04179000	St. Joseph River at Cedarville, IN	763	1900 1931 - 1932 1955 - 1982
04180500	St. Joseph River near Fort Wayne, IN	1,060	1941 - 1955 1984 - present

Notes
Gages are listed from top to bottom from headwaters to mouth.
The period of record for daily mean flows is displayed, and the data are provisional for water years 2014 and 2015.

Table 8. USGS continuously recording stream gages on tributaries of the SJR

Gage ID	Location	Area (mi.^{2})	Period of record (water years)
04177720	Fish Creek at Hamilton, IN	37.5	1970 - present
04177810	Fish Creek near Artic, IN	98	1988 - 2007
04179500	Cedar Creek at Auburn, IN	87.3	1944 - 1973
04180000	Cedar Creek near Cedarville, IN	270	1947 - present

Notes
Gages are listed from top to bottom numerically by gage ID.
The period of record for daily mean flows is displayed, and the data are provisional for water years 2014 and 2015.

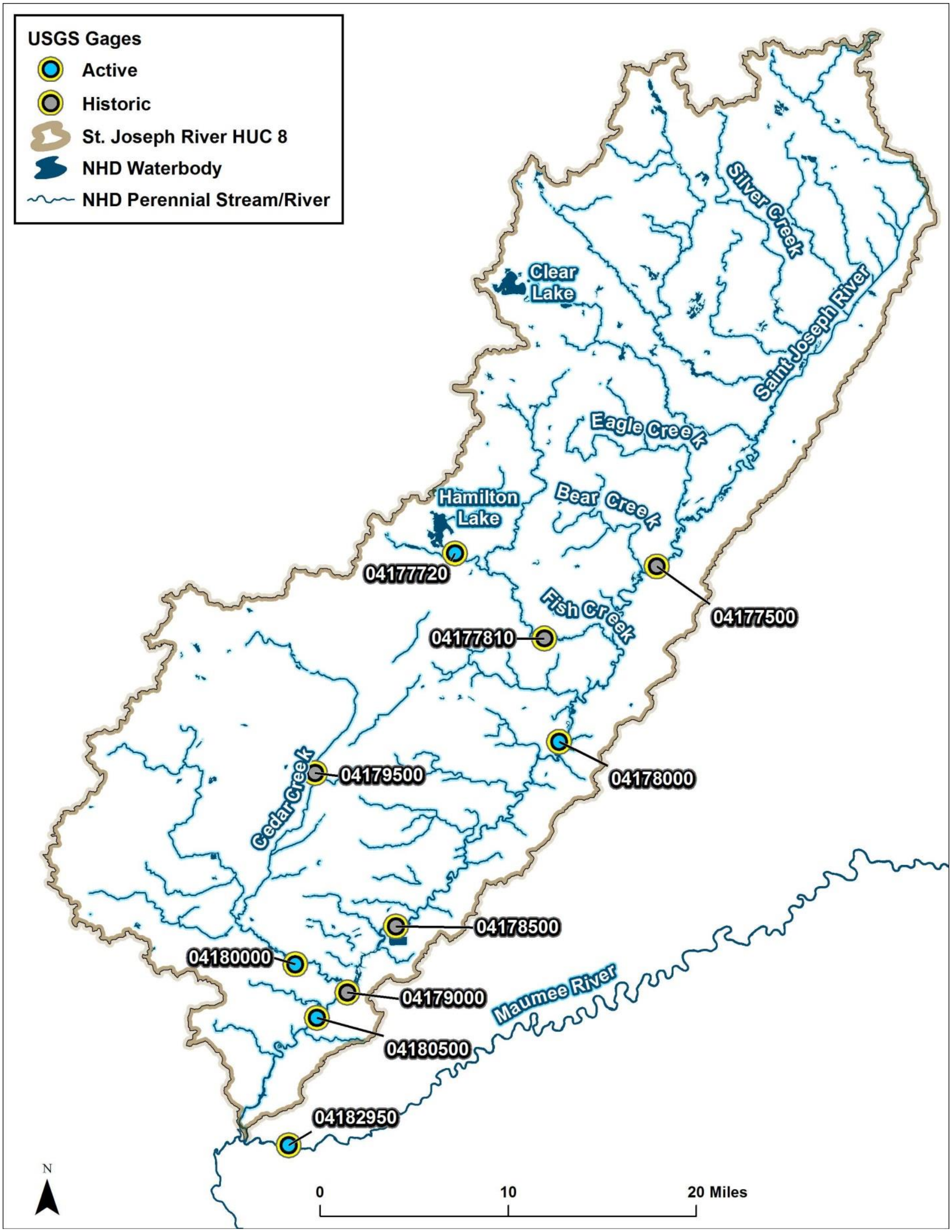


Figure 14. Continuously-recording streamflow USGS gages in the SJRW.

3.8 Community Profile

The SJRW spans three states and is predominantly rural. The southern portion of the watershed is within the Fort Wayne, IN metropolitan area. Most of the basin's population is clustered in the Fort Wayne metropolitan area and small rural cities (e.g., Auburn, IN and Montpelier, OH); refer back to Figure 9 for a map that shows the largest cities in the watershed. Most of the land area of the basin has low population densities.

Population trends from 2000 to 2010 varied by county and municipality. Allen, DeKalb, Noble, and Steuben counties in Indiana increased in population, while Defiance and Williams counties in Ohio decreased in population (Table B-9 in Appendix B). Branch County in Michigan slightly increased in population and Hillsdale County slightly decreased. Most of the relatively significant population changes in the municipalities were due to a few dozen to a few hundred people because most municipalities have populations of less than 2,000 people. Fort Wayne saw an increase of nearly 48,000 people that includes increased development in the metropolitan area in the SJRW and also includes some people in Fort Wayne outside of this watershed. Urbanization is spreading north from Fort Wayne and along the transportation corridors in DeKalb and Steuben counties" (SJRWI 2006, p. 7).

While this project does not explicitly address public drinking water supply designated uses or groundwater quality (as related to potable water usage), watershed stakeholders are concerned with the quality of surface- and groundwater (SJRWI 2006, 2008; Quandt nd, 2015). The SJR is a public "drinking water supply for 250,000 people in Fort Wayne and New Haven" and the "Fort Wayne Three Rivers Filtration Plant processes 34 million gallons" of water per day (SJRWI 2006, p. 10). Raw water withdrawn from the SJR is stored in two reservoirs in the Bear Creek subwatershed: Cedarville and Hurshtown reservoirs[22]. Adjacent areas "are served by private wells or water companies that extract water from wells" (SJRWI 2008, p. 15). Nineteen public water systems in Ohio use wells to withdraw groundwater (Ohio EPA 2015a, p. 15). About 14.9 mgd of groundwater is withdrawn daily in the SJRW for a variety of uses (e.g., drinking water, industrial, agricultural) (Quandt 2015, p. 26). TMDLs were not developed to address public drinking water uses; however, the water quality improvement strategy and TMDL implementation framework discussed in Section 7.3.2 will also help the SJRWI and stakeholders address issues related to surface- and groundwater used for potable water.

[22] Cedarville and Hurshtown reservoirs have surface areas of 408 acres and 265 acres (respectively and maximum depths of 22 feet and 35 feet (respectively). The reservoirs have a combined storage of one billion gallons (SJRWI 2006, p. 10).

3.9 Species of Concern

The SJRW is home to abundant aquatic life that includes endangered and threatened riverine species. Multiple organizations survey aquatic life in the project area. For example, The Nature Conservancy operates the upper SJRW project that has identified 43 species of fish and 31 species of mussels in Fish Creek (SJRWI 2006).

Three freshwater bivalve mussel species are listed as endangered on the U.S. FWS Endangered Species List (Table 9). "Fish Creek supports the last known population of the white cat's paw pearly mussel in the world" (SJRWI 2006, p. 15). Additional freshwater mussel species that are listed by the states as endangered or of special concern are the kidneyshell (*Ptychobranchus fasciolaris)* and purple lilliput (*Toxolasma lividus*) mussels (Table 9). SJRWI (2006) also presents the results of other studies that identified diverse species of freshwater mussels in the SJR and Cedar Creek.

Table 9. Endangered mussel species in the SJRW

Freshwater bivalve mussel species		List of species			
Common name	**Scientific name**	**Federal**	**Indiana**	**Michigan**	**Ohio**
clubshell	*Pleurobema clava*	E	E	E	E
kidneyshell	*Ptychobranchus fasciolaris*	--	SC	SC	SC
northern rifleshell	*Epioblasma torulosa*	E	--	E	E
purple lilliput	*Toxolasma lividus*	--	--	E	E
rabbitsfoot	*Quadrula cylindrical*	T	E	--	E
rayed bean shell	*Villosa fabalis*	--	SC	E	E
round hickory nut	*Obovaria subrotunda*	--	SC	--	--
white cats paw pearly	*Epioblasma obliquata*	E	E	E	E
wavyrayed lampmussel	*Lampsilis fasciola*	--	SC	T	SC

Sources: Michigan DEQ 2015c; ODNR 2014; Ohio EPA 1994, p. 9; SJRWI 2006, p. 16; SJRWI 2008, p. 55.
Note: E = endangered; SC = special concern, T = threatened.

Two snake species that reside in wetlands and floodplain habitats are the copperbelly water snake (*Nerodia erythrogaster*) and eastern massasauga (*Sistrurus c. catenatus*; Quandt nd); both of these species are endangered in Ohio, the eastern massasauga is endangered in Indiana, and the eastern massasauga is also considered as a special concern species in Michigan. The copperbelly water snake is federally threatened (ODNR 2014). The copperbelly water snake was identified in the East Fork of the West Branch of the St. Joseph River (SJRWI 2006, p. 61).

Quandt (nd) and SJRWI 2006, 2008) present additional plant and animal species that are threatened or endangered according to the U.S. FWS or are species that are of concern, of interest, threatened, potentially threatened, or endangered according to the state governments. Some of these species may live in or otherwise use stream or stream-adjacent habitat. For example, the snail campeloma (*Campeloma decisum*) is a species of concern in Indiana that was identified in the SJR (SJRWI 2008, p. 55) and bald eagles (*Halliaeetus leucocephalus*) and are considered as a special concern species in Michigan.

4 Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. These analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody (U.S. EPA 1999). Source assessment methods vary widely with respect to their applicability, ease of use, and acceptability. The purpose of this section is to identify possible sources of the pollutants of concern in the TMDL project area.

To facilitate the source assessment, sources of impairment are evaluated at the subwatershed-level. Using subwatersheds creates an opportunity for watershed managers to relate source information to water quality monitoring results and sets the stage for the TMDL linkage analysis. The ability to summarize information at different spatial scales strengthens the overall TMDL development process and enables more effective targeting of implementation efforts.

The first section below presents the pollutants of concern that cause impairments in the SJRW. The next two sections provide general information regarding point sources and nonpoint sources throughout the SJRW. The chapter continues with presentations of two methods for assessing sources: the SWAT model and load duration curves (LDCs). The impaired subwatersheds are evaluated individually in Section 5 and 6, which include SWAT model results and LDC analyses.

4.1 Pollutants of Concern

Pollutants of concern discussed in this source assessment are *E. coli* bacteria, phosphorus (as total phosphorus), and TSS (a surrogate for sedimentation/siltation). These pollutants can originate from an array of sources including point sources (e.g., WWTPs) and nonpoint sources (e.g. failing HSTS).

4.1.1 Bacteria

Microorganisms are ubiquitous across the world and while most are not harmful to humans, pathogens (i.e., disease causing microorganisms) are a small subset of microorganisms that can cause sickness or death when taken into the body (U.S. EPA 2001). Certain bacteria typically indicate the presence of pathogens. *E. coli* is an indicator of pathogenic bacteria and Indiana, Michigan, and Ohio have established numeric criteria for *E. coli* based upon designated RUs.

Typical point sources of pathogenic bacteria include WWTPs and CSOs (U.S. EPA 2001). Sewage that is not sufficiently treated or that bypasses wastewater treatment (e.g., CSOs) may result in elevated levels of in-stream pathogens when discharged to a surface waterbody. “Other point sources that can contribute substantial loads of pathogens and fecal indicators to waterbodies include concentrated animal feeding operations, slaughterhouses and meat processing facilities; tanning, textile, and pulp and paper factories; and fish and shellfish processing facilities” (U.S. EPA 2001, p. 2-6). Regulated stormwater may transport animal excrement deposited by pets or wildlife to nearby streams via storm sewer infrastructure following precipitation events that result in stormwater runoff. Point sources in the SJRW include WWTPs, CSOs, SSOs, CAFOs, pets and wildlife via regulated stormwater, and illicit sanitary connections to storm sewers.

Nonpoint sources of pathogens can be residential (e.g., HSTS, pets), agricultural (e.g., livestock, manure application to crops fields), and natural (e.g., wildlife). HSTS that are not functioning properly may discharge untreated sewage to downstream waterbodies. Pet excrement deposited in residential areas, wildlife excrement deposited in rural areas, livestock excrement deposited on pastures and barnyards, and manure or septage applied to crop fields or stored improperly may be transported to streams after precipitation events that result in stormwater runoff. Nonpoint sources that may discharge *E. coli* in the

SJRW include failing HSTS, non-CAFO livestock operations, wildlife, pets, and crop management (land application of WWTP sludge, septage, or manure).

Both point and nonpoint sources of pathogens can re-enter the water column through re-suspension of sediments when pathogens are attached to those sediments. Runoff will increase the velocity of water in a stream, which may yield sufficient power to scour the bottom of the stream.

Regardless of the source, once pathogens enter surface waterbodies, in-stream pathogen levels decrease over time. The die-off is controlled by factors including: sunlight, temperature, moisture conditions, and salinity (U.S. EPA 2001, p. 2-7). In-stream pathogen levels are dependent upon the die-off rate and the time and distance from the source to the waterbody of interest.

4.1.2 Nutrients

This section presents discussions of the nutrient phosphorus and concludes with a discussion of limiting nutrients.

4.1.2.1 Phosphorus

At some level, phosphorus is necessary in a waterbody to sustain aquatic life. The natural amount of phosphorus in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no phosphorus, whereas a lowland, mature stream flowing through wetland areas might have naturally high concentrations. As previously mentioned, phosphorus can be released into the environment through different anthropogenic sources including septic systems, WWTPs, fertilizer application, and livestock operations. Once released into the environment, phosphorus generally attaches to soil particles and organic matter and is transported with eroded sediments (U.S. EPA 1999).

Phosphorus, like other nutrients, rarely approaches concentrations in the ambient environment that negatively affect aquatic life; in fact, nutrients are essential in minute amounts for properly functioning, healthy, aquatic ecosystems. However, nutrient concentrations in excess of those minute needs can exert negative effects on the aquatic ecosystem by increasing algal and aquatic plant life production (Sharpley et al. 1994). Increased plant production increases turbidity, decreases average dissolved oxygen concentrations, and increases fluctuations in diurnal dissolved oxygen and pH levels. Such changes shift aquatic species composition away from functional assemblages (composed of intolerant species, benthic insectivores, and top carnivores that are typical of high-quality streams) toward less desirable assemblages of tolerant species, generalists, omnivores, and detritivores that are typical of degraded streams (Ohio EPA 1999). Such a shift in community structure lowers the diversity of the system.

In its evaluation of biological data for reference (i.e., least-affected) streams, Ohio EPA found that IBI and ICI scores do not meet the WWH biocriteria when associated with higher levels of total phosphorus, (Ohio EPA 1999, p. 26). Ohio EPA further concludes that "[t]he processing of nutrients in lotic ecosystems[23] is complex, variable, and affected by abiotic factors such as flow, gradient, ground water quality and quantity, and channel morphology" (Ohio EPA 1999, p.10). In the HELP ecoregion, Ohio EPA (1999, p. 27) finds that low gradient headwaters and wading streams (similar to those in the project area) had higher total phosphorus concentrations than higher gradient streams. An in-depth summary of the effects of nutrients on aquatic life and the interrelationships of water quality, habitat, and biota are presented in the *Associations* document (Ohio EPA 1999).

Typical sources of total phosphorus are human and animal waste, fertilizer application to agricultural crops and urban lawns/gardens, erosion in stream channels, wetlands, and re-suspension of phosphorus bound to sediment from an upstream source. In an analysis of total phosphorus export coefficients from

[23] Lotic refers to flowing water; thus, a lotic ecosystem consists of the biological communities and non-living components of a stream or river.

various studies, Lin (2004) found that feedlots and manure storage yield the largest unit area loads and forestland yields the smallest loads. The ranked land uses are as follows (Lin 2004, Tables 1 and 3):

- Feed lots and manure storage (largest total phosphorus export coefficients)
- Residential
- Industrial
- Row crop agriculture
- Non-row crop agriculture, pasture, and mixed agriculture
- Idle land
- Forest (smallest total phosphorus export coefficients)

It is expected that the results of Lin (2004) would be consistent with the SJRW, which is largely a rural, agricultural watershed. As discussed later in this chapter, there are few large animal operations in the basin and industrial and municipal point sources are limited to a few cities and larger villages. Agricultural activities are expected to contribute the largest relative total phosphorus loads throughout the SJRW, except in subwatersheds with cities and un-sewered towns.

4.1.2.2 Limiting Nutrient

TP is the surrogate pollutant used to represent Indiana's nutrient and IBC listings (IDEM 2014c) and Ohio's nutrient impairments in the SJRW. In addition to phosphorus species, nitrogen species are also important nutrients that can cause impairment to aquatic life. Since IDEM uses TP as a surrogate pollutant for TMDLs to address nutrient impairments and Ohio EPA uses a limiting nutrient analysis (phosphorus is the limiting nutrient in the SJRW), nitrogen species are not discussed in this report. However, many of the sources of nitrogen are also sources of phosphorus (e.g., crop management, livestock operations, WWTPs, HSTS); thus, some of the implementation strategies employed by the SJRW nutrient TMDLs will also address some of the sources of nitrogen. For discussions of phosphorus and nitrogen species and nutrient impairments, refer to Camargo et al. (2005), Eby (2004), Ohio EPA (1999), Spiro and Stigliani (2003), U.S. EPA (1999, 2000).

Ohio EPA uses limiting nutrient analyses to determine whether nitrogen or phosphorus TMDLs should be developed (e.g., Ohio EPA 2012c). In such analyses, the molar concentrations of phosphorus and nitrogen species are compared and different ranges of the ratio of phosphorus species to nitrogen species indicate the limiting nutrient.

Ohio EPA prefers to use a ratio of TP to total nitrogen (TN), although in some cases Ohio EPA has used a ratio of total inorganic nitrogen to total phosphorus (Ohio EPA 2012c) due to the lack of total Kjeldahl nitrogen data to calculate TN. Ratios of other nutrient species have been used elsewhere; for example, nitrate to phosphate (Schanz and Juon 1983) and dissolved inorganic nitrogen to soluble reactive phosphorus (Stelzer and Lamberti 2001).

Ohio EPA uses a threshold ratio of 16:1, which is the Redfield ratio, to determine which nutrient is limiting. Ratios less than 16:1 indicate nitrogen-limitation while ratios greater than 16:1 indicate phosphorus-limitation. The threshold ratio varies considerably throughout the literature:

- Bioassays using periphyton from the River Rhine, found that algal growth in the bioassays was limited by nitrogen at nitrate:phosphate ratios of less than 10:1 and by phosphorus at ratios greater than 20:1 (Schanz and Juon 1983).

- Nutrient amendment experiments in New Zealand gravel bed streams found that nitrogen-limitation and co-limitation occurred over wide ranges of ratios and that phosphorus-limitation occurred around a ratio of 30:1 (Francoeur et al. 1999).
- Stelzer and Lamberti (2001) found that bio-volume was not affected by the ratio of dissolved inorganic nitrogen to soluble reactive phosphorus and that predicting nutrient limitation from stream water has limitations.
- A review of 382 nutrient enrichment experiments showed that the ratio of nitrogen to phosphorus was good at predicting whether or not nitrogen was the limiting nutrient but that predictions were uncertain between ratios of 1:1 and 100:1 (Keck and Lepori 2012).

All of the paired TP and TN concentrations from samples collected along an impaired stream were evaluated with the 16:1 ratio. Ohio EPA decided that when all or most of the ratios of TP:TN for an impaired stream were greater than the 16:1 ratio, a stream was assumed to be phosphorus-limited or co-limited and that a TP TMDL should then be developed. Most of the samples from Ohio's impaired WAUs in the SJRW watershed exhibited ratios greater than 16:1. Thus, TP was selected as the surrogate pollutant for TMDL development for Ohio's TMDLs.

4.1.3 Sedimentation/Siltation

Sedimentation and siltation are controlled by stream hydrology, channel condition, riparian areas, and watershed land use. Impairment occurs when external inputs (e.g., sediment, runoff volume) to the stream become excessive, or when stream characteristics are altered so that the stream can no longer assimilate these stresses, or a combination of both.

Streams with high flows can result in channel scour and erosion of the stream channel. Those steams are also able to transport larger sediment particles further distances. Streams that are dominated by lower flow conditions will deposit sediment and associated pollutants resulting in poor quality habitat and loss of spawning beds. In addition, low flowing streams will have lower dissolved oxygen levels. A stream's assimilative capacity for pollutant loads from the watershed will depend on its ability to balance all those factors.

Hydrology is a major driver for both upland and stream channel erosion and agricultural activities can also alter the hydrologic regime, channel condition, and riparian areas. Agricultural activities such as livestock grazing and the plowing or tilling of crop fields result in de-vegetated, exposed soil that is susceptible to erosion (U.S. EPA 2012a). "Conventional tillage associated with row crop farming results in an accelerated loss of soil from fields, and as a consequence, sedimentation of stream channels" (Myers et al. p. 2). Drain tiles may also increase channel erosion since runoff that travels through tiles has increased peak flows and velocities, both of which increase erosion. Runoff transported by tiles may have higher concentrations of suspended sediment, which may then be deposited (i.e., settle) in the streams or ditches, and thus contribute to sedimentation and habitat issues.

As much of the SJRW is rural and agricultural, urbanization impacts hydrology in only isolated locations. Urban streams tend to drain impervious surfaces that alter the hydrologic regime (e.g., higher magnitude flows, more frequent high flows), which then increases the erosion of the streambed and banks and increases re-suspension of bed sediment (U.S. EPA 2012a). For additional information regarding urban and impervious cover impacts upon hydrology that affect sedimentation, siltation, erosion, and such, refer to Schueler (1995) and Shaver et al. (2007).

Channelized streams are present throughout the project area. Streams are channelized to purposefully direct and control flow in agricultural areas, and to a lesser extent in the SJRW, in urbanized areas. Channelization results in higher peak flows that travel more rapidly; these more powerful flows have greater capacity to erode the channels banks and can carry more sediment farther. The effects of channelization with regards to erosion and sedimentation are presented in Section 4.3.8.

Typical sources of sediment derived from in-stream processes include: incised channels, channel modification, and eroding and collapsing stream banks (U.S. EPA 2012a). Sediment is also derived from eroding soil from anthropogenic activities in both agricultural areas (e.g., livestock grazing, plowing) and urban areas (e.g., construction, roads) and eroding soil from natural processes (e.g., landslides, burnt forests) (U.S. EPA 2012a).

4.2 Point Sources

Point source pollution is defined by CWA section 502(14) as, "any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture."

Point sources can include facilities such as municipal WWTPs, industrial facilities, CAFOs, or regulated stormwater, including MS4s. Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. NPDES permit holders in the SJRW are discussed below.

4.2.1 Industrial Facilities with Individual NPDES Permits

Forty-two facilities hold individual NPDES permits in the SJRW and 18 permittees are industrial or privately owned. Refer to Table C-1, Table C-2, and Table C-3 in Appendix C for a list of individual NPDES permits in Michigan, Ohio, and Indiana. Maps of these facilities are provided in Figure C-1, Figure C-2, and Figure C-3 for Michigan, Ohio, and Indiana, respectively.

4.2.2 Public Facilities with Individual NPDES Permits

Twenty-five public facilities hold individual NPDES permits in the SJRW, including three communities with combined sewer systems (CSSs)[24]. Refer to Appendix C for a list and maps of facilities with individual NPDES permits, which also includes four terminated permits in Indiana. Facilities that are permitted to discharge combined or sanitary sewer overflows or to provide sludge for land application are further evaluated in the following subsections.

4.2.2.1 Combined Sewer Systems

Four facilities are permitted to discharge CSOs in the SJRW (Table 10). These CSSs are potential sources of bacteria and nutrients that impair waterbodies in the project area. The Auburn WWTP, Butler WWTP, Fort Wayne Municipal WWTP, and Montpelier WWTP are permitted to discharge through 14 outfalls into three receiving waterbodies in the SJRW. Each CSS is briefly summarized in this section and available CSO data for Auburn (Table C-5), Butler (Table C-6), Fort Wayne (Table C-7), and Montpelier (Table C-8) are presented in Appendix C.

[24] The cities of Auburn and Butler are CSSs in Indiana and the village of Montpelier is a CSS in Ohio; these three CSSs are wholly within the SJRW. The city of Fort Wayne is also a CSS; however, only a portion of it is in the SJRW and many of its CSO outfalls are in the adjacent Saint Mary's watershed.

Table 10. Public individual NPDES permittees with CSSs

NPDES ID	Facility	CSO outfalls in the SJRW	Receiving waterbody	HU (04100011)
IN0020672	Auburn WWTP	002, 007, 009, 010	Cedar Creek	06 04
IN0022462	Butler WWTP	003	Big Run	05 02
IN0032191	Fort Wayne Municipal WWTP	044, 045, 051, 052, 053, 068	St. Joseph River [a]	08 06
OH0021831	Montpelier WWTP	003, 004, 006	St. Joseph River	03 04

Sources: IDEM 2015, Ohio EPA 2015a,b,c.
Notes
CSO = combined sewer overflow; HU = hydrologic unit; WWTP = wastewater treatment plant.
a. The Fort Wayne combined sewer system discharges to eight waterbodies, including the St. Joseph River.

Auburn

The Auburn WWTP is a 4.5 mgd facility composed of two separate plants that discharge treated effluent to Cedar Creek (Auburn 2011). The CSS has four CSO outfalls, with three outfalls on Cedar Creek and one outfall on John Diehl Ditch (IDEM 2010). Outfall 011 is an outfall for a Wet Weather Storage/Treatment Facility which discharges to Cedar Creek. In addition, CSO 002 is only identified as an emergency CSO and exists for emergency purposes only (IDEM 2015, p. 2, Permit). The LTCP is approved to address the remaining CSOs by approximately 2028.

Butler

The Butler WWTP is 3 mgd and serves about 2,700 people (Rice 2005). "The WWTP processes about 800,000 gallons of wastewater per day, with 500,000 gallons/day coming from industrial areas," with industrial pretreatment (Rice 2005, p. 40). Butler has a CSO treatment facility (Outfall 001) that discharges into Big Run Creek. CSO 003 is currently active and according to the LTCP will only discharge under certain conditions.

Fort Wayne

The P.L. Brunner Water Pollution Control Facility (hereafter, Fort Wayne Municipal WWTP) is a 60 mgd conventional activated sludge WWTP that discharges treated effluent to the Maumee River. Upgrades to the Fort Wayne WWTP have allowed treatment for wet weather flows of up to 100 MGD. Fort Wayne is implementing a LTCP that was approved by IDEM and U.S. EPA as part of *Federal Consent Decree in Civil Action No. 2:07cv 00445* (IDEM 2011). This consent decree was further modified on January 26, 2015 which eliminated satellite disinfection or satellite storage and treatment as the control measures for City CSOs discharging to the St. Joseph River, and replaced those control measures with a plan to install relieve sewers. The agreed upon 18 year implementation schedule for the LTCP allows the city to construct CSO control measures in a planned and orderly fashion. The St. Joseph River controls will be fully implemented by 2019, Maumee River controls by 2022, and St. Mary's River by 2025. The Fort Wayne CSS discharges through 41 CSO outfalls to the following eight waterbodies:

- Baldwin Ditch (3)
- Maumee River (7)
- Natural Drain #4 (1)
- Spy Run Creek (1)
- SJR (6)
- St. Mary's River (19)
- Unnamed ditch to the Maumee River (2)
- Wigman Drain (1).

Montpelier

The Montpelier WWTP serves the village of Montpelier, two small trailer parks (35 units totaling 5,000 gallons per day [gpd]), a middle school (2,000 gpd), and the Enrichment Center (500 gpd; Jones & Henry Engineers, Ltd. 2006). Portions of the service area are a CSS. All lateral and main line sewers discharge to two trunk lines that connect to an interceptor. CSO structures are at each junction of the interceptor with the trunk lines (Washington Street CSO and Randolph Street CSO) and at the pump that connects the interceptor with the WWTP (Randolph Street Pumping Station CSO). A map of the sewer system and specifications for each component of the WWTP are presented in the LTCP (Jones & Henry Engineers, Ltd. 2006).

The village of Montpelier is implementing a LTCP that calls for complete separation of storm and sanitary sewers (Jones & Henry Engineers, Ltd. 2006). The village is installing new gravity sanitary sewer lines and the existing combined sewer lines will become stormwater lines. Montpelier first began to evaluate separating its sewers in 1962 and completed 17 major sewer projects from 1988 through 2004 (Jones & Henry Engineers, Ltd. 2006, p. 3). The LTCP, as revised, calls for six phases of separation that should be completed by 2026. The LTCP assumed nearly stagnant population growth; however, the village population shrunk between the years 2000 and 2010 (Table B-9 in Appendix B). Presently, about 43 percent of the inflow to the secondary WWTP is estimated to be infiltration and inflow, with residential, commercial, and industrial inflows estimated to be 26, 7, and 24 percent, respectively). Once implemented, the infiltration and inflow is expected to be less than one-third of the WWTP inflow; due to the lack of growth, the daily average inflow was assumed to decrease as the infiltration and inflow decreases. The significant population decline in the late 2000s was not anticipated in the LTCP.

4.2.2.2 Sanitary Sewer Systems with Overflows

NPDES permits prohibit SSOs and require all SSOs to be reported to appropriate government agencies. In general, TMDLs require all NPDES permittees to fully comply with their NPDES permits; therefore, WLAs are not allocated to SSOs. If SSOs contribute to impairments, they are addressed by U.S. EPA and the state agencies through the NPDES program. A brief summary of documented SSOs in the SJRW is presented herein. No SSOs were reported at public facilities in Michigan[25].

Ohio EPA has documented SSOs at four of the public facilities with individual NPDES permits in the SJRW: Edgerton WWTP (2PB00047), Montpelier WWTP (2PD00003), Pioneer WWTP (2PB00006), and Edon WWTP (2PA00031). No SSOs were reported at the Edgerton or Edon WWTPs in the past decade (Ohio EPA 2015a). DMR data are summarized in Table C-9 of Appendix C.

The elimination of SSOs is included as part of Fort Wayne's LTCP. The Fort Wayne Municipal WWTP has four SSO outfalls in *Ely Run-St. Joseph River* (04100011 08 05): 072, 074, 075, and 076). These SSO outfalls are part of the Rothman System, and through infrastructure improvements, the SSOs will be eliminated (Fort Wayne 2007, Appendix 5).

4.2.2.3 Biosolids Application Fields

Biosolids, similar to livestock manure and HSTS septage, are applied as a fertilizer to crop fields. In the SJRW, biosolids are applied to four fields in Michigan, seven fields in Ohio (Figure C-2), and 117 fields in Indiana (Figure C-3). Refer to Tables C-10 and C-11 for a list of public facilities with individual NPDES permits that apply their sludge to agricultural fields. WWTP sludge is land applied to four fields in Michigan, and three of those fields receive sludge from WWTPs outside of the SJRW. Conversely, Montpelier WWTP is the only WWTP that supplies sludge to farmers in Ohio for land application in the SJRW. Six facilities in Indiana apply WWTP sludge to 64 fields: Auburn

[25] Aaron Parker, Michigan DEQ, personal communication (via electronic mail), February 23, 2015.

WWTP (35 fields), Beatrice Cheese Company (5), Garrett WWTP (6), Hamilton Conservancy District (2), Pickle Properties, LLC (4), Steel Dynamics Inc. (5), and Waterloo Municipal Sewage Treatment Plant (STP; 7). The remaining 53 fields in Indiana receive WWTP sludge from facilities outside of the SJRW. IDEM allows facilities to market their biosolids, therefore it is possible that additional biosolids may be applied to land within the SJRW.

4.2.3 Concentrated Animal Feeding Operation covered by NPDES Permits

Six CAFOs are in the SJRW, in Indiana and Michigan (Table 11). Michigan DEQ issues general and individual NPDES permits for CAFOs, Ohio EPA issues individual NPDES permits for CAFOs, while IDEM issues individual NPDES permits. Michigan DEQ (2004, 2010)[26] general NPDES permits prohibit discharges (1) during dry weather, (2) during wet weather when control structures are overflowed, washed out, or collapsed, (3) that cause surface waters to violate Michigan WQS, and (4) to groundwater. CAFO general permittees must develop nutrient management plans, and construct control structures and measures to contain 6-months of CAFO waste and production area runoff from a 25-year, 24-hour storm event. All CFOs in Indiana must obtain either a CFO permit or NPDES CAFO permit. For CFOs (regardless of size) that do not discharge manure- or pollutant-bearing water to Indiana surface waters, IDEM issues *CFO Approval*. For CFOs (regardless of size) that discharge manure- or pollutant-bearing water to Indiana surface waters, IDEM issues individual NDPES permits; IDEM issues such permit coverage to non-CAFO-sized CFOs and CAFOs. The discharge of process water is only allowed during certain storm events, and should not result in a violation of water quality standards. See 327 IAC 15-16-7 (d), (e) and (f). IDEM issued individual NPDES permits are more stringent than U.S. EPA CAFO rules, and IDEM permits prohibit discharges of manure, process wastewater, and contaminated stormwater to streams and rivers (IDEM 2012). Michigan's general NPDES permit and Indiana's individual NPDES permits also limit land application of CAFO waste (e.g., application rates, prohibition of application to flooded fields, stream setbacks).

Table 11. CAFOs in the SJRW

NPDES ID	Facility	Animal units	HU (04100011)
Michigan			
MIG010057	Triple T Farms	4,000 hogs	03 02
Ohio			
none			
Indiana			
--	Irish Acres Dairy LLC	2,300 dairy cattle	05 02
--	Phillips Farm	170 dairy calves 1,950 dairy heifers	06 01
--	Sunrise Heifer Farms LLC	2,650 dairy heifers	07 02
--	Mark S. Rekeweg	7,000 finishers 1,100 nursery pigs	08 02
--	Laub Farm LLC	3,600 finishers 2,900 nursery pigs 750 sows	08 02

Sources: IDEM (2014a, 2015a) and Michigan DEQ (2007).
Note: CAFO = concentrated animal feeding operation; HU = hydrologic unit; SJRW = St. Joseph River watershed.

[26] Michigan DEQ (2004) issued a general NPDES permit for new large CAFOs (MIG010000) that was effective June 11, 2004 and expired April 1, 2009, and Michigan DEQ (2010) issued a new general permit (MIG019000) that was effective April 1, 2010 and expired April 1, 2015.

Triple T Farms CAFO wastewater is land applied to about 570 acres of crop fields in Camden and Reading townships of Hillsdale County; an estimated 400 acres are in the SJRW. See the map in Figure C-1 for approximate locations of land application sites in the SJRW.

Indiana's five CAFOs are prohibited from discharging to surface waters. Indiana CAFO waste must be fully contained at their on-site storage structures. CAFO manure and process water can be land-applied to crop fields, under regulated circumstances (IDEM 2012); however, land application is not tracked and locations of land application are not available for mapping.

A single concentrated animal feeding facility (CAFF) is in Ohio and eight confined feeding operations (CFOs) are in Indiana. These operations are not regulated through the NPDES program, nor will they receive WLAs within this TMDL framework. See Section 4.3.6 for discussions of non-CAFO animal facilities.

4.2.4 Facilities Covered by General NPDES Permits (Non-Stormwater, Non-HSTS)

Sixteen facilities hold general NPDES permits in the SJRW for non-stormwater, non-HSTS discharges. Refer to Appendix C for a list of public facilities with general NPDES permits, which also includes one terminated permit in Indiana. Six types of general NPDES permittees (non-stormwater, non-HSTS) are in the SJRW:

- Dimension stone and crushed stone operation (1) in Indiana
- Groundwater petroleum remediation system (1) in Indiana
- Non-contact cooling water systems in Indiana (4), Michigan (1), and Ohio (1)
- Petroleum product terminal (1) in Indiana
- Public swimming pool (1) in Michigan
- Wastewater stabilization lagoons (8) in Michigan

Only the wastewater stabilization lagoons (WWSLs) are pertinent to this TMDL study. None of the other types of general permits allow the discharge of bacteria or nutrients (IDEM 2014b; Michigan DEQ 2009, 2012, 2014a; Ohio EPA 2010a,b). Except for the dimension stone and crushed stone operation general permittee, none of the general permits allow for the discharge of TSS.

Michigan DEQ issues general NPDES permits for WWSL effluent (MIG58000). WWSLs seasonally discharge sanitary or municipal wastewater that is treated in stabilization lagoons (Michigan DEQ 2014a). Discharges are only permitted in the spring and fall[27] and each discharge event requires pre-approval from Michigan DEQ; discharges may not exceed a duration of 10-days within a 14-day period. The general permit includes fecal coliform and TSS effluent limits and Michigan DEQ may impose total phosphorus limits (Michigan DEQ 2014a). Michigan's WWSLs are further discussed, as appropriate, in the subwatershed-by-subwatershed analyses presented in linkage analyses of Section 5 and Section 6.

4.2.5 Facilities and Entities Covered by General NPDES Permits for Stormwater

Regulated stormwater runoff can be a significant source of pollutants to the SJRW. Stormwater runoff can contain bacteria, nutrients, and sediment, in addition to numerous other pollutants. Also, stormwater runoff rates and volumes can cause impacts to stream channels and habitat. The sections below present general information regarding pollutant transport in regulated stormwater (typically urban stormwater) and a summary of each state's stormwater program, including information that is specific to the project area.

[27] Discharges are prohibited in January, February, June, July, August, and September and when the receiving waterbody is frozen.

4.2.5.1 Urban Stormwater

The type of development and land uses generally determine the quality of and constituents in the stormwater (Shaver et al. 2007) as does the level of automobile activity (Burton and Pitt 2002). Stormwater from transportation land uses (e.g., roads, bridges, service stations) can contain petroleum hydrocarbons or copper derived from brake pads whereas stormwater derived from runoff of fertilized residential lawns, golf courses, and manicured or landscaped areas can contain elevated levels of nutrients (Shaver et al. 2007). Urban and suburban stormwater runoff characteristics typically differ considerably as compared to rural and undeveloped areas (Pitt et al. 1995; U.S. EPA 1983).

Any constituents that are deposited on impervious surfaces will typically remain there until they are picked up and transported by urban stormwater. For example, when pet waste is improperly disposed of, it can be picked up by stormwater runoff and washed into storm drains or nearby waterbodies. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in lakes and streams. In undeveloped areas, some constituents will be transported to shallow aquifers as water infiltrates. However, because infiltration cannot occur on impervious surfaces, pollutants that accumulate on impervious surfaces will be rapidly carried to surface waterbodies through runoff or stormwater conveyance systems where they can pose a risk to human and ecological health (Shaver et al. 2007; Schueler 1994).

Many toxic constituents bond to particulate matter and can be transmitted in stormwater while adsorbed to the sediment. For example, “hydrocarbons are normally attached to sediment particles or organic matter carried in urban runoff” (Shaver et al. 2007 p. 3-48). Because stormwater tends to travel rapidly over impervious surfaces, the high-velocity water has an increased “ability to detach sediment and associated pollutants, to carry them off site, and to deposit them downstream” (Burton and Pitt 2002, p. 31). The sediment and adsorbed pollutants can accumulate in bottom sediments “where they are readily available to aquatic organisms and possible re-suspension during future storm events” (Masterson and Bannerman 1994, p. 131). Sedimentation can increase in downstream ponds or slower-moving streams when sediment-laden, high-velocity stormwater discharges to the waterbodies.

Pitt et al. (1996, p.4) evaluated urban stormwater and found that metals were typically detected in high concentrations. Masterson and Bannerman (1994) generally found that heavy metal concentrations in urban streams in Wisconsin exceeded the concentrations in reference streams. Stress and lethality to aquatic organisms can occur from episodic exposure to stormwater laden with metals (Burton and Pitt 2002, p. 77). The typical sources of nutrients (e.g., nitrates and phosphates) in urban runoff include fertilizer runoff from lawns, landscaped areas, and golf courses (Shaver et al. 2007, p. 3-47). Bacteria sources include pet and wildlife waste that are transported via runoff from a precipitation event to storm sewers and streams; illicit connections to the storm sewers are also a potential source of bacteria since the domestic waste from the illicit connection does not get treated. Typical sources of sediment in urban stormwater include bank erosion, which increases due to faster and more powerful stream flows caused by urban development, and runoff from construction or industrial sites that is not properly contained (e.g., silt fences) and treated (e.g., settling pond).

4.2.5.2 Regulated Municipal Separate Storm Sewer System

Regulated MS4 programs vary by state but must follow rules and guidelines established by U.S. EPA. Specifically, regulated MS4s must implement six minimum control measures, which are public education, public involvement, illicit discharge detection and elimination programs, control of construction site runoff, post-construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. In urban areas, the cross-connection of sanitary and storm sewer lines are issues for both WWTPs and MS4s. State NPDES programs require both WWTPs and regulated MS4s to identify and eliminate illicit discharges due to cross-connections.

4.2.5.3 Michigan's Stormwater Program

Michigan DEQ regulates stormwater through its NPDES program[28]. No regulated MS4s or industrial facilities that discharge stormwater are in the SJRW in Michigan; construction sites regulated under a general permit may have been in the SJRW.

From 2001 through 2014, 27 construction sites in Hillsdale County were covered under Michigan's general NPDES permit for stormwater from construction sites (Michigan DEQ 2015b). There are 9 townships in southern Hillsdale County that are at least partially in the SJRW, and 11 construction sites with permit coverage are in these townships. As most of Michigan's sources of regulated stormwater are not in the SJRW, and only a few expired and terminated construction site permit coverages have the potential to be in the SJRW, Michigan's stormwater program is not further discussed.

Residential and commercial properties in the rural portion of Hillsdale County in the SJRW may discharge non-regulated stormwater. Such stormwater should not contain phosphorus from lawn or turf fertilizers because Michigan prohibits such fertilizers from containing available phosphorus (P_2O_5), with certain exemptions (Michigan 2010).

4.2.5.4 Ohio's Stormwater Program

Ohio EPA regulates stormwater through various individual and general NPDES permits. No regulated MS4s or marinas are in the SJRW in Ohio. Industrial facilities and construction sites in the SJRW in Ohio are covered by individual and general NPDES permits.

The Multi-Sector General Permit, which addresses stormwater discharges associated with industrial activities (U.S. EPA ID OHR000005), is effective from January 2012 through December 2016. A *Notice of Intent* and stormwater pollution prevention plan must be submitted to Ohio EPA to receive permit coverage. If industrial activity is completely sheltered from stormwater, *No Exposure Certification* may be obtained. As of February 2015, eight facilities in the SJRW in Ohio are covered by general NPDES permits for stormwater discharges associated with industrial activities (Ohio EPA 2015c; Table C-2 in Appendix C) and 12 facilities were granted no exposure certification.

The NPDES general permit for stormwater discharges associated with small and large construction activities (U.S. EPA ID OHC000003) is effective from April 2013 through April 2018. The previous general permit for stormwater discharges associated with small and large construction activities (U.S. EPA ID OHC00002) was effective from April 2008 through April 2013. A *Notice of Intent* and stormwater pollution prevention plan must be submitted to Ohio EPA to receive permit coverage. Over 30 construction sites were issued permit coverage between 2004 and 2014 in Williams County (Ohio EPA 2015c). Construction sites ranged in size from 0.82 acre to 23 acres (average: 4.9 acres; median: 4.5 acres).

4.2.5.5 Indiana's Stormwater Program

Like Michigan and Ohio, Indiana regulates stormwater through various individual and general NPDES permits. In the SJRW, IDEM regulates stormwater from MS4s (3), industrial facilities (39), and construction sites (256) via NPDES permits.

Urban stormwater that is transported by public conveyance structures that compose an MS4 is covered by Rule 13 of Indiana's general NPDES permit rules (*327 IAC 15-13*) for MS4s. Agents of the MS4 entity must file a *Notice of Intent* and stormwater quality management plan with IDEM to receive permit

[28] Michigan DEQ issued general NPDES permits for stormwater from regulated MS4s (MIG040000 and MIG619000), from industrial facilities (MIG110000, MIG120000, MIG210000, MIG220000, MIG310000, MIG320000, MIG410000, MIG420000, MIG510000, and MIG520000), and from municipally operated industrial facilities (MIG510000 and MIG520000).

coverage. One city and two groups of municipalities and other entities have permit coverage in Indiana's portion of the SJRW (Table 12). As applicable, entities receiving general NPDES permit coverage for discharges associated with industrial activity and construction must notify the regulated MS4(s) if their stormwater is discharged to the MS4(s).

Table 12. Indiana's regulated MS4s in the SJRW

NPDES ID	Permittee or co-permittees	Regulated MS4 area
INR040029	city of Fort Wayne [a,b] Indiana University-Purdue University – Fort Wayne Ivy Tech State College – Northeast Indiana Institute of Technology [c] University of Saint Francis [c]	city limits within the SJRW
INR040119	city of Auburn [b]	city limits
INR040131	Allen County town of Huntertown town of Leo-Cedarville	town limits of Huntertown and Leo-Cedarville plus the *percent developed imperviousness* from the 2011 NLCD (Jin et al. 2013) less the city limits of Fort Wayne

Source: IDEM 2015b
Notes
MS4 = municipal separate storm sewer system; NLCD = National Land Cover Database; SJRW = St. Joseph River watershed.
a. Portions of Fort Wayne are outside of the SJRW.
b. Portions of these municipalities are also combined sewer systems; such portions are not part of the regulated MS4s.
c. The Indiana Institute of Technology is in Maumee River watershed, downstream of the SJRW, and the University of Saint Francis is in the St. Mary's River watershed.

Stormwater associated with industrial activity is covered by Rule 6 of Indiana's general NPDES permit rules (*327 IAC 15-6*) for construction activity. The proprietor, partner, or responsible officer of an industrial facility must file a *Notice of Intent* and stormwater pollution prevention plan with IDEM to receive permit coverage. IDEM issues a *Notice of Sufficiency* if the facility meets the requirements of Rule 6 and can issue a *Notice of Exemption* if the facility's industrial activities are not exposed to stormwater. A GIS analysis of industrial facility locations (IDEM 2015c) identified 39 such facilities in the SJRW; only 37 of the facilities were further evaluated due to plotting errors with two facilities.

Stormwater associated with construction site and land disturbance is covered by Rule 5 of Indiana's general NPDES permit rules (*327 IAC 15-5*) for construction activity. Property site owners must file a *Notice of Intent* and construction plan with IDEM when the construction activity or land disturbance is greater than or equal to 1 acre. Over 250 construction sites in the SJRW were regulated under the general permit between 2004 and 2014.

4.2.6 Properties with General NPDES Permit Coverage for Off-Site Discharging HSTS

Ohio EPA grants general NPDES coverage for off-site discharging HSTS[29]. While off-site discharging HSTS in Defiance and Williams counties are covered by the general NPDES permit (Ohio EPA 2015d), no such HSTS are in the SJRW[30]. Since no HSTS are regulated by the NPDES Program, HSTS are discussed in Section 4.3.2 in the nonpoint sources section.

[29] In Ohio, two general permits are issued depending on which agency determines HSTS eligibility: Ohio EPA (OHL00002; OHL00001 is expired) or local boards of health (OHK00002; OHK00001 is expired). Permit coverage is only granted to discharging systems when a residence cannot be served by an onsite soil adsorption system or by sanitary sewers. Permit coverage is granted for new and replacement systems; existing systems do not have to apply for permits.

[30] The street addresses of off-site discharging HSTS, available from Ohio EPA (2015d), were geocoded and plotted in GIS. Geocoded address are approximate; however, as no geocoded addressed plotted near the SJRW, it is assumed that none are in the SJRW.

4.3 Nonpoint Sources

The term *nonpoint source pollution* is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from stormwater runoff and background conditions. Note that stormwater collected and conveyed through a regulated MS4 is considered a point source. Since agricultural practices such as crop cultivation (52 percent) and pasture/hay (17 percent) cover an estimated 69 percent of the land area in the SJRW, nonpoint source pollution can contribute a significant amount of the total pollutant load. In addition to runoff and erosion, significant nonpoint sources also include home sewage treatment systems and animals.

4.3.1 Stormwater Runoff (Non-Regulated)

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place. The main pollutants of concern associated with agricultural runoff are sediment, nutrients, pesticides, and bacteria. Stormwater from developed areas can be contaminated with oil, grease, chlorides, pesticides, herbicides, nutrients, viruses, bacteria, metals, and sediment. In urban areas, some connections to storm sewers are illicit, which includes residences and businesses that discharge untreated wastewater to the storm sewers.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. The increased peak flows and runoff volumes tend to increase streambank erosion. These more powerful flows have more capacity to move larger sediment particles farther, which may result in downstream sedimentation when the in-stream flow decreases. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through vegetated riparian areas. Thus, runoff transported through drain tiles will contain all of the pollutants that it contained when the runoff entered the tile system; surficial runoff may lose pollutants as it is filtered during infiltration and passes through the vegetated riparian corridor.

For a general review of the effects of urbanization and stormwater and references to additional resources, see the *CADDIS Urbanization Module* (U.S. EPA 2012a) and *The Importance of Imperviousness* (Schueler 1994). Regulated stormwater sources are discussed in Section 4.2.5. Sources of pollutants in non-regulated stormwater are discussed in the sections below.

4.3.2 On-Site Wastewater Treatment Systems

On-site wastewater treatment systems (OWTS) treat sanitary waste and are common in rural areas without sanitary sewer systems and WWTPs. While the Fort Wayne, IN metropolitan area and small cities and villages in Indiana and Ohio are served by public sewers, many small rural communities rely on OWTS. Such communities include Blakeslee, OH, Frontier, MI, and Newville, IN.

"In the modern era, the typical onsite system has consisted primarily of a septic tank and a soil absorption field, also known as a subsurface wastewater infiltration system" (U.S. EPA 2002, p. 1-1). HSTS are a subset of OWTS that treat domestic sanitary waste for one or a few homes; larger OWTS treat clusters of homes or businesses. Hereafter, an HSTS is identified in this report as an *on-lot HSTS* if it uses a septic tank and the septic tank effluent discharges to a (1) a soil absorption field, (2) filter bed system, (3) mound system, or (4) drip distribution system. An HSTS that uses an aeration system that discharges through a pipe outlet to a surface waterbody, like any other point source, is identified as an *off-site discharging HSTS* in this report.

Types of HSTS

Conventional, *on-lot HSTS* are composed of a septic tank and a subsurface wastewater infiltration system (i.e., absorption field).

Off-site discharging HSTS discharge through a pipe to a surface stream after treatment in the aeration tank.

OWTS and HSTS are typically considered nonpoint sources of pollution; however, a subset of HSTS in Ohio are considered point sources and are regulated by Ohio's NPDES program. Ohio EPA issues general NPDES permits for new or replacement HSTS that discharge to waters of the state.[31]

This section includes discussions of general OWTS information (Section 4.3.2.1), and HSTS information specific to Michigan (Section 4.3.2.2), Ohio (Section 0), and Indiana (Section 4.3.2.4). Land application and disposal of septage are presented in the next section (Section 4.3.4).

4.3.2.1 Background

OWTS that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations that contribute to failure are seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When septic systems fail hydraulically due to surface breakouts or inadequate soil filtration, adverse effects on surface waters can result (Horsely and Witten 1996). OWTS contain all the water discharged from homes and business and can be significant sources of pathogens (e.g., bacteria) and nutrients (e.g., total phosphorus and nitrate nitrogen). Effects on surface water from OWTS are dependent on numerous factors, including soil characteristics, topography, hydrography, and their proximity to streams.

If properly designed, sited, installed, operated, and maintained, OWTS will remove suspended solids, biodegradable organic compounds, and fecal coliforms (U.S. EPA 2002, p.3-22). If OWTS do not sufficiently treat wastewater, then the following pollutants may be found in OWTS wastewater: nitrates, pathogens, and phosphorus (U.S. EPA 2002, p. 3-20). If a subsurface pollutant plume expands to the water table, then these pollutants may be transported via ground water and discharged to surface water.

TSS may also be present in OWTS effluent, though most properly working systems remove most of the TSS (e.g., TSS settles out [i.e., sedimentation occurs] in septic tanks). If too much TSS enters the system, it may clog the system and reduce infiltration. Directly discharging OWTS may contaminate surface waters as the TSS forms sludge that will detrimentally affect benthic macroinvertebrates (U.S. EPA 2002).

4.3.2.2 Michigan

Michigan regulatory code (Section 2435 of the Public Health Code, 1978 PA 368, as amended) gives local district health departments the authority to "adopt regulations to properly safeguard the public health and to prevent the spread of diseases and sources of contamination." New OWTS installations and repairs are inspected and permitted by the Branch-Hillsdale-St. Joseph Community Health Agency (BHSJ). Local health departments must be accredited by the state in a process that involves evaluation every three years.[32] OWTS serving one or two homes must follow BHSJ's siting requirement while OWTS serving multiple homes or commercial structures must follow Michigan DEQ siting requirements. Michigan DEQ

31 The Ohio general NPDES permit for HSTS provides coverage for dischargers from select new, replacement, or updated HSTSs serving single-family, two-family or three-family dwellings or residential dwellings or appurtenances as defined by OAC Chapter 3701-29 to waters of the state. The general permit does not cover any discharges that the Ohio EPA Director has determined to be contributing to a violation of a water quality standard.

32 For more information on the accreditation process, and minimum program requirements, please visit https://accreditation.localhealth.net/.

does not have an OWTS installer licensing program. In the SJRW, OWTS installers must register with BHSJ. The agency does not perform *point of sale* inspections but will inspect existing OWTS during a *change of use* (e.g., mobile home converted to permanent home)[33] or when repairs or new system installations are being conducted. Neither Michigan DEQ nor BHSJ fund assistance programs to help residents replace their OWTS in the SJRW.

Michigan DEQ tracks the permitting of HSTS and non-residential OWTS. An estimated 18,547 households were in Hillsdale County, with 6,073 households connected to public sewers, 12,064 households used HSTS, and 410 households used other methods of wastewater treatment (West Virginia University nd). No information regarding failure rates specific to Hillsdale County or southern Michigan is available. The state of Michigan summarizes the failure data into annual statewide reports, which can be found on Michigan's Onsite Wastewater website (go to http://www.michigan.gov/deq) and search for "Onsite wastewater".

4.3.2.3 Ohio

In Ohio, according to *OAC 3718-01(F)*, any decentralized wastewater treatment systems "that receive sewage from a single family, two-family, or three-family dwelling" is defined as a HSTS. Only HSTS are discussed hereafter because no other decentralized wastewater treatment systems[34] are known to operate in the SJRW project area.

The Ohio Department of Health (ODH) regulates HSTS and provides technical assistance to the local health districts for HSTS-issues. Ohio EPA grants general NPDES coverage for off-site discharging HSTS; however, no such permit coverage has been granted in the SJRW. The local health districts permit and inspect HSTS in Ohio. In the SJRW, the Williams County Health District's Environmental Division maintains a wastewater septic system program.

ODH conducted an HSTS study in 2012 to support Ohio EPA's CWA requirements. As reported in the *Household Sewage Treatment System Failures in Ohio* (ODH 2013), approximately 31 percent of HSTS in Ohio are failing; results for pertinent areas are displayed in Table 13.

Table 13. HSTS and failure rates in two counties in the SJRW

Area	No. of HSTS	No. of failing HSTS	Failure rate [a]
Ohio	628,493	193,988	31%
Northwest District [b]	117,819	45,560	39%
Defiance County	2,702	1,432	53%
Williams County	496	484	98%

Sources: ODH 2012
Notes
a. The estimate failure rate includes systems that are old or are no longer allowed to be installed (e.g., discharger to dry wells).
b. Ohio EPA's Northwest District consists of the following counties: Allen, Ashland, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Hardin, Henry, Huron, Lucas, Marion, Mercer, Ottawa, Paulding, Putnam, Richland, Sandusky, Seneca, Van Wert, Williams, Wood and Wyandot.

The most common types of HSTS in Ohio are *septic tank or pretreatment to leaching* (43 percent) and *septic tank or pretreatment to discharge* (17 percent). Most of the Ohio-portion of the SJRW is in Williams County, and *Septic tank or pretreatment to discharge* (65 percent) and *septic tank or pretreatment to unknown* (33 percent) are the most common types of HSTS in Williams County (Table

[33] Aaron Parker, Michigan DEQ, personal communication (via electronic mail), March 19, 2015.
[34] Other types of decentralized wastewater treatment systems that are not HSTS, as defined in Ohio, include systems that treat sanitary waste from one or more businesses.

14). Privies (outhouses) were not reported in this county. ODH's 2012 HSTS study identified 322 discharging HSTS in Williams County (ODH 2012).

Table 14. HSTS types and failure rates in Williams County

HSTS type	No. of HSTS	No. of failing HSTS	Failure rate [a]
Septic tank or pretreatment to leaching	1	0	0%
Septic tank or pretreatment to mound system	8	1	13%
Septic tank or pretreatment to sand filter	0	--	--
Septic tank or pretreatment to discharge	322	319	99%
Septic tank or pretreatment to unknown	165	164	99%
Dry wells	0	--	--
Unknown	0	--	--
Other:	0	--	--

Sources: ODH 2012
Notes
a. The estimate failure rate includes systems that are old or are no longer allowed to be installed (e.g., discharger to dry wells).
b. Dry well systems are no longer allowed and are considered to be failing.

Across Ohio, of the known systems[35], 49 percent of *septic tank or pretreatment to discharge* are reported as failing (ODH 2013). Of the known systems in Williams County, 99 percent of *septic tank or pretreatment to discharge* are reported as failing. HSTS can be reported as failing for one or more reasons. The most common reasons for system failures in Ohio are old systems (44 percent), direct discharges exceed water quality standards (43 percent), and soil limitations (33 percent). Dry well systems are no longer allowed to be installed and all such systems are considered to be failing.

4.3.2.4 Indiana

HSTS are regulated by local health departments in Indiana, while IDEM regulates municipal OWTS. In the early 2000s, an estimated 40 to 50 percent of HSTS in DeKalb County were failing, which is similar to the 40 percent estimated failure rate across Indiana (Rice 2005, p. 29; SJRWI 2008, p. 68-69). In the Cedar Creek portion of Allen County, an estimated 75 percent of HSTS were failing (Rice 2005, p. 6). As part of its LTCP efforts, Fort Wayne also agreed to implement supplemental environmental projects to eliminate septic systems from its jurisdiction (Fort Wayne 2007, Appendices 6 and 7).

4.3.3 Fertilizers and Pesticide Application to Manicured Lawns and Crop Fields

Application of chemicals, including pesticides and fertilizers, is a potential source of nitrogen and phosphorus species in both urban and rural environments. During precipitation events, fertilizers and pesticides can wash off manicured lawns and crop fields and travel overland or through drain tiles or storm sewers to surface streams. Nutrients may travel dissolved in solution or bound to sediment. Unless ammonia is bound to sediment, it will nitrify to nitrate, which contributes to eutrophication and nutrient impairments. Ammonia and total phosphorus derived from fertilizers or pesticides may bind to sediment and travel downstream; such pollutants may persist in the environment long after fertilizer or pesticide application. Finally, the effects of fertilizer-derived loads may be seasonal because fertilizers are applied during the growing season, which varies by crop or landscaped plant.

4.3.3.1 Developed Land

In urban areas, pesticides and fertilizers are applied to manage developed areas such as residential lawns and gardens, athletic fields, parks, recreational facilities, and green spaces surrounding larger industrial or commercial complexes[36]. After precipitation events, pesticides and fertilizers can contribute pollutants to runoff that enters streams through the storm sewers.

[35] The type of HSTS can be reported as 'unknown'; 56 percent of unknown systems were reported as failing. Additionally, 51 percent of *septic tank or pretreatment to unknown* were failing.

[36] Scotts Miracle Gro-Company, whose retail sales compose one-half of lawn fertilizer sales in Ohio, eliminated phosphorus from its lawn maintenance products in 2013 (Ohio EPA 2013, p. 10).

SJRWI (2008) identified greenspaces in Fort Wayne along the SJR as potential sources of fertilizers that migrate into the SJR; such green spaces include IPFW campus, Canterbury Green, Shoaff Park, Concordia University, and River Bend Golf Course.

4.3.3.2 Cultivated Crops

Smith et al (2015b) identified 23 factors that interact in a complex process that results in elevated nutrient loads to Lake Erie. A few factors pertinent to cultivated crops are discussed herein. Generally, in the Western Basin of Lake Erie, crop rotations have transitioned from 4-year and 10-year rotations of multiple crops to 2-year corn-soybean and 3-year corn-soybean winter wheat rotations. The less diverse rotations require more fertilizer application, with corn, specifically, requiring more nutrient fertilizer application than other crops (Smith et al. 2015b, p. 27a). Fertilizer placement, timing, and rate are critical factors that affect phosphorus transport to Lake Erie. Surficial broadcast application tends to occur in the non-growing season (which has less crop uptake of nutrients and more wet, runoff conditions) at higher application rates (which were designed for less productive soils and are high enough to ensure sufficient yield and maintain nutrient levels in the soil) results in more risk of phosphorus loss to runoff (Smith et al. 2015b, p. 27a-28a).

Cultivated crop fields are present throughout the project area and on properties adjacent to impaired streams. Fertilizer application is dependent on numerous factors (e.g., soil type, soil moisture content, crop type). In Ohio the most common fertilization practices are broadcast (no till, 31 percent; till seven or more days after application, 15 percent; and till within seven days of application, 18 percent) and incorporation (with strip tillage, 4 percent; planter, 33 percent) (Ohio EPA 2013b). The following four crops are the most prevalent in the project area and are each briefly discussed: corn, soybean, winter wheat, and hay/alfalfa. The following descriptions of fertilizer application in the SJR TMDL project area are generalized:

- **Corn:** Farmers often apply 28-0-0 solution as a starter fertilizer during spring planting. They will then also side-dress nitrogen-fertilizers 30-days after planting. About half of the famers use anhydrous ammonia while the other half use 28-0-0 solution.

  About 30 to 40 percent of farmers spring-apply a phosphorus fertilizer just before planting; the other 60 to 70 percent of farmers fall-apply phosphorus fertilizer.
- **Soybean:** No fertilizers are applied during the soybean portions of the crop rotations.
- **Winter wheat:** Farmers broadcast 28-0-0 solution or dry 46-0-0 in the spring after fall planting. Phosphorus-fertilizers are applied during planting in the fall.
- **Hay/alfalfa:** No nitrogen-fertilizer is applied. Phosphorus-fertilizers are applied during planting in the spring.

Cropland roadside surveys in 2004 and 2005 found that the amount of conventional tillage, conservation tillage, and no tillage varied considerably between counties in the St. Joseph River watershed (Palmer & Loomis 2006). No tillage ranged from 17 to 39 percent for corn and 60 to 83 percent for soybeans, while the summation of other conservation tillage practices ranged from 20 to 50 percent for corn and from 9 to 23 percent for soybeans (Palmer & Loomis 2006a, p. 6).

4.3.4 Septage Land Application and Disposal/Treatment

Application of domestic septage to farm fields is regulated by local health departments and state regulatory agencies. Domestic septage is pumped by companies that pump, haul, and dispose of septage. Pumped septage may be hauled to WWTPs for disposal and treatment or hauled to farms for land application to crop fields.

Disposal and treatment of septage at WWTPs generally are not sources of pollutants to surface waterbodies. Septage that is spilled by the haulers or at the WWTPs may migrate to and contaminate streams. However, septage spills, like other spills to surface waterbodies, are illegal and are addressed through the NPDES program.

Domestic septage that is applied to crop fields may be transported via runoff from precipitation events to surface streams. Crop fields with septage application that are drained by tiles will more rapidly transport runoff containing septage to streams and open ditches. The tile drains yield larger and faster flows that can carry septage farther downstream.

4.3.4.1 Michigan

Michigan DEQ's Office of Drinking Water and Municipal Assistance administers a septage program that regulates septage haulers, septage storage facilities, and septage receiving facilities through the issuance of licenses and permits (Michigan DEQ 2013). Michigan DEQ's Septage Waste Program works with local health departments. Septage haulers are licensed and must complete continuing septage education classes to renew their licenses (Michigan DEQ 2013). Septage application to crop fields requires a crop plan, soil analysis, and calculated application rates that must be approved by Michigan DEQ. The Department has issued guidance manuals, including manuals for land application and storage facility maintenance.

Five septage haulers are licensed in Hillsdale County and an additional five are licensed in Branch County. One licensed septage hauler in each county is authorized to land apply septage. However, the only crop field that Michigan DEQ authorized for septage application in Hillsdale County is not in the SJRW.

All ten licensed septage haulers transport septage for disposal and treatment at WWTPs. These 10 licensed septage haulers use one or more of the following four WWTPs:

- City of Three Rivers Clean Water Plant (2 haulers in Branch County)
- Coldwater WWTP (3 haulers in Hillsdale County and 5 haulers in Branch County)
- Leoni Township WWTP (4 haulers in Hillsdale County)
- Rollin-Woodstock WWTP (2 haulers in Hillsdale County)

None of these four WWTPs are in the SJRW, nor do any WWTPs in the SJRW accept septage. Additionally, no septage storage facilities are in the SJRW. Thus, as no septage is land applied in the SJRW, disposed of at WWTPs in the SJRW, or stored in the SJRW, Michigan septage cannot be a source of pollutants for Ohio or Indiana nutrient, TSS, or bacteria impairments in the SJRW.

4.3.4.2 Ohio

ODH, Ohio EPA, and local health districts regulated septage haulers and land application of septage (ODH 2004). ODH provides assistance to local health districts for registering septage haulers, while the local health districts themselves issues the registrations. Domestic septage in Ohio may be transferred to public or private WWTPs, transferred to sanitary landfills, or applied to crop fields (ODH 2004). Ohio EPA is only involved in septage land application if the application causes pollution to waters of the state.

4.3.4.3 Indiana

IDEM Office of Land Quality regulates septage pumping, hauling, and application to crop fields. While WWTPs do accept septage for treatment and disposal, IDEM does not track which facilities treat and dispose nor does IDEM track where the septage originated from. In the SJRW, the Fort Wayne Municipal WWTP (IN0032191) and Auburn WWTP (IN0020672) accept septage[37].

The companies that pump and haul septage are required to maintain records of where they pump septage from and where it is disposed of or treated at; however, haulers do not submit this information to IDEM. Septage pumpers/haulers that land apply must submit quarterly reports that include daily application rates, types of septage (e.g., domestic, grease), and application method (i.e., surface, injection, incorporation)[38]. No septage land application sites are in the SJRW (Indiana Geological Survey 2013).

4.3.5 Agricultural Ditches and Drain Tiles

Agricultural ditches and drain tiles are installed to drain excess water from cropland. "Tile drainage is essential to efficient agricultural production in the cool humid regions of the upper Midwestern United States" because spring precipitation exceeds evaporation in corn and soybean fields (Smith et al. 2015a, p. 496). Modern agricultural drainage programs began in Ohio in 1957 following the passage of the Ohio Drainage Laws[39] (Loftus et al. 2006). Today, drainage ditches and drain tiles are considered to be parts of larger drainage management systems that seek "to improve the soil environment for vegetation growth by managing water for irrigation and drainage" (Ohio EPA 2013a, p. 42). Since the SJRW has low relief and poor natural drainage, many of the tributaries to the St. Joseph River "are actively maintained as open drainage ways by county authorities" (Ohio EPA 2015a, p. 62).

Recent research indicates that "losses of [phosphorus] through tile are likely a prevalent loss pathway throughout the Midwestern United States, particularly where reduced tillage systems may have encouraged the development of macropores" (Smith et al. 2015a, p. 500). Nutrients may rapidly travel from the crop field surface down to drain tiles through macropores, and thus, nutrients would not be sequestered in the soil.

Cropland throughout the SJRW is served by drainage ditches and drain tiles, and while most farms have some form of tiling, not all farms are fully tiled. In a study of crop fields in the SJRW, Smith et al. (2015b) found that 25 percent to 80 percent of phosphorus loss occurred via subsurface drain tiles.

4.3.6 Livestock

Livestock are potential sources of bacteria, nutrients, and sediment (indirectly) to streams, particularly when direct access is not restricted or where feeding structures are adjacent to or connected to riparian areas. As previously discussed in Section 4.2.3, CAFOs are regulated point sources in states' NPDES Program. Indiana and Ohio operate non-CAFO regulated livestock operations. Many agricultural and rural properties have small numbers of livestock which do not require CAFO[40] or state permits.

This section includes discussions of general livestock pollution transport pathway information (Section4.3.6.1), and livestock information specific to Michigan (Section 4.3.6.2), Ohio (Section 4.3.6.3), and Indiana (Section 4.3.6.4). Manure land application is discussed in each section.

4.3.6.1 Background

Livestock with unrestricted access to surface waters may deposit waste directly into streams. While moving along the banks and into streams, hoof shear may loosen soil that is then transported downstream by the creek. Livestock moving along the stream banks may trample or consume vegetation, which

[37] Brenda Stephanoff, IDEM Office of Land Quality, personal communication (via electronic mail), August 17, 2015.
[38] Brenda Stephanoff, IDEM Office of Land Quality, personal communication (via electronic mail), August 17, 2015.
[39] The Ohio Drainage Laws are a colloquial reference to the Ohio County Ditch Law (enacted in 1850) that is composed of ORC Chapters 6131, 6133, 6135, and 6137 (Brown and Stearns 1991).
[40] CAFOs are regulated under the CWA by U.S. EPA and the states through the NPDES program. Six CAFOs) in the SJRW; see Section 4.2.3 and Appendix C for CAFO information.

contributes to bank instability, and ultimately, downstream sedimentation. Livestock that have restricted access to surface waters may still contribute bacteria and nutrients to streams if sufficient practices are not implemented to limit runoff from livestock areas. Finally, runoff from crop fields with manure application can transport bacteria and nutrients in the manure via overland flow or through drain tiles to nearby streams. Manure application varies by season and crop; thus, the magnitude of loads of bacteria, nutrients, and sediment from crop field runoff are controlled by when the manure is applied.

Grazing patterns and the types of cattle operations influence the bacteria, nutrient, and sediment loads that livestock contribute to surface waters. Since livestock grazing patterns vary by season, the pollutant loads derived from livestock vary by season. Runoff from an actively grazed pasture during the spring will yield higher loads than those generated from an unused pasture in the winter when the livestock are in barns.

SJRWI inventoried livestock across the SJRW through windshield surveys in 2009. The inventory identified "1,218 locations where livestock were present" (Quandt 2015, p. 58). The WMPs summarize the inventory per project area. For example, Quandt (2015, p. 58) reported 31,386 head of livestock in the upper SJRW and identified 15 locations with livestock access to streams and 13 locations with manure runoff directly to streams.

4.3.6.2 Michigan

Michigan does not permit non-CAFO livestock operations. Hillsdale County has many small livestock operations that are temporary and change seasonally (SJRWI 2006). Countywide data for Hillsdale County were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

Michigan CAFO permits establish requirements for manure land-application. New Michigan rules require farmers who obtain and land-apply CAFO-generated manure to comply with the CAFO land application regulations (Michigan DEQ 2015a).

The Michigan Right to Farm Act, P.A. 93 of 1981, as amended, authorizes the Michigan Commission of Agriculture and Rural Development to develop and adopt Generally Accepted Agricultural and Management Practices (GAAMPs) for farms and farm operations in Michigan. These GAAMPs are based on science and are reviewed annually and revised as considered necessary. GAAMPs promote environmental stewardship, and when MDARD determines that a farm conforms to GAAMPs, then that farmer may use the Right to Farm Act as an affirmative defense in a nuisance lawsuit. If a farm is alleged to be causing a water quality problem, an environmental complaint may be filed by anyone, and an investigation will be conducted by MDARD and/or the MDEQ Water Resources Division. If the management practices on a farm are causing a violation of NREPA Part 31 (Water Resources Protection), then enforcement action may be taken by the MDEQ to address the complaint and compel the farmer to correct the water pollution problem and abate the violation.

Livestock operations may be required to apply for an NPDES permit in accordance with the circumstances set forth in Rule 2196 (R 323.2196) of Part 21 of NREPA. This authority allows the MDEQ to impose pollution controls and conduct inspections, thereby reducing pollutant contamination (i.e., *E. coli* from agricultural operations that have been determined to be significant contributors of pollutants).

4.3.6.3 Ohio

The Ohio Department of Agriculture regulates CAFFs through the Livestock Environmental Permit Program. The CAFF Advisory Committee (of the Ohio Department of Agriculture) defined the numbers of animals that constitute various sizes of CAFFs. The Department issues *Permits to Operate* that require

CAFF owners to submit plans for manure management, insect and rodent control, mortality management, and emergency response (Ohio Department of Agriculture 2011). CAFFs are prohibited from discharging to surface waters. A single CAFF is in the SJRW: Bridgewater Dairy, LLC in Williams County (Table C-14 and Figure C-8 in Appendix C). The Bridgewater Dairy land-applied manure to its own cropland and sells manure to nearby farmers (Bridgewater Dairy 2015)[41]. Ohio EPA (2015, p. 17) identified the Bridgewater Dairy as a potential source of nutrients that may increase in-stream nutrient concentrations in Nettle Creek.

Countywide data for Defiance and Williams counties were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

Non-permitted operations in Ohio must comply with BMP rules in ODA Division of Soil and Water Conservation's Agricultural Pollution Abatement Program.

- Manure collection, storage, and treatment facilities may not overflow (*OAC-901:13-1-02*) or seep (*OAC-901:13-1-03*) and discharge to waters of the state.
- Manure-contaminated runoff from feedlots and manure management facilities may not discharge to waters of the state (*OAC-901:13-1-04*)
- Land application of manure must comply with the Field Office Technical Guide or similar guidance (*OAC-901:13-1-11*)
- Special procedures for watersheds in distress (*OAC-901:13-1-19*)

OAC Chapter 901-13-1 prohibits manure application in the Western Lake Erie watershed (1) on snow covered or frozen soil, (2) when the top 2-inches of soil are saturated from precipitation, and (3) when the local weather forecast indicate a 50 percent chance of precipitation exceeding 0.5-inch in 24-hours. The exceptions are if (1) the manure is injected into the ground, (2) the manure is incorporated within 24-hours of application, (3) the manure is applied to a growing crop, or (4) during an emergency with pre-approval.

4.3.6.4 Indiana

In Indiana, the IDEM Office of Land Quality regulates both CAFOs and CFOs. Refer to Section 4.2.3 for a discussion of IDEM-issued NPDES CAFO permits. A CAFO is essentially a large CFO. IDEM regulates and must approve facility design and construction/expansion, facility setbacks, manure handling and storage, and manure land application. Eight CFOs are in the Indiana portion of the SJRW (Table C-15 and Figure C-8 in Appendix C).

Small livestock operations and hobby farms are throughout the SJRW in Indiana and some of the small hobby farms allow livestock direct access to streams (Rice 2005). Countywide data for Allen DeKalb, Noble, and Steuben counties were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

4.3.7 Wildlife

Wildlife such as deer, raccoon, waterfowl, riparian small mammals (e.g., beaver, otter) can be sources of bacteria and nutrients. The animal habitat and proximity to surface waters are important factors that determine if animal waste can be transported to surface waters. Waterfowl and riparian mammals deposit waste directly into streams while other riparian species deposit waste in the floodplain, which can be transported to surface waters by runoff from precipitation events. Animal waste deposited in upland areas

[41] Liquid manure is applied at a rate of 8,000 to 13,500 gallons per acre and solid manure is applied at 40 to 50 tons per acre (Bridgewater Dairy 2015).

can also be transported to streams and rivers; however, due to the distance from uplands to surface streams, only larger precipitation events can sustain sufficient amounts of runoff to transport upland animal waste to surface waters.

4.3.8 Erosion

Sedimentation and siltation were identified throughout the SJRW. For sedimentation (i.e., deposition of sediment) to occur, a source of sediment must be present. Various forms of erosion are a common source of sediment. Typically, erosion will increase as stream velocity and peak flow increases. Runoff over impervious surfaces and through agricultural drain tiles will have higher velocities and peak flows, and thus, increase erosion.

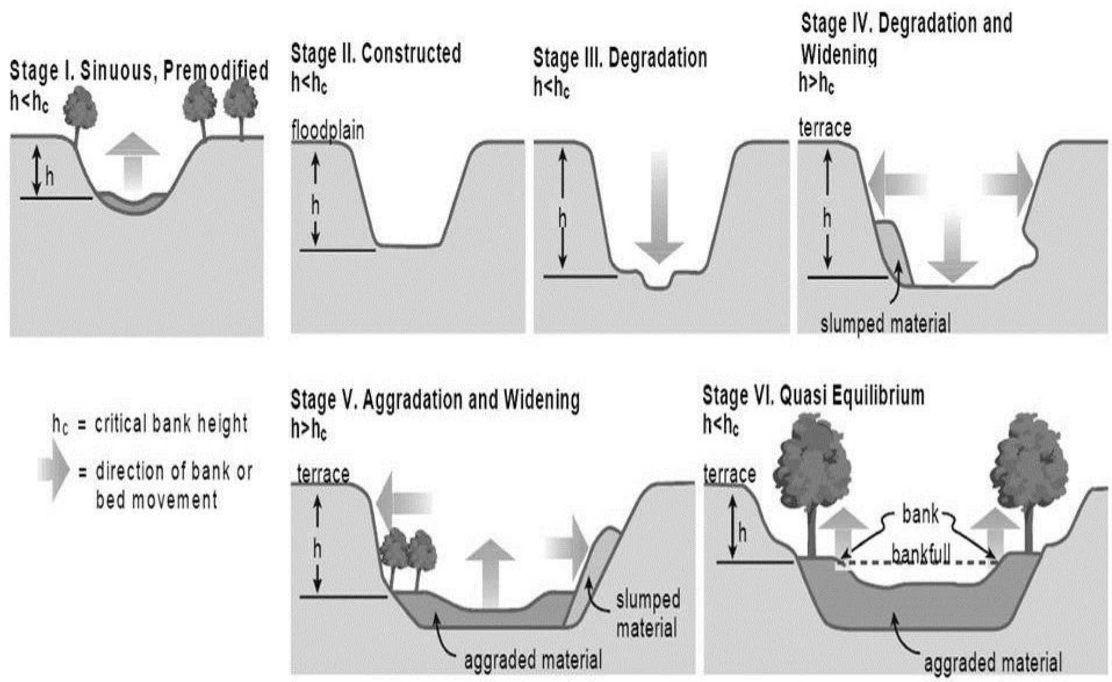
4.3.8.1 Sheet and Rill Erosion

Sheet erosion is the detachment of soil particles by raindrop impact and their removal by water flowing overland as a sheet instead of in channels or rills. Rill erosion refers to the development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hillsides. Sheet and rill erosion occur more frequently in areas that lack or have sparse vegetation. Sheet and rill erosion may contribute to a phosphorus impairment if the sediment that is eroded includes phosphorus attached to the sediment particles. Sheet or rill erosion may also transport pathogens from animal waste that was deposited by livestock, pets, or wildlife and from manure or septage that is applied to crop fields. Conservation tillage (e.g., no-till, mulch till, ridge till) "reduces sheet and rill erosion, reduces concentrated flow, and enhances infiltration" (Myers et al. 2000, p. 7).

4.3.8.2 Bank and Channel Erosion

Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance. This can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. Hydrology is a major driver for both sheet/rill and stream channel erosion.

Stream geomorphology pertains to the shape of stream channels and their associated floodplains. The capacity of a stream system to assimilate pollutants such as sediment, nutrients, and organic matter depends on features related to its geomorphology. This is especially the case for floodplains which, if connected to the channel, can store large quantities of sediment. A conceptual model of channel evolution was used to characterize varying stages of channel modification through time, as illustrated in Figure 15 (Simon and Hupp 1986). Stage I, undisturbed conditions, is followed by the construction phase (Stage II) where vegetation is removed or the channel is modified significantly (through altered hydrology, for example). Degradation (Stage III) follows and is characterized by channel incision. Channel degradation leads to an increase in bank heights and angles, until critical conditions of the bank material are exceeded. Eventually, stream banks fail by mass wasting processes (Stage IV). Sediments eroded from upstream degrading reaches and tributary streams are deposited along low-gradient downstream segments. This process reflects channel aggradation and begins in Stage V. Aggradation continues until stability is achieved through a reduction in bank heights and bank angles. Stage VI (re-stabilization) is characterized by the relative migration of bank stability upslope, point-bar development, and incipient meandering. Stages I and VI represent two true *reference* or attainment conditions.



Source: Simon and Hupp 1986.

Figure 15. Channel evolution model.

Bank erosion is a natural process. Acceleration of this process, however, leads to a disproportionate sediment supply, channel instability, and aquatic habitat loss (Rosgen 2006). Bank erosion processes are driven by two major components: streambank characteristics (e.g., erodibility) and hydraulic forces. Many land use activities affect both these components, which can lead to increased bank erosion. Riparian vegetation and floodplain protection provide internal bank strength. Bank strength can protect banks from fluvial entrainment and subsequent collapse. For instance, when riparian vegetation is changed from woody species to annual grasses, the internal strength is weakened, thus accelerating bank erosion processes. The material from the eroded banks is later deposited via sedimentation in a segment of the stream that is flowing more slowly or where water stops flowing (e.g., a lake).

Confronted by more frequent and severe floods that increase hydraulic forces, stream channels must respond. They typically increase their cross-sectional area to accommodate the higher flows. As described previously, this is done either through widening of the stream banks, down cutting of the stream bed, or frequently both. This phase of channel instability, in turn, triggers a cycle of stream bank erosion and habitat degradation.

Discharge flow rate is a major factor that affects sediment transport in stream systems. Higher discharge volumes lead to increased flow velocities. As channels are incised and flow velocities increase, shear stress and stream power exerted on the channel bed and banks increases. This effect, combined with channel stability, determines the amount of sediment that is mobilized, which in turn influences habitat and aquatic biota. In many areas of the SJRW, storm flows are higher than occurred under predevelopment conditions because of land use changes and increased efficiency brought about by channelization in urban and rural areas. These storm flows have greater power to erode sediment and can transport larger sediment loads downstream. When the sediment finally settles, within a slowly flowing reach or standing waterbody, it may impair aquatic life by filling in fish and benthic macroinvertebrate stream-bottom habitat.

Channelization increases peak flows as it allows flood waves to pass more quickly through the basin, increasing the volume and the erosive force of the water. Because bank erosion is often a symptom of larger, more complex problems, long-term solutions often involve much more than bank stabilization.

4.3.8.3 St. Joseph River Watershed

"Soil-erosion rates from cropland in the Maumee River Basin reported in the tillage transect files range from less than 1.0 to 5.0 ton/acre" (Myers et al. 2000, p. 15). The combined Tiffin River watershed and SJRW contribute little TSS to the Maumee River (9.3 percent) as compared to the combined Auglaize and St. Mary's rivers watersheds (47 percent), despite the Tiffin and St. Joseph rivers draining 29 percent of the Maumee River basin and the Auglaize and St. Mary's rivers draining 54 percent of the Maumee River basin (Myers et al. 2000). The poorly drained soils with high runoff potential in the combined Auglaize and St. Mary's rivers' watersheds contributed more suspended sediment loads than the moderately to somewhat poorly drained soils with moderate runoff potential in the combined Tiffin and St. Joseph rivers' watersheds.

4.4 Soil and Water Assessment Tool

Watershed simulation modeling using the U.S. Department of Agriculture's Agriculture Research Service-supported Soil and Water Assessment Tool (SWAT) was used to support the source assessment and TMDL development[42]. A new SWAT model was developed that incorporates elements of existing SWAT models for the SJRW and Maumee River basin (e.g., Purdue's SWAT model [Chaubey 2014]). The model results are presented in Section 4.4.2.

4.4.1 Revised SWAT Model

The SWAT model was developed following the requirements set forth in the quality assurance project plan (Tetra Tech 2015). Model development, calibration, validation, and quality assurance/quality control are presented in the model report (Appendix D). The following key factors of the new model distinguish it from the existing models; these updates are described in more detail in the model report:

- The new model was developed in SWAT 2012 revision 635, which was the most recent revision available when modeling activities began in the summer of 2015.
- The model domain was the *St. Joseph River* HU (HUC 041000003).
- Model hydrography was re-delineated to account for the selected model domain, new flowline NHD (revised by USGS), new Ohio EPA water quality and flow sample sites, and TMDL locations for this TMDL study.
- Hydrologic response units were re-developed using the 2011 NLCD (Jin et al. 2013), revised HSGs, and new cropland spatial data from NASS.
- Corn-soybean, corn-soybean-winter wheat, and winter wheat-alfalfa hay were simulated on HSG A and B soils with various tillage practices and application of chemical fertilizers and manure.
- The point sources input boundary conditions include additional point sources (that were not included in existing models either because they were too small or were not yet permitted) and include additional DMR data (i.e., more recent data).

[42] Tetra Tech did not evaluate other candidate models because rural agriculture composes a considerable portion of the project area, and SWAT is the only available model that incorporates a plant growth model based upon growing degree days and heat units. The plant growth algorithms incorporate nutrient uptake from the soil and thus influences the amount available for transmission to water bodies. Other commonly used watershed simulation models, like Load Simulation Program in C++ and Hydrologic Simulation Program in FORTRAN, do not include plant growth models.

- New HSTS type and failure rate information provided by ODH (2012, 2013) were also incorporated.
- Calibration and validation were performed with expanded datasets that include water chemistry grab samples collected by Ohio EPA in 2013, additional water chemistry grab samples at existing IDEM long-term sample sites (i.e., new data from 2012-2015) and continuous flow data recorded by USGS and Ohio EPA since development of the existing SWAT models.

4.4.2 SWAT Model Results

Two types of SWAT-derived loads are presented in this report

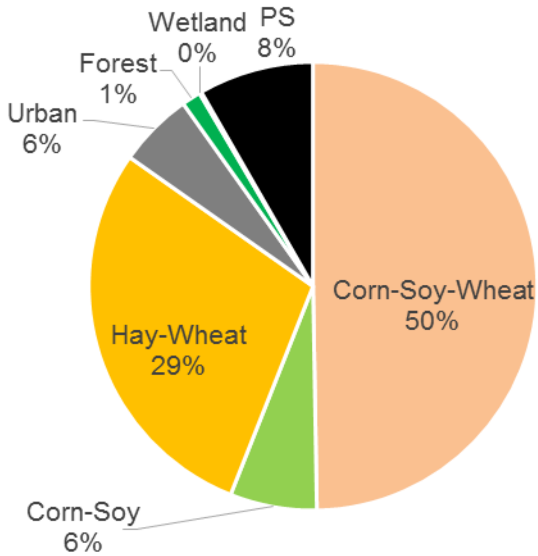
- In-stream loads represent the loads at a particular location, which is cumulative of all upstream load inputs and in-stream processes. These loads are plotted as daily loads on LDCs and used for the calculation of necessary reductions.
- Source loads represent the loads derived from surface and interflow runoff from various hydrologic response units (defined by the land cover, HSG, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads (across the 11-year SWAT model simulation period) in pie-charts and used to assess the relative dominance of various types of sources.

The following subsections present a brief discussion of the modeled results by pollutant; SWAT model results are evaluated in greater detail with LDCs and other assessments by subwatershed in Section 5, Section 6, and Appendix F. Basin-scale figures of pollutant loads by 12-dighit HU are presented in Appendix E.

4.4.2.1 Total Phosphorus

SWAT-simulated source loads indicate that crops are the dominant source of TP load to streams in the SJRW (Figure 16). Across the SJRW, 56 percent of the TP source load is from Indiana, 23 percent is from Ohio, and 21 percent is from Michigan; these results do not account for in-stream processes. TP source loads from the eight HUC10s vary from 9 to 17 percent of the total load across the SJRW and roughly coincide with land area per HUC10.

Maps of unit area loads of TP are presented in Figure E-1 of Appendix E. As simulated in SWAT, urbanized subwatersheds yielded less unit area TP loads (e.g., Fort Wayne is in subbasins 1 through 5 in Figure E-1, while Auburn is in subbasins 17 and 21 in Figure E-1).



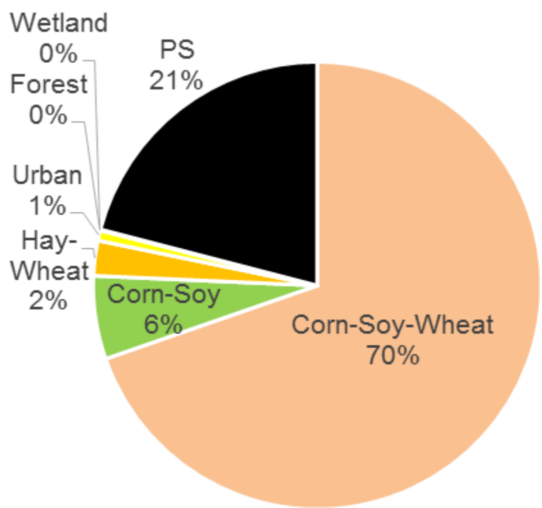
Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure 16. Summary of SWAT-simulated annual TP loads that drain to streams in the SJRW.

4.4.2.2 Total Suspended Solids

SWAT-simulated source loads indicate that crops are the dominant source of TSS load to streams in the SJRW (Figure 17). Across the SJRW, 63 percent of the TSS source load is from Indiana, 19 percent is from Ohio, and 18 percent is from Michigan; these results do not account for in-stream processes.

Maps of unit area loads of TSS are presented in Figure E-2 of Appendix E. As simulated in SWAT, urbanized subwatersheds yielded less unit area TSS loads (e.g., Fort Wayne is in subbasins 1 through 5 in Figure E-1, while Auburn is in subbasins 17 and 21 in Figure E-2).



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"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure 17. Summary of SWAT-simulated annual TSS loads that drain to streams in the SJRW.

4.5 Load Duration Curves

LDCs were used to assess the sources of pollutants that cause the impairments. Evaluations of LDCs are presented in the subwatershed-by-subwatershed linkage analyses in Section 5 and Section 6 and the LDC charts are presented in Appendix F. This section presents the methods to develop the LDCs.

4.5.1 Flow Duration Curve Development

An LDC is developed from a flow duration curve (FDC) and a target (targets are discussed in Section 4.5.2). A FDC is developed by generating a flow frequency table and plotting the data points to form a curve. The flow data must meet the secondary data requirements described in the QAPP (Tetra Tech 2015; e.g., reasonableness, completeness, and representativeness). The flow data must reflect a range of flows, from extremely high flows to extremely low flows. For the FDCs developed in the SJRW project area, flows were estimated through SWAT modeling.

4.5.2 LDC Targets

TP and TSS LDCs were developed using targets discussed in Section 2.3. In Indiana, targets apply to all streams whereas targets vary by stream size in Ohio. These targets, which were derived from monthly and seasonal analyses, were used as daily LDC targets.

The LDCs used to assess RU impairments were developed for *E. coli* since Indiana and Ohio use *E. coli* as the sole pathogen indicator. As previously described in Section 2.2.2, the seasonal geometric mean criteria were used as daily LDC targets.

4.5.3 Loading Capacity

LDCs are developed using the FDCs and pollutant targets. Essentially, the FDC is multiplied by the pollutant target and then converted to proper units. The LDC is the loading capacity for a given waterbody; for the impaired Indiana or Ohio waterbodies addressed in this TMDL report, the LDC (i.e., loading capacity) is the TMDL. Observed and simulated loads are then plotted with the LDC to determine when the loading capacity of the waterbody is exceeded.

Each of Ohio’s and Indiana’s water chemistry grab samples was converted to a load by multiplying the concentration by flow and converting to the appropriate units. The flows associated with state agencies’ water chemistry samples were SWAT-estimated.

These observed loads and simulated loads are plotted as points with the LDC. Points plotting above the LDC represent deviations from the pollutant target and the allowable load. Those points plotting below the curve represent compliance with pollutant targets and the allowable load. The area beneath the LDC is interpreted as the loading capacity of the stream (the LDC is the maximum loading capacity that is at the concentration of the pollutant target).

5 Aquatic Life Use Linkage Analysis

The objective of this linkage analysis is to provide the link between TP and TSS sources and the observed water quality impairments. For this project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the ALU impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions of TP and TSS and their likely effect on the observed ALU impairments in Indiana. Potential sources that impair designated ALUs (based upon information presented in Section 4) are summarized in Table 16. Summaries of the data are presented in Section F-2 of Appendix F for Indiana.

Eighteen segments across eleven 12-digit HUs are listed for IBC, seven segments across three 12-digit HUs are listed for nutrients, and two segments in different 12-digit HUs are listed for dissolved oxygen (IDEM 2014c). Five TP TMDLs were developed to address IBC listings, two TP TMDLs were developed to address nutrient listings, and one TP TMDL was developed to address IBC and TP listings. All six TSS TMDLs were developed to address IBC listings.

The following sections summarize the available sampling data for each HU with ALU-impaired segments and identify the source(s) that are most likely to cause the impairment. More detailed analyses for each HU are provided in Appendix F. A summary of sources is provided in Table 15.

Table 15. Summary of potential sources of TP and TSS

Potential source	Source assessment	Presence/absence [a]		Discussed in linkage analysis
		No. of sources	No. of HUC12s	
Point Sources				
Facilities covered by individual NPDES permits that discharge treated or untreated sanitary wastewater				
Treated effluent	Section 4.2	13 active facilities	12	Yes [b]
Combined sewer overflows	Section 4.2.2.1	3 communities	3	Yes
Sanitary sewer overflows	Section 4.2.2.2	1 community	1	Yes
Facilities or MS4s covered by individual or general NPDES permits that discharge stormwater				
Construction sites	Section 4.2.5	>250 sites	19	Yes [c]
Industrial facilities		40 facilities	16	Yes [c]
Regulated MS4s		3 MS4s	9	Yes [c]
Animal feeding operations covered by NPDES permits				
Concentrated animal feeding operations	Section 4.2.3	5 CAFOs	4	Yes [d]
Illicit discharges (i.e., not covered by NPDES permits)				
Sanitary sewer cross-connections with storm sewers	Section 4.2.5.2	*Assumed present but uncommon*		No [c]
Untreated sanitary wastewater	Section 4.2	*Assumed absent*		No [c]
Unpermitted industrial or construction stormwater discharges	Section 4.2.5	*Assumed absent*		No [c]
Nonpoint sources				
Crop agriculture				
Fertilizer and pesticide application	Section 4.3.3	*Assumed present and common*		Yes [b,]
Land application of biosolids	Section 4.2.2.3	119 fields	15	Yes [d]
Land application of manure	Section 4.3.6	*Assumed present*		No [c,]
Land application of septage	Section 4.3.4	*None*	0	No [d]
Animals				
Confined feeding operation	Section 4.3.6	8 CFOs	7	Yes [d]
Livestock (e.g., hobby farms)	Section 4.3.6	*Assumed present*		Yes [c]
Wildlife	Section 4.3.7	*Assumed present*		No [c,d]
HSTS				
Properly functioning off-site discharging HSTS	Section 4.3.2	*Assumed present*		No
Malfunctioning or failing HSTS	Section 4.3.2	*Assumed present*		Yes [c,d]

Notes

CAFO = concentrated animal feeding operation; CFO = concentrated feeding operation; HSTS = household sewage treatment system; MS4 = municipal separate storm sewer system; NPDES = National Pollutant Discharge Elimination System.

a. Presence and absence in the HUC12s in Indiana, which excludes areas of Ohio that drain to one of these WAUs.

b. SWAT modeling was used to evaluate this source

c. No data are available to quantitatively assess the impact of these sources on the impairments.

d. Analysis of qualitative data indicate these sources may contribute to the impairments but their contribution is insignificant.

5.1 West Branch Fish Creek (HUC 041000003 04 01)

West Branch Fish Creek is in Indiana and the subwatershed is bisected by the Indiana East-West Toll Road (I-80) and U.S. route 20. The subwatershed is agricultural with many woodlots. Rural residential properties are adjacent to cultivated crop fields and pastures.

IDEM listed two segments of West Branch Fish Creek (INA0341_01 and INA0341_02) for IBC. IDEM collected samples at two sites on one segment of West Branch Fish Creek. All eight TP and TSS concentrations were below targets (Section F-2.2). As such, TP and TSS TMDLs were not developed for these impaired segments.

5.2 Town of Alvarado-Fish Creek (HUC 041000003 04 05)

This subwatershed begins in Indiana at the confluence of West Branch Fish Creek with Fish Creek. After the confluence, Fish Creek flows southerly toward the Ohio-Indiana border before it then flows southwest away from the border. The landscape is dominated by crop agriculture with some woodlots, especially along Fish Creek. Rural residences are throughout the subwatershed.

5.2.1 Monitoring Data

IDEM collected samples from six sites along Fish Creek and one site on an unnamed tributary to Fish Creek (Section F-2.3). TP and TSS concentrations collected from 1999 through 2014 at long-term site LEJ050-0006 on Fish Creek exceeded applicable targets, especially during high flow conditions. TSS concentrations collected at three additional sites on Fish Creek also exceeded the target. TP and TSS concentrations from the single sample on the unnamed tributary to Fish Creek did not exceed applicable targets. IDEM listed segment INA0345_01 of Fish Creek for IBC and DO.

5.2.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.3. No permitted point sources are in this HU. TP and TSS loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading and over 99 percent of TSS loading, with hay-winter wheat (63 percent of TP and 34 percent for TSS) and corn-soybean-winter wheat (29 percent of TP and 60 percent of TSS) contributing the most source loading.

5.2.3 Conclusions

One segment in Indiana is listed for IBC and DO. Ambient water chemistry grab samples are not very indicative of impairment due to TP but do indicate some impairment due to TSS. Daily in-stream TP loads and TSS loads simulated in SWAT exceed targets. The anthropogenic sources of TP and TSS loads to the HU are OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Town of Alvarado-Fish Creek* (*04 05). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient and sediment loads.

5.3 Cornell Ditch-Fish Creek (HUC 041000003 04 06)

Fish Creek flows through predominantly agricultural land with few residences and few woodlots in Indiana and Ohio. Only Fish Creek (none of its tributaries) has a forested riparian corridor. The confluence of Fish Creek with the St. Joseph River is in Ohio just upstream of the city of Edgerton.

5.3.1 Monitoring Data

IDEM (seven sites), Ohio EPA (three sites), SJRWI (one site), and USGS (one site) sampled Fish Creek and IDEM (two sites) sampled an unnamed tributary to Fish Creek (Section F-2.4). TP and TSS concentrations collected from 1999 through 2014 at long-term site LEJ050-0007 on Fish Creek exceeded applicable targets. TSS concentrations collected at three additional sites on Fish Creek also exceeded the target. TP and TSS concentrations from one of the two sample sites on the unnamed tributary to Fish Creek exceeded applicable targets. IDEM listed segment INA0346_01 of Fish Creek and segment INA0346_T1003 of the unnamed tributary to Fish Creek for IBC.

5.3.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.4. No permitted point sources are in this HU but point sources are in upstream HUs. An analysis of TP and TSS data indicated that TP is likely bound to sediment and the source of high TP and TSS concentrations is potentially upland and in-channel sediment erosion. Evaluation of SWAT source loads indicated that crop field runoff was the source of 94 percent of the TP loading and 92 percent of TSS loading, with hay-winter wheat contributing the most TP source loading (57 percent) and corn-soybean-winter wheat contributing the most TSS loading (61 percent). SWAT results indicated that upstream point sources contributed 2 percent of the TP loading and 7 percent of the TSS loading.

5.3.3 Conclusions

Two segments in Indiana are listed for IBC. Ambient water chemistry grab samples are not very indicative of impairment due to TP but do indicate some impairment due to TSS. Daily in-stream TP loads and TSS loads simulated in SWAT exceed targets. The anthropogenic sources of TP and TSS loads to the HU are OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Cornell Ditch-Fish Creek* (*04 06). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient and sediment loads.

5.4 Big Run (HUC 041000003 05 02

Big Run flows easterly and is mostly in Indiana. The subwatershed includes many named tributaries (e.g., Donnell, John Smith, King, and Mary Metcalf ditches). While most of the subwatershed is rural and agricultural, the city of Butler is mostly in the Big Run subwatershed. U.S. route 6 and railroad lines bisect the subwatershed. As with much of the SJRW, forested woodlots are throughout the subwatershed.

IDEM listed two segments of Big Run (INA0352_04 and INA0352_05) for IBC. TP and TSS data collected from both segments were always below applicable targets (Section F-2.5). As such, TP and TSS TMDLs were not developed for these impaired segments.

5.5 Cedar Lake-Cedar Creek (HUC04100003 06 01)

Cedar Creek begins at the outflow of Cedar Lake in DeKalb County. The main tributary to Cedar Lake is Leins Ditch. About half of the Leins Ditch subwatershed is drained by McCullough Ditch that begins at the outlet of Indian Lake. Besides numerous small lakes and woodlots (including a few large woodlots in the headwaters) the land cover is predominantly agricultural. A small portion of the lower subwatershed includes industrial and commercial development, which is the outskirts of the town of Waterloo (e.g., Techo Bloc quarry and manufacturing facility). The U.S. Route 6 interchange with Interstate 69 is just upstream of the outlet of the subwatershed.

5.5.1 Monitoring Data

IDEM sampled 4 sites in this subwatershed (Section F-2.6). TP and TSS concentrations collected from 2011 through 2014 at long-term site LEJ080-0005 on Cedar Creek exceeded applicable targets. IDEM listed two segments of Cedar Creek (INA0361_03 and INA0361_04) for nutrients.

5.5.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.6. The only permitted point sources are for stormwater covered by general NPDES permits. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 96 percent of the TP loading, with corn-soybean-winter wheat contributing the most TP source loading (54 percent).

5.5.3 Conclusions

Two segments in Indiana are listed for nutrients. Ambient water chemistry grab samples collected at the HU outlet were not evaluated for TP. Daily in-stream TP loads simulated in SWAT infrequently exceed targets. The anthropogenic sources of TP loads to the HU are regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through TP a TMDL developed at the HU outlet of *Cedar Lake-Cedar Creek* (*06 01). Implementation of a TP through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

5.6 Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)

This subwatershed is composed of a short segment of Cedar Creek from the confluence of Dibbling Ditch to the confluence with Mason Ditch. Most the subwatershed drains to two tributaries of Cedar Creek: Dibbling Ditch and Schwartz Ditch. The Dibbling Ditch subwatershed is almost all rural, agricultural but does include the outskirts of the town of Ashley (to the north of this HU). The Schwartz Ditch subwatershed is also rural and agricultural. Cedar Creek flows along the perimeter of the town of Waterloo.

5.6.1 Monitoring Data

IDEM (3 sites) and SJRWI (4 sites) sampled streams in this subwatershed (Section F-2.7). TP concentrations in SJRWI samples exceeded applicable targets. IDEM listed four segments of Cedar Creek (INA0362_02, INA0362_03, INA0362_04, and INA0363_03) as impaired by nutrients.

5.6.2 Sources of Impairment

Potential sources of TP in this HU are discussed in Section F-2.7. The Waterloo Municipal STP (IN0020711; a sanitary WWTP) and Waterloo Public Water Supply (IN0049433; a WTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two industrial facilities and seven construction sites. Except during low-flow conditions, Waterloo Municipal STP effluent TP loads are insignificant; however, large effluent discharges during in-stream low flow conditions would become the dominant source of TP. Evaluation of SWAT source loads indicated that crop field runoff was the source of 89 percent of the TP loading, with corn-soybean-winter wheat contributing the most source loading (56 percent). SWAT results indicated that point sources covered by individual NPDES permits contributed 6 percent of the TP loading.

5.6.3 Conclusions

Four segments in Indiana are listed for nutrients. Ambient water chemistry grab samples collected at the HU outlet were not evaluated for TP. Daily in-stream TP loads simulated in SWAT infrequently exceed targets. The anthropogenic sources of TP loads to the HU are a WWTP, WTP, regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through a TP TMDL developed at the HU outlet of *Dibbling Ditch-Cedar Creek* (*06 02). Implementation of a TP through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

5.7 Matson Ditch-Cedar Creek (HUC 04100003 06 03)

The Matson Ditch subwatershed is predominantly rural and agricultural. Residential properties are at a higher density in the lower reaches of the subwatershed in areas closer to the town of Waterloo. The unnamed tributary to Matson Ditch meanders through crop fields and woodlots, with no forested riparian buffers along the segments flowing through crop fields. The unnamed tributary passes through culverts under state route 427 and county roads 16 and 51; it then flows in a straightened channel parallel to country road 51 until its confluence with Matson Ditch.

5.7.1 Monitoring Data

IDEM (1 site) and SJRWI (1 site) sampled streams in this subwatershed (Section F-2.8). IDEM samples indicated nutrient impairment (elevated TP and chlorophyll-*a* concentrations and low DO concentrations). IDEM listed the unnamed tributary to Matson Ditch (INA0363_T1001) as impaired by nutrients.

5.7.2 Sources of Impairment

Potential sources of TP in this HU are discussed in Section F-2.8. No permitted point sources are in this HU. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading, with corn-soybean-winter wheat contributing the most source loading (57 percent).

5.7.3 Conclusions

One segment is listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TP during low-flows. Daily in-stream TP loads simulated in SWAT infrequently exceed targets in high flow through mid-range flow conditions. The anthropogenic sources of TP loads to the HU are OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through a TP TMDL developed at the confluence of the unnamed tributary to Matson Ditch with Matson Ditch in *Matson Ditch-Cedar Creek* (*06 03). Implementation of a TP TMDL through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads
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5.8 Smith Ditch-Cedar Creek (HUC 04100003 06 04)

This subwatershed is composed of Cedar Creek from the confluence of Matson Ditch to the confluence with John Diehl Ditch. Three tributaries in this HU drain to Cedar Creek: Smith Ditch, Metcalf Ditch, and an unnamed tributary. The Smith Ditch subwatershed, upstream of the unnamed tributary to Smith Ditch (INA0364_T1003), is rural and agricultural. Smith Ditch and its unnamed tributary are channelized and straightened without forested riparian buffers. The lower reaches of Smith Ditch (INA0364_T1002) flow through the city of Auburn.

IDEM listed one segment of Smith Ditch (INA0364_T1001) for IBC. IDEM collected samples at one site on the impaired segment of Smith Ditch. All three TP and TSS concentrations were below targets (Section F-2.9). As such, TP and TSS TMDLs were not developed for this impaired segment.

5.9 Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)

This HU is composed of the John Diehl Ditch from the confluence of Peckhart Ditch to the confluence with Cedar Creek. Much of the HU is composed of the Peckhart Ditch subwatershed, while most of the John Diehl Ditch subwatershed is contained in the *Headwaters John Diel Hitch* HU (HUC 041000003 07 01). The largest tributary to Peckhart Ditch is Ober Ditch.

5.9.1 Monitoring Data

IDEM (3 sites) and SJRWI (4 sites) sampled ditches in this subwatershed (Section F-2.10). TP and TSS concentrations in IDEM samples exceeded applicable targets. IDEM listed one segment of Peckhart Ditch (INA0364_T1001) for IBC and DO.

5.9.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.10. The only permitted point sources are for stormwater covered by general NPDES permits. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading and over 99 percent of TSS loading, with corn-soybean-winter wheat contributing the most source loading (80 percent of TP loading and 91 percent of TSS loading).

5.9.3 Conclusions

One segment is listed for IBC and DO. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TP and TSS during moist conditions. Daily in-stream TP loads simulated in SWAT infrequently exceed targets in high flow and moist conditions, while simulated TSS loads more often exceed in the high flow and moist conditions. The anthropogenic sources of TP and TSS loads to the HU are regulated industrial facility stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the confluence of the Peckhart Ditch with John Diehl Ditch in *Peckhart Ditch-John Diehl Ditch* (*07 02). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

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5.10 Black Creek (HUC 04100003 07 04)

The Black Creek subwatershed is predominantly rural and agricultural. Segments of streams and ditches throughout the subwatershed are straightened and channelized. The western half of the subwatershed drains to Bilger Ditch; most residences are adjacent to row crop fields and there are many undeveloped woodlots. Wahn Ditch is the only major tributary to Bilger Ditch. Below the confluence of Bilger Ditch with Black Creek, Black Creek flows around the town of La Otto. The lower reaches of Black Creek, as it flows due east, are bounded by wider, forested riparian buffers.

5.10.1 Monitoring Data

IDEM (1 site) and SJRWI (3 sites) sampled streams and ditches in this subwatershed (Section F-2.11). TSS concentrations in one IDEM sample exceeded the applicable target. IDEM listed one segment of Black Creek (INA0374_05) for IBC.

5.10.2 Sources of Impairment

Potential sources of TSS in this HU are discussed in Section F-2.11. The LaOtto RSD WWTP (IN0058611; a sanitary WWTP) is covered by an individual NPDES permit, while a general NPDES permit for stormwater discharges cover two construction sites. Effluent TSS loads were typically an order of magnitude less than in-stream TSS loads. Evaluation of SWAT source loads indicated that crop field runoff was the source of 83 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (75 percent). SWAT results indicated that the LaOtto RSD WWTP contributed 17 percent of the TSS loading.

5.10.3 Conclusions

One segment is listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TSS during dry conditions. Daily in-stream TSS loads simulated in SWAT occasionally exceed targets in high flow and moist conditions. The anthropogenic sources of TSS loads to the HU are a sanitary WWTP, regulated construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TSS in this HU. The anthropogenic sources were addressed through a TSS TMDL developed at the HU outlet of *Black Creek* (*07 04). Implementation of a TSS TMDL through the installation of agricultural runoff BMPs should reduce in-stream sediment loads.

5.11 King Lake-Little Cedar Creek (HUC 04100003 07 05)

With the exception of the town of Avilla and city of Garrett in the headwaters of unnamed tributaries to Little Cedar Creek, this HU is predominantly agricultural, with most rural residences adjacent to row crop fields. Several subdivision have developed near Avilla, Garrett, and in the lower segments of Little Cedar Creek below the confluence of Black Creek (e.g., around the Holiday Lakes). Numerous small ponds and woodlots are scattered across the landscape. King Lake is south of Avilla and is an in-channel lake along an unnamed tributary of Little Cedar Creek.

5.11.1 Monitoring Data

IDEM (2 sites) and SJRWI (3 sites) sampled streams and ditches in this subwatershed (Section F-2.12). TSS concentrations in one IDEM sample exceeded the applicable target. IDEM listed two segments of Little Cedar Creek (INA0375_05 and INA0375_06) and a segment of an unnamed tributary to Little Cedar Creek (INA0375_T1007) for IBC

5.11.2 Sources of Impairment

Potential sources of TSS in this HU are discussed in Section F-2.12. The Avilla WTP (IN0052035), Avilla WWTP (IN0020664; a sanitary WWTP), and Indian Springs Recreational Campground (IN0032107; a seasonal sanitary WWTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two industrial facilities and 10 construction sites. Evaluations of SWAT-simulated in-stream loads indicates that effluent loads are orders of magnitude less than in-stream loads. Evaluation of SWAT source loads indicated that crop field runoff was the source of 84 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (76 percent). SWAT results indicated that point sources covered by individual NPDES permits contributed 16 percent of the TSS loading.

5.11.3 Conclusions

Three segments are listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TSS during dry conditions. Daily in-stream TSS loads simulated in SWAT infrequently exceed targets in moist conditions through dry conditions but frequently exceed during high flows. The anthropogenic sources of TSS loads to the HU are sanitary WWTPs, a WTP, regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TSS in this HU, although point source loads likely have a significant impact during low flow conditions. The anthropogenic sources were addressed through a TSS TMDL developed at the HU outlet of *King Lake-Little Cedar Creek* (*07 05). Implementation of a TSS TMDL through the installation of agricultural runoff BMPs should reduce in-stream sediment loads.

5.12 Dosch Ditch-Cedar Creek (HUC 04100003 07 07)

This HU begins on Cedar Creek at the confluence of John Diehl Ditch and ends at the confluence of Cedar Creek with the SJR just below the Cedarville Reservoir. The Garret City Ditch and Schmadel Ditch discharge to Cedar Creek in the northern portion of this HU. Little Cedar and Willow creeks discharge to Cedar Creek in the southwest corner of this HU where Cedar Creek switches from flowing southwest to flowing southeast. The lower reaches of Cedar Creek flow through large, forested parcels.

Much of the city of Garrett and the outskirts of the city of Auburn are in the northern portion of this HU. The southeast, lower portion of the HU is composed of subdivisions and the suburban-rural transition along the city of Fort Wayne. Much of the land from Garrett and Auburn to Fort Wayne is row crops with adjacent rural residences.

5.12.1 Monitoring Data

IDEM (15 sites) and SJRWI (4 sites) sampled streams and ditches in this subwatershed (Section F-2.13). TP and TSS concentrations exceeded targets at three sites on Cedar Creek but did not exceed at the site on Dosch Ditch. IDEM listed two segments of Cedar Creek (INA0377_03 and INA0377_04) and one segment of Dosch Ditch (INA0377_T1002) for IBC. IDEM also listed one segment of Dosch Ditch as impaired by nutrients.

5.12.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.13. The Garret City WWTP (IN0029969; a sanitary WWTP), is covered by an individual NPDES permit, while general NPDES permits for stormwater discharges cover three MS4s, four industrial facilities and 17 construction sites. Evaluations of SWAT-simulated in-stream loads indicate that effluent loads are orders of magnitude less than in-stream loads. Permitted point sources are also in upstream HUs. Evaluation of SWAT source loads indicated that crop field runoff was the source of 83 percent of the TP loading and 78 percent of the TSS loading, with corn-soybean-wheat contributing the most source loading (64 percent for TP and 70 percent for TSS). SWAT results indicated that point sources covered by individual NPDES permits contributed 10 percent of TP loading and 21 percent of the TSS loading.

5.12.3 Conclusions

Three segments are listed for IBC and one segment is listed for nutrients. Ambient water chemistry grab samples indicate a few TP exceedances in the high flow and moist conditions and indicate many TSS exceedances in the high flow through mid-range flows. Daily in-stream TP and TSS loads simulated in SWAT infrequently exceed TP targets in high flow through mid-range flows and frequently exceed TSS targets in high flow through dry conditions. The anthropogenic sources of TP and TSS loads to the HU are a sanitary WWTP, regulated MS4, industrial facility, and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Dosch Ditch-Cedar Creek* (*07 05). Implementation of TP and TSSs TMDL through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce in-stream nutrient and sediment loads.

5.13 Becketts Run-St. Joseph River (HUC 04100003 08 06)

This HU begins on the SJR at the confluence of Becketts Run and ends at the confluence of the SJR with the St. Mary's River where the Maumee River is formed. The HU is dominated by the city of Fort Wayne, with subdivisions along Becket's Run and downtown Fort Wayne and dense residential areas in the lower half of the HU.

5.13.1 Monitoring Data

IDEM (8 sites) and SJRWI (2 sites) sampled streams and ditches in this subwatershed (Section F-2.14). TP and TSS concentrations exceeded targets at three sites on the SJR. IDEM listed one segment of the SJR (INA0386_01) for IBC.

5.13.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.14. The DuPont WTP - North End (IN0060127, terminated)[43] and Fort Wayne Municipal WWTP (IN0032191; a sanitary WWTP but only CSO and SSO outfalls are in this HU) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two MS4s, two industrial facilities and 63 construction sites. Evaluation of SWAT source loads indicated that crop field runoff was the source of 85 percent of the TP loading and 80 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (50 percent of TP and 66 percent of TSS). SWAT results indicated that point sources covered by individual NPDES permits contributed 8 percent of TP loading and 19 percent of the TSS loading.

5.13.3 Conclusions

One segment is listed for IBC. Ambient water chemistry grab samples indicate a few TP exceedances in the high flow and moist conditions and indicate many TSS exceedances in the high flow and moist conditions and few TSS exceedances in the mid-range flows and dry conditions. Daily in-stream TP and TSS loads simulated in SWAT infrequently exceed TP targets in high flow through mid-range flows and frequently exceed TSS targets in high flow through mid-range flows. The anthropogenic sources of TP and TSS loads to the HU are a CSOs and SSOs at sanitary WWTP, a WTP, regulated MS4, industrial facility, and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production in upstream subwatersheds is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Becketts Run-St. Joseph River* (*08 06). Implementation of TP and TSSs TMDL through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce instream nutrient and sediment loads.

[43] Dupont WTP (IN0060127) was terminated February 3, 2015. This permit is included in discussion because it was active during the SWAT modeling period and may have contributed to the impairment.

6 Recreational Use Linkage Analysis

The objective of this linkage analysis is to provide the link between bacteria sources and the observed water quality impairments. For this project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the RU impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions of bacteria and their likely effect on the observed RU impairments in Ohio and Indiana. Potential sources of *E. coli* that impair designated RUs (based upon information presented in Section 4) are summarized in Table 16. Summaries of the data are presented in Section F-3 of Appendix F for Indiana. The remainder of this section presents weight-of-evidence analyses by HU.

All 14 of Ohio's WAUs are impaired by *E. coli* (Ohio EPA 2014a) and will be addressed through the development of *E. coli* TMDLs at a later date.

Sixty-one of Indiana's segments are impaired by *E. coli* (IDEM 2014c) and were addressed through the development of *E. coli* TMDLs. Since RU impairments are ubiquitous and subwatershed physical characteristics are fairly homogenous, this linkage analysis is at the 10-digit HU scale.

Table 16. Summary of potential sources of bacteria

Potential source	Source assessment	Presence/absence [a] No. of sources	Presence/absence [a] No. of HUC12s	Discussed in linkage analysis
Point Sources				
Facilities covered by NPDES permits that discharge treated or untreated sanitary wastewater				
Treated effluent [a]	Section 4.2	13 active facilities	12	Yes [b]
Combined sewer overflows	Section 4.2.2.1	3 communities	3	Yes
Sanitary sewer overflows	Section 4.2.2.2	1 community	1	Yes
Facilities or MS4s covered by NPDES permits that discharge stormwater				
Industrial facilities	Section 4.2.5	40 facilities	16	Yes [b]
Regulated MS4s		3 MS4s	9	Yes [b]
Animal feeding operations covered by NPDES permits				
Concentrated animal feeding operations	Section 4.2.3	5 CAFOs	4	Yes
Illicit discharges (i.e., not covered by NPDES permits)				
Sanitary sewer cross-connections with storm sewers	Section 4.2.5.2	*Assumed present but uncommon*		No [c]
Untreated sanitary wastewater	Section 4.2	*Assumed absent*		No
Unpermitted industrial stormwater discharges	Section 4.2.5	*Assumed absent*		No
Nonpoint sources				
Crop agriculture				
Land application of biosolids	Section 4.2.2.3	119 fields	15	No
Land application of manure	Section 4.3.6	*Assumed present*		Yes [b]
Land application of septage	Section 4.3.4	*Absent*		No
Animals				
Confined feeding operation	Section 4.3.6	8 CFOs	7	Yes
Livestock (e.g., hobby farms)	Section 4.3.6	*Assumed present*		Yes
Wildlife	Section 4.3.7	*None*	0	No [b]
HSTS				
Properly functioning off-site discharging HSTS	Section 4.3.2	*Assumed present*		No [c]
Malfunctioning or failing HSTS	Section 4.3.2	*Assumed present*		No [c,]
Illicit discharges				
Cross-connections with agricultural drain tiles	Section 4.3.2	*Assumed present*		No [c]
Unpermitted land application of biosolids	Section 4.3.2	*Assumed absent*		No [c,]

Notes

CAFO = concentrated animal feeding operation; CFO = concentrated feeding operation; HSTS = household sewage treatment system; MS4 = municipal separate storm sewer system; NPDES = National Pollutant Discharge Elimination System.

a. Facilities that are not permitted to discharge bacteria are excluded (e.g., water treatment plants).

b. No data are available to quantitatively assess the impact of these sources on the impairments.

c. Analysis of qualitative data indicate these sources may contribute to the impairments but their contribution is insignificant.

6.1 Fish Creek (HUC 04100003 04)

Fish Creek flows into and out of Indiana and Ohio and its mouth on the SJR is in Ohio. Like the SJRW, the Fish Creek subwatershed is dominated by rural agriculture and residential property. The lowest reaches of Fish Creek "supported a diverse and well organized community of aquatic organisms" (Ohio EPA 1994a, p. 9). These reaches also support three federally endangered bivalve mollusk species[44] and three state endangered bivalve mollusk species[45].

6.1.1 Monitoring Data

Ohio EPA collected 5 samples at three sites (Table F-5) in the Fish Creek subwatershed, while IDEM collected between 2 and 7 samples at 18 sites in the subwatershed (Table F-6). *E. coli* in Ohio ranged from 250 to 1,400 counts/100 mL, with geometric means from 575 to 667 counts/100 mL. All three Ohio assessment sites were in nonattainment. Excluding samples collected from Hamilton Lake, *E. coli* in Indiana ranged from 192 to 17,329 counts/100 mL, with geometric means from 445 to 2,888 counts/100 mL. RU attainment was assessed at 14 locations and IDEM found all 14 sites to be in nonattainment.

6.1.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.2. The Hamilton Lake Conservancy District (IN0050822; a sanitary WWTP) and Hamilton Water Works (IN0060216; a WTP) are covered by individual NPDES permits, while a general NPDES permit for stormwater discharges cover two industrial facilities. Effluent loads were typically orders of magnitude less than in-stream *E. coli* loads.

6.1.3 Conclusions

Two WAUs in Ohio and 9 segments in Indiana are impaired by *E. coli* in *Fish Creek* (HUC 04100003 04). Ambient water chemistry grab samples indicate frequent exceedances. The anthropogenic sources of *E. coli* loads to the HU are a sanitary WWTP, a WTP, regulated industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through five *E. coli* TMDLs in Indiana:

- West Branch Fish Creek at the outlet of the *West Branch Fish Creek* HU (HUC 04100003 04 01)
- Fish Creek at the outlet of the *Headwaters Fish Creek* HU (*04 02)
- Hiram Sweet Ditch at the outlet of *Hiram Sweet Ditch* HU (*04 04)
- Fish Creek at the outlet of *Town of Alvarado-Fish Creek* HU (*04 05)
- Fish Creek at Indiana-Ohio state line (*04 06)

These sources will also be addressed through two Ohio TMDLs in the SJRW that will be finalized at a later date:

- Fish Creek at the Ohio-Indiana state line (*04 02)
- Fish Creek at the outlet of *Cornell Ditch-Fish Creek* HU (*04 06)

Implementation of *E. coli* TMDLs through the installation of agricultural and urban runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

[44] The three federally endangered bivalve mollusk species are: northern riffle shell, club shell mussel, and white catspaw pearly mussel (Ohio EPA 1994a, p. 9).
[45] The three state endangered bivalve mollusk species are: rayed bean shell, rabbits foot, and purple liliput mussels (Ohio EPA 1994a, p. 9).

6.2 Sol Shank Ditch-St. Joseph River (HUC 04100003 05)

The SJR flows southwest through Williams and Defiance counties, with Big Run joining the SJR before it flows into Indiana. Much of the Big Run subwatershed is in Indiana. Buck Creek and Sol Shank Ditch flow east and join the SJR in Indiana. Big Run flows through Butler, IN, which is the largest developed area in the 10-digit HU, while the SJR flows through the village of Edgerton, OH. Rural agriculture dominates the landscape in both states and this area has less forested riparian buffers and woodlots than the Fish Creek subwatershed to the north.

6.2.1 Monitoring Data

Ohio EPA collected 5 samples from one site on Big Run and 5 to 10 samples from multiple sites on the SJR (Table F-5), while IDEM collected 5 samples from one site on Big Run and 2 samples from one site on the SJR (Table F-6). *E. coli* in Big Run ranged from 78 to 1,210 counts/100 mL with a geometric mean of 290 counts/100 mL; this site was on a segment in non-attainment of its RU. *E. coli* in the SJR was 230 and 260 counts/100 mL; there were insufficient data to assess RU attainment on the SJR.

6.2.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.3. Permitted point sources in Ohio and Indiana are discussed in Section F-3.3.3. The Butler WWTP (IN0022462; a sanitary WWTP with CSOs and SSOs) and Steel Dynamics Inc. (IN0059021; sanitary and industrial waste) are covered by individual NPDES permits in Indiana, while East Side High School (ING250077) and Stafford Gravel, Inc. (ING490043) are covered by general NPDES permits along with six industrial facilities authorized to discharge stormwater. Only sanitary wastewater and industrial stormwater are permitted to contain *E. coli*. Effluent loads were typically orders of magnitude less than in-stream *E. coli* loads.

6.2.3 Conclusions

Four WAUs in Ohio and two of segments in Indiana are impaired by *E. coli* in *Sol Shank Ditch-St. Joseph River* (HUC 04100003 05). Ambient water chemistry grab samples indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are a sanitary WWTP, an industrial facility with sanitary and industrial waste, regulated industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through an *E. coli* TMDL in Indiana:

- Big Run at the Indiana-Ohio state line (*05 02)

These sources will also be addressed through four TMDLs in Ohio that will be finalized at a later date:

- SJR at the outlet of the *Bluff Run-St. Joseph River* HU (HUC 04100003 05 01)
- Big Run at the outlet of the *Big Run* HU (*05 02)
- SJR at the outlet of the *Russell Run-St. Joseph River* HU (*05 03)
- SJR at the outlet of the *Willow Run-St. Joseph River* HU (*05 05)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

6.3 Mason Ditch-Cedar Creek (HUC 04100003 06)

Cedar Creek begins at the outflow of Cedar Lake in DeKalb County. Besides numerous small lakes and woodlots (including a few large woodlots in the headwaters) the land cover is predominantly agricultural and rural with the cities of Auburn and Waterloo in the lower portion of the HU. A small portion of the lower subwatershed includes industrial and commercial development.

6.3.1 Monitoring Data

IDEM collected 5 or 6 samples from 5 sites on Cedar Creek and 5 sites on its tributaries (Table F-6). *E. coli* in Cedar Creek ranged from 10 to 25,000 counts/100 mL with geometric means at the 5 sites ranging from 247 to 1,499 counts/100 mL; all of the 5 sites were on segments that did not attain their RU. *E. coli* in the tributaries ranged from 20 to 1,300 counts/100 mL with geometric means at the 5 sites ranging from 155 to 937 counts/100 mL; four sites were on segments that did not attain their RU and one site was on a segment with insufficient data to assess RU attainment.

6.3.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.4. Four industrial facilities discharge non-contact cooling water or industrial process water that is not authorized to contain *E. coli* and are covered by individual NPDES permits. The Auburn WWTP (IN0020672; a sanitary WWTP with CSOs), the Waterloo Municipal STP (IN0020711; a sanitary WWTP), and Waterloo Public Water Supply (IN0049433; a WTP) are also covered by individual NPDES permits. Nine industrial facilities and one MS4 are covered by general NPDES permits for stormwater discharges. Only sanitary wastewater and stormwater are permitted to contain *E. coli*. With the exception of CSOs, effluent loads were typically orders of magnitude less than in-stream *E. coli* loads, only if very large effluent loads occur during low-flow conditions do effluent loads become a significant source of *E. coli*.

6.3.3 Conclusions

Twenty segments in Indiana are impaired by *E. coli* in *Matson Ditch-Cedar Creek* (HUC 04100003 06). Ambient water chemistry grab samples are limited but do indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs (one with CSOs), regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through four *E. coli* TMDLs:

- Cedar Creek at the outlet of the *Cedar Lake-Cedar Creek* (HUC 04100003 06 01)
- Cedar Creek at the outlet of the *Dibbling Ditch-Cedar Creek* HU (*06 02)
- Unnamed tributary to Mason Ditch at the confluence with Mason Ditch HU (*06 03)
- Cedar Creek at the outlet of the *Smith Ditch-Cedar Creek* HU (*06 04)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

6.4 Cedar Creek (HUC 04100003 07)

Lower Cedar Creek begins near Auburn, where Cedar Creek flows southerly toward the Fort Wayne metropolitan area and then flows easterly along the northern boundary of the metropolitan area. Little Cedar Creek is a major tributary to Cedar Creek. Most of the HU south of Auburn and Garrett City is rural and agricultural.

6.4.1 Monitoring Data

IDEM collected 5 to 9 samples from 4 sites on Cedar Creek, 4 to 6 samples from 3 sites on Little Cedar Creek, and 5 or 6 samples from 6 sites on their tributaries (Table F-6).

- **Cedar Creek:** concentrations ranged from 5 to 6,867 counts/100 mL with geometric means at the 4 sites ranging from 236 to 873 counts/100 mL; 3 sites were on segments that did not attain their RU and 1 site was on a segment that had insufficient data to assess RU attainment.
- **Little Cedar Creek:** concentrations ranged from 104 to 2,419 counts/100 mL with geometric means at the 3 sites ranging from 378 to 639 counts/100 mL; all of the 3 sites were on segments that did not attain their RU.
- **Tributaries:** concentrations ranged from 29 to 19,863 counts/100 mL with geometric means at the 6 sites ranging from 64 to 7,196 counts/100 mL; 4 sites were on segments that did not attain their RU and 2 sites were on segments that had insufficient data to assess RU attainment.

6.4.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.5. Several sanitary WWTPs and the Avilla Water Department (IN0052035; a WTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover nine industrial facilities and an MS4. At the four WWTPs, geometric means of effluent loads were typically several orders of magnitude less than in-stream loads in the high flow through mid-range flow conditions. Effluent loads at elevated concentrations may be contributing significantly to in-stream loads in the low flow zone. Because the effluent DMR does not include raw data, it is not possible to determine if the extremely elevated in-stream concentrations during low flow conditions are due to effluent discharges.

6.4.3 Conclusions

Twenty-three segments in Indiana are impaired by *E. coli* in *Cedar Creek* (HUC 04100003 07). Ambient water chemistry grab samples are limited but do indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs, regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through five *E. coli* TMDLs:

- Peckhart Ditch at the confluence with John Diehl Ditch (HUC 04100003 07 02)
- Black Creek at the outlet of the *Black Creek* HU (*07 04)
- Little Cedar Creek at the outlet of the *King Lake-Little Cedar Creek* HU (*07 05)
- Willow Creek at the outlet of the *Willow Creek* HU (*07 06)
- Cedar Creek at the outlet of the *Dosch Ditch-Cedar Creek* HU (*07 07)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs may reduce in-stream *E. coli* loads that impair the RU.

6.5 St. Joseph River (HUC 04100003 08)

The mainstem SJR in this HU begins downstream of the Ohio-Indiana state border, just below the confluence of Sol Shank Ditch. The HU is predominantly agricultural in the northeast half and transitions to suburban and then urban to the southwest in the greater Fort Wayne metropolitan area. Cedar Creek is the largest tributary to the SJR in this HU. Water is diverted to the Cedarville and Hurshtown reservoirs. At the outlet of this HU, the St. Joseph River joins the Saint Mary's River to form the Maumee River.

6.5.1 Monitoring Data

IDEM collected 5, 6, or 82 samples from 7 sites on the SJR and 2 samples from 1 site on Tiernan Ditch (Table F-6). *E. coli* in the SJR ranged from 5 to 28,000 counts/100 mL with geometric means at the 7 sites ranging from 87 to 1,336 counts/100 mL; 4 sites were on segments that did not attain their RU and 3 sites were on segments that had insufficient data to assess RU attainment.. *E. coli* in Tiernan Ditch was 150 and 170 counts/100 mL; this site was on a segment that had insufficient data to assess RU attainment.

6.5.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.6. Several WTPs, Deer Track Estates WWTP (IN0059749; a sanitary WWTP), and Fort Wayne Municipal WWTP (IN0032191 a sanitary WWTP but only CSO and SSO outfalls are in this HU) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover 13 industrial facilities and two MS4s. At the Deer Track Estates WWTP, geometric means of effluent loads were typically several orders of magnitude less than in-stream loads.

6.5.3 Conclusions

Three segments in Indiana are impaired by *E. coli* in *St. Joseph River* (HUC 04100003 08). Ambient water chemistry grab samples are limited but do indicate infrequent exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs (including one with CSOs and SSOs), regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through two *E. coli* TMDLs:

- SJR just upstream of the confluence with Bear Creek (HUC 04100003 08 02)
- SJR at the outlet of the *Swartz Cannahan Ditch-St. Joseph River* HU (*08 03)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs may reduce in-stream *E. coli* loads that impair the RU.

7 TMDLS and Allocations

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. When future growth (FG) is a concern and can be quantified, it is also included. Conceptually, this is defined by the following equation:

$$TMDL = \sum WLA + LA + MOS + AFG$$

The TMDL was calculated at the target, which is typically the most conservative numeric criterion for a given constituent, multiplied by the flow and converted to appropriate units. For example, the total phosphorus TMDL for a hypothetical headwaters stream at the 50^{th} percentile flow (10 cfs) would be calculated as

TMDL = (50^{th} percentile flow) x (target) x (conversion factors)
(10 cfs) x (0.30 mg/L) x (86,400 s/d) x (28.3168 L/ft^3) x (2.205 x 10^{-6} lb/mg)
16.2 lb/d

All loads are reported on a daily time-scale. The loads shown in the TMDL tables are calculated at the flow duration interval that represents the midpoint of the flow zone (e.g., for the high-flow zone [0 to 10^{th} percentile], the TMDL was calculated at the 5^{th} percentile).

7.1 Load Duration Curves

Allowable pollutant loads in the SJRW TMDL project area were determined using LDCs. Discussions of load duration curves are in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). The LDC approach for this project was presented in Section 4.5. LDCs for the impaired HUs are presented in the linkage analyses presented in Appendix F.

7.2 Allocations

Load duration analyses were conducted for 12-digit HUs that contained one or more impaired segment. For both ALU and RU impairments, LDCs and TMDLs were typically developed at the outlet of a 12-digit HU. In cases where a 12-digit HU was bisected by the Indiana-Ohio state line, LDCs and TMDLs were developed at the state line when Indiana waters flowed into Ohio waters. In similar cases where Ohio waters flowed into Indiana waters, LDCs and TMDLs were developed at the outlet of the 12-digit HU (in Indiana) with a boundary condition set at the state line.

Necessary percent reductions were calculated at TMDL sites using the LDCs IDEM *E. coli*, TP, or TSS monitoring data[46] and SWAT-estimated flows. The reductions were calculated as the subtraction of the TMDL from the maximum of observed loads per flow zone and then divided by the maximum observed loads per flow zone. This calculation generates the portion of the observed load that must be reduced to achieve the TMDL. The necessary reductions were calculated at the midpoint of the flow duration intervals (e.g., the 5^{th} percentile high flow conditions [0^{th} to 10^{th} percentile]) using the maximum of observed loads within the selected flow duration interval.

[46] In-stream water quality data were obtained from IDEM.

A summary of the allowable loads and allocations in the project area is presented in this section. TMDL allocation tables are presented in Appendix H.

7.2.1 TMDL Targets and Loading Capacity

TMDL targets for ALU impairments were set to 0.30 mg/L TP (refer back to Section 2.3.1.3) and to 30 mg/L TSS (refer back to Section 2.3.3.3). The targets for each TMDL are presented in Table 18 in Section 0.

TMDL targets for RU impairments were derived from numeric criteria. The targets were based upon the geometric mean criteria for the applicable recreation use (Section 2.2.2). The targets for each TMDL are presented in Table 18 in Section 0.

7.2.2 Load Allocation

The LA is the load contribution from nonpoint sources and natural background levels. It was calculated as the remainder of the load from the loading capacity after the WLAs, MOS, and FGR are allocated.

7.2.3 Upstream State Contribution

Upstream state contributions were calculated for the Indiana SJRW TMDLs where appropriate (i.e., where waters in Ohio drained to an impaired waters in Indiana). Upstream state contributions were developed in response to CWA regulations that discourage upstream or adjacent jurisdictions from negatively impacting the water quality in downstream waters (U.S. EPA 2012b). In the event that downstream waters are determined to be impaired, the upstream contributions must be assigned a portion of the loading capacity (TMDL) for the impaired water. Refer back to Section 2 for a discussion of U.S. EPA (2012) draft guidance on multijurisdictional TMDLs and how U.S. EPA encourages the development of separate loads for upstream or adjacent states in the downstream state's TMDLs.

For Indiana's TMDLs, the upstream state contributions for Ohio are identified as "Ohio upstream contribution" unless Ohio EPA is developing a TMDL for such a location, in which case the upstream contribution in the Indiana TMDL is identified as the name of Ohio EPA's TMDL. For example, Indiana's *E. coli* TMDL for Fish Creek at the outlet of HUC 04100003 04 02 includes an upstream contribution for Ohio that is identified as "Fish Creek (HUC 04100003 04 02; Ohio-Indiana state line)" because Ohio EPA is developing an *E. coli* TMDL at the state line, where Fish Creek flows back to Indiana from Ohio.

Since Ohio EPA is not developing TP or TSS TMDLs for the SJR, Indiana's TP and TSS TMDLs on the SJR include separate upstream state contributions for both Ohio and Michigan, in lieu of allocating to a "Ohio and Michigan combined" upstream states contribution.

7.2.4 Wasteload Allocations

Wasteload allocations were allocated for permitted point sources, including facilities with individual NPDES permits and regulated stormwater (MS4s, construction, and industrial). WLAs are based upon permit limits and design flows, except for WLAs associated with stormwater that were based upon an area ratio of the regulated stormwater area and the TMDL subwatershed. For all TMDLs, the non-stormwater WLAs, MOS, and AFG were allocated first. The remaining load was then allocated to stormwater WLAs and LAs.

7.2.4.1 Individual NPDES Permittees (Non-Stormwater)

WLAs for individual NPDES permittees, except for stormwater individual permittees, were calculated as the design flow multiplied by the effluent limits, as reported in the permit, and converted to proper units. The calculation for the *E. coli* WLA for the Garrett WWTP (IN0029969) is presented below as an example.

Individual WLA = (design flow) * (monthly average permit limit) * (unit conversions)
$(1.2 * 10^6$ gpd) * (125 counts/100 mL) *(1,000 mL/L) * (3.78541 L/gal)
$5.7 * 10^9$ c/d

Individual WLAs apply to all flow zones within the LDC-TMDL framework, unless the permits or IDEM identifies unique circumstances for which a WLA would not apply to certain flow zones (e.g., IDEM prohibits dry weather CSO discharges).

For the following three TP TMDLs in Indiana, most of the WLAs for individual NPDES permittees (non-stormwater) were calculated using the July through September average of monthly DMR flow data, in lieu of average design flow, and a TP target of 1.0 mg/L:

- Cedar Creek at the HU outlet (*06 02)
- Cedar Creek at the HU outlet (*07 07)
- SJR at the HU outlet (*08 06)

If the average design flows were used, along with a TP target of 1.0 mg/L, the summation of WLAs would exceed the loading capacity of the streams within the low flow duration zone. During the low flow duration zone, these streams can be dominated by effluent flow. However, the in-stream TMDL target is 0.30 mg/L; thus, during the low flow duration zone, the loading capacity that is dominated by effluent flow is calculated with a 0.30 mg/L TP target while all the effluent load would be allocated using a 1.0 mg/L TP target. Since the summation of WLAs cannot exceed the loading capacity, IDEM decided to allocate individual NPDES (non-stormwater) point sources using the July through September average of monthly DMR flow data that is more representative of summer effluent discharges; these flows are presented in Table 17. For two facilities[47], the WLAs were calculated using average design flows because the July through September average DMR flows were not less than average design flows.

Table 17. July through September average DMR flows for specified point sources

HUC12	NPDES	Facility	July through September average DMR flow (mgd)
06 02	IN0020711	Waterloo Municipal STP	0.187
07 07	IN0020664	Avila WWTP	0.286
	IN0020672	Auburn WWTP [a]	1.984
	IN0022969	Garrett Municipal WWTP	0.563
	IN0032107	Indian Springs Rec Campground	0.004
	IN0047473	Corunna WWTP	0.013
	IN0058611	La Otto Regional Sewer District	0.020
08 06	IN0022462	Butler WWTP [a]	0.907
	IN0058441	St. Joe - Spencerville RSD	0.065

Notes
DMR = discharge monitoring report; mgd = million gallons per day; NPDES = National Pollutant Discharge Elimination System; STP = sewage treatment plant; WLA = wasteload allocation; WWTP = wastewater treatment plant.
a. Flows for the Auburn WWTP (IN0020672) and Butler WWTP (IN0022462) WLAs for treated effluent. The WLAs for combined sewer overflows were not affected by these low flow duration zone calculations.

[47] The WLAs for Auburn Gear (IN0000566; does not apply to the separate WLAs for non-contact cooling water or industrial storm water) and Steel Dynamics Inc. (IN0059201; does not apply to the separate WLA for industrial stormwater) were calculated using the average design flows and a TP target of 1.0 mg/L.

7.2.4.2 Individual NPDES Permittees with Industrial Stormwater Discharges

Individual WLAs per industrial facility were developed using a ratio of the areas of the industrial facility and TMDL subwatershed. In cases where an industrial facility covered by an individual NPDES permit has multiple waste streams, separate individual WLAs were developed for stormwater and process water.

The industrial facility's regulated area is the area of the parcel that the address of the permittee is associated with, including adjacent parcels if such parcels are owned by the same entity. The ratio (industrial facility's regulated area divided by TMDL subwatershed area) was rounded up to the next one-tenth of a percent (e.g., 16.36 percent rounded up to 16.4 percent). For very small facilities, when the area-ratio was less than 0.1 percent, then the area-ratio was rounded up to 0.1 percent. A calculation of the ratio for the Contech U.S., LLC (IN0046043) facility in the *Smith Ditch-Cedar Creek* (*06 04) is presented below as an example:

$$\text{Ratio} = \text{(regulated area) / (TMDL subwatershed area)}$$
$$\text{Ratio}_{IN0046043} = \text{(12.91 acres) / (23,334 acres)}$$
$$0.00055$$
$$0.1\ \%$$

The area-ratio was then applied to the quantity of the TMDL (i.e., the loading capacity) less the summation of non-stormwater WLAs, MOS, and AFG. Because the individual WLAs are calculated using an area-ratio applied to a TMDL that varies by flow condition (i.e., a LDC), the WLA varies by flow condition. A calculation of the WLA for the Contech U.S., LLC (IN0046043) in the *Smith Ditch-Cedar Creek* (*06 04) for *E. coli* in the high flow zone is presented below as an example:

$$\text{WLA} = \text{Ratio} * [\text{TMDL} - (\sum \text{WLA}_{\text{non-stormwater}} + \text{MOS} + \text{AFG})]$$
$$\text{WLA}_{3ID00070} = 0.1\% * [2.05*10^{11} - (5.17*10^{8} + 2.05*10^{10} + 1.02*10^{10})] \quad \text{(in counts/day)}$$
$$0.1\% * [1.74*10^{11}]$$
$$1.74*10^{8} \text{ counts/day}$$

7.2.4.3 Individual NPDES Permittees (CSOs)

WLAs for CSOs were developed for the cities of Auburn, Butler, and Fort Wayne based upon their approved LTCPs and/or Consent Decree. The WLAs for each permitee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP. Both TMDLs and LTCPs have the goal of using their unique functions to attain WQS, but the TMDLs should not be seen as superseding LTCPs. Each permitee is working on Long-Term Control Plan implementation with IDEM (and EPA) to address long-term control of CSO discharges to the St. Joseph River. As the LTCPs are implemented, the annual impacts of CSOs upon water quality will be reduced considerably.

7.2.4.4 General NPDES Permittees (Non-Stormwater)

The approach for developing WLAs for individual NPDES permits was also applied to general NPDES permits, unless the general NPDES permits are for stormwater or HSTS.

7.2.4.5 Industrial Stormwater Covered by a General NPDES Permit

Gross WLAs per TMDL subwatershed were developed using a ratio of the summation of the areas of the regulated industrial facilities in each TMDL subwatershed and the area of the TMDL subwatershed. The area-ratio was rounded up to the next one-tenth of a percent (e.g., 0.23 percent rounded up to 0.3 percent).

Then, as described in Section 0, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG.

7.2.4.6 Construction Stormwater Covered by a General NPDES Permit

Gross WLAs per TMDL subwatershed were developed using a ratio of the summation of the areas of the regulated construction sites in each TMDL subwatershed and the area of the TMDL subwatershed. The area-ratio was rounded up to the next one-tenth of a percent (e.g., 0.67 percent rounded up to 0.7 percent). Then, as described in Section 0, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG.

7.2.4.7 Municipal Separate Storm Sewer System Stormwater Covered by a General NPDES Permit

For each regulated MS4 entity, the individual WLA was calculated using a ratio of the surrogate regulated MS4 area to the drainage area of the TMDL subwatershed. The surrogate regulated areas are discussed in Section 4.2.5.5. The surrogate regulated area is then divided by the TMDL subwatershed areas to calculate an area-ratio. As with the industrial stormwater WLAs, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG. Because the individual WLAs are calculated using an area ratio applied to a TMDL that varies by flow condition (i.e., a LDC), the WLA varies by flow condition.

7.2.5 Allocation for Future Growth

AFG were assigned to all TMDLs to account for potential new sources. An AFG of 5 percent was assumed for all Indiana TMDLs based upon best professional judgment. An evaluation of 2000 and 2010 Census data showed that population grew in Allen, DeKalb, Noble and Steuben, counties. Evaluation of individual municipalities showed that the following cities and towns significantly increased in population: Auburn, Avila, Clear Lake, Fort Wayne, Garrett, Huntertown, and Leo-Cedarville. The AFG of 5 percent was calculated using county population change (in percent) multiplied by the relative area of each county within the SJRW, and rounded to the nearest percent.

In addition to the explicit AFG, an implicit AFG is in each TMDL with individual NPDES WLAs. As discussed in Section 7.2.4.1, the WLA for each individual, non-stormwater NPDES permittee was developed using the permitted design flow. Most facilities are discharging below design flow; therefore, the facilities have additional capacity (in their WLA) that can be used in the future.

7.2.6 Margin of Safety

The CWA requires that a TMDL include an MOS to account for uncertainty in the relationship between LAs and WLAs and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

Both implicit and explicit MOS were developed. The ALU TMDLs were developed at targets that represent monthly or seasonal averages for reference conditions but were applied as daily TMDL targets. Similarly, the seasonal geometric mean *E. coli* criteria were applied as daily TMDL targets. These are conservative target assumptions. An additional implicit MOS for *E. coli* TMDLs applies because the load duration analysis does not address the die-off of pathogens.

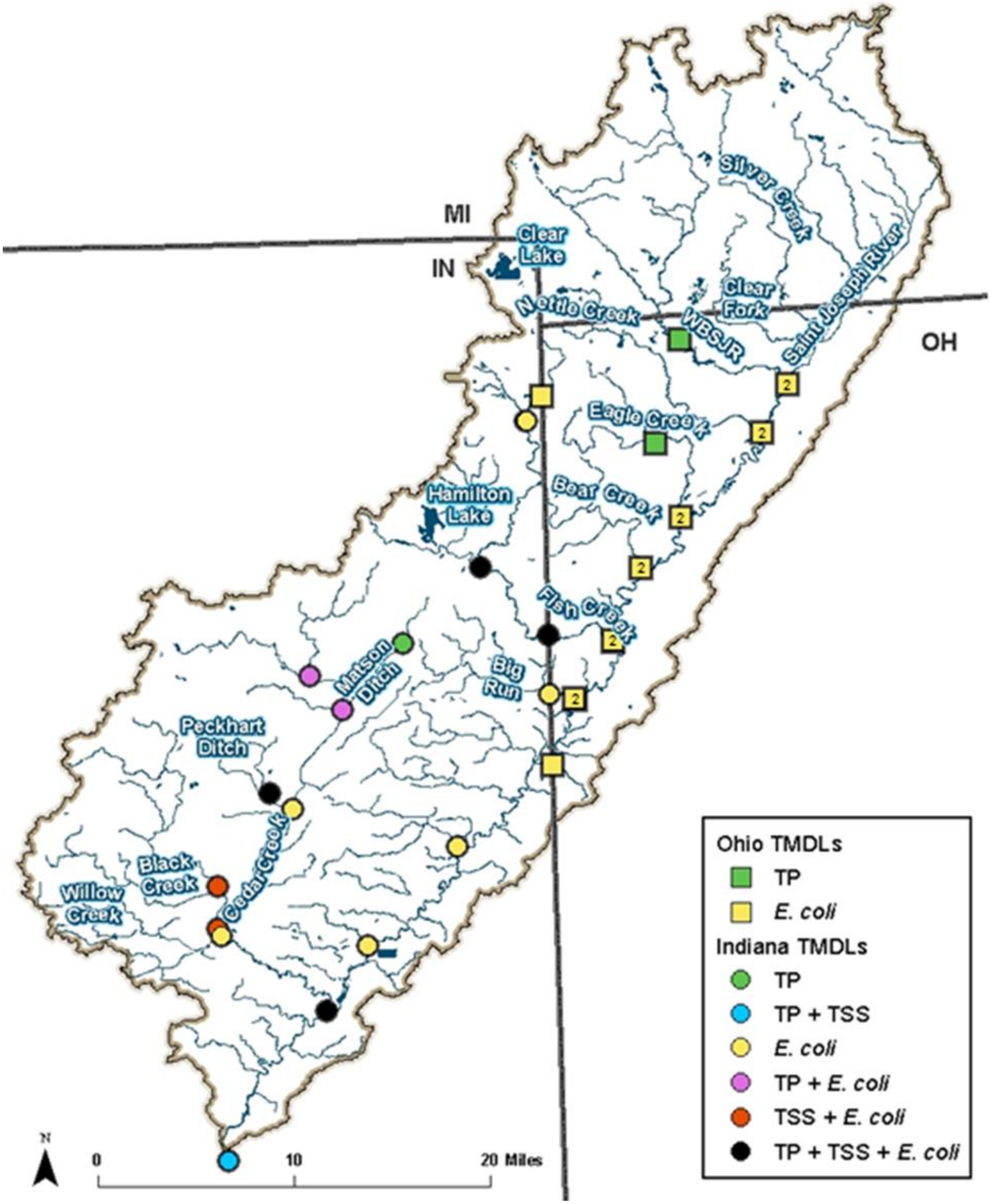
An explicit MOS of 10 percent of the TMDL was allocated for *E. coli* TMDLs and an explicit MOS of 5 percent was allocated for TP TMDLs. This explicit MOS was specified because the use of the load duration curves is expected to provide reasonably accurate information on the loading capacity of the stream, but the estimate of the loading capacity could be subject to potential error associated with the SWAT modeling used to estimate flows in the project area. The 5 percent MOS for the TP TMDLs is to account for the uncertainty associated with the modeling estimates of flow (i.e., the allowable load might be estimated too low if the model underestimates the actual flow in the stream). An additional 5 percent MOS is applied for the *E. coli* TMDLs because bacterial sampling results are highly heterogeneous and analytical determinations of bacterial counts also have relatively low laboratory precision.

7.3 Summary of TMDLs and Reductions

Seventeen HUC12s in Indiana's portion of the SJRW were not in full attainment of their ALUs and RUs. LDC-based TMDLS were developed for each waterbody-pollutant combination (i.e., 32 LDCs). Necessary reductions were calculated for each flow zone of each LDC.

7.3.1 TMDLs

ALU impairments were addressed through eight TP TMDLs and seven TSS TMDLs, while RU impairments were addressed through 17 *E. coli* TMDLs (Figure 18 and Table 18). A TP TMDL and TSS TMDL were developed at the mouth of the SJR; most TMDLs were developed for tributaries.



Notes
TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.
Ohio E. coli TMDL symbols along the SJR overlap Ohio E. coli TMDL symbols at the mouths of tributaries to the SJR.

Figure 18. TMDLs in the SJRW.

Table 18. LDC and TMDL locations and targets

Stream	Location	Pollutant	Target	Impairments addressed	Site to calculate reductions
Fish Creek (HUC 04100003 04)					
West Branch Fish Creek (HUC 04100003 04 01)					
Fish Creek	HUC12 outlet	*E. coli*	125	INA0341_01, INA0341_02	LEJ050-0064
Headwaters Fish Creek (HUC 04100003 04 02) [a]					
Fish Creek	HUC12 outlet	*E. coli*	125	INA0342_01, INA0342_T1003, INA0342_T1004	LEJ050-0023
Hiram Sweet Ditch (HUC 04100003 04 04)					
Hiram Sweet Ditch	HUC12 outlet	*E. coli*	125	INA0344_03	LEJ050-0054
Town of Alvarado-Fish Creek (HUC 04100003 04 05)					
Fish Creek	HUC12 outlet	TP	0.30	INA0345_01	LEJ050-0006
		TSS	30	INA0345_01	LEJ050-0006
		E. coli	125	INA0345_01	LEJ050-0066
Cornell Ditch-Fish Creek (HUC 04100003 04 06) [a]					
Fish Creek	state border	TP	0.30	INA0346_01, INA0346_T1003	LEJ050-0007
		TSS	30	INA0346_01, INA0346_T1003	LEJ050-0007
		E. coli	125	INA0346_01, INA0346_T1003	LEJ050-0068
Sol Shank Ditch-St. Joseph River (04100003 05) [a]					
Big Run (HUC 04100003 05 02)					
Big Run	state border	*E. coli*	125	INA0352_03, INA0352_04	LEJ060-0015
Mason Ditch-Cedar Creek (HUC 04100003 06)					
Cedar Lake-Cedar Creek (HUC 04100003 06 01)					
Cedar Creek	HUC12 outlet	*E. coli*	125	INA0361_03, INA0361_04, INA0361_T1001, INA0361_T1002	LEJ080-0005
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)					
Cedar Creek	HUC12 outlet	*E. coli*	125	INA0362_02, INA0362_03, INA0362_04, INA0362_T1004, INA0363_03	LEJ080-0006
Mason Ditch (HUC 04100003 06 03)					
Unnamed tributary to Mason Ditch	confluence with Mason Ditch	TP	0.30	INA0363_T1001	LEJ080-0013
		E. coli	125	INA0363_T1001	LEJ080-0013
Smith Ditch-Cedar Creek (HUC 04100003 06 04)					
Cedar Creek	HUC12 outlet	*E. coli*	125	INA0364_01, INA0364_02, INA0364_03, INA0364_04, INA0364_05, INA0364_06, INA0364_T1001, INA0364_T1002	LEJ080-0009

Stream	Location	Pollutant	Target	Impairments addressed	Site to calculate reductions
Cedar Creek (HUC 04100003 07)					
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)					
Peckhart Ditch	HUC12 outlet	TP	0.30	INA0372_01	LEJ090-0040
		TSS	30	INA0372_01	LEJ090-0040
		E. coli	125	INA0372_01, INA0372_02, INA0372_T1002, INA0372_T1002A, INA0372_T1003	LEJ090-0034 LEJ090-0040
Black Creek (HUC 04100003 07 04)					
Black Creek	HUC12 outlet	TSS	30	INA0374_05	LEJ090-0041
		E. coli	125	INA0374_03, INA0374_04, INA0374_05, INA0374_T1008, INA0374_T1009, INA0374_T1010	LEJ090-0041
King Lake-Little Cedar Creek (HUC 04100003 07 05)					
Little Cedar Creek	HUC12 outlet	TSS	30	INA0375_05, INA0375_06, INA0375_T1007	LEJ090-0002 LEJ090-0033
		E. coli	125	INA0375_01, INA0375_02, INA0375_03, INA0375_04, INA0375_05, INA0375_06	LEJ090-0010
Willow Creek (HUC 04100003 07 06)					
Willow Creek	HUC12 outlet	*E. coli*	125	INA0376_02, INA0376_03, INA0376_T1004	LEJ090-0020
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)					
Cedar Creek	HUC12 outlet	TP	0.30	INA0377_03, INA0377_04, INA0377_T1002	LEJ090-0026
		TSS	30	INA0377_03, INA0377_04, INA0377_T1002	LEJ090-0026
		E. coli	125	INA0377_01, INA0377_02, INA0377_03, INA0377_04, INA0377_T1001	LEJ090-0011
St. Joseph River (HUC 04100003 08)					
Metcalf Ditch-St Joseph River (HUC 04100003 08 02)					
SJR	just upstream of Bear Creek	*E. coli*	125	INA0382_01	LEJ070-0008
Swartz Carnahan Ditch-St Joseph River (HUC 04100003 08 03)					
SJR	HUC12 outlet	*E. coli*	125	INA0383_01, INA0383_T1003	LEJ070-0026
Becketts Run-St. Joseph River (HUC 04100003 08 06)					
SJR	HUC12 outlet	TP	0.30	INA0386_01	LEJ100-0003
		TSS	30	INA0386_01	LEJ100-0003

Notes
EBSJR = East Branch St. Joseph River; HUC= hydrologic unit code; RM = river mile; SJR = St. Joseph River; WBSJR = West Branch St. Joseph River.
a. TMDLs to address impaired WAUs in Ohio will be published at a later date.

7.3.2 Necessary Pollutant Reductions to Achieve TMDLs

Pollutant reductions are necessary to achieve TMDLs (Table 19). They are calculated as the difference between the observed load with the LDC, and then divided by the observed load. If sufficient observed loads were available, necessary reductions were calculated for each of the five flow zones using the maximum of the observed loads per flow zone and the midpoint of the flow zone (e.g., 5^{th} duration interval for the high flow zone [0^{th} to 10^{th} duration interval]).

Necessary reductions to achieve the *E. coli* TMDLs were calculated using IDEM's grab samples (i.e., observed data) and SWAT-simulated flows. For some TMDLs, only five samples were collected between 2004 and 2014. Thus, few observed loads could be calculated for some flow zones and no reductions could be calculated for other flow zones.

For nine TMDLs, IDEM collected grab samples in 2000 and 2001, which is before the SWAT model simulation period (i.e., 2004-2014). *E. coli* observed loads could not be calculated for these samples, and thus, necessary load reductions could not be calculated. Instead, concentration-based load reductions were calculated. If five samples were collected within a 30 day period during Indiana's recreation season, the geometric mean of those five samples was evaluated with Indiana's geometric mean criterion (see Section 2.2 for a discussion of Indiana's WQS). If less than five samples were collected during such a timeframe, the sample with the largest *E. coli* concentration was compared with Indiana's single sample maximum criterion to calculate a necessary reduction.

For TP and TSS, necessary reductions were also calculated using IDEM grab samples and SWAT-simulated flow. IDEM collected many samples in each flow zone from Fish Creek, Cedar Creek, and the SJR; only a few samples were collected from smaller streams. Due to the lack of data in some flow zones, similar to the *E. coli* evaluation, no observed loads could be calculated for some flow zones and for other flow zones loads would be derived from one or two samples.

Calculated pollutant load reductions for the SJR River ranged from 0 to 99 percent for *E. coli* and from 0 to 66 percent for TP (Table 19), and 14 to 95 percent for TSS (Table 19). Reductions for the tributaries ranged from 14 to 99 percent for *E. coli*, 0 to 84 percent for TP; and 0 to 95 percent for TSS.

Table 19. Necessary pollutant reductions to achieve TMDLs

Stream	RM	Pollutant	High flow (0-10)	Moist conditions (10-40)	Mid-range flows (40-60)	Dry conditions (60-90)	Low flow (90-100)
Headwaters East Branch Black River (HUC 04100003 04)							
West Branch Fish Creek (HUC 04100003 04 01)							
West Branch Fish Creek	outlet	*E. coli*	--	61%	91%	90%	--
Fish Creek (HUC 04100003 04 02)							
Fish Creek	outlet	*E. coli*	97% [a]				
Hiram Sweet Ditch (HUC 04100003 04 02)							
Hiram Sweet Ditch	outlet	*E. coli*	68% [a]				
Fish Creek (HUC 04100003 04 05)							
Fish Creek	outlet	TP	80%	48%	none	none	none
		TSS	83%	92%	50%	none	none
		E. coli	--	--	--	--	89%
Fish Creek (HUC 04100003 04 06)							
Fish Creek	outlet	TP	15%	30%	10%	none	none
		TSS	88%	78%	34%	1%	none
		E. coli	--	--	--	--	93%
Sol Shank Ditch-St. Joseph River (04100003 05)							
Big Run (HUC 04100003 05 02)							
Big Run	state line	*E. coli*	--	--	--	none	80%
Mason Ditch-Cedar Creek (HUC 04100003 06)							
Cedar Lake-Cedar Creek (HUC 04100003 06 01)							
Cedar Creek	outlet	TP	--	--	--	--	--
		E. coli	99% [a]				
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)							
Cedar Creek	outlet	TP	--	--	--	--	--
		E. coli	54% [b]				
Mason Ditch (HUC 04100003 06 03)							
unnamed tributary to Mason Ditch	Mouth	TP	--	--	none	none [c]	none
Smith Ditch-Cedar Creek (HUC 04100003 06 04)							
Cedar Creek	Outlet	*E. coli*	54% [b]				

Stream	RM	Pollutant	High flow (0-10)	Moist conditions (10-40)	Mid-range flows (40-60)	Dry conditions (60-90)	Low flow (90-100)
Cedar Creek (HUC 04100003 07)							
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)							
Peckhart Ditch	outlet	TP	--	11%	none	none	none
		TSS	--	44%	none	18%	none
		E. coli	--	--	93%	99%	>99%
Black Creek (HUC 04100003 07 04)							
Black Creek	outlet	TSS	--	none	--	none	39%
		E. coli	--	--	--	--	84%
King Lake-Little Cedar Creek (HUC 04100003 07 05)							
Little Cedar Creek	outlet	TSS	--	--	--	none	82%
		E. coli	19% [b]				
Willow Creek (HUC 04100003 07 06)							
Willow Creek	outlet	*E. coli*	84% [b]				
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)							
Cedar Creek	outlet	TP	70%	68%	none	none	none
		TSS	93%	95%	12%	none	none
		E. coli	86% [b]				
St. Joseph River (HUC 04100003 08)							
Metcalf Ditch-St Joseph River (HUC 04100003 08 02)							
SJR	BC [d]	*E. coli*	80% [b]				
Swartz Carnahan Ditch-St Joseph River (HUC 04100003 08 03)							
SJR	outlet	*E. coli*	--	87%	none	none	1%
Becketts Run-St. Joseph River (HUC 04100003 08 06)							
SJR	outlet	TP	69%	65%	9%	none	none
		TSS	94%	95%	26%	48%	none

Notes
HUC = hydrologic unit code; RM = river mile; SJR = St. Joseph River; TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids
A double dash (“--“) indicates that no observed data are available for the specified flow zone.
A “none” indicates that no reduction is necessary.
a. A concentration-based reduction was calculated using Indiana’s single sample maximum criterion because grab samples were collected prior to the model simulation period and less than five samples were collected within a 30-day period in Indiana’s recreation season.
b. A concentration-based reduction was calculated using Indiana’s geometric mean criterion because grab samples were collected prior to the model simulation period and five samples were collected within a 30-day period in Indiana’s recreation season.
c. A single sample of 0.36 mg/L at the 81st flow duration interval is above the LDC; however, the sample is below the LDC at the 75th flow duration interval, which is the midpoint of the dry conditions flow zone.
d. St. Joseph River just upstream of the confluence of Bear Creek.

8 Water Quality Improvement Strategy

Restoration methods to bring an impaired water body into attainment with water quality standards generally involve an increase in the water body' s capacity to assimilate pollutants, a reduction of pollutant loads to the water body, or some combination of both. A water quality improvement strategy has been developed to identify the priority activities that can be undertaken to achieve water quality improvements, and eventually attainment of the designated use.

Several sources of anthropogenic pollutants were identified in the project area[48]. The sources of pollutants are discussed in Source Assessment (Section 4) and linkage analyses (Section 5 and Section 6). While no segments of waterbodies in Michigan are listed as impaired for their ALU or RU, waterbodies in Michigan likely contribute pollutant loads to the impaired WAUs in Ohio. As this is an Ohio TMDL report, the focus of the water quality improvement strategy is upon the Ohio WAUs; however, pertinent information regarding Michigan sources and implementation opportunities are included in this chapter.

The goals and indicators of the implementation framework are presented in Section 8.1, while potential best management practices (BMPs) are presented in Section 8.2. Section 8.3 discusses TMDL implementation through Indiana's NPDES programs. Section 8.4 presents programs that can be used to fund implementation activities. Reasonable assurance of TMDL implementation is discussed in Section 8.4.

8.1 Implementation Goals and Indicators

For each pollutant (i.e., *E. coli*, TP, and TSS), IDEM has identified broad goal statements and indicators. This information is to help watershed stakeholders determine how to track implementation progress over time and also provides the information necessary to complete a watershed management plan.

8.1.1 *E. coli* Goal and Indicator

The *E. coli* goal is for each stream in the SJRW to meet the TMDL target of 125 counts per 100 mL. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the *E. coli* TMDL target.

8.1.2 TP Goal and Indicator

The TP goal is for each stream in the SJRW to meet the TMDL target of 0.30 mg/L. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the TP TMDL target.

8.1.3 TSS Goal and Indicator

The TSS goal is for each stream in the SJRW to meet the TMDL target of 30 mg/L. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the TSS TMDL target.

8.2 Implementation Activity Options

Any number or combination of implementation activities might contribute to water quality improvement, whether applied at sites where the actual impairment was identified or at other locations where sources contribute indirectly to the water quality impairment. Table 20 summarizes implementation activities.

[48] As discussed in Section 2.4, PCBs are not addressed in this TMDL report.

Table 20. Potentially suitable BMPs to achieve TMDLs

Implementation Activities	Pollutant			Point Sources					Nonpoint Sources						
	Bacteria	Nutrients	Sediment	WWTPs and Industrial Facilities	CSOs	Regulated Stormwater Sources	CAFOs	Illicit connections	Cropland	Pastures and Livestock Operations	CFOs	Streambank Erosion	OWTS	Wildlife/Domestic Pets	Urban NPS Runoff
Inspection and maintenance	X	X	X	X	X	X	X						X		
Outreach and education and training	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
System replacement	X	X			X			X					X		
Conservation tillage/residue management	X	X	X						X						
Cover crops	X	X	X						X			X			
Filter strips	X	X	X			X	X		X	X	X	X			X
Grassed waterways	X		X				X		X		X	X			
Riparian forested/herbaceous buffers	X	X	X				X		X	X	X	X		X	X
Manure handling, storage, treatment, and disposal	X	X					X			X	X				
Composting	X	X				X									X
Alternative watering systems	X		X							X		X			
Stream fencing (animal exclusion)	X	X	X							X		X			
Prescribed grazing	X	X	X							X		X			
Conservation easements	X	X	X			X			X	X					X
Two-stage ditches		X	X			X			X			X			X
Rain barrel		X	X			X						X			X
Rain garden		X	X		X	X						X			X
Street rain garden		X	X		X	X						X			X
Block bioretention		X	X		X	X						X			X
Regional bioretention		X	X		X	X						X			X
Porous pavement		X	X		X	X						X			X
Green alley		X	X		X	X						X			X
Green roof		X	X		X	X						X			X
Dam modification or removal		X	X									X			
Levee or dike modification or removal		X	X												
Stormwater planning and management	X	X	X	X	X	X						X	X	X	X

Implementation Activities	Pollutant			Point Sources					Nonpoint Sources						
	Bacteria	Nutrients	Sediment	WWTPs and Industrial Facilities	CSOs	Regulated Stormwater Sources	CAFOs	Illicit connections	Cropland	Pastures and Livestock Operations	CFOs	Streambank Erosion	OWTS	Wildlife/Domestic Pets	Urban NPS Runoff
Comprehensive Nutrient Management Plan	X	X							X		X				
Constructed Wetland	X	X	X	X	X	X		X	X			X		X	X
Critical Area Planting			X							X		X			
Drainage Water Management		X							X			X			
Heavy Use Area Pad	X		X							X					
Nutrient Management Plan		X							X	X		X			
Terrace			X						X						
Land Reconstruction of Mined Land			X									X			
Sediment Basin		X	X			X									X
Pasture and Hay Planting	X	X	X						X	X	X	X		X	
Streambank and Shoreline Protection			X						X	X	X	X		X	X
Conservation Crop Rotation		X	X						X						
Field Border	X	X							X	X	X			X	
Waste Treatment Lagoon	X	X					X			X	X				

Notes
CAFO = concentrated animal feeding operation; CFO = confined feeding operation; CSO = combined sewer overflow; NPS = nonpoint source; OWTS = on-site wastewater treatment system; WWTP = wastewater treatment plant.
Illicit connections represents illicitly connected “Straight Pipe” systems.

8.3 Point Sources

Recommendations for entities covered by NPDES permits can be implemented through IDEM's regulatory authority. Specific recommendations for facilities covered by individual NPDES permits are provided in Section 8.3.1. Sewer systems with CSOs and SSOs are discussed in Section 8.3.2 while entities covered by general NPDES permits are discussed in Section 8.3.3.

8.3.1 Facilities Covered by Individual NPDES Permits in Indiana

Reductions for TP loads will be necessary at several facilities according to calculated TMDLs in locations where TP contribute to ALU impairments. Recommendations for NPDES permits, according to calculated TMDLs, are summarized in Appendix I Table I -1 for TP and Table I-2 for TSS.

Reductions for *E. coli* loads will also be necessary at several facilities according to calculated TMDLs in locations where *E. coli* causes nonattainment of RUs. Recommendations for NPDES permits, according to calculated TMDLs, are summarized by discharger and watershed in Table I -3.

IDEM will work with permit holders to accomplish any needed reductions in loadings. New and renewed individual NPDES permits will account for WLAs allocated during TMDL development. Existing permit conditions for TP, TSS, and *E. coli* for facilities not listed in Table I -1, Table I-2, and Table I -3 should remain unchanged.

8.3.2 Sewer Systems Covered by Individual NPDES Permits with CSOs or SSOs in Indiana

CSOs occurred at three CSSs (i.e., Auburn, Butler, and Fort Wayne) and SSOs were documented at some permitted treatment facilities. The WLAs for each permitee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. WLA are shown in Table I-4, and Table I -5. To comply with the TMDLs, the Auburn, Butler, and Fort Wayne CSSs must comply with their LTCP and their NPDES permits that are both approved by IDEM. Fort Wayne must also comply with its consent decree that is approved by a federal court with input from U.S. EPA and IDEM. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities of the LTCP. Both TMDLs and LTCPs have the goal of using their unique functions to attain WQS, but the TMDLs should not be seen as superseding LTCPs. SSOs received no WLAs because these illicit discharges are prohibited. Through Indiana's regulatory authority, required improvements and compliance schedules for both CSOs and SSOs are written into facilities' NPDES permits. As the LTCPs are implemented and as SSOs are eliminated, the potential impacts of CSOs and SSOs upon water quality will be reduced considerably.

8.3.3 Facilities Covered by General NPDES Permits in Indiana

Industrial facilities that are covered by general NPDES permits received WLAs when such entities contributed to ALU or RU impairments; however, IDEM will not include such WLAs in the renewals of the general permits. Four facilities covered by general permits (non-stormwater; see Table C-3 in Appendix C) received individual WLAs. Facilities that discharge industrial stormwater that are covered by the general NPDES permit are included in HU-scale gross WLAs. Entities covered by the general permit for MS4 stormwater received individual WLAs.

Entities covered by general NPDES permits must comply with permit requirements (e.g., implementing certain BMPs) and IDEM may ensure compliance through the agency's regulatory authority. Additionally, county health departments, local government agencies, and SWCDs work with IDEM and TMDL project area stakeholders to reduce pollutant loads through various environmental and compliance programs.

8.4 Summary of Programs

There are a number of federal, state, and local programs that either require or can assist with the implementation activities recommended for the SJRW in the implementation table. A description of these programs is provided in this section and Table 21 summarizes spending for some of these programs within the SJRW.

Table 21. Fiscal year 2015 funding for programs in the Indiana portion of the SJRW

Program	Type	Agency	Allen County	DeKalb County	Noble County	Steuben County
	Local		$163,500	$198,686	$45,642	$80,831
CWI	State	SSCB	$10,000	$85,885	$10,000	$10,885
GBDP		IDNR	--	--	$5,015	--
LARE		IDNR	$32,000	$12,000	$16,500	$308,055
WHCP		IDNR	--	--	$2,461	$1,170
CRP/CREP	Federal	FSA	$656,191	$1,044,500	$674,498	$630,812
CSP		NRCS	$60,987	$803,612	$207,320	$1,309
EQIP		NRCS	$626,089	$957,434	$1,179,519	$51,688
GRP		NRCS	--	--	$3,389	--
WRP/WREP		NRCS	$461,217	$10,649	--	--
Total			**$2,009,984**	**$3,112,766**	**$2,144,343**	**$1,084,750**

Source: Indiana Conservation Partnership (http://www.in.gov/isda/icpreports/)
Note: CRP/CREP = Conservation Reserve Program / Conservation Reserve Enhancement Program; CSP = Conservation Stewardship Program; CWI = Clean Water Indiana; EQIP = Environmental Quality Incentives Program; FSA = Farm Service Agency; GBDP = Game Bird Habitat Development Program; GRP = Grassland Reserve Program; IDNR = Indiana Department of Natural Resources; LARE = Lake and River Enhancement Program; NRCS = Natural Resources Conservation Service; SSCB = State Soil Conservation Board; WHCP = Wildlife Habitat Cost-Share Program; WRP/WREP = Wetland Reserve Program / Wetland Reserve Enhancement Program.

8.4.1 Federal Programs

8.4.1.1 Clean Water Act Section 319(h) Grants

Section 319 of the federal CWA contains provisions for the control of nonpoint source pollution. The section 319 program provides for various voluntary projects throughout the state to prevent water pollution and also provides for assessment and management plans related to waterbodies in Indiana impacted by nonpoint source (NPS) pollution. The Watershed Planning and Restoration Section within the Watershed Assessment and Planning Branch of the Office of Water Quality administers the section 319 program for the NPS-related projects.

U.S. EPA offers CWA section 319(h) grant monies to the state on an annual basis. These grants must be used to fund projects that address nonpoint source pollution issues. Some projects which the Office of Water Quality has funded with this money in the past include developing and implementing WMPs, BMP demonstrations, data management, educational programs, modeling, stream restoration, and riparian buffer establishment. Projects are usually two to three years in length. Section 319(h) grants are intended to be used for project start-up, not as a continuous funding source. Units of government, nonprofit groups, and universities in the state that have expertise in nonpoint source pollution problems are invited to submit section 319(h) proposals to the Office of Water Quality.

8.4.1.2 Clean Water Action Section 205(j) Grants

CWA section 205(j) provides for planning activities relating to the improvement of water quality from nonpoint and point sources by making funding available to municipal and county governments, regional planning commissions, and other public organizations. For-profit entities, non-profit organizations, private associations, universities and individuals are not eligible for funding through section 205(j). The

CWA states that the grants are to be used for water quality management and planning, including, but not limited to:

- Identifying most cost effective and locally acceptable facility and non-point source measures to meet and maintain water quality standards;
- Developing an implementation plan to obtain state and local financial and regulatory commitments to implement measures developed under subparagraph A;
- Determining the nature, extent, and cause of water quality problems in various areas of the state.

The section 205(j) program provides for projects that gather and map information on nonpoint and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and develop watershed management plans.

8.4.1.3 USDA's Conservation Technical Assistance

The purpose of the Conservation Technical Assistance program is to assist land-users, communities, units of state and local government, and other Federal agencies in planning and implementing conservation systems. The purpose of the conservation systems is to reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands.

One objective of the program is to assist individual land-users, communities, conservation districts, and other units of State and local government and Federal agencies to meet their goals for resource stewardship and assist individuals in complying with State and local requirements. USDA's Natural Resources Conservation Service (NRCS) assistance to individuals is provided through conservation districts in accordance with the Memorandum of Understanding signed by the Secretary of Agriculture, the Governor of the State, and the conservation district. Assistance is provided to land-users voluntarily applying conservation practices and to those who must comply with local or State laws and regulations.

Another objective is to provide assistance to agricultural producers to comply with the highly erodible land and wetland (Swampbuster) provisions of the 1985 Food Security Act as amended by the Food, Agriculture, Conservation and Trade Act of 1990 (16 U.S.C. 3801 et. seq.), the Federal Agriculture Improvement and Reform Act of 1996, and wetlands requirements of Section 404 of the CWA. NRCS makes HEL and wetland determinations and helps land-users develop and implement conservation plans to comply with the law. The program also provides technical assistance to participants in USDA cost-share and conservation incentive programs.

NRCS collects, analyzes, interprets, displays, and disseminates information about the condition and trends of the Nation's soil and other natural resources so that people can make good decisions about resource use and about public policies for resource conservation. They also develop effective science-based technologies for natural resource assessment, management, and conservation.

There are many programs within the USDA NRCS that assist with water conservation. The 2014 Farm Bill has streamlined many of these programs to further enable farmers, ranchers, and forest landowners to get assistance. These programs include:

- Environmental Quality Incentives Program
- Conservations Stewardship Program
- Agricultural Management Assistance
- Agricultural Water Enhancement Program

- Cooperative Conservation Partnership Program
- Conservation Innovation Grants
- Emergency Watershed Protection Program
- Wildlife Habitat Incentive Program
- Conservation Technical Assistance
- Conservation of Private Grazing Land
- Farm and Ranch Lands protection program
- Agricultural Conservations Easement Program
- Grassland Reserve Program
- Healthy Forest Reserve program
- Wetlands Reserve Program
- Regional Conservation Partnership Program

Currently in the greater Western Lake Erie Basin, there is a Regional Conservation Partnership Program, The Tri-State Western Lake Erie Basin Phosphorus Reduction Initiative that is funded for five years. It is a multi-state RCPP project that brings together more than 40 partnering organizations from Michigan, Ohio and Indiana to reduce the runoff of phosphorous into the Western Lake Erie Basin. A diverse team of partners will use a targeted approach to identify high-priority sub-watersheds for phosphorus reduction and increase farmer access to public and private technical assistance—including innovative demonstrations of practices that NRCS does not yet cover in Michigan, Ohio, and Indiana. Identified actions are coordinated with the Ohio Lake Erie Phosphorus Task Force Report and will move Lake Erie toward goals developed in the Great Lakes Water Quality Agreement Annex 4 Nutrient Strategies. The partners will gage success and monitor results using project-wide water quality monitoring and watershed modeling conducted by national experts from multiple scientific entities and institutions (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/oh/programs/farmbill/rcpp/?cid=nrcseprd362006).

8.4.2 State Programs

8.4.2.1 State Point Source Control

The State's Point Source Control, administered by the IDEM Office of Water Quality's Permitting section is charges with fulfillment of the CWA through the NPDES permit program. The purpose of the NPDES permit is to control the point source discharge of pollutants into the waters of the State such that the quality of the water of the State is maintained in accordance with applicable water quality standards. NPDES permit requirements ensure that the minimum amount of control is imposed upon any new or existing point source through the application of technology-based treatment requirements. Control of discharges from WWTPs, industrial facilities, MS4s, and CSOs consistent with WLAs is implemented through the NPDES program. The Storm water and Sediment Control Program works primarily with developers, contractors, realtors, property holders and others to address erosion and sediment concerns on non-agricultural lands, especially those undergoing development.

8.4.2.2 State Nonpoint Source Control Program

The State's Nonpoint Source Program, administered by the IDEM Office of Water Quality's Watershed Planning and Restoration Section, focuses on the assessment and prevention of nonpoint source water pollution. The program also provides for education and outreach to improve the way land is managed. Through the use of federal funding for the installation of BMPs, the development of watershed management plans, and the implementation of watershed restoration pollution prevention activities, the program reaches out to citizens so that land is managed in such a way that less pollution is generated.

Nonpoint source projects funded through the Office of Water Quality are a combination of local, regional, and statewide efforts sponsored by various public and not-for-profit organizations. The emphasis of these projects has been on the local, voluntary implementation of nonpoint source water pollution controls. The

Watershed Planning and Restoration Section administers the section 319 funding for nonpoint source-related projects, as well as section 205(j) grants.

To award 319 grants, Watershed Planning and Restoration Section staff review proposals for minimum 319(h) eligibility criteria and rank each proposal. In their review, members consider such factors as: technical soundness; likelihood of achieving water quality results; strength of local partnerships; and competence/reliability of contracting agency. They then convene to discuss individual project merits and pool all rankings to arrive at final rankings for the projects. All proposals that rank above the funding target are included in the annual grant application to U.S. EPA, with U.S. EPA reserving the right to make final changes to the list. Actual funding depends on approval from U.S. EPA and yearly congressional appropriations.

Section 205(j) projects are administered through grant agreements that define the tasks, schedule, and budget for the project. IDEM project managers work closely with the project sponsors to help ensure that the project runs smoothly and the tasks of the grant agreement are fulfilled. Site visits are conducted at least quarterly to touch base on the project, provide guidance and technical assistance as needed, and to work with the grantee on any issues that arise to ensure a successful project closeout.

8.4.2.3 Indiana State Department of Agriculture Division of Soil Conservation

The Division of Soil Conservation's mission is to ensure the protection, wise use, and enhancement of Indiana's soil and water resources by increasing agricultural economic benefits by assisting Indiana's farmers in the application of advanced agronomic technologies while improving upon Indiana's soil health and water quality.

The Division administers the Clean Water Indiana soil conservation and water quality protection program under guidelines established by the State Soil Conservation Board, primarily through the local SWCDs in direct service to land users. The Division staff includes field-based resource specialists who work closely with land users, assisting in the selection, design, and installation of practices to reduce soil erosion on agricultural land. District Support Specialists work cooperatively with soil and water conservation districts and other conservations partners in the design of programs that reach land users, the general public, governmental officials, and primary and secondary educational institutions on the husbandry and management of soil and water resources. The Storm water and Sediment Control Program works primarily with developers, contractors, realtors, property holders and others to address erosion and sediment concerns on non-agricultural lands, especially those undergoing development.

8.4.2.4 Indiana Conservation Partnership

The Partnership is comprised of eight Indiana agencies and organizations who share a common goal of promoting conservation. To that end, the mission of the Indiana Conservation Partnership is to provide technical, financial and educational assistance needed to implement economically and environmentally compatible land and water stewardship decisions, practices and technologies. Working together, the partnership provides technical, educational, and financial assistance to citizens to solve erosion and sediment-related problems occurring on the land or impacting public waters.

8.4.2.5 Indiana Department of Natural Resources, Division of Fish and Wildlife

The Lake and River Enhancement program utilizes a watershed approach to reduce nonpoint source sediment and nutrient pollution of Indiana's and adjacent states' surface waters to a level that meets or surpasses state water quality standards. To accomplish this goal, the program provides technical and financial assistance to local entities for qualifying projects that improve and maintain water quality in public access lakes, rivers, and streams.

8.4.2.6 State Revolving Fund Loan Program

The State Revolving Fund (SRF) is a fixed rate, 20-year loan administered by the Indiana Finance Authority. The SRF provides low-interest loans to Indiana communities for projects that improve wastewater and drinking water infrastructure. These projects include septic education and mainline hookups. The Program's mission is to provide eligible entities with the lowest interest rates possible on the financing of such projects while protecting public health and the environment. SRF also funds non-point source projects that are tied to a wastewater loan. Any project where there is an existing pollution abatement need is eligible for SRF funding.

8.4.2.7 Hoosier Riverwatch

Hoosier Riverwatch, administered by the IDEM Office of Water Quality Watershed Assessment and Planning Branch, is a water quality monitoring initiative which aims to increase public awareness of water quality issues and concerns through hands-on training of volunteers in-stream monitoring and cleanup activities. Hoosier Riverwatch collaborates with agencies and volunteers to educate local communities about the relationship between land use and water quality and to provide water quality information to citizens and governmental agencies working to protect Indiana's rivers and streams.

8.4.3 Local Programs

Programs taking place at the local level are key to successful TMDL implementation. Local Partners such as the SJRWI and participating county SWCDs are instrumental to bringing grant funding into the SJRW to support local protection and restoration projects. This section provides a brief summary of the local programs taking place in the SJRW that will help to reduce *E. coli*, nutrient, and sediment loads, as well as provides ancillary benefits to the watershed.

8.4.4 Local Watershed Group

The SJRWI and local SWCDs have received grant funding to develop and implement WMPs throughout the SJRW. They continue to follow implementation actions as outlined in the action registers of each WMP. A list of completed watershed management plans for the SJRW is included below:

- Cedar Creek WMP, 01-383, (http://www.in.gov/idem/nps/3261.htm)
- St. Joseph River (Lower)-Bear Creek WMP, 5-73, (http://www.in.gov/idem/nps/3200.htm)
- St. Joseph River (Maumee) WMP, 02-502, (http://www.in.gov/idem/nps/3201.htm)[49]
- St. Joseph River (Middle) WMP, 10-65, (http://www.in.gov/idem/nps/3901.htm)[50]
- St. Joseph River (Upper) WMP, 2-16, (http://www.in.gov/idem/nps/3961.htm)[51]

8.5 Reasonable Assurance

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that state and local agencies, governments, and private groups mount a committed effort to carry out or facilitate such actions. For successful implementation, adequate resources must also be available.

[49] St. Joseph River (Maumee) WMP, 02-502, is for the entire 8-digit HUC that includes portions of Ohio and Michigan.
[50] St. Joseph River (Middle) WMP, 10-65, includes portions of Ohio.
[51] St. Joseph River (Upper) WMP, 2-16, includes portions of Ohio and Michigan.

When a TMDL is developed for waters impaired by point sources only, the issuance of a NPDES permit(s) provides the reasonable assurance that the WLAs contained in the TMDL will be achieved. This is because title 40 of the *Code of Federal Regulations* section 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with the assumptions and requirements of any available WLA in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources and the WLA is based on an assumption that nonpoint source load reductions will occur, U.S. EPA (1991) TMDL guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. To that end, IDEM coordinates with organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. Efforts specific to this watershed are described below.

8.5.1 Lake Erie Western Basin

Charged with coordinating binational actions to manage phosphorous loadings and concentrations in the Great Lakes, Indiana has been an active member of the Nutrients Annex 4 binational subcommittee of the Great Lakes Water Quality Agreement since its establishment in 2013. The Agreement's Lake Ecosystem Objectives include the following:

- Minimize the extent of hypoxic zones in the Great Lakes due to excessive phosphorous loading with emphasis on Lake Erie.
- Maintain levels of algal biomass below nuisance level conditions.
- Maintain algal species consistent with healthy aquatic ecosystems in nearshore waters.
- Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health.
- Maintain an oligotrophic state, relative algal biomass, and algal species consistent with healthy aquatic ecosystems in the open waters of Lakes Superior, Michigan, Huron and Ontario.
- Maintain mesotrophic conditions in the open waters of the western and central basins of Lake Erie, and oligotrophic conditions in the eastern basin of Lake Erie.

Commitments under the Nutrients Annex include the following:

- By February 2016, establish binational Phosphorous objectives, loading targets and allocations for the nearshore and offshore waters to achieve the Lake Ecosystem Objectives for each lake, starting with Lake Erie.
- Assess and where necessary, develop/implement regulatory and non-regulatory programs/measures to reduce phosphorous loadings from agricultural, rural non-farm, urban and industrial point and nonpoint sources.
- By 2018, develop a binational phosphorous reduction strategy and *Domestic Action Plans* designed to meet nearshore and open water phosphorous objectives and loading targets for Lake Erie.

On February 22, 2016, the United States and Canada adopted new phosphorus reduction targets for Lake Erie (Table 22).

Table 22. Binational phosphorus load reduction targets

Lake Ecosystem Objectives Great Lakes Water Quality Agreement Annex 4, Section B	**Western Basin of Lake Erie**	**Central Basin of Lake Erie**
Minimize the extent of hypoxic zones in the Waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie	40 percent reduction in total phosphorus entering the Western Basin and Central Basin of Lake Erie – from the United States and from Canada – to achieve 600 million tons Central Basin load	
Maintain algal species consistent with healthy aquatic ecosystems in the nearshore Waters of the Great Lakes	40 percent reduction spring total and soluble reactive phosphorus loads from the following watersheds where localized algae is a problem:	
	Thames River – Canada Maumee River – U.S. River Raisin – U.S. Portage River – U.S. Toussaint Creek – U.S. Leamington Tributaries - Canada	Sandusky River – U.S. Huron River, OH – U.S.
Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the Waters of the Great Lakes	40 percent reduction in spring total (860 million tons) and soluble reactive phosphorus (186 million tons) loads from the Maumee River (U.S.)	*not applicable*

Indiana's Domestic Action Plan will be led by IDEM and developed by a steering committee comprised of representatives from different stakeholder sectors. The Plan will follow an outline that includes: 1) Purpose, 2) Background, 3) Goals, 4) Objectives, 5) Tactics, and 6) Measuring and Reporting Progress.

Indiana's portion of the Western Lake Erie Basin is comprised of the St. Joseph, Maumee, Auglaize, and St. Mary's watersheds. The SJR and the St. Mary's River enter Indiana from Ohio and, at their confluence, form the Maumee River, which flows eastward into Ohio with its mouth at Lake Erie. The 40 percent reduction in spring-time TP and soluble reactive phosphorus noted in Table 22 for the Maumee River translates to a flow weighted mean concentration of 0.23 mg/L TP and 0.05 mg/L soluble reactive phosphorus. Progress toward these target values will be measured on the Maumee River as close to the Indiana-Ohio border as feasible. A draft of Indiana's Domestic Action Plan will be available by December 31, 2016.

8.5.2 Local Zoning and Regional Planning

Local zoning is typically controlled at the county or municipality level. Local zoning can be a useful tool for implementing some recommendations of the TMDL, such as stream bank setbacks for developing land. Local governments typically conduct planning to meet the sewage disposal needs of the community.

Planning should account for long-range sewer and treatment needs by looking at projections for community growth and development. Comprehensive land use planning, where available, is an excellent tool that can help those assessing the sewage disposal needs of a community or group of communities. In highly populated areas, regional solutions involving several communities have proven to be a cost-effective means to solve sewage disposal problems.

8.5.3 Past and Ongoing Water Resources Evaluation

IDEM maintains six fixed station monitoring sites in the SJRW that are sampled monthly for various constituents. IDEM executes a probabilistic monitoring design in one of nine major river basins each year. The SJR is part of the Great Lakes system, and was monitored in 2000, 2005 and 2010[52]. The SJRW will be monitored through the probabilistic program in 2018 as part of the Great Lakes Basin.

IDEM also performs fish tissue monitoring, which monitors about a fifth of the state each year. The SJRW was monitored as part of the Great Lakes Basin in 2015 and will be monitored for fish tissue again in 2020.

All NPDES-permitted wastewater treatment facilities are required to routinely sample their effluent as a condition of their permits. Monitoring parameters and frequencies vary and are dictated by individual permit requirements according to pollutants of concern, plant design flow, and other considerations. In many cases, entities are also required to collect ambient water quality samples upstream and downstream of their discharge location to provide data regarding potential effects on stream water quality. NPDES-permitted dischargers are required to report their self-monitoring results to IDEM monthly as a condition of their permits.

Early communications should take place between IDEM and any potential collaborators to discuss research interests and objectives. Areas of overlap should be identified, and ways to make all parties' research efforts more efficient should be discussed. Ultimately, important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

8.5.4 Adaptive Management

An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al. 1999). If chemical water quality does not show improvement or waterbodies are still not attaining WQS after the improvement strategy has been carried out, a TMDL revision would be initiated. IDEM would initiate the revision if no other parties wish to do so.

As part of an adaptive management approach, monitoring will be key component of the implementation efforts in the SJRW. Ambient monitoring provides the data used to assess progress towards achieving needed load reductions and meeting water quality standards. BMP effectiveness monitoring provides information that determines if planned activities are, in fact, being implemented and if management practices are performing as expected. Together, information from both monitoring components guide actual plan implementation through each phase using adaptive management.

Under adaptive management, the SJRW implementation efforts should use an iterative approach; one that continues while better data are collected, results analyzed, and the watershed plan enhanced. In this way, implementation activities can focus on a cumulative reduction in loadings under a plan that is flexible enough to allow for refinement, reflects the current state of knowledge about the system, and is able to incorporate new, innovative techniques.

Progress towards implementing planned activities and the performance of installed management measures will be evaluated through BMP effectiveness monitoring. Data collected as part this effort is typically

[52] Previous probabilistic monitoring design was a fifth of the state each year, but this was revised in 2010, starting in 2011 to do a ninth of the state each year

qualitative information, which tracks both direct (e.g., acres managed under stewardship programs, miles of stream with adequate riparian buffers) and indirect (e.g., number of outreach events, mailed self-assessment survey of properties adjacent to surface waters of the SJRW, partner organization field inventories) activities.

It is recommended that BMP effectiveness monitoring address annual implementation (i.e., installed this year), cumulative implementation, and cumulative implementation with an adjustment for practices that have exceeded their expected lifespan. These totals should be compared with implementation targets and full implementation potential to indicate progress over time.

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Appendix A.

Waterbodies, Impairments, and Assessment Sites

Contents

Tables

Abbreviations and Acronyms

IDEM	Indiana Department of Environmental Management
Michigan DEQ	Michigan Department of Environmental Quality
Ohio EPA	Ohio Environmental Protection Agency
SJRW	St. Joseph River watershed

A-1. Hydrologic Units in the SJRW

Table A-1. Hydrologic units in the SJRW

HUC-12 (04100003)	Hydrologic unit	State(s)	Drainage area (square miles) [a]
East Branch St. Joseph River (HUC 04100003 01)			
01 01	Pittsford Millpond-East Branch St Joseph River	MI	27.5
01 02	Anderson Drain-East Branch St Joseph River	MI	23.1
01 03	Laird Creek	MI	16.1
01 04	Bird Creek-East Branch St Joseph River	MI,OH	29.6
01 05	Silver Creek	MI	27.1
01 06	Clear Fork-East Branch St Joseph River	MI,OH	49.9
West Branch St. Joseph River (HUC 04100003 02)			
02 01	Cambia Millpond-East Fork West Branch St Joseph River	MI	26.6
02 02	East Fork West Branch St Joseph River	MI	22.0
02 03	West Fork West Branch St Joseph River	IN,MI	49.5
02 04	West Branch St Joseph River	MI,OH	16.2
Nettle Creek-St. Joseph River (HUC 04100003 03)			
03 01	Nettle Creek	IN,MI,OH	36.4
03 02	Cogswell Cemetery-St Joseph River	OH	9.7
03 03	Eagle Creek	OH	34.9
03 04	Village of Montpelier-St Joseph River	OH	20.8
03 05	Bear Creek	IN,OH	24.4
03 06	West Buffalo Cemetery-St Joseph River	OH	13.7
Fish Creek (HUC 04100003 04)			
04 01	West Branch Fish Creek	IN	15.6
04 02	Headwaters Fish Creek	IN,OH	13.8
04 03	Hamilton Lake	IN	16.5
04 04	Hiram Sweet Ditch	IN	22.3
04 05	Town of Alvarado-Fish Creek	IN,OH	16.0
04 06	Cornell Ditch-Fish Creek	IN,OH	24.7
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)			
05 01	Bluff Run-St Joseph River	OH	23.7
05 02	Big Run	IN,OH	30.2
05 03	Russell Run-St Joseph River	OH	18.0
05 04	Buck Creek	IN,OH	18.2
05 05	Willow Run-St Joseph River	IN,OH	16.4
05 06	Sol Shank Ditch-St Joseph River	IN,OH	27.2
Matson Ditch-Cedar Creek (HUC 04100003 06)			
06 01	Cedar Lake-Cedar Creek	IN	28.9
06 02	Dibbling Ditch-Cedar Creek	IN	27.1
06 03	Matson Ditch	IN	17.5
06 04	Smith Ditch-Cedar Creek	IN	19.0
Cedar Creek (HUC 04100003 07)			
07 01	Headwaters John Diehl Ditch	IN	20.4
07 02	Peckhart Ditch-John Diehl Ditch	IN	18.7
07 03	Sycamore Creek-Little Cedar Creek	IN	24.7
07 04	Black Creek	IN	24.6
07 05	King Lake-Little Cedar Creek	IN	23.5
07 06	Willow Creek	IN	32.2
07 07	Dosch Ditch-Cedar Creek	IN	36.7

continued on the next page

St. Joseph River (HUC 04100003 08)			

HUC-12 (04100003)	Hydrologic unit	State(s)	Drainage area (square miles) [a]
08 01	Hursey Ditches-Bear Creek	IN	27.3
08 02	Metcalf Ditch-St Joseph River	IN	33.6
08 03	Swartz Carnahan Ditch-St Joseph River	IN	19.8
08 04	Cedarville Reservoir-St Joseph River	IN	20.2
08 05	Ely Run-St Joseph River	IN	28.4
08 06	Becketts Run-St Joseph River	IN	20.5

Notes
HUC = hydrologic unit code.
a. The drainage area, rounded to the nearest one-tenth square miles, was calculated in ArcGIS in the following projection: state plane Ohio North, North American Datum 1983.

A-2. Impairments in the SJRW

Table A-2. Ohio's designated uses for waterbodies in the SJRW

Waterbody	ALU				Recreation	
	WWH	EWH	MWH	LRW	PCR	SCR
Maumee River - all other segments	X					
St. Joseph River	X				X	
Willow Run	X				X	
Amaden Ditch	X				X	
Greens Ditch	X				X	
Big Run	X				X	
Fish Creek - state line (RM 5.6) to county road 3 (RM 2.4)		X			X	
- all other segments	X				X	
Bluff Run	X				X	
Ziegler Ditch	X				X	
Bear Creek - headwaters to RM 1.2			X		X	
- all other segments	X				X	
Tamarack Ditch	X				X	
Eagle Creek	X				X	
North Branch	X				X	
Nettle Creek	X				X	
J. Lattener Ditch				X		X
West Branch St. Joseph River	X				X	
Each Branch St. Joseph River	X				X	
Clear Fork	X				X	
Silver Creek	X				X	

Source: OAC-3745-1-11.
Note: ALU = aquatic life use; AWS = agricultural water supply; EWH = exceptional warmwater habitat; IWS = industrial water supply; LRW = limited resources water; MWH = modified warmwater habitat - channel modification; PCR = primary contact recreation; RM = rivermile; SCR = secondary contact recreation; WWH = warmwater habitat.
All listed waterbodies are agricultural water supplies and industrial water supplies.

Table A-3. Aquatic life use impairments in Ohio

HUC-12 (04100003)	Waterbody	Waterbody ID	Attainment	Cause(s) of impairment	Source(s) of impairment
East Branch St. Joseph River (04100003 01)					
01 06	Clear Fork	04-416-000	Partial	▪ Natural conditions	▪ Natural sources
West Branch St. Joseph River (04100003 02)					
02 04	West Branch St. Joseph River	04-414-000	Partial	▪ Nutrients	▪ Unknown
Nettle Creek-St. Joseph River (04100003 03)					
03 01	Nettle Creek	04-413-000	Partial	▪ Direct habitat alteration	▪ Habitat modification
03 03	Eagle Creek	04-411-000	Partial	▪ Direct habitat alteration ▪ Nutrients	▪ Habitat modification ▪ Agricultural nonpoint sources

Source: Angela Defenbaugh & Cathy Alexander, Ohio EPA, personal communication (via electronic mail), December 17, 2014.
Notes
The table is sorted by HUCs.
HUC = hydrologic unit code.

Table A-4. Recreation use impairments in Ohio

HUC-12 (04100003)	Waterbody	Waterbody ID	Attainment
East Branch St. Joseph River (04100003 01)			
01 06	Clear Fork	04-416-000	Non-attainment
	East Branch St. Joseph River	04-415-000	Non-attainment
	Silver Creek	04-417-000	Non-attainment
West Branch St. Joseph River (04100003 02)			
02 04	West Branch St. Joseph River	04-414-000	Non-attainment
Nettle Creek-St. Joseph River (04100003 03)			
03 01	Nettle Creek	04-413-000	Non-attainment
03 02	St. Joseph River	04-400-000	Non-attainment
03 03	Eagle Creek	04-411-000	Non-attainment
	North Branch Eagle Creek	04-412-000	Non-attainment
03 04	St. Joseph River	04-400-000	Non-attainment
03 05	Bear Creek	04-409-000	Non-attainment
03 06	St. Joseph River	04-400-000	Non-attainment
Fish Creek (04100003 04)			
04 02	Fish Creek	04-405-000	Non-attainment
04 06	Fish Creek	04-405-000	Non-attainment
Sol Shank Ditch-St. Joseph River (04100003 05)			
05 01	St. Joseph River	04-400-000	Non-attainment
05 02	Big Run	04-404-000	Non-attainment
05 03	St. Joseph River	04-400-000	Non-attainment
05 05	St. Joseph River	04-400-000	Non-attainment

Source: Angela Defenbaugh & Cathy Alexander, Ohio EPA, personal communication (via electronic mail), December 17, 2014.
Notes
The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom alphabetically.
HUC = hydrologic unit code.

Table A-5. Aquatic life use impairments in Indiana

HUC-12 (04100003)	County	Assessment unit ID	Assessment unit name	Cause(s) of impairment
Fish Creek (HUC 04100003 04)				
04 01	Steuben	INA0341_01	West Branch Fish Creek	Impaired biotic communities
		INA0341_02		
04 05	DeKalb	INA0345_01	Fish Creek	Impaired biotic communities
				Dissolved oxygen
04 06	DeKalb	INA0346_01	Fish Creek	Impaired biotic communities
		INA0346_T1003	Fish Creek - unnamed tributary	Impaired biotic communities
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)				
05 02	DeKalb	INA0352_04	Big Run	Impaired biotic communities
		INA0352_05		
Mason Ditch-Cedar Creek (HUC 04100003 06)				
06 01	DeKalb	INA0361_03	Cedar Creek	Nutrients
		INA0361_04		
06 02	DeKalb	INA0362_02	Cedar Creek	Nutrients
		INA0362_03		
		INA0362_04		
		INA0363_03		
06 03	DeKalb	INA0363_T1001	Mason Ditch - unnamed tributary	Impaired biotic communities
06 04	DeKalb	INA0364_T1001	Smith Ditch	Impaired biotic communities
Cedar Creek (HUC 04100003 07)				
07 02	DeKalb	INA0372_01	Peckhart Ditch	Impaired biotic communities
		INA0372_01		Dissolved oxygen
07 04	DeKalb	INA0374_05	Black Creek	Impaired biotic communities
07 05	DeKalb	INA0375_05	Little Cedar Creek	Impaired biotic communities
	Allen	INA0375_06		
	DeKalb	INA0375_T1007	Little Cedar Creek - unnamed tributary	Impaired biotic communities
07 07	DeKalb	INA0377_03	Cedar Creek	Impaired biotic communities
	Allen	INA0377_04	Cedar Creek	Impaired biotic communities
	DeKalb	INA0377_T1002	Dosch Ditch	Impaired biotic communities
				Nutrients
St. Joseph River (HUC 04100003 08)				
08 06	Allen	INA0386_01	St. Joseph River	Impaired biotic communities

Source: Draft 2014 Indiana 303d list (IDEM 2014b)
Notes
The table is sorted by HUCs.
HUC = hydrologic unit code.

Table A-6. Recreation use impairments in Indiana

HUC-12 (04100003)	County	Assessment unit ID	Assessment unit name	Cause(s) of impairment
Fish Creek (HUC 04100003 04)				
04 01	Steuben	INA0341_01	West Branch Fish Creek	*E. coli*
		INA0341_02		
04 02	Steuben	INA0342_01	Fish Creek	*E. coli*
		INA0342_T1003	Fish Creek - unnamed tributary	*E. coli*
		INA0342_T1004		
04 04	DeKalb	INA0344_03	Hiram Sweet Ditch	*E. coli*
04 05	Steuben	INA0345_01	Fish Creek	*E. coli*
04 06	DeKalb	INA0346_01	Fish Creek	*E. coli*
		INA0346_T1003	Fish Creek - unnamed tributary	*E. coli*
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)				
05 02	DeKalb	INA0352_04	Big Run	*E. coli*
		INA0352_05		
Mason Ditch-Cedar Creek (HUC 04100003 06)				
06 01	DeKalb	INA0361_01	McCullough Ditch	*E. coli*
		INA0361_01A	McCullough Ditch - upstream Indian Lake	*E. coli*
		INA0361_02	Leins Ditch	*E. coli*
		INA0361_03	Cedar Creek	*E. coli*
		INA0361_04		
		INA0361_T1001	McCullough Ditch - unnamed tributary	*E. coli*
		INA0361_T1002		
06 02	DeKalb	INA0362_02	Cedar Creek	*E. coli*
		INA0362_03		
		INA0362_04		
		INA0362_T1004	Swartz Ditch	*E. coli*
		INA0363_03	Cedar Creek	*E. coli*
06 03	DeKalb	INA0363_T1001	Mason Ditch - unnamed tributary	*E. coli*
06 04	DeKalb	INA0364_01	Cedar Creek	*E. coli*
		INA0364_02		
		INA0364_03		
		INA0364_04		
		INA0364_05		
		INA0364_06		
		INA0364_T1001	Smith Ditch	*E. coli*
		INA0364_T1002		

HUC-12 (04100003)	County	Assessment unit ID	Assessment unit name	Cause(s) of impairment
Cedar Creek (HUC 04100003 07)				
07 02	DeKalb	INA0372_01	Peckhart Ditch	*E. coli*
		INA0372_02	Diehl Ditch	*E. coli*
		INA0372_T1002	Ober Ditch	*E. coli*
		INA0372_T1002A		
		INA0372_T1003	Ober Ditch - unnamed tributary	*E. coli*
07 04	Noble	INA0374_03	Black Creek	*E. coli*
		INA0374_04		
	DeKalb	INA0374_05		
	Noble	INA0374_T1008	Bilger Ditch	*E. coli*
		INA0374_T1009	Wahn Ditch	*E. coli*
		INA0374_T1010	Black Creek - unnamed tributary	*E. coli*
07 05	DeKalb	INA0375_01	Little Cedar Creek	*E. coli*
		INA0375_02		
		INA0375_03		
		INA0375_04		
		INA0375_05		*E. coli*
	Allen	INA0375_06	Little Cedar Creek	*E. coli*
07 06	Allen	INA0376_02	Willow Creek	*E. coli*
		INA0376_03		
		INA0376_T1004	Krumlauf Ditch	*E. coli*
07 07	DeKalb	INA0377_01	Cedar Creek	*E. coli*
		INA0377_02		
		INA0377_03		
	Allen	INA0377_04	Cedar Creek	*E. coli*
	DeKalb	INA0377_T1001	Garrett City Ditch	*E. coli*
St. Joseph River (HUC 04100003 08)				
08 02	DeKalb	INA0382_01	St. Joseph River	*E. coli*
08 03	Allen	INA0383_01	St. Joseph River	*E. coli*
	Allen	INA0383_T1003	Bogger Ditch	*E. coli*

Source: Draft 2014 Indiana 303d list (IDEM 2014b)
Notes
The table is sorted by HUCs.
HUC = hydrologic unit code.

A-3. Assessment Sites in the SJRW

Table A-7. Michigan DEQ assessment sites on tributaries to the St. Joseph River

Waterbody	Site ID	Site name	Level III ecoregion	Stream type
East Branch St. Joseph River (HUC 04100003 01)				
Pittsford Millpond-East Branch St. Joseph River (HUC 04100003 01 01)				
Otto Creek	300231	at Rumsey Road	ECBP	warmwater
East Branch St. Joseph River	300220	at Tripp Road	ECBP	coldwater
Anderson Drain-East Branch St. Joseph River (HUC 04100003 01 02)				
East Branch St. Joseph River	300222	at Camcross Road	ECBP	warmwater
	300221	at Prattville Road	ECBP	warmwater
Goose Creek	300229	at Prattville Road	ECBP	warmwater
Laird Creek (HUC 04100003 01 03)				
Laird Creek	300262	at Camden Road	ECBP	warmwater
	300225	at Territorial Road	ECBP	warmwater
Bird Creek-East Branch St. Joseph River (HUC 04100003 01 04)				
Bird Creek	300261	at Camden Road	ECBP	warmwater
	300224	at Hartly Road	ECBP	warmwater
East Branch St. Joseph River	300260	at Camden Road	ECBP	warmwater
	300223	at Pittsford Road	ECBP	warmwater
Silver Creek (HUC 04100003 01 05)				
South Fork Silver Creek	300219	Campton Road	ECBP	warmwater
Silver Creek	300263	at Camden Road	ECBP	warmwater
Clear Fork-East Branch St. Joseph River (HUC 04100003 01 06)				
Clear Fork Creek	300218	at Hillsdale Road	ECBP	warmwater
Nile Ditch	300228	at Tamarack Road	ECBP	warmwater
West Branch St. Joseph River (HUC 04100003 02)				
Cambia Millpond-East Fork West Branch St. Joseph River (HUC 04100003 02 01)				
East Fork West Branch St. Joseph River	300215	at Card Road	ECBP	warmwater
East Fork West Branch St. Joseph River (HUC 04100003 02 02)				
East Fork West Branch St. Joseph River	300216	at Burt Road	ECBP	warmwater
	300264	at Camden Road	ECBP	warmwater
	300217	at Territorial Road	ECBP	warmwater
West fork West Branch St. Joseph River (HUC 04100003 02 03)				
Prouty Drain	300214	at Brott Road	ECBP	warmwater
West Fork West Branch St. Joseph River	300267	at Bump Road	ECBP	warmwater
	300209	at Brott Road	ECBP	warmwater
	300266	at Montgomery Road	ECBP	warmwater
	300211	at Edon Road	ECBP	warmwater
	300212	at Camden Road	ECBP	warmwater
	300205	at Camden Road	ECBP	warmwater
	300213	at Territorial Road	ECBP	warmwater

Sources: Michigan DEQ 2004, 2005a,b
Notes
ECBP = Eastern Corn Belt Plains; HUC = hydrologic unit code.
The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom as upstream to downstream.

Table A-8. Ohio EPA assessment sites on tributaries to the St. Joseph River

Waterbody	RM	Site ID	Site name	Drainage area (sq. mi.)	Size	Level III ecoregion	ALU
East Branch St. Joseph River (HUC 04100003 01)							
Clear Fork-East Branch St. Joseph River (HUC 04100003 01 06)							
Clear Fork	6.22	P08K32	SR-576	15.1	H	ECBP	WWH
	2.17	P08K31	CR-13	21.1	W	ECBP	WWH
East Branch St. Joseph River	4.77	P08K30	CR-S	95.0	B	ECBP	WWH
	1.06	P08K29	SR-15	163.0	B	ECBP	WWH
Silver Creek	1.25	P08S23	CR-15	31.4	H	ECBP	WWH
West Branch St. Joseph River (HUC 04100003 02)							
West Branch St. Joseph River (HUC 04100003 02 04)							
West Branch St. Joseph River	10.48	P08S22	near state line, TR-S	98.0	B	ECBP	WWH
	8.50	P08K28	upstream of Lake Seneca, CR-8	99.0	B	ECBP	WWH
	3.13	P08S21	downstream of Lake Seneca, TR-115	109.0	B	ECBP	WWH
	0.70	302198	US-20, near mouth	114.3	B	ECBP	WWH
Nettle Creek-St. Joseph River (HUC 04100003 03)							
Nettle Creek (HUC 04100003 03 01)							
Nettle Creek	14.48	P08S09	upstream of Nettle Lake, TR-72	19.1	H	ECBP	WWH
	11.23	P08K25	downstream of Lake Sa Su An, CR-7	25.0	W	ECBP	WWH
	5.08	P08K24	CR-8.50, adjacent to Bridgewater Dairy	31.0	W	ECBP	WWH
	1.37	P08S06	CR-N-30	36.0	W	ECBP	WWH
Eagle Creek (HUC 04100003 03 03)							
Eagle Creek	8.28	P08K22	CR-675	21.1	W	ECBP	WWH
	4.90	P08K21	CR-M	24.2	W	ECBP	WWH
	0.50	P08S01	CR-J	34.7	W	ECBP	WWH
North Branch Eagle Creek	0.02	P08K23	at mouth, CR-M-50	12.9	H	ECBP	WWH
Bear Creek (HUC 04100003 03 05)							
Bear Creek	5.70	P08K18	downstream of Edon WWTP, CR-675	13.6	H	ECBP	MWH
	2.43	P08K15	CR-I	22.0	W	ECBP	MWH
	0.54	510150	SR-34	24.2	W	ECBP	WWH
Fish Creek (HUC 04100003 04)							
Headwaters Fish Creek (HUC 04100003 04 02)							
Fish Creek	30.54	P08K12	upstream of Columbia, CR-P-25	8.8	H	ECBP	WWH
Cornell Ditch-Fish Creek (HUC 04100003 04 06)							
Fish Creek	5.40	P08K10	downstream of state line, TR-171	106.0	W	ECBP	EWH
	2.40	P08K09	CR-3	108.0	W	ECBP	EWH
	0.38	P08S20	Edgerton, SR-49	109.0	W	ECBP	WWH

Waterbody	RM	Site ID	Site name	Drainage area (sq. mi.)	Size	Level III ecoregion	ALU
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)							
Big Run-St. Joseph River (HUC 04100003 05 02)							
Big Run	0.30	P08K08	Edgerton, Conkle Road	30.0	W	ECBP	WWH

Source: Ohio EPA 2013.
Notes
ALU = aquatic life use designation; B = boating; CR = county road; ECBP = Eastern Corn Belt Plains; EWH = exceptional warmwater habitat; H = headwaters; MWH = modified warmwater habitat; RM = river mile; SR = state route; TR = township road; US = United States route; W = wading; WWH = warmwater habitat; WWTP = wastewater treatment plant.
The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom as upstream to downstream.

Table A-9. Ohio EPA assessment sites on the St. Joseph River

Waterbody	RM	Site ID	Site name	Drainage area (sq. mi.)	Size	Level III ecoregion	ALU
Nettle Creek-St. Joseph River (HUC 04100003 03)							
Cogswell Cemetery-St. Joseph River (HUC 04100003 03 02)							
St. Joseph River	81.18	P08S19	upstream of Montpelier, CR-N	288.0	B	ECBP	WWH
Montpelier-St. Joseph River (HUC 04100003 03 04)							
St. Joseph River	76.72	302199	CR-M dead end, at fairgrounds	338.0	B	ECBP	WWH
	73.24	P08S18	downstream of Montpelier, CR-10	337.0	B	ECBP	WWH
West Buffalo-St. Joseph River (HUC 04100003 03 06)							
St. Joseph River	62.08	P08S17	SR-34	394.0	B	ECBP	WWH
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)							
Bluff Run-St. Joseph River (HUC 04100003 05 01)							
St. Joseph River	56.77	P08S16	upstream of Edgerton WWTP, CR-E75	435.0	B	ECBP	WWH
Russell Run-St. Joseph River (HUC 04100003 05 03)							
St. Joseph River	51.90	P08K03	downstream of Edgerton WWTP	552.0	B	ECBP	WWH
	49.75	510180	downstream of Edgerton, SR-49	554.0	B	ECBP	WWH
	47.30	P08K02	County Line Road	556.0	B	ECBP	WWH
Willow Run-St. Joseph River (HUC 04100003 06)							
St. Joseph River	42.34	510220	near Ohio-Indiana state line, SR-249	609.0	B	ECBP	WWH

Source: Ohio EPA 2013.
Notes
ALU = aquatic life use designation; B = boating; CR = county road; ECBP = Eastern Corn Belt Plains; RM = river mile; SR = state route; WWH = warmwater habitat; WWTP = wastewater treatment plant.
The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom as upstream to downstream.

Table A-10. IDEM assessment sites on tributaries to the St. Joseph River

Waterbody	Site ID	Site name	Level III ecoregion
West Branch St. Joseph River (04100003 02)			
Headwaters Fish Creek (HUC 04100003 02 03)			
Clear Lake	3869	LEJ020-0001	SMNIDP
	8864	LEJ020-0002	SMNIDP
Lake Anne	9334	LEJ020-0004	SMNIDP
Round Lake	9042	LEJ020-0003	SMNIDP
Nettle Creek-St. Joseph River (04100003 03)			
Nettle Creek (HUC 04100003 03 01)			
Handy Lake	9331	LEJ030-0002	SMNIDP
Long Lake	8976	LEJ030-0001	SMNIDP
Mirror Lake	9332	LEJ030-0003	SMNIDP
Fish Creek (04100003 04)			
West Branch Fish Creek (HUC 04100003 04 01)			
West Branch Fish Creek	6930	LEJ050-0020	SMNIDP
	9921	LEJ050-0064	SMNIDP
Headwaters Fish Creek (HUC 04100003 04 02)			
Fish Creek	6054	LEJ050-0015	SMNIDP
	6937	LEJ050-0023	SMNIDP
Hamilton Lake (HUC 04100003 04 03)			
Black Creek	6032	LEJ050-0014	SMNIDP
Hamilton Lake	3848	LEJ050-0009	SMNIDP
	8922	LEJ050-0061	SMNIDP
UT of Black Creek	3523	LEJ050-0002	SMNIDP
Hiram Sweet Ditch (HUC 04100003 04 04)			
Ball Lake	8818	LEJ050-0060	SMNIDP
Fish Creek	6995	LEJ050-0050	SMNIDP
	6997	LEJ050-0052	SMNIDP
	6023	LEJ050-0013	SMNIDP
	7000	LEJ050-0054	SMNIDP
(effluent)	6999	LEJ050-0053, Hamilton WWTP	SMNIDP
Town of Alvarado-Fish Creek (HUC 04100003 04 05)			
Fish Creek	3868	LEJ050-0010	SMNIDP
Fish Creek	6947	LEJ050-0027	SMNIDP
Fish Creek	1928	LEJ050-0006	SMNIDP
Fish Creek	6952	LEJ050-0029	SMNIDP
Fish Creek	6958	LEJ050-0032	SMNIDP
Fish Creek	13144	LEJ050-0066	SMNIDP
UT of Fish Creek	6944	LEJ050-0026	SMNIDP
Cornell Ditch-Fist Creek (HUC 04100003 04 06)			
Fish Creek	6966	LEJ050-0040	ECBP
	3790	LEJ050-0008	ECBP
	6961	LEJ050-0035	ECBP
	6003	LEJ050-0012	ECBP
	2005	LEJ050-0007	ECBP
	13168	LEJ050-0068	ECBP
	13300	LEJ050-0011	ECBP

Waterbody	Site ID	Site name	Level III ecoregion
UT of Fish Creek	3516	LEJ050-0001	ECBP
	6993	LEJ050-0048	ECBP
Sol Shank Ditch-St. Joseph River (04100003 05)			
Big Run (HUC 04100003 05 02)			
Big Run	13189	LEJ060-0015	ECBP
	3559	LEJ060-0002	ECBP
Buck Creek (HUC 04100003 05 04)			
Metcalf Ditch	3559	LEJ060-0002	ECBP
	15068	LEJ-05-0001	ECBP
Matson Ditch-Cedar Creek (04100003 06)			
Cedar Lake-Cedar Creek (HUC 04100003 06 01)			
Cedar Creek	4182	LEJ080-0005	SMNIDP
Indian Lake	9140	LEJ080-0012	SMNIDP
Leins Ditch	13172	LEJ080-0016	SMNIDP
UT of Leins Ditch	9756	LEJ080-0014	SMNIDP
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)			
Cedar Creek	5990	LEJ080-0011	SMNIDP
	4184	LEJ080-0006	SMNIDP
Swartz Ditch	4186	LEJ080-0008	ECBP
Matson Ditch (HUC 04000003 06 03)			
UT Matson Ditch	9746	LEJ080-0013	SMNIDP
Smith Ditch-Cedar Creek (HUC 04100003 06 04)			
Cedar Creek	4185	LEJ080-0007	ECBP
	5976	LEJ080-0010	ECBP
	3793	LEJ080-0004	ECBP
	4189	LEJ080-0009	ECBP
West Smith Ditch	13184	LEJ080-0017	ECBP
Cedar Creek (04100003 07)			
Headwaters John Diehl Ditch (HUC 04100003 07 01)			
John Diehl Ditch	5983	LEJ090-0025	SMNIDP
Wiley Lake	9189	LEJ090-0030	SMNIDP
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)			
John Diehl Ditch	4190	LEJ090-0018	ECBP
Peckhart Ditch	13160	LEJ090-0040	ECBP
	9793	LEJ090-0034	ECBP
Black Creek (HUC 04100003 07 04)			
Black Creek	13164	LEJ090-0041	ECBP
King Lake-Little Cedar Creek (HUC 04100003 07 05)			
Little Cedar Creek	3826	LEJ090-0010	SMNIDP
	5959	LEJ090-0024	ECBP
	9787	LEJ090-0033	ECBP
	4187	LEJ090-0017	ECBP
UT of Little Cedar Creek	3568	LEJ090-0002	ECBP
Willow Creek (HUC 04100003 07 06)			
Willow Creek	5946	LEJ090-0023	ECBP
	4192	LEJ090-0020	ECBP

Waterbody	Site ID	Site name	Level III ecoregion
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)			
Cedar Creek	3794	LEJ090-0009	ECBP
Cedar Creek	4188	LEJ090-0021	ECBP
Cedar Creek	9733	LEJ090-0031	ECBP
Cedar Creek	2001	LEJ090-0008	ECBP
Cedar Creek	3519	LEJ090-0001	ECBP
Cedar Creek	6645	LEJ090-0026	ECBP
Cedar Creek	3571	LEJ090-0003	ECBP
Cedar Creek	3870	LEJ090-0011	ECBP
Cedar Creek	5935	LEJ090-0022	ECBP
Dosch Ditch	3587	LEJ090-0004	ECBP
Garrett City Ditch	3900	LEJ090-0016	ECBP
	3889	LEJ090-0013	ECBP
	3890	LEJ090-0014	ECBP
	3891	LEJ090-0015	ECBP
(effluent)	3888	LEJ090-0012, Garrett WWTP	ECBP
St. Joseph River (HUC 04100003 08)			
Bear Creek (HUC 0410000 08 01)			
Bear Creek	3535	LEJ070-0002	ECBP
	5969	LEJ070-0020	ECBP
Swartz Cannahan Ditch-St. Joseph River (04100003 08 03)			
Dunton Lake	9129	LEJ070-0023	ECBP
Hilkey Ditch	4165	LEJ070-0015	ECBP
Swartz-Carnahan Ditch	4166	LEJ070-0016	ECBP
	5951	LEJ070-0018	ECBP
	4167	LEJ070-0017	ECBP
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)			
Cedarville Reservoir	9121	LEJ070-0022	ECBP
Ely Run-St. Joseph River (HUC 04100003 08 05)			
Revert Ditch	4163	LEJ100-0012	ECBP
Tiernan Ditch	4162	LEJ100-0011	ECBP
Tiernan Ditch	4161	LEJ100-0010	ECBP
Tiernan Ditch	4057	LEJ100-0005	ECBP
Tiernan Ditch	4160	LEJ100-0009	ECBP
Tiernan Ditch	5924	LEJ100-0014	ECBP
Becketts Run-St. Joseph River (HUC 04100003 08 06)			
Becketts Run	3555	LEJ100-0001	ECBP

Source: IDEM 2014a

Notes

ECBP = Eastern Corn Belt Plains; SMNIDP = Southern Michigan/Northern Indiana Drift Plain; UT = unnamed tributary.

The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom as upstream to downstream per waterbody.

Table A-11. IDEM assessment sites on the St. Joseph River

Waterbody	Site ID	Site name	Level III ecoregion
Sol Shank Ditch-St. Joseph River (04100003 05)			
Willow Run-St. Joseph River (HUC 04100003 05 05)			
St. Joseph River	3817	LEJ060-0007	ECBP
Hoodelmier Ditch-St. Joseph River (HUC 04100003 05 06)			
St. Joseph River	2006	LEJ060-0006	ECBP
	3511	LEJ060-0001	ECBP
St. Joseph River (HUC 04100003 08)			
Metcalf Ditch-St. Joseph River (HUC 04100003 08 02)			
St. Joseph River	3872	LEJ070-0008	ECBP
	3495	LEJ070-0001	ECBP
	5966	LEJ070-0019	ECBP
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)			
St. Joseph River	9782	LEJ070-0027	ECBP
	9764	LEJ070-0026	ECBP
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)			
St. Joseph River	3784	LEJ070-0006	ECBP
	13119	LEJ070-0028	ECBP
Ely Run-St. Joseph River (HUC 04100003 08 05)			
St. Joseph River	2007	LEJ100-0002	ECBP
Becketts Run-St. Joseph River (HUC 04100003 08 06)			
St. Joseph River	13180	LEJ100-0026	ECBP
	15053	LEJ-08-0005	ECBP
	8031	LEJ100-0018	ECBP
	3783	LEJ100-0004	ECBP
	8029	LEJ100-0016	ECBP
	9068	LEJ100-0023	ECBP
	2009	LEJ100-0003	ECBP
	5907	LEJ100-0013	ECBP

Source: IDEM 2014a
Notes
ECBP = Eastern Corn Belt Plains.
The table is sorted by HUCs and the sites are listed in each 12-dighit HUC from top to bottom as upstream to downstream.

A-4. References

IDEM (Indiana Department of Environmental Management). 2014a. Fish community, fish tissue, Index of Biotic Integrity, macroinvertebrate community, and water chemistry monitoring data files. IDEM. Provided by Staci Goodwin (IDEM) via file transfer protocol site on December 9, 2014.

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———. 2005b. Biological Surveys to Tributaries of the Maumee (St. Joseph) River Watershed in Hillsdale and Lenawee Counties, Michigan, June 7-15, 2005. MI/DEQ/WD-05/103. Michigan DEQ, Water Bureau. November 29, 2005 (revised). Provided by Aaron Parker (Michigan DEQ) via SharePoint on November 18, 2014.

Ohio EPA (Ohio Environmental Protection Agency). 2013. *Biological and Water Quality Survey of the St. Joseph River and Selected Tributaries. Williams and Defiance Counties, Ohio.* Ohio EPA, Division of Surface Water. May 21, 2013. Provided by Angela Defenbaugh (Ohio EPA) via electronic mail on October 20, 2014.

Appendix B.

Additional Watershed Characterization Information

Contents

Tables

Figures

Acronyms and Abbreviations

ALU	aquatic life use
ARS	Agricultural Research Service (U.S. Department of Agriculture)
EBSJR	East Branch St. Joseph River
HSG	hydrologic soil group
HSTS	household sewage treatment system
HUC	hydrologic unit code
IDEM	Indiana Department of Environmental Management
Michigan DEQ	Michigan Department of Environmental Quality
NASS	National Agricultural Statistics Service (U.S. Department of the Interior)
NCDC	National Climactic Data Center (U.S. Department of Commerce)
NRCS	Natural Resources Conservation Service (U.S. Department of Agriculture)
Ohio EPA	Ohio Environmental Protection Agency
OWTS	on-site wastewater treatment systems
RM	river mile
SJR	St. Joseph River
SJRW	St. Joseph River watershed
SJRWI	St. Joseph River watershed Initiative
SWAT	Soil and Water Assessment Tool
USCB	U.S. Census Bureau (U.S. Department of Commerce)
USDA	U.S. Department of Agriculture's
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WBSJR	West Branch St. Joseph River
WFWBSJR	West Fork of the West Branch of the St. Joseph River
WMP	watershed management plan
WQS	water quality standards
WRCC	Western Reserve Climate Center
WWH	warmwater habitat

B-1 Previous Studies

The Indiana Department of Environmental Management (IDEM), Michigan Department of Environmental Protection (Michigan DEQ), Ohio Environmental Protection Agency (Ohio EPA), St. Joseph River Watershed Initiative (SJRWI), Purdue University, and other entities have thoroughly studied the St. Joseph River watershed (SJRW). This section provides a summary of selected previous work. Additional studies regarding specific topics (e.g., SJRWI's conservation tillage study) are referenced throughout this report.

B-1.1 Biological and Water Quality Studies

Michigan DEQ and Ohio EPA published their biological and water quality data collected during various surveys between 1993 and 2015. The published studies include evaluations of their data, watershed characterizations, and source assessments.

B-1.1.1 Biological and Water Quality Study of the St. Joseph River and Selected Tributaries (Ohio EPA 1994)

Ohio EPA sampled the St. Joseph River (SJR), the West Branch St. Joseph River (WBSJR) and Bear, Fish, and Silver creeks in 1992; the Agency also conducted a mini-study in Bear and Fish creeks in 1991. The WBSJR and Silver Creek were in full attainment of their warmwater habitat (WWH) designations while portions of Bear and Fish creeks were in partial attainment of aquatic life use (ALU) designations. In 1992, the entire length of the SJR in Ohio was in partial attainment of its WWH designation. Exceedances of the primary contact recreation criteria occurred in the SJR, WBSJR, and Bear and Silver creeks.

The partial attainment of WWH criteria in the SJR was due to fish community health. "The benthic macroinvertebrate fauna was characterized as good to exceptional," but did show some impacts from siltation and embedding (Ohio EPA 1994, p. 2). Ohio EPA described the fish community health as follows:

> The fish assemblage within the St. Joseph River mainstem was more indicative of marginal habitat quality. Past channel modification, maintenance activities, and low gradient coupled with the delivery of clayey silts from agricultural nonpoint sources has resulted in a heavy bedload of sediment, siltation, and modest channel heterogeneity. As a consequence of the present condition of instream habitats significant components of the fish community were diminished (Ohio EPA 1994, p. 2)

In Fish Creek, fish community health achieved WWH criteria but "the performance of benthic macroinvertebrate fauna was diminished" and was "reflective of moderate nutrient enrichment from agricultural nonpoint sources and modified habitat" (Ohio EPA 1994, p. 6). Poor physical habitat impacted aquatic life in Bear Creek. Agricultural channelization of these streams contributed to poor habitat quality that diminished aquatic community health.

Exceedances of fecal coliform criteria were typically due to agricultural nonpoint sources. Bear Creek exceedances were also caused by home sewage treatment system (HSTS) discharges to storm sewers in the villages of Blakeslee and Edon.

B-1.1.2 Biological Surveys of Tributaries in the Vicinity of Two CAFOs in the St. Joseph and Bean/Tiffin Watersheds (Michigan DEQ 2004)

Michigan DEQ assessed the fish and macroinvertebrate communities' health and habitat in three warmwater tributaries to the SJR in 2003: Nile Ditch, Goose Creek, and Otto Creek. Fish community health was acceptable in each of the streams. Macroinvertebrate community health, as measured by

Procedure 51 at one site on each stream, was acceptable. All three streams' habitat was affected by dredging, canopy removal, and snagging. Habitat was marginal (moderately impaired) in Nile Ditch and Goose Creek and poor (severely impaired) in Otto Creek. Michigan DEQ generally found better macroinvertebrate community health and habitat in streams that were not recently dredged.

B-1.1.3 Bacteria Source Load Tracking (Ross and Loomis 2004)

Antibiotic Resistance Analysis was used to determine the sources of bacteria in the SJRW. Ambient in-stream bacteria data were collected from SJRWI sampling sites in 2002-2005 and certain areas were targeted (e.g., livestock operations, sewer overflows). A database of bacterial strains was created using fecal matter samples from horses, swine, dairy cattle, and beef cattle at 4H and county fairs in Allen (IN), DeKalb (IN), Hillsdale (MI), and Williams (OH) counties, from cats and dogs at animal shelters in Fort Wayne and DeKalb County, and from humans at rest stops along I-69.

The study results show that livestock operations (swine, dairy cattle, and beef cattle) contribute relatively small proportion of bacteria throughout the SJRW. Human sources tended to also contribute relatively low proportions (10 to 15 percent) of the in-stream bacteria, except certain areas. Throughout the watershed, geese tended to contribute a relatively large proportion of the bacteria.

B-1.1.4 Biological and Water Quality Study of Fish Creek (Ohio EPA 2005)

Ohio EPA has thoroughly studied Fish Creek and has issued five reports describing their studies (Ohio EPA 1993, 1994b, 1995, 2003, 2005). Fish Creek supports diverse aquatic communities and has been repeatedly studied due, in part, to a spill of 30,000 gallons of diesel fuel from a pipeline rupture on September 15, 1993. Fish, macroinvertebrate, water column, and sediment data were collected multiple times since the spill by Ohio EPA, Ohio Department of Natural Resources, IDEM, The Nature Conservancy, and U.S. Fish and Wildlife Service.

Macroinvertebrate community health has typically met water quality standards (WQS). Attainment of biological criteria at river miles (RMs) 14.3 and 8.3 has not varied over time, while a decline was observed at RM 7.5 (though criteria are still met). At RM 5.4, the ICI has attained its exceptional warmwater habitat use, except in 1993 following the spill and 1997 for unknown reasons (Ohio EPA 2005, p. 20). At RM 0.3, the ICI has attained the WWH use, and even the exceptional warmwater habitat criteria. IDEM also evaluated macroinvertebrate community health using the macroinvertebrate Index of Biotic Integrity (mIBI) and Helsenhoff Biotic Index (HBI); most sample sites attained criteria.

Fish community health was considerably worse than macroinvertebrate community health. Poor fish communities were identified at the two most upstream sample locations due to high proportions of pollution tolerant species and IBI scores throughout the stream were generally lower than expected (Ohio EPA 2005, p. 28). Multiple surveys identified heavy silt layers that caused extensive embeddedness.

By 2002, only strontium exceeded Ohio's WQS all other constituents in the water column or sediment were at or below standards or targets (Ohio EPA 2005). In 1997, levels of fecal coliform and total phosphorus exceed WQS and targets (Ohio EPA 2003). Also in 1997, seven polycyclic aromatic hydrocarbons were detected at low levels from sediment collected in lower Fish Creek, below the spill; only one polycyclic aromatic hydrocarbon was detected in 2002. Ohio EPA had reported a "moderately strong diesel fuel odor" in bottom sediments in 1994 that was not observed in 1997 (Ohio EPA 2003, p. 14). Additional tests in 1997 showed that fish had "little or no exposure to organic contaminants" (Ohio EPA 2003, p. 6).

B-1.1.5 A Biological Study of the East and West Branches of the St. Joseph River Watershed and Bean Creek Watershed in Southern Lenawee and Hillsdale Counties (Michigan DEQ 2005a)

The East Branch St. Joseph River (EBSJR) and WBSJR in Michigan were sampled in 2000. Habitat was fair (moderately impaired) in the EBSJR subwatershed, except for poor (severely impaired) habitat in Laird Creek due to sedimentation and low flow and slightly impaired habitat at a site on the EBSJR. Macroinvertebrate community health ranged from acceptable to excellent and met the OIALW designated use. Except for zinc in Clear Fork Creek, all water chemistry results in the East Branch subwatershed met Michigan's WQS.

Many streams in the WBSJR subwatershed are maintained as ditches and drains (Michigan DEQ 2005a, p. 4). Habitat ranged from fair to good, and macroinvertebrate community health ranged from acceptable to excellent. Similar to the EBSJR subwatershed, the WBSJR subwatershed also met the OIALW designated use. Mercury was detected in the West Branch and zinc in Silver Creek at levels above their respective WQSs. Phosphorus, ammonia, arsenic, and zinc each exceeded expected ranges at a few sites.

B-1.1.6 Biological Surveys of Tributaries to the Maumee (St. Joseph) River Watershed in Hillsdale and Lenawee Counties, Michigan (Michigan DEQ 2005b)

Michigan DEQ sampled eight sites across EBSJR and WBSJR subwatersheds in 2005. The West Fork of the West Branch of the St. Joseph River (WFWBSJR) had excellent habitat and macroinvertebrate community health in the headwaters and both decreased downstream. Habitat quality decreased due to "a lack of stable substrates […], an increase in hydrologic instability (flashiness), and a loss of buffering capabilities resulting from a diminished riparian zone" (Michigan DEQ 2005b, p. 5). A general increase in nutrient concentrations was observed. Portions of the East Fork of the West Branch of the St. Joseph River (EFWBSJR) were impounded, dredged, and straightened. Habitat was good and macroinvertebrate community health was excellent. Nutrient levels were within expected ranges.

The EBSJR is also dredged and straightened, but the headwaters receives a substation amount of groundwater. Habitat was poor (severely impaired) but macroinvertebrate community health was excellent, though populations had low densities. Silver, Laird, and Bird creeks are tributaries of the East Branch, and Silver and Laird creeks are less channelized. Silver and Laird creeks had good habitat and excellent macroinvertebrate community health; streams were flashy and had expected nutrient levels. Bird Creek had good habitat and macroinvertebrate community health with low nutrient concentrations. All the sites attained Michigan's WQS.

B-1.1.7 Biological and Water Quality Study of the St. Joseph River Basin, 2013 (Ohio EPA 2015)

In 2013, Ohio EPA sampled 24 sites for bacteria, 33 sites for biology, and 35 sites for water chemistry. All 24 sites sampled for *E. coli* resulted in high bacteria concentrations and every site failed to meet the *E. coli* geometric mean criterion (Ohio EPA 2015). All eight the sites on the mainstem of the SJR attained WWH biocriteria and 23 of 25 sites on tributaries to the SJR met their respective biocriteria. Fish and macroinvertebrate communities' health at the eight sites on the SJR ranged from marginally good to exceptional (Ohio EPA 2015, p. 48, 60). Fish community health on the tributaries to the SJR ranged from fair to exceptional, while macroinvertebrate community health ranged from marginally good to exceptional (Ohio EPA 2015, p. 49, 78)

Ohio EPA (2015, p. 1) found that "[t]he biological integrity of the St. Joseph River watershed has improved since the streams were last sampled in 1992". In 1992, all the sites sampled for fish failed to meet WWH biocriteria and the "fish assemblage was dominated by tolerant, omnivorous, or otherwise generalist species" (Ohio EPA 2015, p. 93). In 2013, all eight sites met biocriteria and Ohio EPA (2015, p. 91) found "a strong and significant statistical difference" between IBIs from 1992 and 2013.

While water quality is generally good throughout the watershed, "[s]ome of the streams in the study area [Ohio's portion of the SJRW] were affected by agricultural runoff, sedimentation, and direct habitat alteration" (Ohio EPA 2015, p. 9).

B-1.2 Soil and Water Assessment Tool Modeling Studies

IDEM, Purdue University, the U.S. Department of Agriculture's Agricultural Research Service (USDA ARS), and the University of Michigan developed Soil and Watershed Assessment Tool (SWAT) models for the SJRW or the Cedar Creek subwatershed. Purdue University's recent SWAT modeling (Chaubey et al. 2014; see Section B-1.2.5) will be used to support SWAT model development for this TMDL project.

B-1.2.1 Cedar Creek Watershed SWAT Modeling (Rice 2005)

IDEM developed a SWAT model for the Cedar Creek subwatershed to evaluate management scenarios for agricultural practices[1]. The SJRWI and Allen, DeKalb, and Noble soil and water conservation districts provided row crop management practices and septic systems information. The SWAT model simulated total suspended solids, total nitrogen, and total phosphorus. Due to the lack of monitoring data, water quality calibration and validation of the model was limited.

IDEM also evaluated *E. coli* in the Cedar Creek watershed. As SWAT does not simulate bacteria, IDEM used load duration curves and the Bacteria Indicator Tool. The load duration curve results showed that runoff-derived source loading contributed the most *E. coli*. Using the Bacteria Indicator Tool, IDEM concluded that failing HSTS contributed relatively low *E. coli* loading as compared to other sources.

B-1.2.2 Atrazine SWAT Modeling (Larose et al. 2007; Heathman et al. 2008; Quansah et al. 2008)

Researchers at Purdue University and USDA ARS developed SWAT models for the SJRW and Cedar Creek subwatershed with various study objectives involving in-stream atrazine levels. Larose et al. (2007) developed a SWAT model for the Cedar Creek subwatershed that was calibrated and validated using USGS flow and atrazine (National Water Quality Assessment Program) data for a site at the mouth of Cedar Creek. Heathman et al. (2008, p. 554) developed un-calibrated SWAT and Annualized Agricultural Non-Point Source (AnnAGNPS) models for the Cedar Creek subwatershed "to test accuracy and applicability of the SWAT2005 and AnnAGNPS models for estimating streamflow and atrazine loss". Quansah et al. (2008) developed a SWAT model for the SJRW to evaluate the impacts of tillage practices on in-stream atrazine levels, which is a concern for public water supplies. This model was calibrated/validated with data from three USGS gages and SJRWI atrazine data. None of the studies evaluated nutrients, sediment, or *E. coli*, and thus, are not further discussed herein.

B-1.2.3 Impact of Watershed Subdivision and Soil Data Resolution on SWAT Model Calibration and Parameter Uncertainty (Kumar and Merwade 2009)

Purdue University researchers developed 24 SWAT models, 12 models each for the SJRW and Cedar Creek subwatershed, using either STATSGO or SSURGO soil data and variously sized critical source areas. They used Purdue's TeraGrid system to autocalibrate 14 parameters using 7 years of daily streamflow data (1993 through 1999). Kumar and Merwade (2009, p. 1185) concluded that "calibration results are different depending on whether [the Nash-Sutcliff efficiency coefficient] or [Model Bias] is used as the performance indicator". They also found that "[v]isual inspection of simulated hydrograph

[1] Row crop inputs for each scenario and inputs hydrologic response units are presented in the appendices of *Water Quality Modeling Analysis for the Cedar Creek Watershed* (Rice 2005).

and manual adjustment of parameters may become necessary to ensure appropriate water balance in a hydrologic model" because autocalibration can yield water balances and parameterization results that are not consistent with the actual watershed (Kumar and Merwade 2009, p. 1192).

B-1.2.4 Impacts of conservation buffers and grasslands on total phosphorus loads using hydrologic modeling and remote sensing techniques (Larose et al. 2011)

Researchers at the University of Michigan and USDA ARS developed a SWAT model for the Cedar Creek subwatershed to evaluate the impacts of vegetated buffers and conservation grasslands on TP loads. Streamflow was calibrated at the USGS gage at Cedarville (04180000) from 1993-2002 and validated for 2006-2008; the F34 stream gage maintained by USDA ARS National Soil Erosion Research Laboratory (NSERL) was also used for validation. TP was calibrated for 2003-2007 using NSERL data. Scenario results indicated that the greatest TP load reductions were associated with the combination of all the simulated conservation practices implemented and that conservation grassland alone resulted in the lowest TP reductions (Larose et al. 2011, p. 128).

B-1.2.5 Cumulative Impacts of BMP Implementation in the Maumee River Basin – BMP Effect Modeling (Chaubey et al. 2014)

Purdue University developed a SWAT model for the SJR, St. Mary's River, and upper Maumee River watersheds, under a grant from the U.S. EPA Great Lakes National Program Office, to support WMP development and BMP implementation. The model was auto-calibrated/validated at multiple sites, including three sites for hydrology and one site for water quality in the SJRW[2]. The hydrological calibration was excellent while the water quality calibration was generally good. The model was run to simulate the years 1993 through 2009. Purdue University evaluated various BMPs through SWAT model scenario development at field-, watershed-, and basin-scales.

The researchers found that "[c]onservation crop rotation and no-till, which were most widely applied conservation practices in the study watershed, provided the greatest sediment load reduction at a watershed scale, while conservation crop rotation and cover crop reduced the greatest amount of nutrients (Chaubey et al. 2014, p. 9). They also found that site-specific, landscape, and topographic factors limited BMP effectiveness. SWAT modeling of BMP effectiveness showed that "conservation practice implementation may not be focused in the areas of the watershed where they are most needed" (Chaubey et al. 2014, p. 89).

B-1.3 Watershed Management Plans

Five watershed management plans (WMPs) were developed by or in coordination with the SJRWI.

B-1.3.1 St. Joseph River Watershed Management Plan (SJRWI 2006)

One of the goals of the 2006 revision of the SJR WMP was to begin managing the *entire* SJRW. The WMP identified sediment, nutrient, bacteria, and pesticide pollutants, their potential sources, and how some entities are addressing these sources. This WMP also seeks to assist stakeholders with developing WMPs for each of the subwatersheds (formerly 11-digit hydrologic unit codes [HUCs]). The additional goals are to reduce levels of alachlor, ammonia, atrazine, bacteria, glyphosate, pH, and total phosphorus to water quality standards or target levels (as appropriate) and the reduction of sediment loads by 30 percent.

[2] The hydrological parameterization was within predefined ranges while the water quality parameterization was at or near the upper and lower limits of the predefined ranges (Chaubey et al. 2014, p. 61)

SJRWI (2006) identified the following critical areas: Bear Creek, Big Run, Cedar Creek watershed including Garrett City Ditch, EBSJR, WBSJR, Nettle Creek, and northern Allen County including Tiernan Ditch. These critical areas were designated based, in part, upon analyses of SJRWI's water quality data that showed elevated concentrations of turbidity, nutrients, *E. coli*, and atrazine.

B-1.3.2 Cedar Creek Watershed Management Plan (Loomis 2008)

SJRWI was awarded a CWA section 319 grant to develop a WMP for the Cedar Creek subwatershed that is composed of two HUs[3]: *Matson Ditch-Cedar Creek* (HUC 04100003 06) and *Cedar Creek* (HUC 04100003 07). The grant was used to replace failing HSTS, plant trees, install two-stage ditches (in lieu of installing buffers and filter strips), and installed rain gardens. A cost-share program funded the installation of 24 HSTS, including 19 conventional systems and five alternative systems[4]. SJRWI also helped to develop an HSTS maintenance DVD.

The grant originally called for restoration activities that were not competitive with programs managed by the Farm Service Agency and U.S. Fish and Wildlife Service. Instead, a two-stage ditch development project was installed along the Van Gorder and Davis-Freeman ditches that are tributary to Little Cedar Creek, which is a critical area for sedimentation. About 1.33 lineal miles of managed drainage ditches were converted to two-stage ditches, with additional support provided by the Maumee River Basin Commission.

SJRWI supported the installation of seven rain gardens, including the installation of four rain gardens as a demonstration project at the Ricke Park lodge. A level spreader that routes parking lot stormwater runoff at the Ricke Park lodge to a swale was also installed. Other projects that demonstrate environmentally friendly landscaping included a pervious concrete installation at an outdoor theater and a buffer with multiple species of grasses planted for bank stabilization.

B-1.3.3 Lower St. Joseph - Bear Creek Watershed Management Plan (SJRWI 2008)

SJRWI developed a WMP for the *St. Joseph River* HU that is presently HUC 04100003 08); the WMP addressed two former 11-digit HUCs: L*ower St. Joseph* (formerly HUC 04100003 100) and *Bear Creek* (formerly HUC 04100003 070). The WMP characterizes the project area; identifies pollutants, targets, and impairments; discusses pollutant loads and potential reductions; recommends future best management practices (BMPs) and other activities; and describes the WMP goals[5]. Stakeholder perceptions and concerns are presented throughout the WMP; stakeholder concerns ranged from drinking water protection and water quality to public access and recreation to preservation, dredging and community involvement (SJRWI 2008).

SJRWI identified and assessed the main sources of water quality issues involving *E. coli* bacteria, nutrients, sediment, and pesticides. The four main sources of bacteria are combined sewer overflows, failing on-site wastewater treatment systems (OWTS)[6] , wildlife, and livestock and domestic pets. Five source areas for bacteria were delineated: (1) combined sewer overflows in Fort Wayne, (2) failing OWTS in urban and suburban Fort Wayne, (3) un-sewered communities in DeKalb County, (4) failing OWTS and animals in the SJR-Cedarville Reservoir and Swartz-Carnahan subwatersheds, and (5)

[3] Loomis (2008) developed the WMP for *Upper Cedar Creek* (HUC 04100003 080) and *Lower Cedar Creek* (HUC 04100003 090). After the 11-digit to 10-digit HUC conversion, these HUs became *Matson Ditch-Cedar Creek* (HUC 04100003 06) and *Cedar Creek* (HUC 04100003 07), respectively.
[4] The five alternative systems are "three Presby systems adjusted to non-standard site and layout specifications; one engineered wetland pre-treatment system, and one secondary pre-treatment peat filter system" (Loomis 2008, p. 4).
[5] SJRWI's (2008, p. 87-88) quantified goals include the reductions of *E. coli* by 95 percent, TSS by 63 percent, atrazine by 50 percent, and total phosphorus by 2.6 percent.
[6] On-site septic systems are essentially equivalent to home sewage treatment systems (HSTS), a common term for such systems in Ohio.

nuisance geese at the Indiana University-Purdue University Fort Wayne (IPFW) campus and other urban areas along the SJR (SJRWI 2008, p. 68-69).

Agriculture, loss of stabilized and vegetated banks, and construction activities were identified by SJRWI as the sources of sediment; SJRWI also identified four source areas: (1) construction and development in northern Allen County, (2) conventional tillage, lack of cover crops, and livestock access to streams (e.g., hoof-shear on the banks) in DeKalb County, (3) agricultural development in the floodplains, and (4) construction of new roads and salt/sand mixture application to roads during the winter (SJRWI 2008, p. 70-71). The sources of pesticides are runoff from crop fields and urban lawns and recreational areas. SJRWI (2008, p. 71-71) identified four source areas for pesticides, which are all urban or agricultural applications of pesticides in floodplains. Similar to sediment and pesticides, SJRWI (2008, p. 72) found the sources of nutrients to be: stormwater runoff from agriculture and urban areas, failing OWTS, CSOs, livestock, domestic animals, wildlife, and dredging operations. The nutrient source areas are: (1) stormwater runoff from agricultural and urban areas and failing OWTS in Swartz-Carnahan Ditch and affect Cedarville Reservoir, (2) stormwater runoff from urban areas, nuisance geese and failing OWTS that affect the St. Joseph Reservoir, (3) agriculture in the floodplains, and (4) ditch management, including periodic maintenance.

B-1.3.4 Middle St. Joseph River Watershed Management Plan (draft; Quandt nd)

SJRWI developed a WMP for the Middle St. Joseph River (the *Sol Shank Ditch-St. Joseph River* HU, which is HUC 04100003 05). The WMP presents stakeholder concerns, summarizes previous studies, and evaluates the project area by subwatershed. Subwatershed sections in various chapters characterize the subwatersheds, describe the land use, identify causes and sources, estimates loads and necessary reductions, and outlines goals for each subwatershed. Eleven major sources of pollutants are identified:

- Permitted point sources
- Butler, IN combined sewers
- Stormwater runoff from industrial areas
- Improperly placed or faulty septic systems that are failing
- Livestock with direct access to streams and operations that are adjacent to or otherwise directly drain to streams
- Land use management on erodible soils
- Row crops that are tiled
- Row crop management that uses conventional tillage
- Lack of functional riparian buffers
- Stream bank erosion
- Quarries

A load reduction analysis found that nitrate plus nitrite loads needed to be reduced throughout the project area but total phosphorus and total dissolved solids loads did not need reductions.

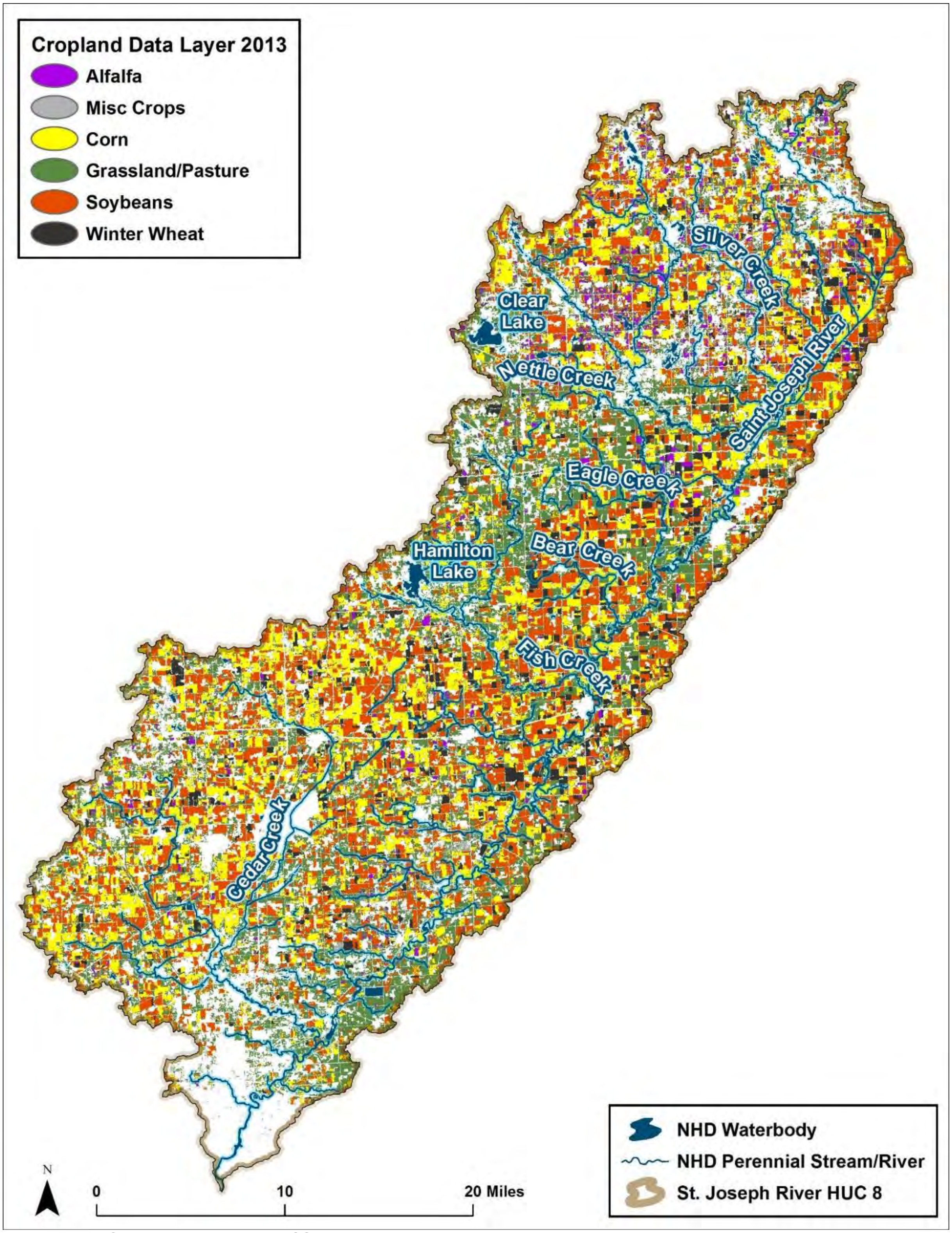
Quandt (nd) classified critical areas into categories based upon water quality, livestock operations, stream buffer widths, subsurface drainage, on-site wastewater treatment, and stormwater from developed areas. The Willow Run subwatershed was the highest prioritized water quality critical area, due to nitrate plus nitrite loads, and was followed by the Bluff and Big runs subwatersheds as the second highest priorities. Willow, Russell, and Bluff runs are critical areas due to in-stream turbidity. All current and future confined feeding operations, any operations where livestock have direct access to streams, and small animal operations within 100 feet of a stream or ditch are considered critical areas. All stream segments with buffer widths of less than 20 feet are considered critical and critical buffer widths were recommended by the adjacent lands' percent slope. Areas with unmanaged tiles and on-site wastewater treatment systems that are faulty or failing are both also considered critical areas. Butler, IN and Edgerton, OH, are also critical areas due to storm flow from impervious areas.

B-1.3.5 Upper SJRW Management Plan (Quandt 2015)

SJRWI developed a WMP for the Upper SJR in *East Branch St. Joseph River* (HUC 04100003 01), *West Branch St. Joseph River* (*02), *Nettle Creek-St. Joseph River* (*03), and *Fish Creek* (*04). Like the previous WMP (i.e., Quand [nd]), this WMP presents stakeholder concerns, summarizes previous studies, characterizes the watershed, catalogues sources, and evaluates the project area by subwatershed. Subwatershed sections in various chapters characterize the subwatersheds, describe the land use, identify causes and sources, estimates loads and necessary reductions, and outlines goals for each subwatershed. This WMP also inventories water quality data per subwatershed that was collected by U.S. EPA, IDEM, Michigan DEQ, Ohio EPA, SJRWI, and the Steuben County Lakes Council.

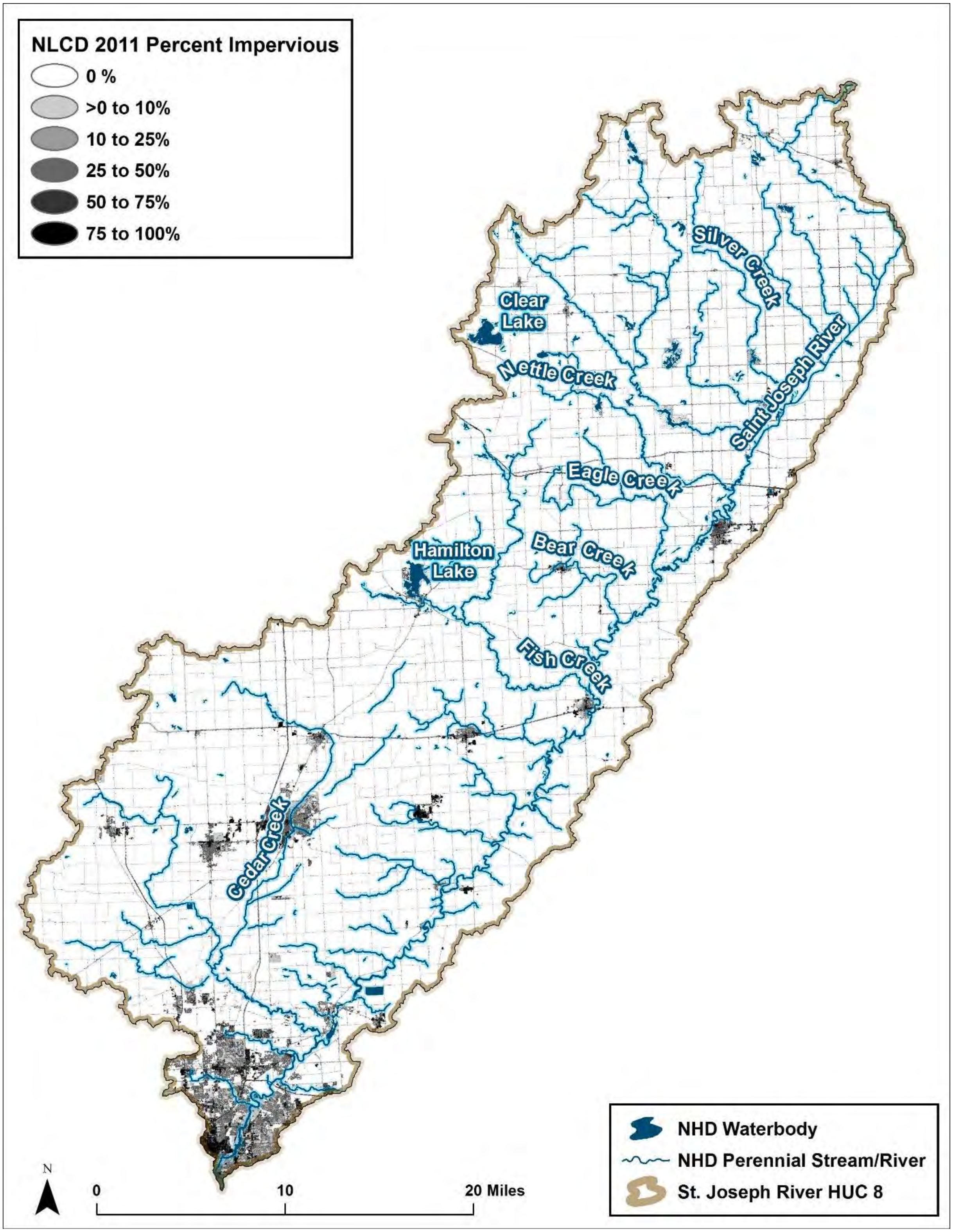
Quandt (2015) identified critical areas in the upper SJRW for pollutant reductions (for TP, turbidity, *E. coli*, dissolved reactive phosphorus), buffer width along headwaters streams and streambank erosion, and urban land use (i.e., Lake Seneca, Pioneer and Montpelier, Ohio, and Clear Lake and Hamilton Lake, Indiana). Goals, indicators (water quality, administrative, and social), and management measures were developed for each critical area.

B-2 Land Use and Land Cover



Source: 2013 Cropland Data Later (NASS 2013).

Figure B - 1. Cropland in the SJRW.



Source: 2011 *Percent Impervious Cover* in the National Land Cover Dataset (Jin et al. 2013).

Figure B - 2. Impervious cover in the SJRW.

B-3 Geology and Soils

Source: Woods et al. 2014a,b

Figure B - 3. Level III ecoregions in the SJRW.

Table B - 1. Level IV ecoregion physiography and geology in the SJRW

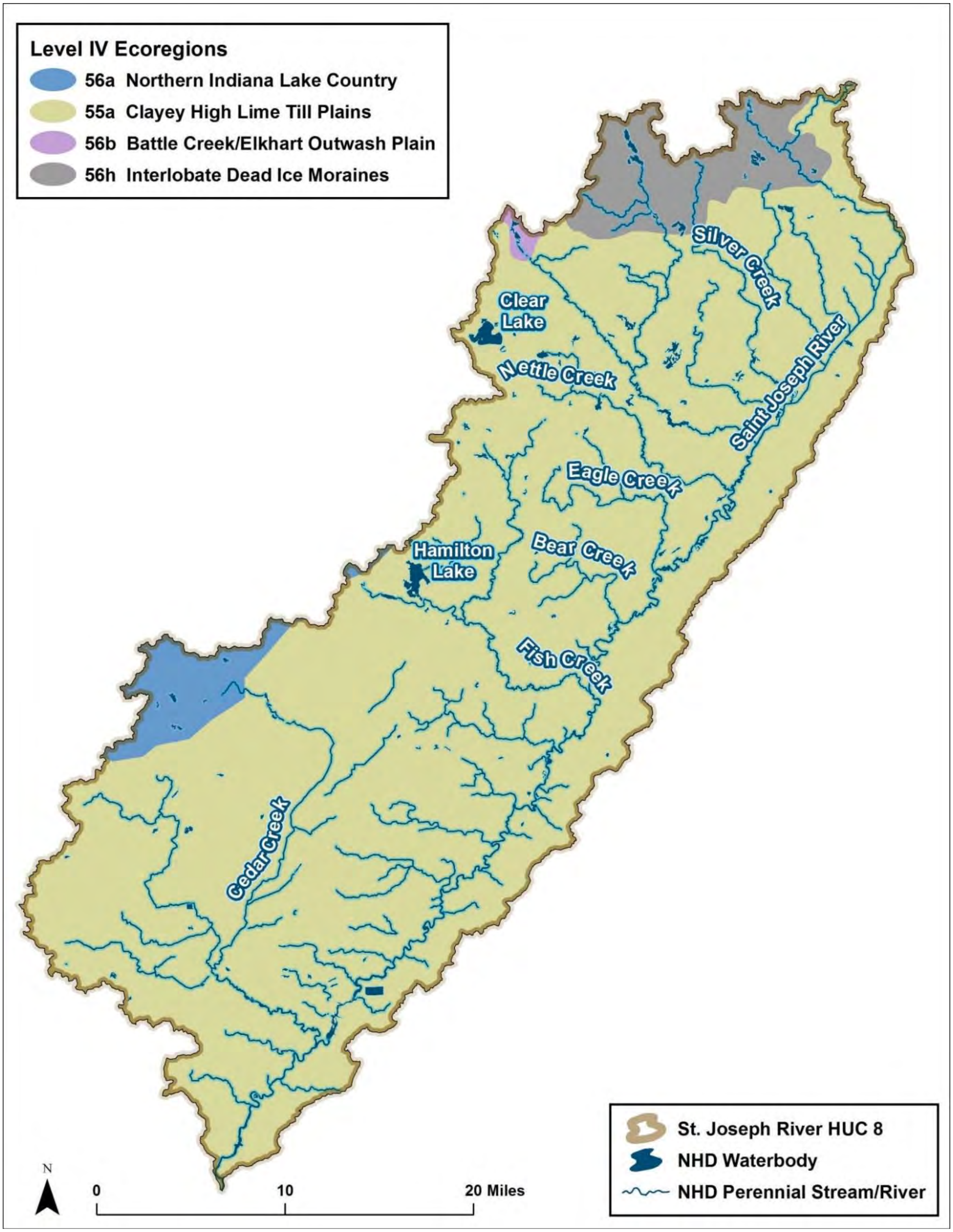
Ecoregion	Physiography	Geology
Clayey, High Lime Till Plains (55a)	Glaciated. Broad nearly level glacial till plain; also basins and end moraines. Low gradient streams.	Clayey, high lime, late-Wisconsinan glacial till, lacustrine deposits, and scattered loess overlie Paleozoic shales, carbonates, and sandstones.
Northern Indiana Lake Country (56a)	Glaciated. Hummocky plain. End moraines with many lakes, ponds, marshes, bogs, kettles, kames, and relict meltwater channels are present. Low to medium gradient streams with sand and gravel bottoms, and low sediment loads.	Late-Wisconsinan drift; also organic material. Deposits overlie Paleozoic shale, limestone, and dolomite.
Battle Creek/ Elkhart Outwash Plain (56b)	Glaciated. Nearly level to rolling drift plain with end moraines, glacial outwash landforms, lacustrine flats, and scattered potholes.	Loamy glacial till; also Quaternary glacial outwash, dune sand, lacustrine deposits, organic material, and alluvium overlie Paleozoic shale, limestone, and dolomite.
Interlobate Dead Ice Moraines (56h)	The Interlobate Dead Ice Moraines ecoregion encompasses a band of coarse-textured end moraines, kames, and outwash sands extending across much of the width of the Lower Peninsula. They consist of ice-contact topography or dead-ice moraine; it formed where ice melted in place within a stalled glacier, leaving numerous kettle ponds in its wake. Lakes also occur in pitted outwash channels.	*not available*

Source: Woods et al. 2014a,b

Table B - 2. Level IV ecoregion soils in the SJRW

Ecoregion	Common soil series
Clayey, High Lime Till Plains (55a)	Widespread: Blount, Pewamo, Glynwood, Morley. In east: Bennington, Cardington. In west: Del Rey, Eel. On lake plains: Nappanee, Milford.
Northern Indiana Lake Country (56a)	Glynwood, Morley, Fox, Oshtemo, Rawson, Houghton, Wawasee, Boyer.
Battle Creek/ Elkhart Outwash Plain (56b)	Riddles, Crosier, Brookston, Metea, Oshtemo, Tyner, Brady, Tracy.
Interlobate Dead Ice Moraines (56h)	Riddles, Hillsdale, Gilford,Spinks,Houghton, Boyer, Miami, Marlette, Lapeer, Oshtemo, Capac.

Source: Woods et al. 2014a,b



Source: Woods et al. 2014a,b

Figure B - 4. Level IV ecoregions in the SJRW.

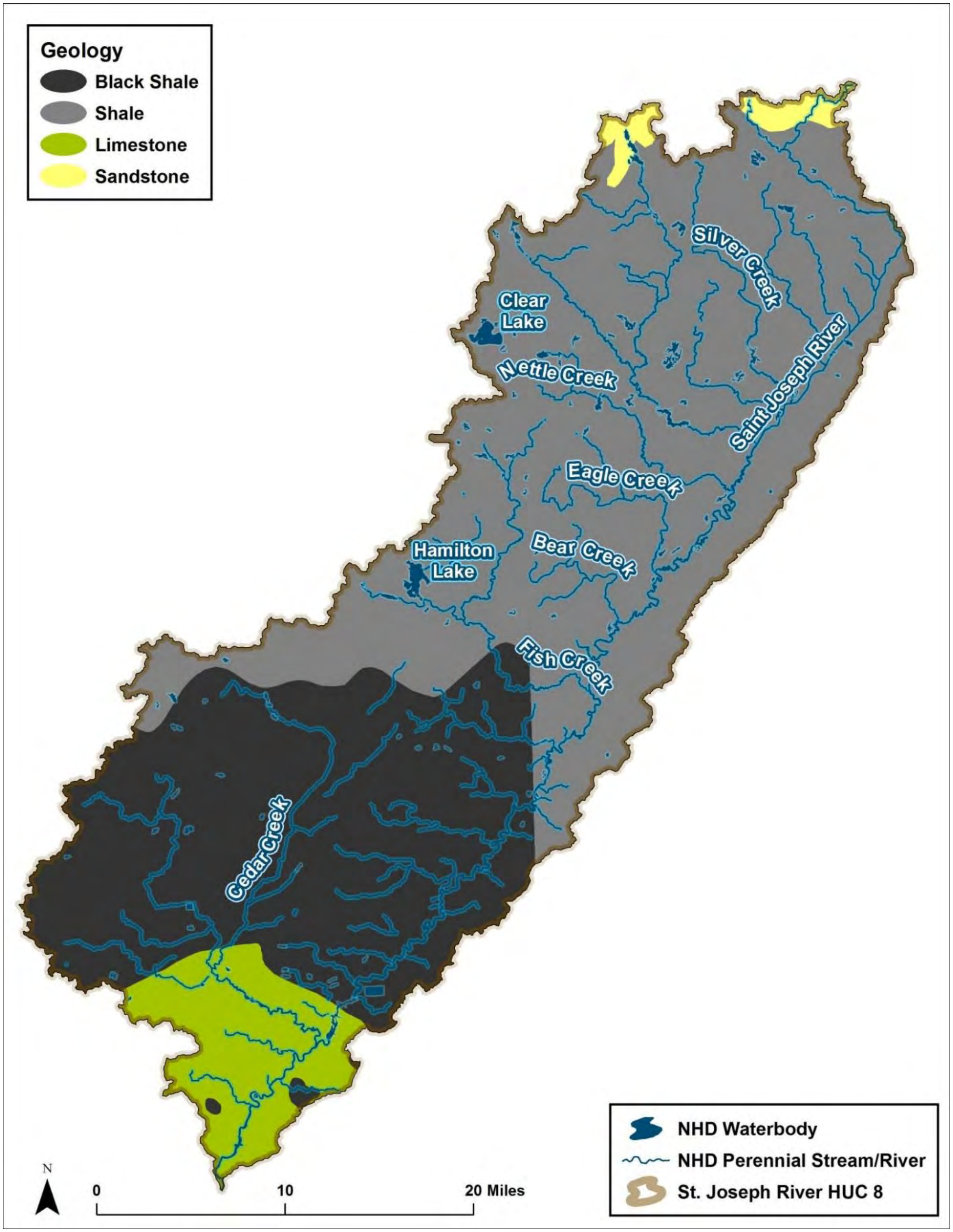


Figure B - 5. Bedrock geology underlying the SJRW.

Table B - 3. HSG descriptions

HSG	Group description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well- to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A/D B/D C/D	Dual HSGs. Certain wet soils are placed in group D solely on the basis of the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity might be favorable for water transmission. If these soils can be adequately drained, they are assigned to dual HSGs (A/D, B/D, and C/D) according to their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the un-drained condition.

Source: Soil Data Viewer 6.0 (NRCS 2011).

Table B - 4. HSG distribution in the SJRW

HUC 10	Watershed Name	A	B	C	D	A/D	B/D	C/D	NR
01	East Branch Saint Joseph River	4%	9%	**41%**	18%	7%	8%	12%	1%
02	West Branch Saint Joseph River	9%	12%	**29%**	18%	8%	10%	10%	3%
03	Nettle Creek-Saint Joseph River	3%	1%	8%	**51%**	4%	8%	24%	2%
04	Fish Creek	7%	2%	20%	**41%**	4%	7%	16%	3%
05	Sol Shank Ditch-Saint Joseph River	4%	1%	3%	**60%**	3%	5%	23%	1%
06	Matson Ditch-Cedar Creek	6%	8%	7%	**46%**	3%	9%	19%	1%
07	Cedar Creek	4%	3%	12%	**47%**	4%	7%	21%	2%
08	Saint Joseph River	4%	2%	6%	**60%**	1%	3%	22%	2%

Notes
NR = not reported.
Bolded values are the largest percentage per HUC 10.
Values might not sum to 100 percent because of rounding.

B-4 Climate

Table B - 5. Climate data summary for Angola, IN (station 120200)

Parameter [a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	31.0	33.1	43.7	57.4	69.6	78.8	83.0	81.1	74.4	62.2	47.1	34.5
Low	15.8	16.5	25.4	36.4	47.4	57.3	61.3	59.5	52.3	41.3	30.9	20.6
Precipitation	2.2	1.9	2.7	3.4	3.6	3.6	3.5	3.4	3.1	2.7	2.8	2.5
Snowfall	9.2	8.7	5.7	1.8	0.2	0.0	0.0	0.0	0.0	0.3	3.4	7.8

Source: WRCC 2014.
Notes:
Summary of data collected at Angola, IN NCDC station 120200 from January 1, 1893 through October 25, 2014.
a. All four parameters are monthly averages. High and low are in degrees Fahrenheit. Average precipitation is in inches water equivalent. Average snowfall is in inches of snow.

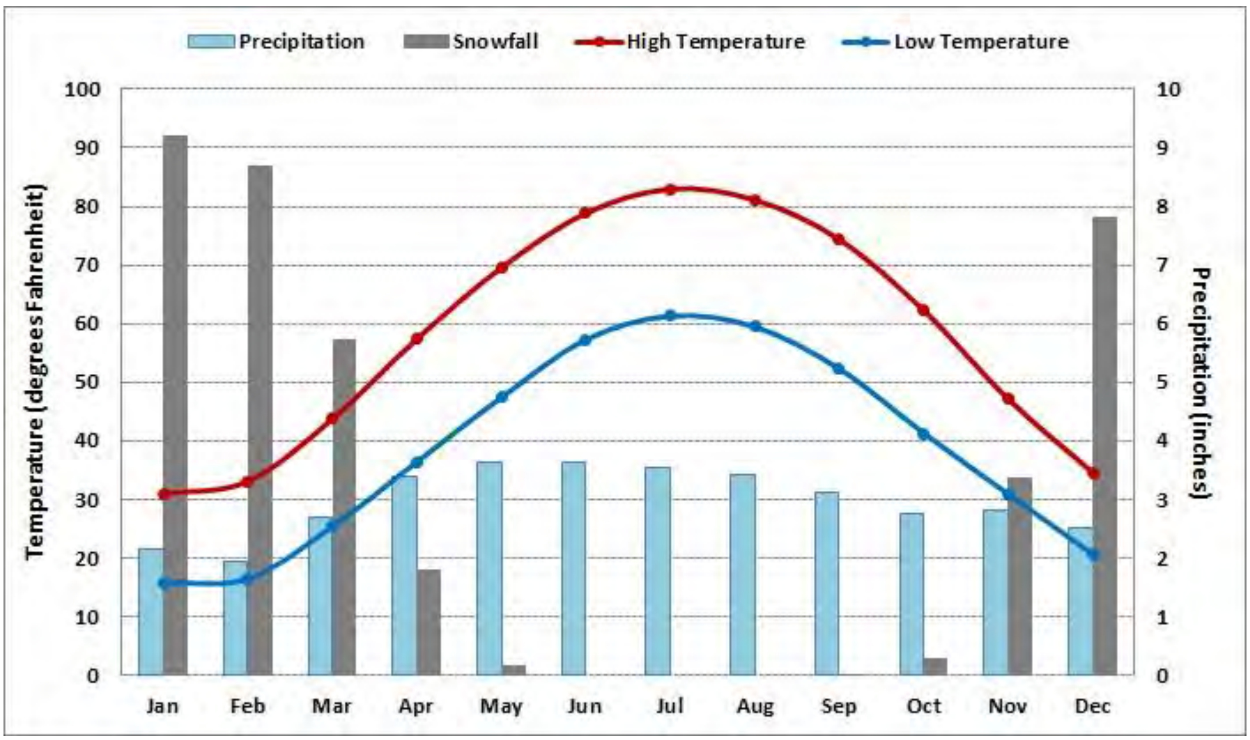


Figure B - 6. Temperature and precipitation summary at Angola, IN (station 120200).

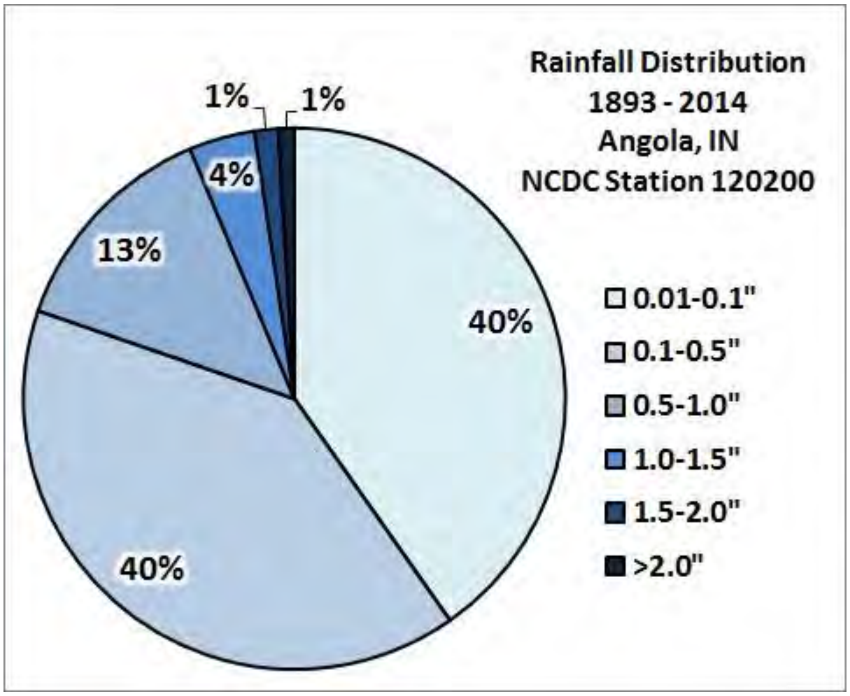


Figure B - 7. Precipitation intensity at Angola, IN (station 120200).

Table B - 6. Climate data summary for Montpelier, OH (station 335438)

Parameter [a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	32.4	34.6	45.9	59.5	71.5	80.9	85.2	83.2	76.3	64.0	48.7	35.9
Low	16.3	17.1	26.2	36.6	46.9	56.5	60.6	58.5	51.3	40.3	30.9	21.0
Precipitation	2.1	2.0	2.7	3.3	3.7	3.5	3.3	3.2	2.9	3.3	2.6	2.3
Snowfall	7.9	7.9	4.5	0.7	0.0	0.0	0.0	0.0	0.0	0.1	2.0	6.6

Source: WRCC 2014.
Notes:
Summary of data collected at Montpelier, OH NCDC station 335438 from June 1, 1893 through October 25, 2014.
a. All four parameters are monthly averages. High and low are in degrees Fahrenheit. Average precipitation is in inches water equivalent. Average snowfall is in inches of snow.

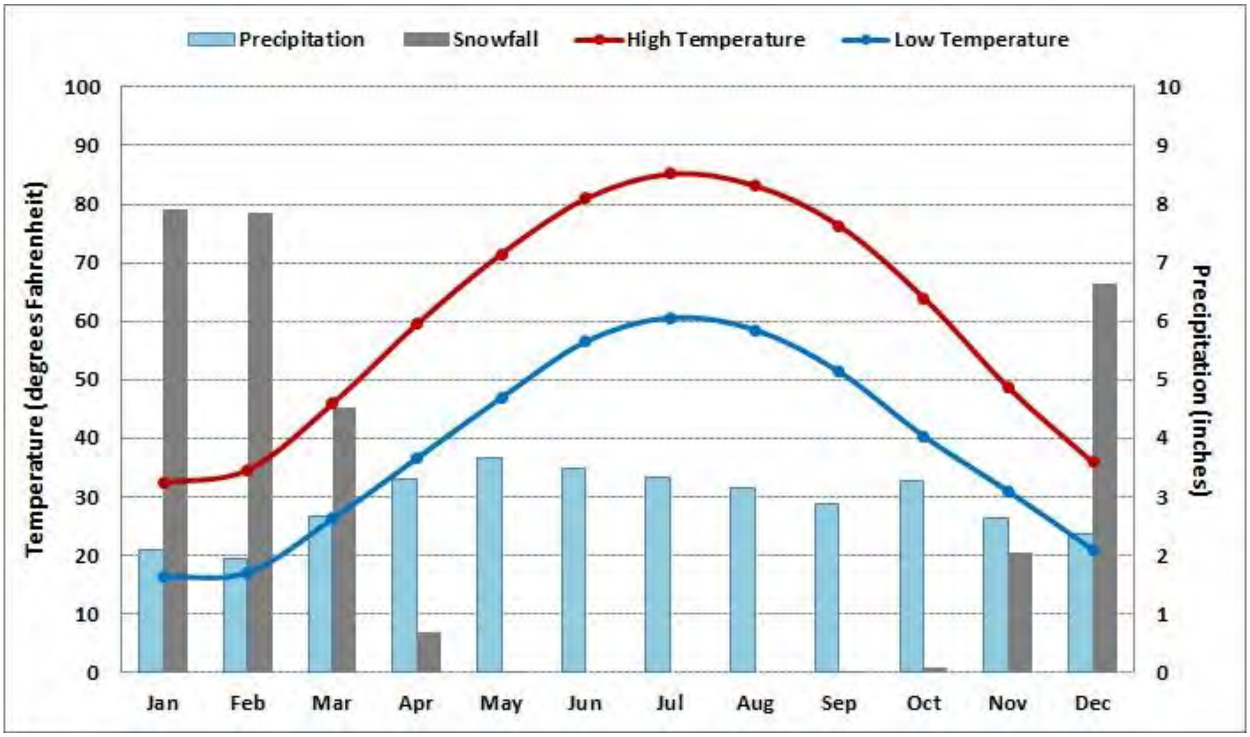


Figure B - 8. Temperature and precipitation summary at Montpelier, OH (station 335438).

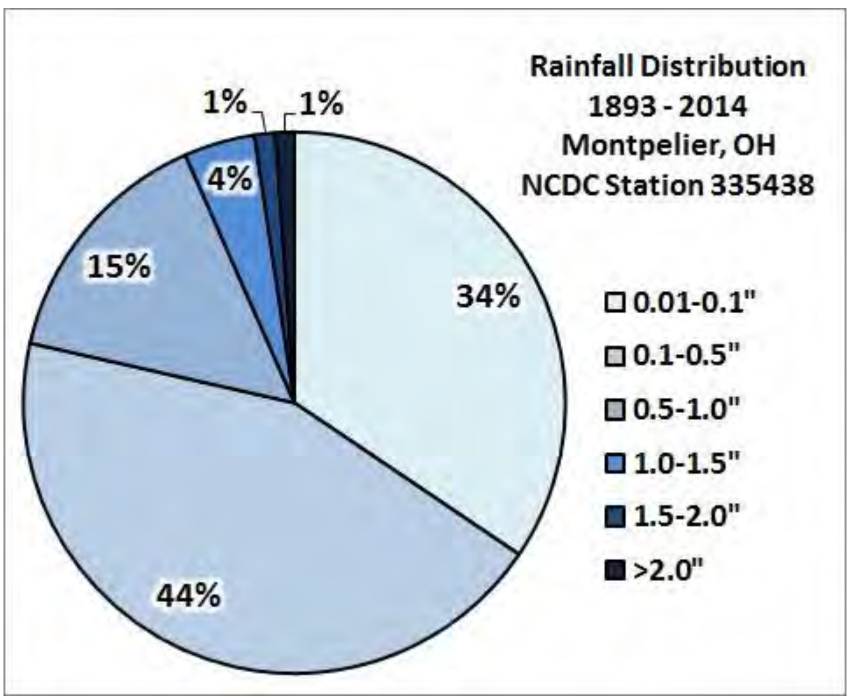


Figure B - 9. Precipitation intensity at Montpelier, OH (station 335438).

Table B - 7. Climate data summary for Hillsdale, MI (station 203823)

Parameter [a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	30.9	33.3	44.0	57.7	69.6	79.0	83.3	81.2	74.2	61.7	46.9	34.4
Low	15.2	16.0	24.9	35.4	46.0	55.6	59.3	57.3	50.6	40.1	30.3	20.0
Precipitation	2.2	2.0	2.7	3.2	3.6	3.8	3.3	3.1	3.2	2.7	2.8	2.5
Snowfall	11.4	10.2	6.7	1.8	0.1	0.0	0.0	0.0	0.0	0.2	3.9	9.9

Source: WRCC 2014.
Notes:
Summary of data collected at Hillsdale, MI NCDC station 203823 from September 1, 1891 through October 25, 2014.
a. All four parameters are monthly averages. High and low are in degrees Fahrenheit. Average precipitation is in inches water equivalent. Average snowfall is in inches of snow.

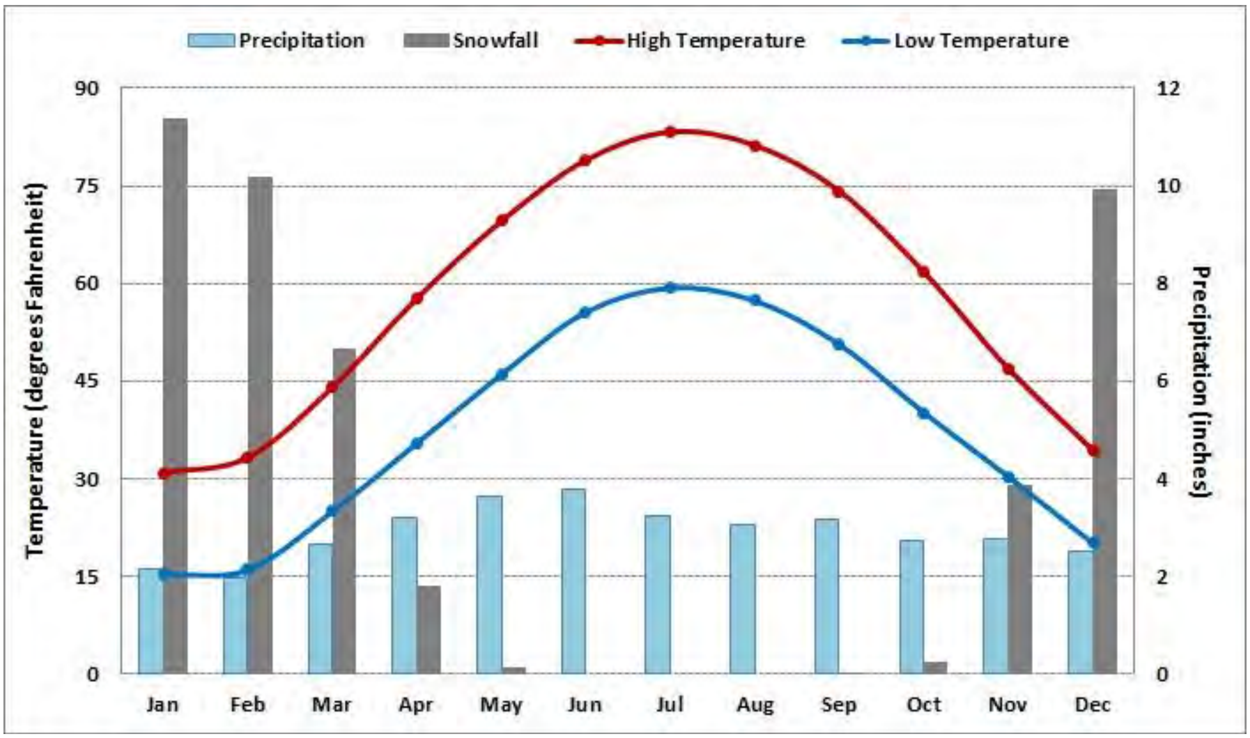


Figure B - 10. Temperature and precipitation summary at Hillsdale, MI (station 203823).

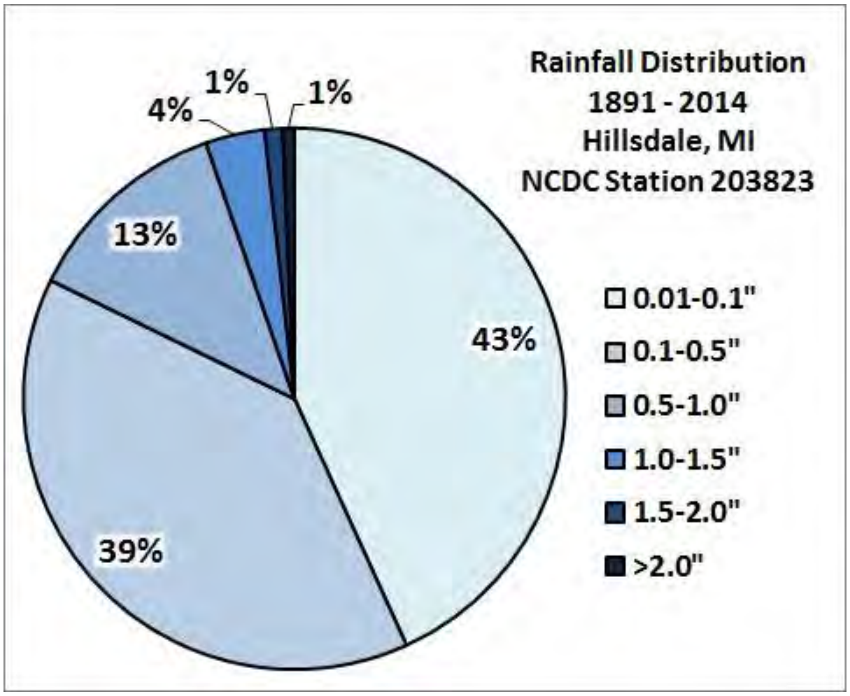


Figure B - 11. Precipitation intensity at Hillsdale, MI (station 203823).

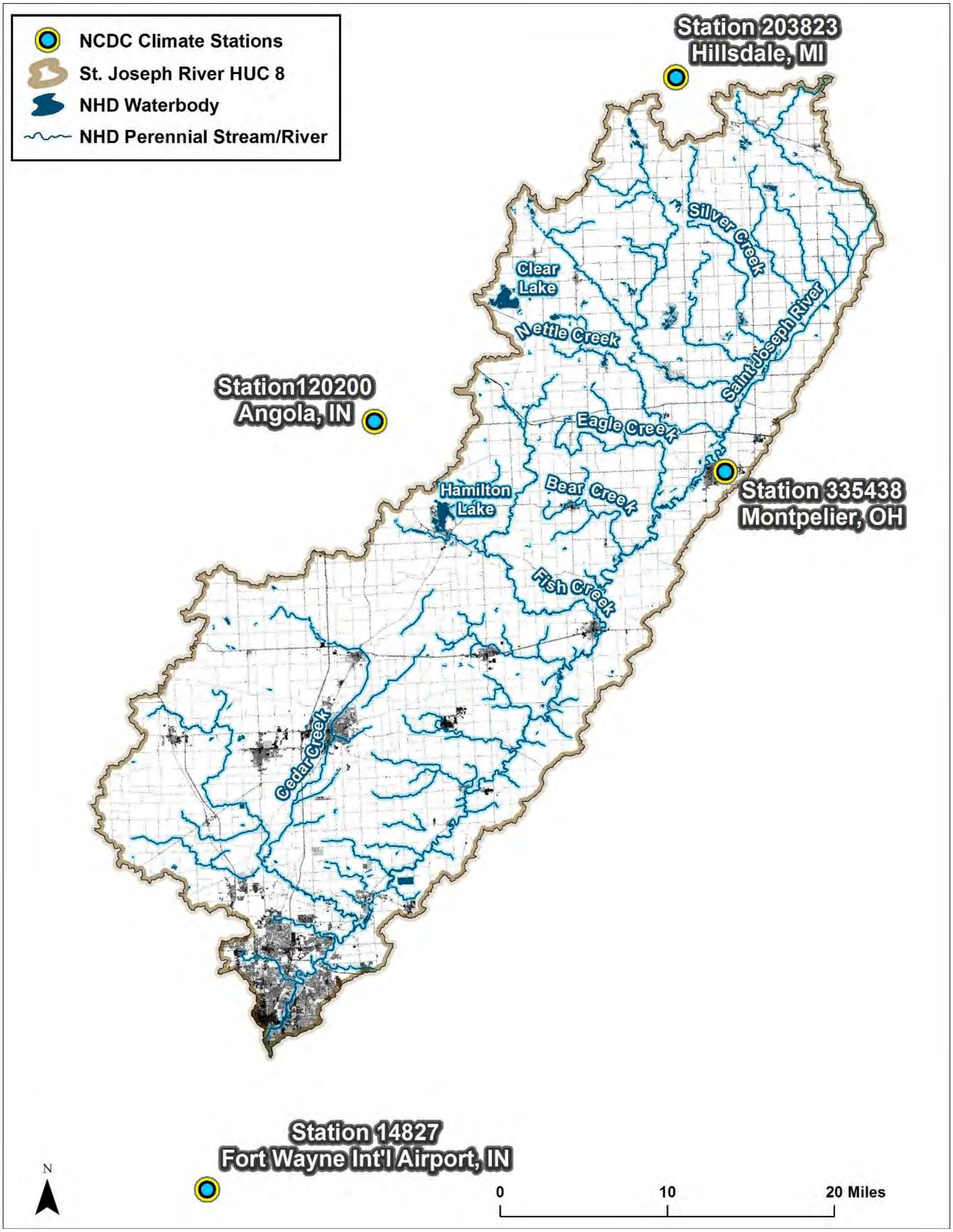


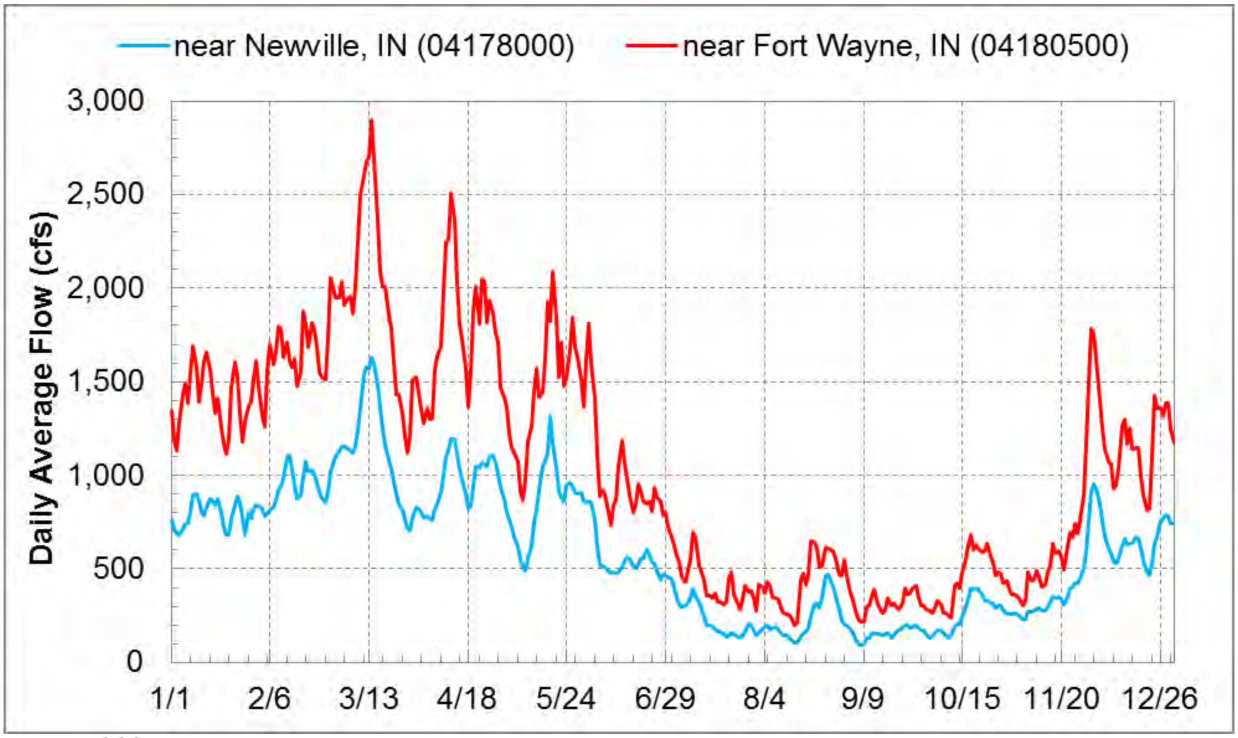
Figure B - 12. NCDC climate stations in and near the SJRW.

B-5 Hydrology

Table B - 8. USGS sites with field measurements data

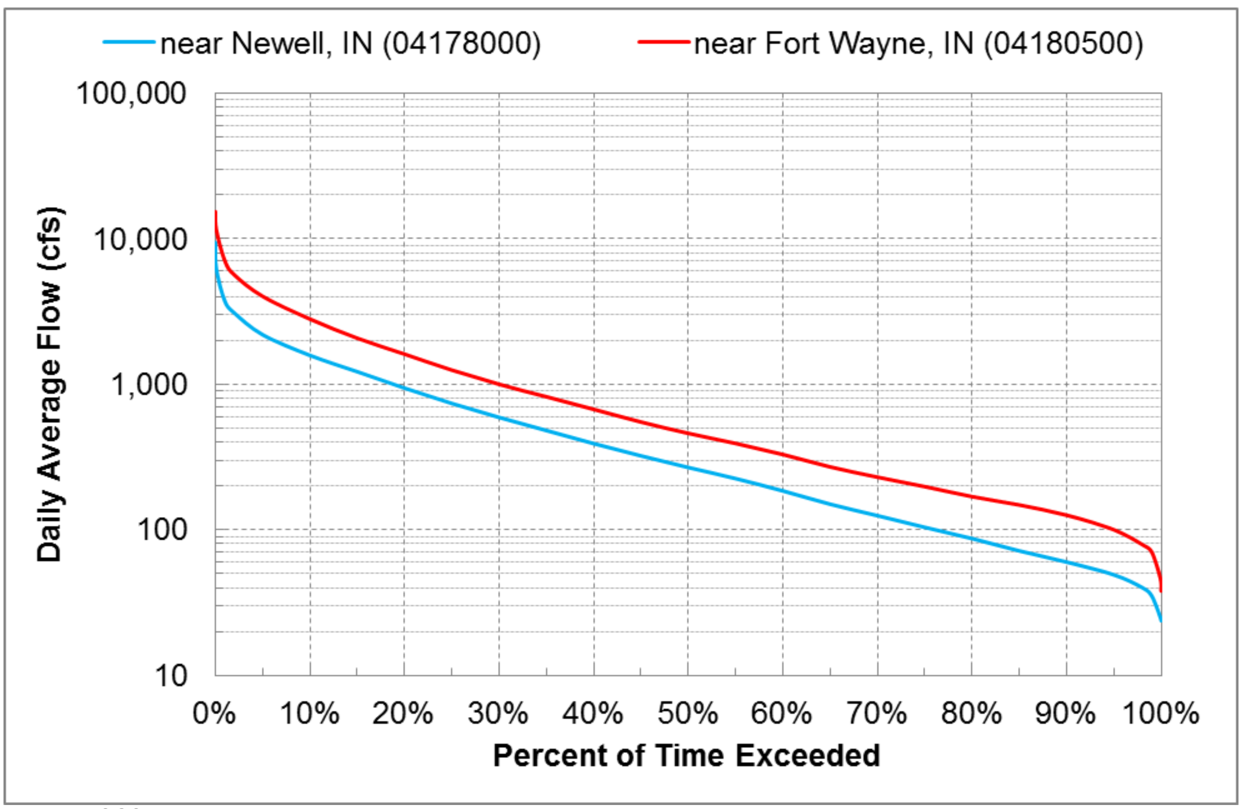
Site ID	Location	Area (mi.^{2})	No. of flows	Period of record (water years)
04177063	East Branch St. Joseph River near Pittsford, MI	22.1	1	1989
04177064	East Branch St. Joseph River near Pittsford, MI	24.2	1	1989
04177067	East Branch St. Joseph River near Pittsford, MI	27.1	1	1989
04177080	East Branch St. Joseph River at Territorial Road near Waldron, MI	70.8	12	1963, 1973 -1975
04177085	Laird Creek near Waldron, MI	16.3	3	1962, 2004
04177094	Clear Fork at Hillsdale Road near Camden, MI	n/a	1	1967
04177220	Clear Lake outlet at Long Lake Road at Montgomery, MI	15.1	1	1963
04177221	Prouty Drain at State Highway M-49 near Reading, MI	n/a	1	1982
04177222	Prouty Drain at Abbott Road near Reading, MI	n/a	3	1982-1984
04177223	Prouty Drain at Brott Road near Reading, MI	n/a	3	1982-1984
04177225	WFWBSJR near Montgomery, MI	32.2	2	1963
04177240	WFWBSJR near Austin, MI	47	3	1963, 1967, 1977
04177250	EFWBSJR near Woodbridge, MI	30.4	2	1963
04177260	EFWBSJR near Austin, MI	50.2	3	1963, 1967, 1977
04177310	Mill Stream Drain at Territorial Road near Camden, MI	11.2	2	1963, 1967
04177720	Fish Creek at Hamilton, IN	37.5	366	1969 - 2014
04177800	Fish Creek near Artic, IN	95.8	15	1968 - 1975
04177810	Fish Creek near Artic, IN	98	73	1998 - 2007
04177900	Big Run at Butler, IN	16.7	15	1968 - 1975
04178000	St. Joseph River near Newille, IN	610	315	1947 - 2014
04178400	Bear Creek near Saint Joe, IN	23.9	12	1972 - 1976
04178500	St. Joseph River at Hursh, IN	734	18	1950 - 1954
04179308	Dibbling Ditch near Waterloo, IN	12.9	9	1976 - 1978
04179310	Cedar Creek near Waterloo, IN	48.8	20	1968 - 1977
04179500	Cedar Creek at Auburn, IN	87.3	69	1946 – 1953 1963 – 1974
04179520	Cedar Creek at 18th Street at Auburn, IN	90.2	95	2001 – 2014
04179560	John Diehl Ditch at Auburn, IN	37.5	4	1988 – 1989
04179800	Little Cedar Creek near Garrett, IN	72.3	17	1972 – 1978
04179900	Willow Creek near Huntertown, IN	19.0	8	1976 - 1978
04180000	Cedar Creek near Cedarville, IN	270	631	1946 – 2014
04180500	St. Joseph River near Fort Wayne, IN	1,060	195	1984 – 2014
04180600	St. Joseph River at Fort Wayne, IN	n/a	9	1988 - 1991
04180610	St. Joseph River at Parnell Avenue at Fort Wayne, IN	1,094	1	2014

Source: USGS 2014a.
Notes
Sites are listed from top to bottom numerically by gage ID.
EFWBSJR = East Fork West Branch St. Joseph River; n/a = not available; WFWBSJR = West Fork West Branch St. Joseph River.



Source: USGS 2014b.

Figure B - 13. Average daily mean flow for active gages on the St. Joseph River (WY 1994-2013).



Source: USGS 2014b.

Figure B - 14. Flow duration curves for the active gages on the St. Joseph River (WY 1994-2013).

B-6 Community Profile

Table B - 9. Populations of select counties and municipalities in the SJRW

Location	Population in 2000	Population in 2010	Population change
Allen County, Indiana	**331,849**	**355,329**	**+7.1%**
Fort Wayne (city)	205,727	253,691	+23.3%
Grabill (town)	1,113	1,053	-5.4%
Huntertown (town)	1,771	4,810	+171.6%
Leo-Cedarville (town)	2,782	3,603	+29.5%
DeKalb County, Indiana	**40,285**	**42,223**	**+4.8%**
Auburn (city)	12,074	13,086	+8.4%
Altona (town)	198	197	-0.5%
Butler (city)	2,725	2,684	-1.5%
Corunna (town)	254	254	0.0%
Garrett (city)	5,803	6,286	+8.3%
Saint Joe (town)	478	460	-3.8%
Waterloo (town)	2,200	2,242	+1.9%
Noble County, Indiana	**46,275**	**47,536**	**+2.7%**
Avilla (town)	2,049	2,401	+17.2%
Steuben County, Indiana	**33,214**	**34,185**	**+2.9%**
Clear Lake (town)	244	339	+38.9%
Branch County, Michigan	**45,787**	**45,248**	**-1.2%**
No populated places [a]	--	--	--
Hillsdale County, Michigan	**46,527**	**46,688**	**+0.3%**
Camden (village)	550	512	-6.9%
Montgomery (village)	386	342	-11.4%
Defiance County, Ohio	**39,500**	**39,037**	**-1.2%**
No populated places [a]	--	--	--
Williams County, Ohio	**39,188**	**37,642**	**-3.9%**
Blakeslee (village)	130	96	-26.2%
Edgerton (village)	2,117	2,012	-5.0%
Edon (village)	898	834	-7.1%
Holiday City (village)	49	52	+6.1%
Montpelier (village)	4,320	4,072	-5.7%
Pioneer (village)	1,460	1,380	-5.5%

Source: USCB 2014.
Notes
Listed populations are for the entire county or municipality and may include portions outside of the St. Joseph River watershed.
a. No incorporated municipalities are in the very small portions of Branch and Defiance counties that are within the St. Joseph River watershed.

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Appendix C.

Additional Source Assessment Information

Content

Tables

Figure

C-1. Point Sources

Table C- 1. Facilities with NPDES permits in Michigan

NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
Individual						
MI0055417	Shilling Farm Site	GW clean-up [a]	0.015	--	Unnamed tributary to Silver Creek	01 05
General						
MI010057	Triple T Farms	CAFO	--	--	--	02 03
MIG250455	R C Plastics Inc. - Osseo	NCCW [a]	0.042	--	Twin Lakes drain	01 01
MIG580006	Pittsford SSDS WWSL	WWSL	0.121	--	East Branch St. Joseph River	01 01
MIG580007	Waldron WWSL		0.088	--	East Branch St. Joseph River	01 04
MIG580008	Amboy Township WWSL		0.055	--	Silver Creek	01 06
MIG580009	Reading WWSL		0.180	--	Prouty Drain	02 03
MIG580011	Camden WWSL		0.066	--	West Fork West Branch St. Joseph River	02 03
MIG580013	Amboy Township Lake Diane WWSL		0.060	--	Clear Fork	01 06
MIG760002	Michindoh Conference Center	PSP [a]	0.013 [b]	--	Weatherwood Lake [b]	01 01

Sources: Michigan DEQ (2007, 2014) and U.S. EPA (2014)
Notes
CAFO = concentrated animal feeding operation; GW = groundwater; mgd = million gallons per day; NCCW = non-contact cooling water; NPDES = National Pollutant Discharge Elimination System; PPT = petroleum products terminal; PSP = public swimming pool; SJRW = St. Joseph River watershed; WWSL = wastewater stabilization lagoon.
a. These permittees are not expected to discharge bacteria or nutrients.
b. Michindoh Conference Center may only discharge during the recreation season and discharges to Weatherwood Lake and the East Branch of the St. Joseph River.

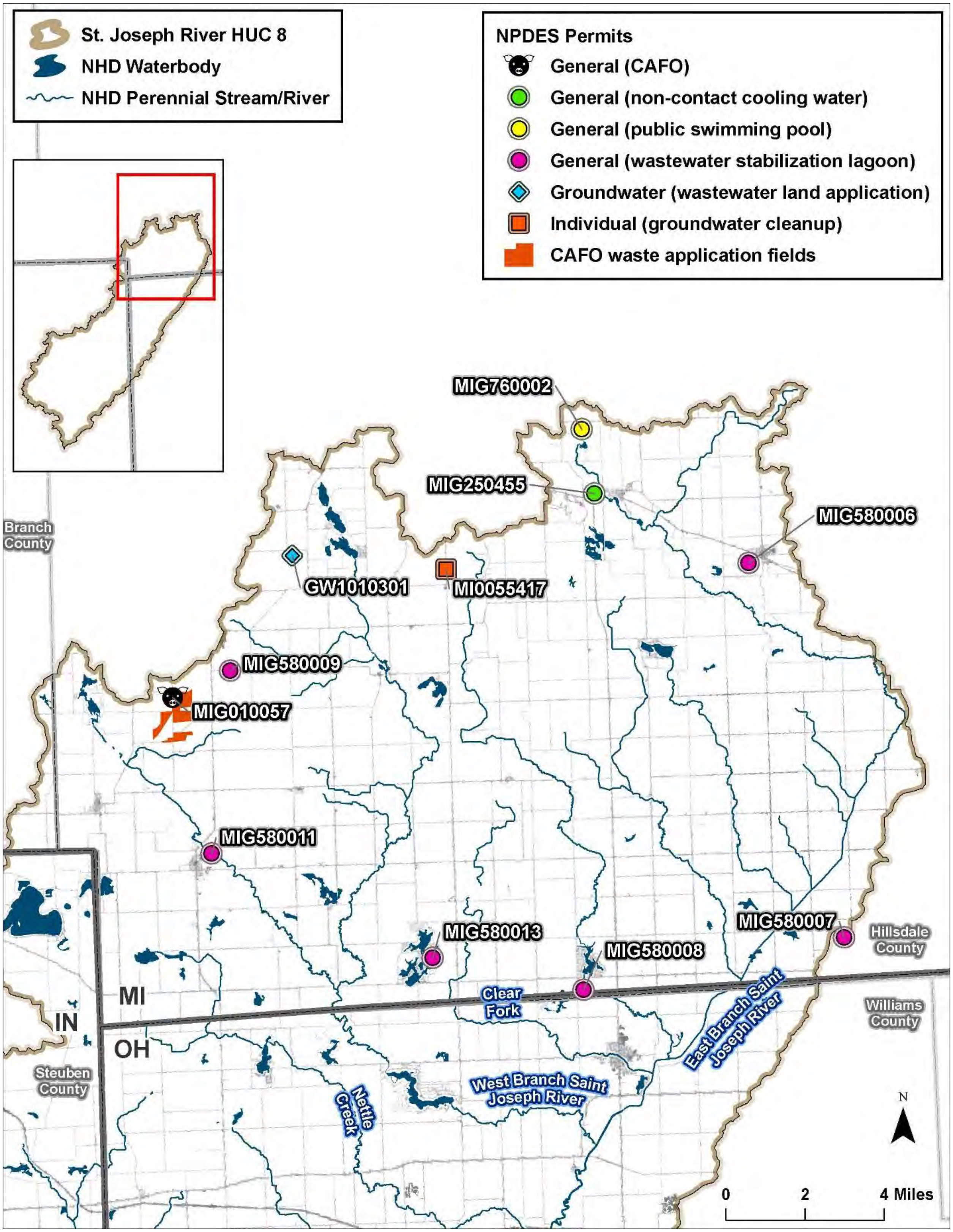


Figure C-1. NPDES permittees in Michigan.

Table C- 2. Facilities with NPDES permits in Ohio

NPDES ID	Ohio ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
Individual							
OH0021164	2PB00047	Edgerton WWTP	sanitary	0.2	1 [a]	St. Joseph River	05 01
OH0021831	2PD00003	Montpelier WWTP	sanitary	1.0	4 (3) [a,b]	St. Joseph River	03 04
OH0022535	2PB00006	Pioneer WWTP	sanitary	0.50	1 [a]	EB of St. Joseph River	01 06
OH0002941	2IC00007	Chase Brass and Copper Co. Inc.	stormwater	--	1	M-50 roadside ditch	03 02
OH0053376	2PG00046	Nettle Lake STP	sanitary	0.105	1	Nettle Creek	03 01
OH0095141	2PA00031	Edon WWTP	sanitary	0.20	1 [a]	Bear Creek	03 05
OH0030562	2IZ00040	Edgerton WTP	WTP	--	1	St. Joseph River	05 03
OH0122351	2PR00108	Exit One	sanitary	0.035	1	Eagle Creek	03 03
OH0138177	2IW00039	Montpelier WTP No. 2	WTP	-- [c]	1	St. Joseph River [c]	03 04
OH0138631	2IY00120	Aqua Ohio Lake Seneca WTP	WTP	0.008	1	St. Joseph River	02 04
OH0141852	2IW00041	Northwest Water District WTP	WTP, stormwater	--	1	Eagle Creek	03 03
OH0142069	2PR00272	Lazy River Campground	sanitary	0.04575	1	UD to St. Joseph River	03 02
General (non-stormwater, non-HSTS)							
--	2GN00012	Winzeler Stamping, Coupling, and Ferrule Plant No. 2	NCCW [d]	-- [d]	--	St. Joseph River	03 04
General (industrial stormwater)							
--	2GR00293	Plas-Tec Corp.	stormwater	--	--	--	03 05
--	2GR00511	Edgerton Auto Salvage	stormwater	--	--	--	05 03
--	2GR00559	Diversified Machine Inc.	stormwater	--	--	--	03 05
--	2GR00574	Matsu Ohio Inc.	stormwater	--	--	--	05 03
--	2GR00627	Gerken Materials Inc.	stormwater	--	--	--	03 02
--	2GR01535	Dimension Hardwoods	stormwater	--	--	--	03 05
--	2GR01736	Edgerton Forge Inc.	stormwater	--	--	--	05 03
--	2GR01859	Pahl Ready Mix Concrete Inc.	stormwater	--	--	--	05 03

Sources: Ohio EPA (2015b,c) and U.S. EPA (2014)
Notes
Facilities are listed in alphanumeric order by NPDES ID.
EB = East Branch; HSTS = household sewage treatment system; mgd = million gallons per day; NPDES = National Pollutant Discharge Elimination System; SJRW = St. Joseph River watershed; STP = sewage treatment plant; UD = unnamed ditch; WTP = water treatment plant; WWTP = wastewater treatment plant.
a. The NPDES permit identified sanitary sewer overflows at this facility.
b. The number of combined sewer overflow outfalls is in parentheses.
c. Overflow from the finishing pond at Montpelier WTP No. 2 discharges to the St. Joseph River via a tile and drainage ditch.
d. This permittee is not expected to discharge bacteria or nutrients and discharges less than 1 gallon per day of non-contact cooling water.

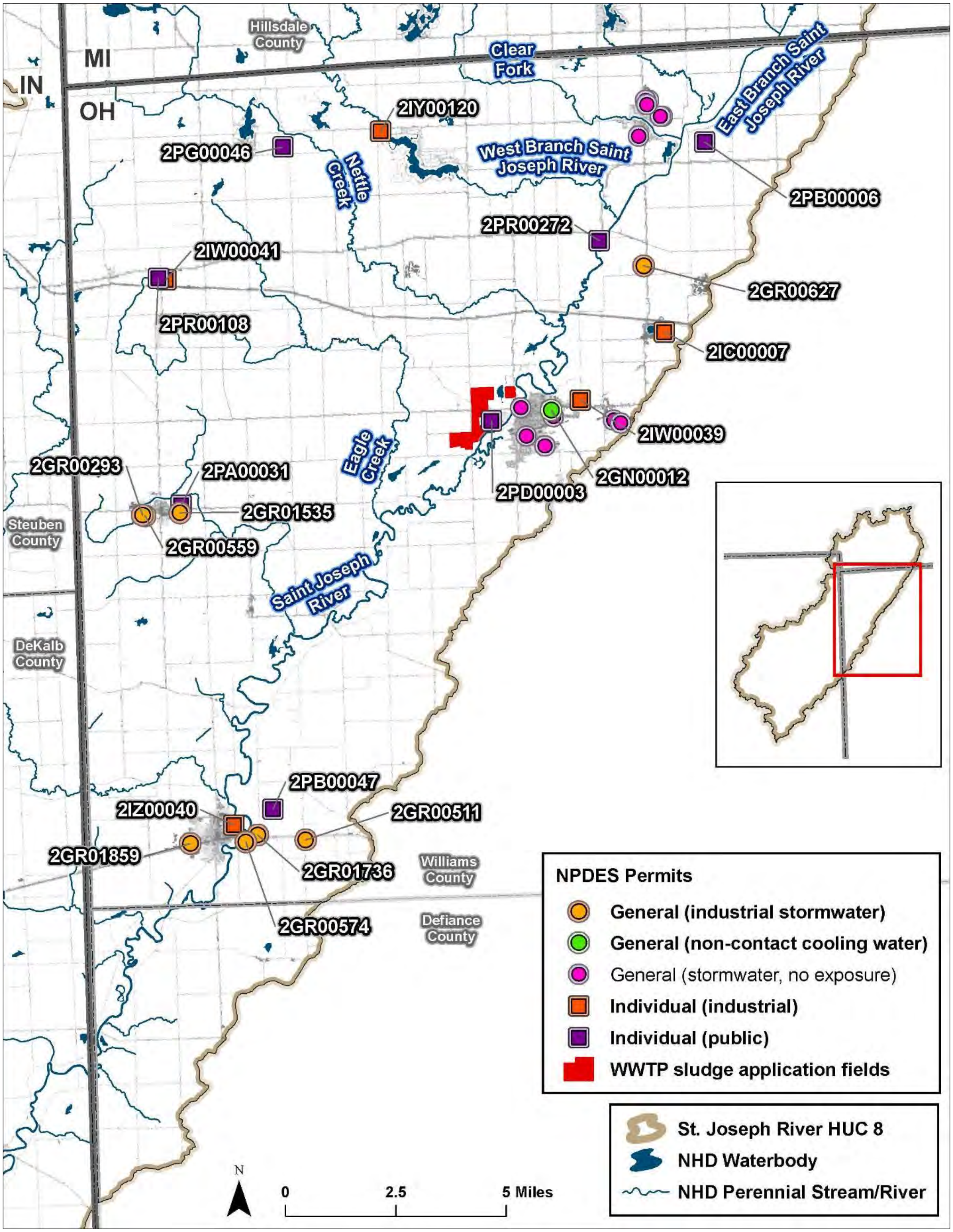


Figure C-2. NPDES permittees in Ohio.

Table C- 3. Facilities with NPDES permits in Indiana

NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
Individual						
IN0000566	Auburn Gear Inc.	multiple	0.1	2	Cedar Creek	06 04
IN0000868	Rieke Packaging Systems	NCCW, stormwater	0.76	1	Cedar Creek	06 04
IN0020664	Avilla WWTP	sanitary	0.6	1	UT to L. Cedar Creek	07 05
IN0020672 [b]	Auburn WWTP	sanitary	4.5	5 (4) [c]	Cedar Creek	06 04
IN0020711	Waterloo Municipal STP	sanitary	0.369	2	Cedar Creek	06 02
IN0022462 [d]	Butler WWTP	sanitary	3.0	3 (1)[c]	Big Run	05 02
IN0029969	Garrett WWTP	sanitary	1.2	1	Garrett City Ditch	07 07
IN0032107	Indian Springs Rec Campground	sanitary	0.04	1	Little Cedar Creek	07 05
IN0032191	Fort Wayne Municipal WWTP	sanitary	--	[1] [e]	Krunckenberg Ditch	08 06
			--	[3] [e]	Salgy Drain	
			--	6 (6) [c,e]	St. Joseph River	
IN0032981	Pickle Properties, LLC	industrial, sanitary	0.24	1	Hindman Ditch	08 01
IN0044369	Grabill Water Works	WTP	0.05	1	Witmer Ditch	08 04
IN0046043	Contech U.S., LLC (also known as Shiloh Die Cast)	NCCW, stormwater	0.58	4	Grandstaff Ditch	06 04
IN0046761	Tower Automotive USA II	NCCW [a]	0.15	1	Grandstaff Ditch	07 02
IN0047473	Corunna WWTP	sanitary	0.024	1	UT to John Diehl Ditch	07 01
IN0050822	Hamilton Lake Conservancy District	sanitary	0.45	1	Hiram Sweet Ditch	04 04
IN0052035	Avilla Water Department	WTP	0.034	1	UT to Kings Lake	07 05
IN0058441	St. Joe - Spencerville Regional Sewer District	sanitary	0.17	1	St. Joseph River	08 02
IN0058611	La Otto Regional Sewer District	sanitary	0.05	1	Black Creek	07 04
IN0059021	Steel Dynamics Inc.	multiple [f]	1.2	2	Sol Shank Ditch	05 06
IN0060216	Hamilton Water Works	WTP	0.058	1	William Egbert Ditch	04 04
IN0061263	Metal Technologies	NCCW, stormwater	0.02	1	Diehl Ditch	07 02
IN0063061	Fort Wayne Utilities – Honeysuckle Site	WTP	0.02	1	Schwartz-Carnahan Ditch	08 03
General (non-stormwater)						
ING080271	Northcrest Shopping Center	GWPRS	--	--	Stoney Run Creek	08 06

NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
ING340037	Benchmark Distribution Terminals	PPW	--	--	Schwartz Ditch	06 02
ING250077 [g]	Eastside High School	NCCW [a]	--	--	storm sewers to Big Run	05 02
ING490043	Stafford Gravel Inc.	DSCSO	--	--	Christoffel Ditch	05 05
General (industrial stormwater)						
INR210049	Irving Ready Mix Inc	stormwater	--	--	--	08 05
INRM00121	Sauder Manufacturing Company	stormwater	--	--	--	08 04
INRM00144	Sauder Manufacturing Company	stormwater	--	--	--	08 04
INRM00174	Zentis Food Solutions LLC	stormwater	--	--	--	unknown
INRM00184	Aggregate Industries Klink Concrete	stormwater	--	--	--	06 02
INRM00244	United Parcel Service, Waterloo	stormwater	--	--	--	06 01
INRM00263	Rhinehart Finishing LLC	stormwater	--	--	--	08 02
INRM00406	R3 Composites Corporation	stormwater	--	--	--	08 04
INRM00421	Sechlers Pickles Incorporated	stormwater	--	--	--	08 01
INRM00487	IPI Waterloo Recycling Center LLC	stormwater	--	--	--	06 02
INRM00501	Dekalb County Airport	stormwater	--	--	--	07 07
INRM00519	Momentive Performance Materials	stormwater	--	--	--	07 07
INRM00652	Griffith Rubber Mills - Taylor Rd	stormwater	--	--	--	07 07
INRM00784	Omnisource Corporation - Auburn	stormwater	--	--	--	06 04
INRM00918	Electric Motors & Specialties Incorporated	stormwater	--	--	--	07 03
INRM00939	NUCOR Fastener	stormwater	--	--	--	08 02
INRM00941	Nucor Building Systems	stormwater	--	--	--	06 01
INRM00973	Therma Tru Corporation	stormwater	--	--	--	05 04
INRM00978	Nucor Vulcraft - St. Joe Division	stormwater	--	--	--	08 02
INRM00985	New Millennium Building Systems, LLC	stormwater	--	--	--	05 02
INRM01012	Guardian Automotive Products Incorporated	stormwater	--	--	--	08 04
INRM01097	Rieke Packaging System	stormwater	--	--	--	04 04
INRM01108	M & W Countertops Inc	stormwater	--	--	--	08 04
INRM01118	FXI, Incorporated	stormwater	--	--	--	06 04
INRM01167	Cooper Standard Automotive	stormwater	--	--	--	06 04
INRM01208	Victor Reinz Valve Seals LLC	stormwater	--	--	--	07 05
INRM01228	Smith Field Airport	stormwater	--	--	--	08 06
INRM01233	Auburn Transfer Station	stormwater	--	--	--	05 06

NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
INRM01370	Ball Brass And Aluminum Foundry Inc	stormwater	--	--	--	07 02
INRM01494	Kautex Incorporated	stormwater	--	--	--	07 05
INRM01504	AZZ Galvanizing	stormwater	--	--	--	04 04
INRM01605	De Kalb Molded Plastics Company	stormwater	--	--	--	05 02
INRM01671	Speedway Transit Mix and Concrete Plant Management	stormwater	--	--	--	08 06
INRM01734	International Paper Company	stormwater	--	--	--	05 02
INRM01740	Harsco Industrial IKG	stormwater	--	--	--	07 07
INRM01759	OmniSource Corporation	stormwater	--	--	--	06 01
INRM01768	Metal X Auburn	stormwater	--	--	--	07 02
INRM01781	Magna Exteriors & Interiors	stormwater	--	--	--	08 04
INRM01782	Auburn Gear Incorporated	stormwater	--	--	--	06 04

Sources: IDEM (2014b) and U.S. EPA (2014)

Notes

Facilities are listed in alphanumeric order by NPDES ID.

Concentrated animal feeding operations are prohibited from discharging to surface waterbodies in Indiana, and thus, are not presented in this table.

DSCSO = dimension stone and crushed stone operations; GWPRS= groundwater petroleum remediation systems; mgd = million gallons per day;; n/a = not available; NCCW = non-contact cooling water; NPDES = National Pollutant Discharge Elimination System; PPW = petroleum product terminal; STP = sewage treatment plant; UT = unnamed tributary; WTP = water treatment plant; WWTP = wastewater treatment plant.

a. These permittees are not expected to discharge bacteria or nutrients.

b. The Auburn combined sewer system is also permitted via INM020672.

c. The number of combined sewer overflow outfalls is in parentheses.

d. The Butler WWTP's three outfalls are reported as inactive.

e. Fort Wayne Municipal WWTP has sanitary sewer overflow outfalls on Krunckenberg Ditch and Salgy Drain and CSO outfalls on the St. Joseph River.

f. Steel Dynamics Inc. (IN0059021) discharges sanitary wastewater and industrial process water to the Butler WWTP and discharges NCCW, stormwater, reverse osmosis backwash water, boiler blowdown, boiler condensate, and other stormwater to detention ponds that then discharge to Sol Shank Ditch.

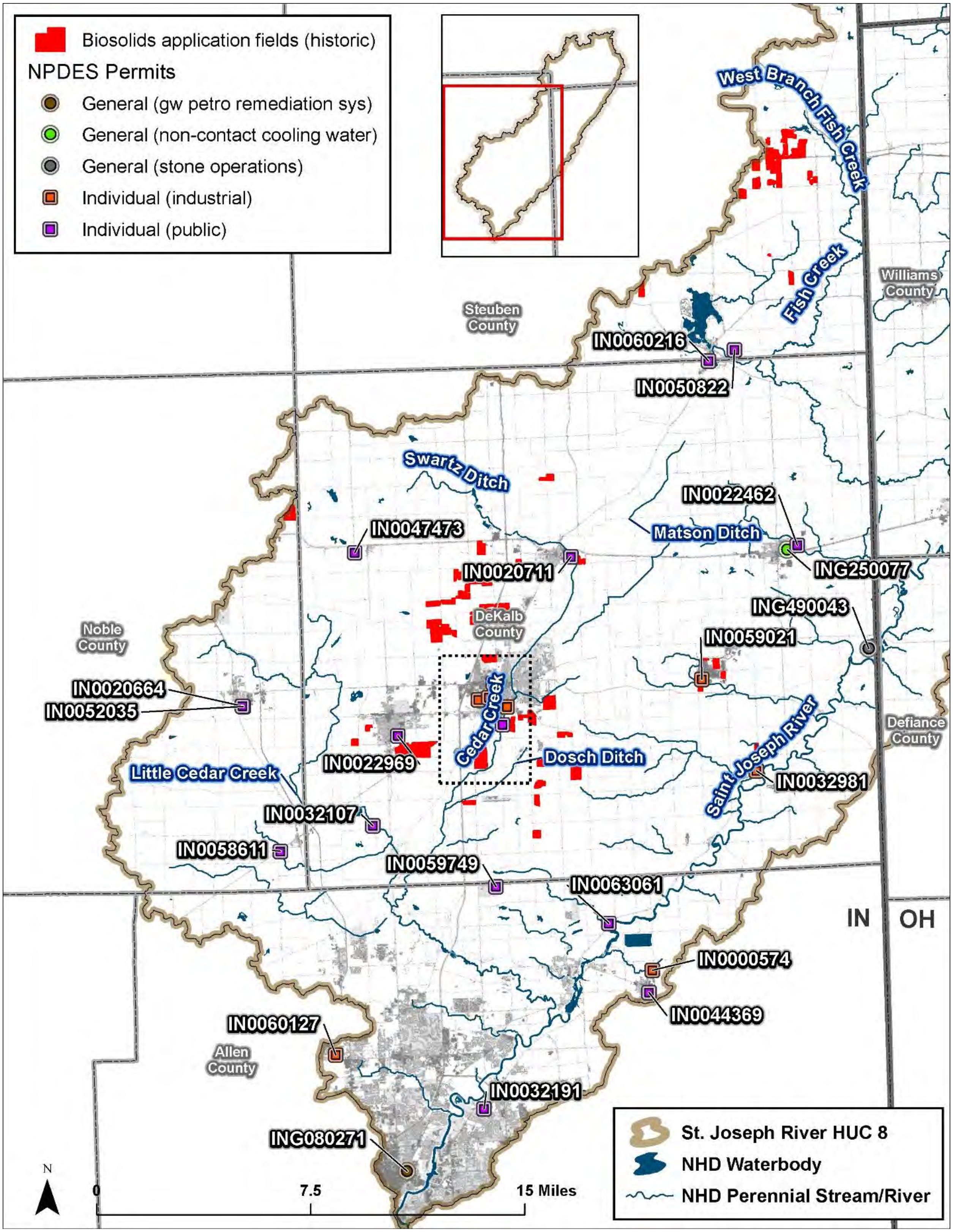
g. East Side High School (ING250077) was formerly covered by individual NPDES permit IN0055808

Table C- 4. Former facilities that previously held NPDES permit coverage in Indiana

Former NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
Individual						
IN0000361	Cooper Tire and Rubber Company	NCCW [a]	--	1	Grandstaff Ditch	06 04
IN0000370	Dana Corp. Spicer Clutch Div.	NCCW [a]	--	1	Cedar Creek	06 04
IN0000515	Citation Bohn Aluminum	NCCW, stormwater	--	--	Teutsh Ditch	05 02
IN0000574	Eagle-Picher Plastic Division	NCCW [a]	--	--	Haifley Ditch	08 04
IN0000621	Beatrice Cheese Company	--	--	2	Halkey Ditch	08 03
IN0000639	Universal Tool and Stamping Company	multiple	--	--	Teutsh Ditch	05 02
IN0023116	Huntertown WWTP	sanitary	--	1	Willow Creek Ditch	07 06
IN0025267	Leo Elementary and High Schools	sanitary	--	1	SJR	08 04
IN0029955	Hidden Valley MHP	sanitary	0.0054	1	UT to Little Cedar Creek	07 03
IN0038491	Auburn Rest Area I-69 South	sanitary	--	1	UT to Schmadel Ditch	07 07
IN0038504	Auburn Rest Area I-69 North	sanitary	--	1	UT to Schmadel Ditch	07 07
IN0042561	Wawasee Sewer and Water	sanitary	--	1	Cromwell Ditch	07 06
IN0046248	Nucor Fastener Plant	--	--	--	SJR	08 02
IN0049433	Waterloo Public Water Supply	WTP	--	1	County drain to Cedar Creek	06 02
IN0051136	Nucor Corp. – Vulcraft Division	--			UD to SJR	08 02
IN0051659	DeKalb Molded Plastics Company	--	--	--	Teutsch Ditch	05 02
IN0053651	Auburn Foundry, Inc. Plant #1	NCCW	--	1	Grandstaff Ditch	06 04
IN0055808	DeKalb County East Community School District	--	--	--	Big Run	05 02
IN0059749	Deer Track Estates WWTP	sanitary	0.007	1	UT to J.E. Piquognt Ditch	08 03
IN0060127	Dupont Water Treatment Plant - North End	WTP	0.1	1	wetland to Keefer Creek	08 06
IN0061255	Auburn Foundry, Inc. Plant 1	NCCW [a]	0.011	4	Peckhart Ditch	06 04
IN0061590	Auburn Foundry Landfill	stormwater	0.057	1	Garrett City Drain	07 07
General (non-stormwater)						
ING250015	Allen County War Memorial Coliseum	NCCW [a]	--	--	SJR	08 06
ING250019	Auburn Foundry Inc., Plant #2		--	--	wetland to John Diehl Ditch	07 02

Former NPDES ID	Permitee	Discharge type	Design flow (mgd)	No. of outfalls	Receiving waterbody	WAU (04100003)
ING250019	Auburn Foundry Inc., Plant #1		--	--	Grandstaff Ditch	06 04
ING250048	Eaton Corp Clutch Division		--	--	storm sewers to Cedar Creek	06 04
ING250065	Meridian Automotive Services		--	--	Witmer Haifley Ditch	08 04
ING340018	Marathon Oil Co.	PPT	--	--	UT to Cedar Creek [b]	06 02

Sources: IDEM (2014b) and U.S. EPA (2014)
Notes
Facilities are listed in alphanumeric order by former NPDES ID.
These facilities' permits were terminated, voided, or are otherwise inactive.
mgd = million gallons per day; MHP = mobile home park; NCCW = non-contact cooling water; NPDES = National Pollutant Discharge Elimination System; PPT = petroleum products terminal; SJR = St. Joseph River; UD = unnamed ditch; UT = unnamed tributary; WTP = water treatment plant; WWTP = wastewater treatment plant.
a. These permittees should not have discharged bacteria or nutrients.
b .Marathon Oil Co. discharged through two outfalls to Cedar Creek via an unnamed tributary, which is likely Schwartz Ditch.



Note: The inset map is on the next page.

Figure C-3. NPDES permittees (non-stormwater) in Indiana.

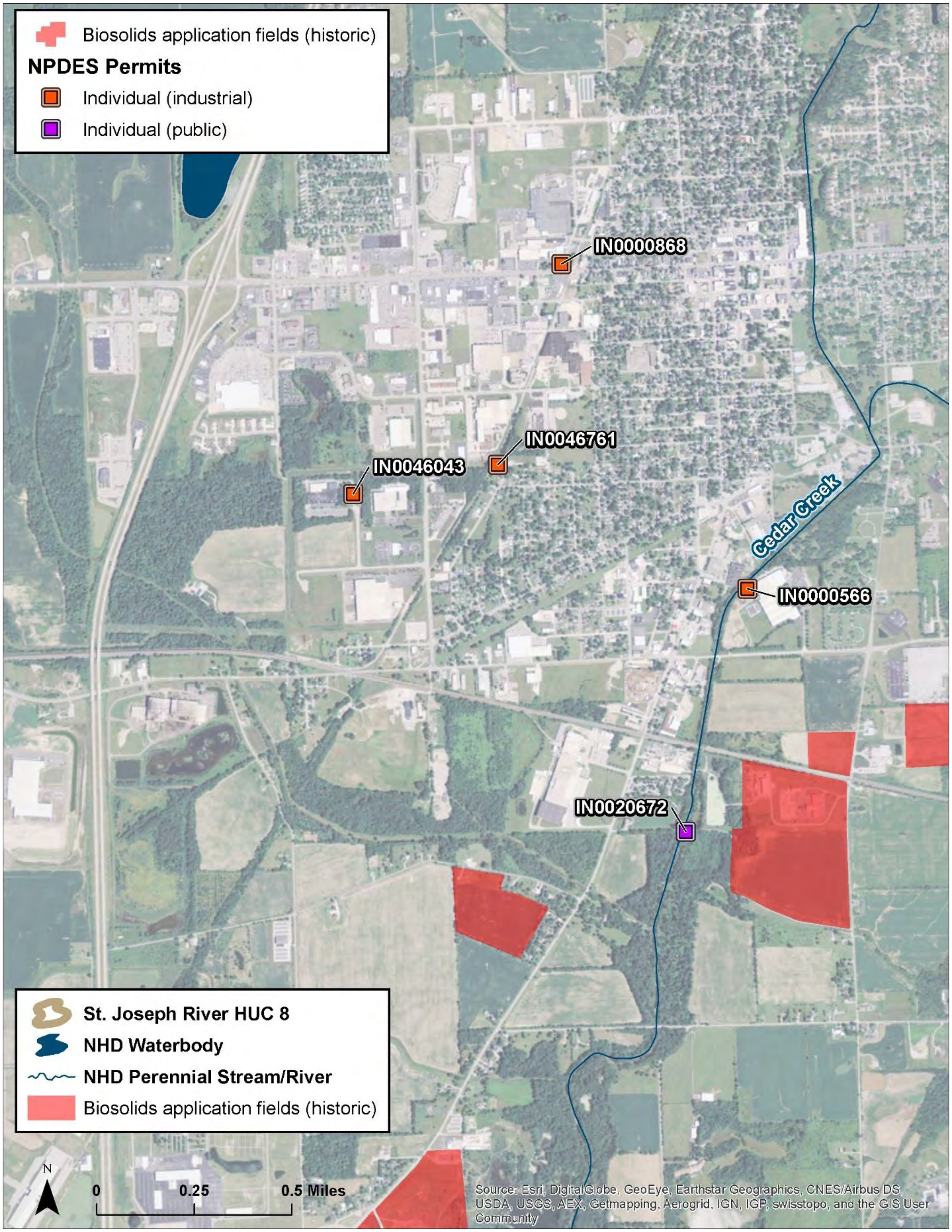
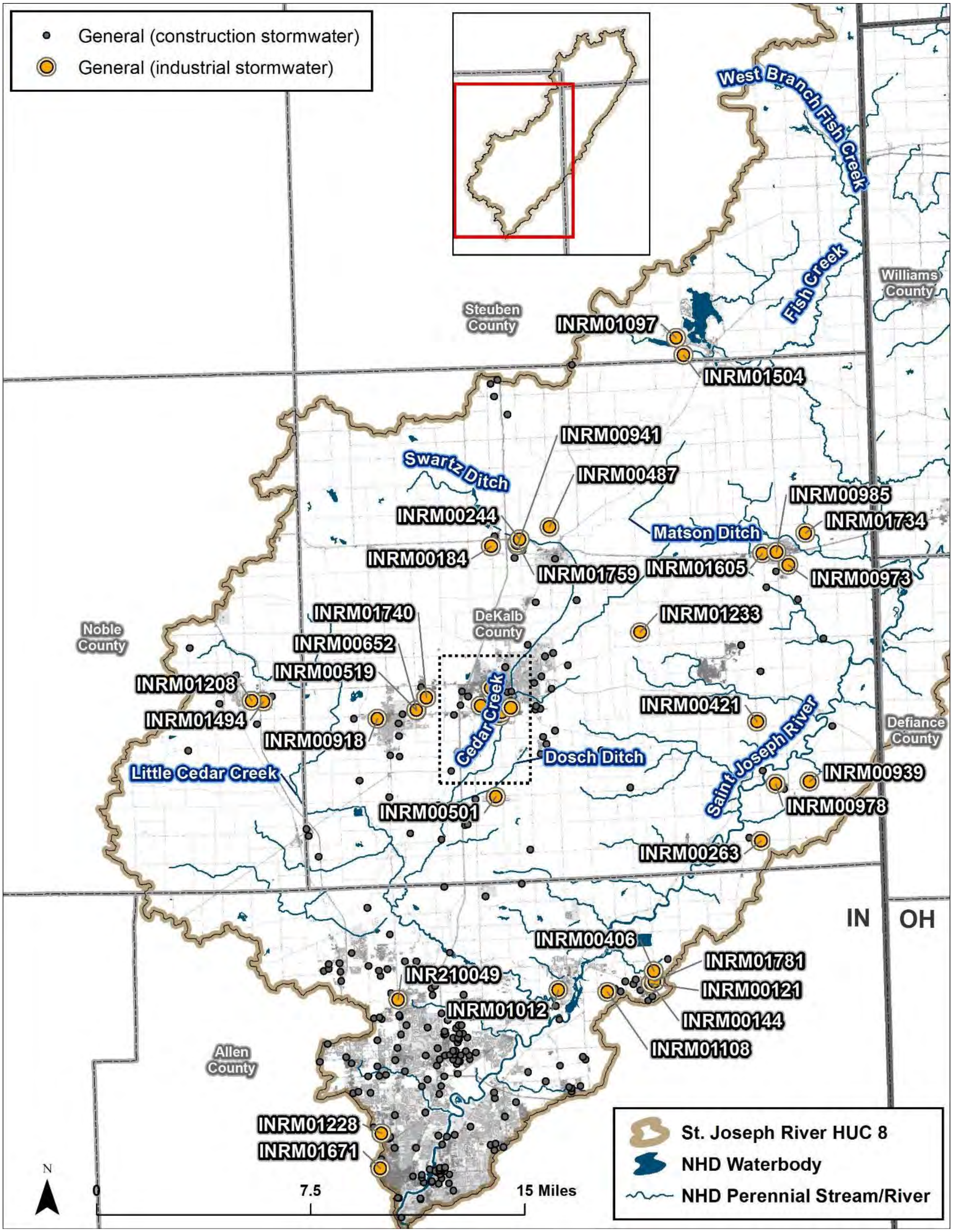


Figure C-4. NPDES permittees (non-stormwater) in and around Auburn, Indiana.



Note: The inset map is on the next page.

Figure C-5. NPDES stormwater permittees in Indiana.

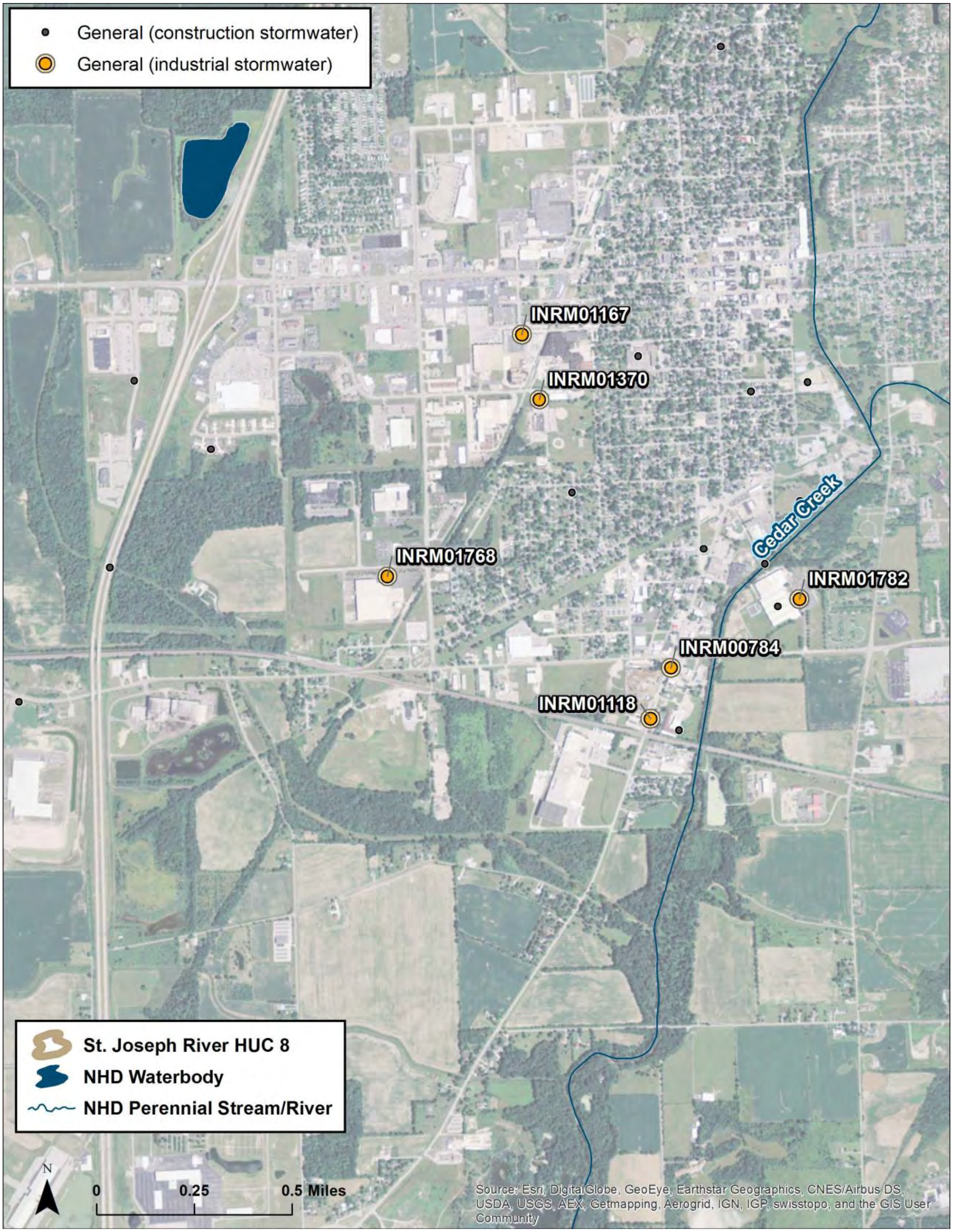


Figure C-6. NPDES stormwater permittees in and around Auburn, Indiana.

Table C- 5. Auburn WWTP (IN0020672) CSO summary, January 2010 through December 2014

Outfall	Receiving waterbody	No. of CSO events	No. of months with CSO events	CSO volume (million gallons per month)		
				Minimum	Maximum	Average
002 [a]	Cedar Creek	47	13	1.80	46.41	17.50
007	Cedar Creek	15	12	<0.01	92.00	8.58
009	Cedar Creek	19	13	<0.01	7.47 [b]	1.13
010	John Diehl Ditch	5	5	0.01	0.09	0.06
011 [c]	Cedar Creek	18	13	0.04	14.56	5.44

Sources: IDEM 2015b
Notes
CSO = combines sewer overflow; WWTP =wastewater treatment plant.
a. CSO outfall 002 became an emergency bypass (electrical or mechanical failure) and ceased operation as a CSO outfall in 2012.
b. In April 2010, an overflow of 747 million gallons was reported; it is assumed that this value should be 7.47 million gallons.
c. CSO outfall 011 became active in April of 2011.

Table C- 6. Butler WWTP (IN0022462) CSO summary, January 2008 through May 2015

Outfall	Receiving waterbody	No. of CSO events	No. of months with CSO events	CSO volume (million gallons per month)		
				Minimum	Maximum	Average
003	Big Run	205	68	<0.01	19.25	1.63

Sources: IDEM 2015b
Notes
CSO = combines sewer overflow; WWTP =wastewater treatment plant.

Table C- 7. Fort Wayne Municipal WWTP (IN0020672) CSO summary, January 2010 through December 2014

Outfall	Receiving waterbody	No. of CSO events	No. of months with CSO events	CSO volume (million gallons per month)		
				Minimum	Maximum	Average
044	St. Joseph River	43	22	<0.01	0.38	0.03
045	St. Joseph River	12	8	0.01	0.11	0.04
051	St. Joseph River	77	34	<0.01	2.23	0.21
052	St. Joseph River	171	56	<0.01	9.98	0.99
053	St. Joseph River	39	20	<0.01	1.27	0.24
068	St. Joseph River	52	27	<0.01	1.68	0.23

Sources: IDEM 2015b
Note: CSO = combines sewer overflow; WWTP =wastewater treatment plant.

Table C- 8. Montpelier WWTP (2PD00003) CSO summary, June 2004 through December 2012

Outfall	Receiving waterbody	No. of CSO events	CSO event volume (mgd)		
			Minimum	Maximum	Average
003	St. Joseph River	51 [a]	0.02	2.70	0.61
004	St. Joseph River	41	0.02	1.50 [b]	0.39 [b]
005	St. Joseph River	--	--	--	--

Sources: Ohio EPA 2015a
Notes
Volumes are rounded to the nearest one-hundredth of a million gallons per day.
A double dash ("--") indicates that no data were available.
CSO = combines sewer overflow; mgd = million gallons per day; WWTP =wastewater treatment plant.
a. CSO occurrences are reported for 49 dates but overflow volumes are reported for 51 dates.
b. On August 18, 2009, an overflow of 450 mgd was reported; it is assumed that this value should be 0.450 mgd.

Table C- 9. Ohio WWTP SSO summary, 2004 through 2014

NPDES ID	Ohio ID	Permitee	No. of SSO events
OH0021164	2PB00047	Edgerton WWTP	0 [a]
OH0021831	2PD00003	Montpelier WWTP	51 [b]
OH0022535	2PB00006	Pioneer WWTP	8 [c]
OH0095141	2PA00031	Edon WWTP	0

Sources: Ohio EPA 2015a
Notes
SSO = sanitary sewer overflow; WWTP =wastewater treatment plant.
a. Edgerton WWTP (2PB00047) reported zero SSOs per month from October 2006 through December 2007.
b. The 51 SSOs at Montpelier WWTP (2PD00003) were reported on dates between December 28, 2007 and August 1, 2012.
c. All eight SSOs at Pioneer WWTP (2PB00006) occurred in October 2011.

Table C- 10. WWTP sludge application sites in Michigan and Ohio

Source of sludge	State agency field ID	Area (acres) [a]	HUC (04100003)
Michigan			
Hudson WWTP [b]	DB-01	40	02 02
Detroit WWTP [b]	GM-01	42	03 01
Camden WWSL	JD-02	n/a	02 02
Hudson WWTP [b]	LB-01	60	03 01
Ohio			
Montpelier WWTP	8600027	45	03 04
	8600028	9	
	8600029	26	
	8600031	32	
	8600032	15	
	8600037	100	
	8600038	137	

Sources: Michigan DEQ (2014), and Ohio EPA (2015b)
HUC = hydrologic unit code; n/a = not available; WWSL = wastewater stabilization lagoon; WWTP = wastewater treatment plant.
a. Field areas were rounded to the nearest acre.
b. These WWTPs are not in the St. Joseph River watershed (HUC 041000011).

Table C- 11. WWTP sludge land application sites in Indiana

Source of WWTP sludge	Site ID	Area (acres) [a]	HUC (04100003)	Land application				
				No. [b]	Months	Years	Method	Crop [c]
Angola Municipal STP [d]	JG-55.4	96	04 01	4	Aug	2003	Injection	Corn
	OT-02-WM1	46	04 01	1	Nov.-Dec	1995	Injection	--
	OT-19-RD1	37	04 03	7	Apr, May	1990	--	--
		7	04 04					
	SC-35-B9	54	04 01	--	--	--	--	--
	SC-35-B10	56	04 01	20	Jan, Apr, Dec	1992-1995	Injection	--
	YO-25-B2	143	04 01	29	Apr-Jun, Oct, Dec	1990	--	--
	YO-25-B5	45	04 01	--	--	--	--	--
	YO-25-B6	13	04 01	--	--	--	--	--
	YO-30-B1	49	04 01	--	--	--	--	--
	YO-30-B3	31	04 01	7	Jun-Jul	1990	--	--
	YO-30-B4	20	04 01	12	Oct, Nov	1993-1994	--	--
	YO-31-JG1	12	04 01	--	--	--	--	--
	YO-31-JG2	7	04 01	--	--	--	--	--
	YO-31-JG3	5	04 01	--	--	--	--	--
	YO-31-JG4	2	04 01	--	--	--	--	--
	YO-31-JG5	4	04 01	--	--	--	--	--
	YO-31-JG6	17	04 01	--	--	--	--	--
	YO-36-B10	26	04 01	--	--	--	--	--
	YO-36-B11	14	04 01	--	--	--	--	--
	YO-36-B7	135	04 01	--	--	--	--	--
	YO-36-B9	32	04 01	--	--	--	--	--
Apollo Disposal, Inc. [d]	PUT-1	3	04 03	--	--	--	--	--
Auburn Municipal STP [e]	120-001	47	07 02	1	Jan	1992	Incorporation	--
	120-002	64	07 02	9	Jan, Oct, Nov, Dec	1992-1999	Incorporation, injection	Corn
	120-003	24	07 02	1	Jan	1992	Incorporation	--
	49A-001	48	07 02	--	--	--	--	--
	BRA-001	17	07 07	9	Mar-Apr, Oct-Nov	1985	--	--
	BRA-002	16	07 07	20	Mar-Apr, Jun, Oct, Nov	1985-1986	--	--
	BRO-101	27	06 04	34	Jul-Oct	1988	Injection	--
		<1	08 01					
	BUT-003	76	06 04	2	Nov	1999	Injection	Corn
	BUT-006	7	06 04	13	Aug-Sep	1990	--	--
	BUT-007	24	06 04	27	Oct-Nov	1990	--	--

Source of WWTP sludge	Site ID	Area (acres) [a]	HUC (04100003)	Land application				
				No. [b]	Months	Years	Method	Crop [c]
(continued)	BUT-05A	25	06 04	28	Aug-Sep	1992	--	--
	BUT-05B	41	06 04	4	Apr, Nov	1990, 1999	Injection	Soybean
Auburn Municipal STP [e]	CLI-001	5	07 02	--	--	--	--	--
		12	06 02					
	CLI-002	11	06 02	4	Jun	1993	Surficial	--
		12	07 02					
	CLI-003	8	06 02	--	--	--	--	--
		17	07 02					
	CLI-004	9	07 02	4	Jan-Feb	1992	Incorporation	--
		46	06 02					
	CLI-005	8	06 02	5	Feb, Aug	1992, 1999	Incorporation, injection	Corn
		52	07 02					
	CLI-006	1	06 02	--	--	--	--	--
		16	07 02					
	CLU-SO6	15	06 01	--	--	--	--	--
		54	06 02					
		2	06 03					
	DAV-001	10	07 07	15	Sep-Oct	1992	--	--
		11	07 02					
	GCF-001	15	07 02	20	Jan, Mar, Dec	1992-1994	Injection	--
	GCF-002	42	07 02	30	Mar, Apr, Dec	1992-1994	Injection	--
	GCF-003	15	07 02	11	Jan-Feb	1993	--	--
	GCF-004	30	07 02	25	Jul-Sep	1993	--	--
	GEN-001	77	07 02	18	Jan, Jun, Aug, Oct	1992-1999	Incorporation, injection	Corn, soybean
	GRA-001	22	07 07	7	Mar, Dec	1986-1987	Injection	--
	GRA-002	32	07 07	19	Jan, Dec	1986-1987	Injection	--
	GRA-003	46	07 07	19	Feb-Mar	1987	Injection	--
	GRA-004	51	07 07	1	Nov	1986	--	--
	HOB-001	2	07 02	2	Apr	1993	--	--
	HOB-002	2	07 02	2	Apr	1993	--	--
	HOB-003	6	07 02	--	--	--	--	--
	HOB-004	24	07 02	2	May	1993	--	--
	HOB-005	15	07 02	7	Jun-Jul	1993	--	--
	HOB-006	33	07 02	--	--	--	--	--
	HOB-007	23	07 02	10	May-Jun	1993	Surficial	--
	HOB-008	35	07 02	6	Jun	1993	--	--

Source of WWTP sludge	Site ID	Area (acres) [a]	HUC (04100003)	Land application				
				No. [b]	Months	Years	Method	Crop [c]
(continued)	HOB-009	25	07 02	10	May	1992	--	--
Auburn Municipal STP [e]	HOB-010	5	07 02	--	--	--	--	--
	HOB-011	9	07 02	--	--	--	--	--
	HOB-012	7	07 02	--	--	--	--	--
	INF-001	51	07 02	16	Jan, Aug, Sept, Oct, Nov	1992-1999	Incorporation, injection	Corn
	ROO-P01	41	07 02	2	Jan-Feb	1992	--	--
	SAN-001	12	07 02	1	Dec	1991	Surficial	--
	SAN-002	10	07 02	2	Dec	1991	Surficial	--
	SAN-003	15	07 02	1	Jan	1992	Incorporation	--
	SAN-004	7	07 02	7	Jan, Dec	1992-1993	Incorporation	--
	SAN-005	14	07 02	11	Jan, Oct-Dec	1992-1993	Incorporation	--
	SAN-006	23	07 02	9	Jan, Apr	1992-1993	Incorporation	--
	SMI-001	27	08 01	67	Jul, Aug, Sept, Oct, Nov	1987-1999	Incorporation, injection	Soybean
		52	06 04					
	SMI-002	40	06 04	2	Nov	1999	Injection	Corn
	STO-004	1	08 01	16	May, Oct, Nov	1988-1991	Injection	--
		9	06 04					
	STO-005	20	06 04	12	Apr, Aug	1987-1988	Injection	--
	STO-006	1	08 01	5	Apr, May	1988-1989	Injection	--
		7	06 04					
	WOL-101	31	08 01	27	Jul, Aug, Sep, Oct	1990-1991	--	--
	WOL-102	12	08 01	2	May	1990	--	--
Beatrice Cheese Company	1	13	07 07	11	Sep.	1994	--	--
		21	08 01					
	4	44	08 01	--	--	--	--	--
	6	106	08 01	--	--	--	--	--
	7	11	07 07	--	--	--	--	--
	7	24	08 01	--	--	--	--	--
	BCC-AUBURN	40	08 01	--	--	--	--	--
Garrett Municipal STP [f]	42186	1	07 03	--	--	--	--	--
		29	07 05					
	54 9-13	2	07 07	--	--	--	--	--
		76	07 05					
	52 1-8	7	07 05	6	Nov	1995	--	--
	52 1-8	163	07 07					
	KE-03-CG1	10	07 07	4	Jul, Nov	1993-1994	--	--

Source of WWTP sludge	Site ID	Area (acres) [a]	HUC (04100003)	Land application				
				No. [b]	Months	Years	Method	Crop [c]
(continued)	KE-10-CF1	38	07 05	14	Oct, Nov	1990-1994	--	--
		<1	07 07					
Garrett Municipal STP [f]	MA1S & MA2N	5	07 03	--	--	--	--	--
		14	07 05					
Hamilton Lake Conservancy District	BOWERS	8	04 04	211	all 12 months	1986-1991	--	Grass
	TEEGARDIN	8	04 03	149	Apr-Dec	1992-1998	Injection	Corn, grass, soybean
		33	04 04					
Kendallville Municipal STP [d]	GC-1	2	06 02	2	Aug, Sep	1999	Injection	Corn
		49	07 02					
	PER-301	6	07 01	1	Dec	1993	--	Corn
	PER-302	9	07 01	2	Dec	1993	--	--
	PER-304	14	07 01	1	Dec	1993	--	Corn
	PER-305	8	07 01	1	Dec	1993	--	Corn
	PER-306	19	07 01	1	Dec	1993	--	Corn
	PER-307	22	07 01	1	Dec	1993	--	Corn
	PER-308	31	07 01	1	Dec	1993	--	--
Ralph Sechler & Sons, Inc. [g]	SEC-A	14	08 01	3	Aug	1983	--	--
	SEC-B	6	08 01	--	--	--	--	--
	SEC-C	8	08 01	--	--	--	--	--
	SEC-C	<1	08 02	--	--	--	--	--
	SEC-D	12	08 02	--	--	--	--	--
Steel Dynamics, Inc.	SDI-1	6	05 06	--	--	--	--	--
	SDI-2	20	05 06	--	--	--	--	--
	SDI-3	18	05 06	--	--	--	--	--
	SDI-4	18	05 06	--	--	--	--	--
	SDI-5	25	05 06	--	--	--	--	--
Waterloo Municipal STP	DANG-101	2	06 02	5	Apr, May, Oct, Nov	1989-1999	Injection	Corn, soybean
		2	06 03					
	DANG-102	19	06 02	18	Apr, May, Oct, Nov	1989-1999	Injection	Corn, soybean
	DANG-103	6	06 02	4	Apr, May, Oct	1989-1999	Injection	Corn, soybean
	DANG-104	8	06 02	5	Apr, May, Oct	1989-1999	Injection	Corn, soybean
	DANG-105	6	06 02	3	Apr, Oct	1989-1995	Injection	Soybean
	DUNN-201	33	06 02	--	--	--	--	--
	DUNN-202	11	06 02	--	--	--	--	--
	HINE-301	25	06 02	37	Mar-Oct	1992-1998	--	--

Sources: IDEM 2015c
HUC = hydrologic unit code; STP = sewage treatment plant; WWTP = wastewater treatment plant.

A double dash ("--") indicates that land application data are not available.
a. Field areas were rounded to the nearest acre.
b. Number of land applications at the specified site.
c. Crop that was grown on the field that the land application occurred on.
d. These WWTPs are not in the St. Joseph River watershed (HUC 04100003).
e. The Auburn Municipal STP is also known as the Auburn WWTP (IN0020672).
f. The Garrett Municipal STP is also known as the Garrett WWTP (IN0029969).
g. Ralph Sechler & Sons, Inc. is also known as Pickle Properties, LLC (IN0032981).

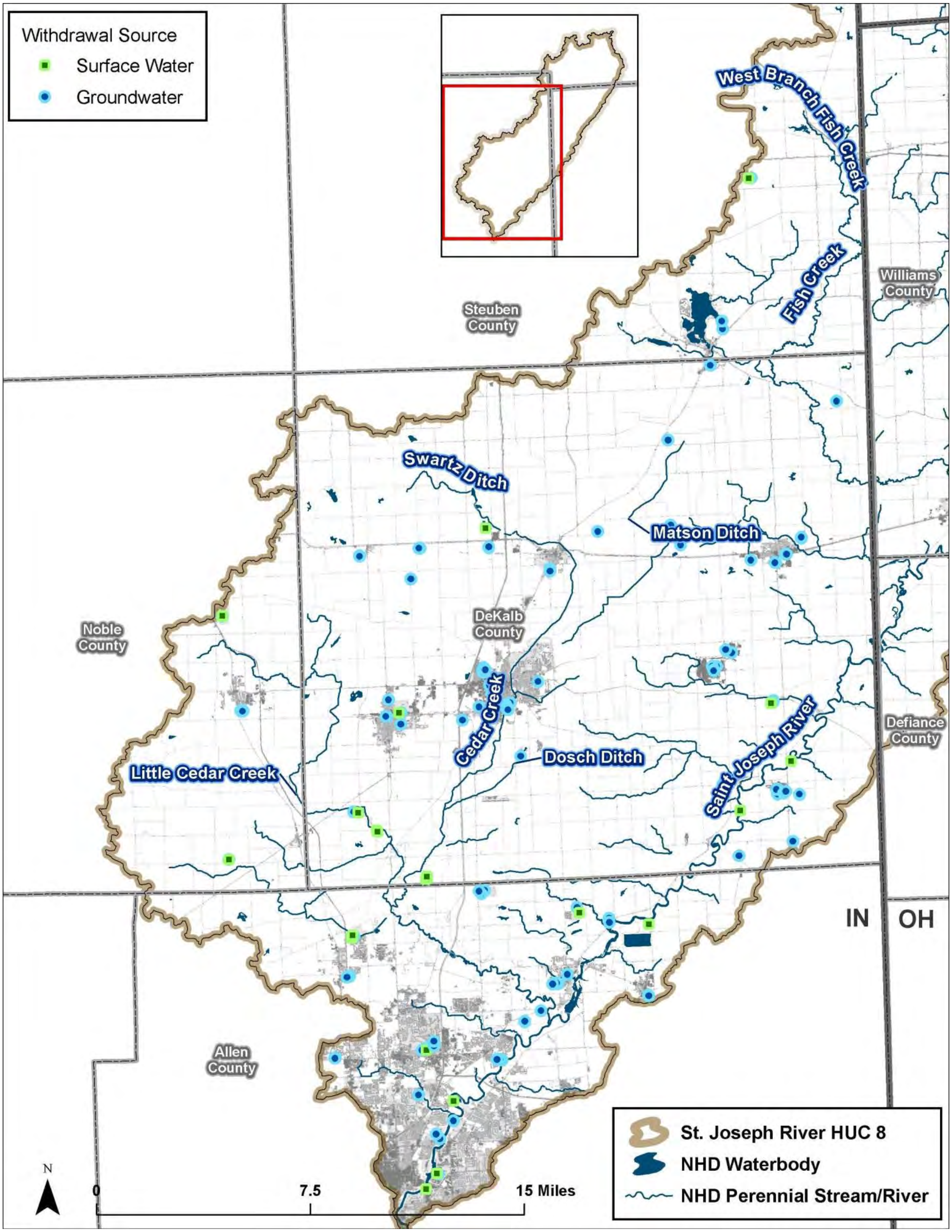


Figure C-7. Surface and groundwater withdrawals in Indiana.

C-2.Nonpoint Sources

Table C- 12. Livestock animal units by county in the SJRW, cattle, hogs, horses, goats, and sheep

Animal unit	County	No. of animal units	No. of farms
Cattle and calves	Hillsdale (MI)	22,554	385
	Williams (OH)	18,413	157
	Defiance (OH)	10,605	129
	Steuben (IN)	8,863	136
	DeKalb (IN)	15,422	170
	Noble (IN)	18,050	313
	Allen (IN)	16,114	344
Hogs and pigs	Hillsdale (MI)	21,713	48
	Williams (OH)	10,315	31
	Defiance (OH)	5,675	22
	Steuben (IN)	(D)	20
	DeKalb (IN)	8,933	22
	Noble (IN)	93,660	57
	Allen (IN)	34,093	58
Horses and ponies	Hillsdale (MI)	1,994	331
	Williams (OH)	720	81
	Defiance (OH)	363	70
	Steuben (IN)	569	108
	DeKalb (IN)	596	111
	Noble (IN)	1,891	287
	Allen (IN)	5,260	530
Goats	Hillsdale (MI)	545	68
	Williams (OH)	362	23
	Defiance (OH)	813	26
	Steuben (IN)	211	27
	DeKalb (IN)	256	23
	Noble (IN)	435	49
	Allen (IN)	737	43
Sheep and lambs	Hillsdale (MI)	2,810	27
	Williams (OH)	702	24
	Defiance (OH)	597	26
	Steuben (IN)	443	17
	DeKalb (IN)	436	16
	Noble (IN)	1,526	52
	Allen (IN)	855	38

Source: 2012 Census of Agriculture (NASS 2014, county-level data in Tables 11, 12, 13, 14, and 18 of each state's section).
Note: (D) = not available.

Table C- 13. Livestock animal units by county in the SJRW, poultry

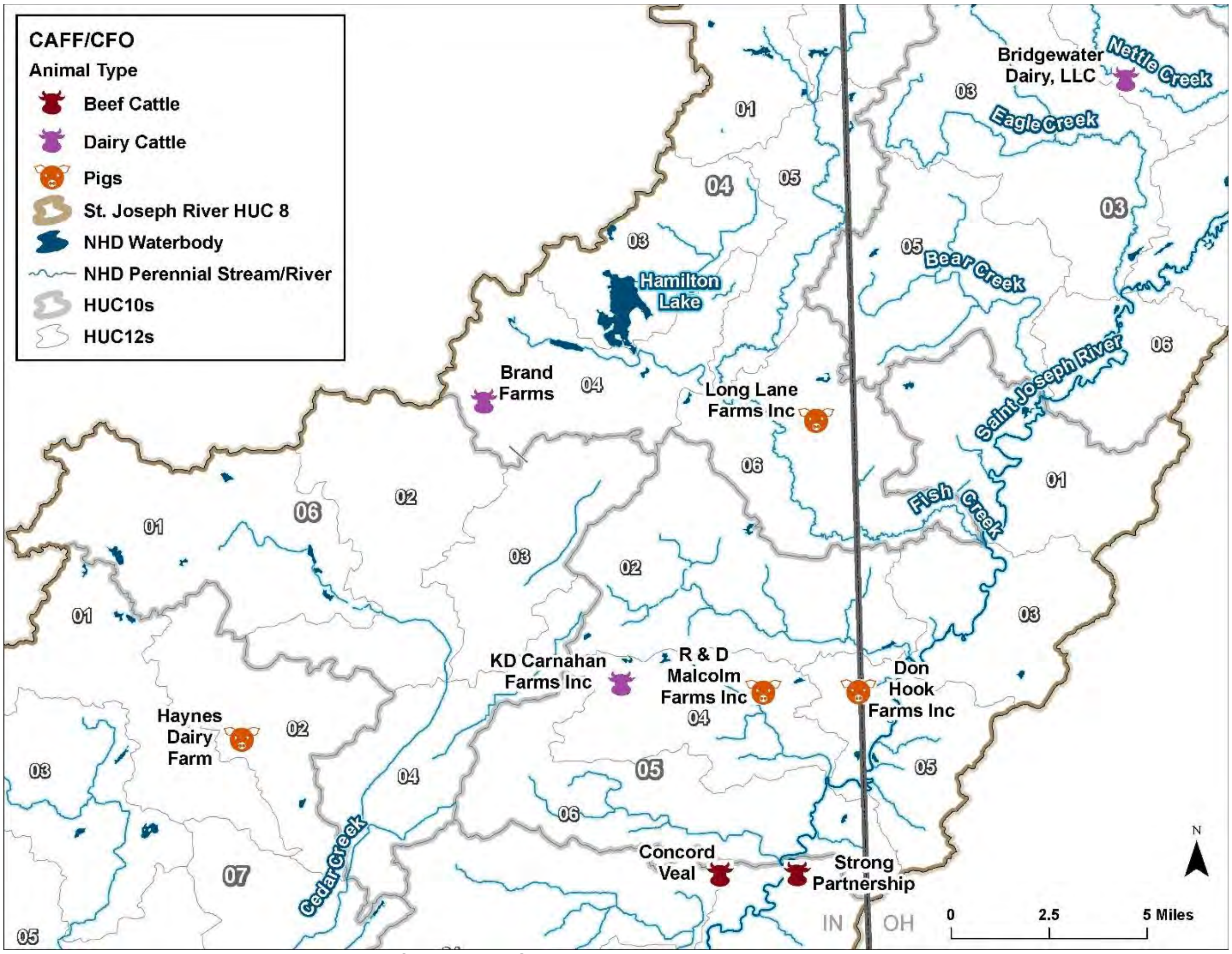
Animal unit	County	No. of animal units	No. of farms
Layers	Hillsdale (MI)	4,282	182
	Williams (OH)	1,063	36
	Defiance (OH)	1,745	50
	Steuben (IN)	877	43
	DeKalb (IN)	1,179	52
	Noble (IN)	(D)	93
	Allen (IN)	46,508	184
Pullets	Hillsdale (MI)	778	27
	Williams (OH)	293	9
	Defiance (OH)	31	3
	Steuben (IN)	94	5
	DeKalb (IN)	162	11
	Noble (IN)	(D)	4
	Allen (IN)	218	8
Broilers/Meat	Hillsdale (MI)	1,434	42
	Williams (OH)	100	7
	Defiance (OH)	(D)	5
	Steuben (IN)	160	7
	DeKalb (IN)	(D)	4
	Noble (IN)	270,589	23
	Allen (IN)	(D)	59
Turkeys	Hillsdale (MI)	189	28
	Williams (OH)	(D)	2
	Defiance (OH)	0	0
	Steuben (IN)	(D)	1
	DeKalb (IN)	45	9
	Noble (IN)	69	6
	Allen (IN)	168	11

Source: 2012 Census of Agriculture (NASS 2014, county-level data in Table 19 for each state's section).
Note: (D) = not available.

Table C- 14. Non-CAFO, state-permitted animal operations in the SJRW

Program	Facility	Animal units	HU (04100011)
Michigan			
Michigan DEQ does not permit non-CAFO animal operations			
Ohio			
CAFF	Bridgewater Dairy LLC	3,900 dairy cattle	03 01
Indiana			
CFO	Brand Farms	120 beef cattle 465 dairy calves 400 dairy cattle 115 dairy heifers	04 04
CFO	Concord Veal	536 veal calves	08 01
CFO	Don Hook Farms Incorporated	780 finishers 320 nursery pigs 246 sows	05 05
CFO	Haynes Dairy Farm	300 finishers 400 nursery pigs 264 sows	07 02
CFO	KD Carnahan Farms Inc.	70 dairy calves 204 dairy cattle 280 dairy heifers	05 04
CFO	Long Lane Farms Incorporated	1,300 finishers 625 nursery pigs 110 sows	04 06
CFO	R&D Malcom Farms Incorporated	192 finishers 384 nursery pigs 125 sows	05 04
CFO	Strong Partnership (also known as: Strong Farms LLC)	990 beef calves	08 02

Sources: IDEM (2014a, 2015) and Ohio EPA (2014)
Notes
Non-CAFO animal operations are sorted alphabetically per state.
CAFF = concentrated animal feeding facility; CAFO = concentrated animal feeding operation; CFO = confined feeding operation; HU = hydrologic unit; SJRW = St. Joseph River watershed.



Note: Brand Farms has both dairy and beef cattle, and Concord Veal has veal calves.

Figure C-8. Non-CAFO, state-permitted animal operations in the SJRW.

Table C- 15. Crop information for counties in the SJRW

Practice	Units	Hillsdale County, MI	Williams County, OH	Steuben County, IN	Noble County, IN	DeKalb County, IN	Allen County, IN
Farm land							
Farm land	No. [a]	1,530	984	562	1,163	924	1,725
	Acres	262,363	208,012	104,570	181,491	160,984	270,808
Cropland	No. [a]	1,353	901	490	1,016	805	1,490
	Acres	207,931	181,570	84,596	150,121	136,807	241,522
Harvested cropland	No. [a]	873	556	310	802	503	1,300
	Acres	180,038	157,459	73,909	137,908	123,036	229,452
Pastureland, all types [b]	No. [a]	605	215	218	499	250	698
	Acres	11,161	4,045	4,254	8,044	3,013	8,541
Drainage and irrigation (subset of farm land)							
Irrigated farms	No. [a]	71	13	19	50	17	39
	Acres	9,141	1,281	2,053	13,713	722	395
Farm land drained by tiles [c]	No. [a]	469	480	202	520	455	940
	Acres	70,175	86,592	31,670	72,917	78,964	161,133
Farm land artificially drained by ditches [c]	No. [a]	153	174	99	186	155	265
	Acres	17,353	15,295	10,539	11,719	11,139	31,183
Selected crops harvested (subset of harvested cropland)							
Corn for grain	No. [a]	392	327	152	430	271	744
	Acres	68,583	53,366	33,193	63,274	46,041	93,109
Corn for silage or greenchop	No. [a]	84	18	23	86	26	41
	Acres	6,801	3,999	3,067	4,780	2,336	1,517
Winter wheat	No. [a]	141	217	56	94	105	247
	Acres	10,441	15,477	3,832	2,731	7,191	13,303
Soybean for beans	No. [a]	76	403	161	400	325	720
	Acres	76,723	76,208	27,475	54,920	62,561	110,614
Forage [d]	No. [a]	511	193	191	441	206	580
	Acres	16,046	7,368	6,356	10,988	5,548	10,452
Tillage [c] (subset of farm land)							
No-till	No. [a]	254	362	137	366	322	600
	Acres	68,456	81,711	44,585	70,551	80,578	108,577
Conservation tillage	No. [a]	190	177	82	206	111	303
	Acres	60,660	46,075	12,505	36,531	23,448	46,107
Conventional tillage	No. [a]	337	206	78	212	139	569
	Acres	35,804	22,939	10,846	20,766	14,565	65,232
Other practices [c] (subset of farm land)							
Cover crop	No. [a]	101	93	35	128	63	109
	Acres	5,935	9,908	3,448	14,255	3,750	6,204
Conservation easement	No. [a]	82	102	45	63	78	116
	Acres	5,359	3,227	1,423	2,437	4,636	4,346

Source: 2012 Census of Agriculture (NASS 2014a, county-level data in Table 1 for each state's section).
Notes
(D) = not available.
a. Number of farms.
b. *Pastureland (all types)* represents: (1) *permanent pasture and rangeland, other than cropland and woodland pastured*, which is a subset of *farm land*; 2) *woodland pastured*, which is a subset of *woodland;* and (3) *other pasture and grazing land that could have been used for crops without additional improvements*, which is a subset of *cropland*.
c. Source: NASS 2014b.
d. Land used for all hay and all haylage, grass silage, and greenchop.

C-3. References

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Appendix D.

SWAT Model Report

Content

Tables

Figures

Abbreviations and Acronyms

CAFO	concentrated animal feeding operation
CDL	cropland data layer
GIS	geographic information systems
HSG	hydrologic soil group
IDEM	Indiana Department of Environmental Management
Michigan DEQ	Michigan Department of Environmental Quality
MOD16	MODIS Global Evapotranspiration Project
NASA	National Aeronautics and Space Agency
NASS	National Agricultural Statistics Service (U.S. Department of Agriculture)
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NSE	Nash-Sutcliffe coefficient
Ohio EPA	Ohio Environmental Protection Agency
RE	relative average error
RMSE	root mean square error
RSR	RMSE-observations standard deviation ratio
SJR	St. Joseph River
SJRW	St. Joseph River watershed
SJRWI	St. Joseph River Watershed Initiative
SSURGO	Soil SURvey GeOgraphic database
SWAT	Soil and Water Assessment Tool
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WWTP	wastewater treatment plant

Units of Measure

cfs	cubic feet per second
km	kilometer

D-1 SWAT Model Configuration

The SWAT model for the St. Joseph River watershed (SJRW; eight-digit hydrologic unit code [HUC] 04100003) was setup using ArcSWAT version 2012.10_1.15 (Winchell et al. 2013). ArcSWAT is an ArcGIS based interface that facilitates the model-setup process and the generation of input files. The SJRW SWAT model was parameterized, calibrated, and validated using SWAT Editor version 2012.10_2.18. SWAT Editor a standalone program that reads the project database generated by ArcSWAT and allows the user to edit input files and execute model runs. The following sections provide an overview of the watershed model development and the dataset used for input.

D-1.1 Watershed Model Segmentation

SWAT is a lumped parameter model which represents average response of a given upland unit with a local subbasin. The averaging is applied across model subbasins (term used for a SWAT partitioning units). 12-digit HUC were generally used as model subbasins with sub-divisions made for flow and water quality stations, locations of large waterbodies, as well as along state boundaries. Modeled reaches consisted of National Hydrography Dataset (NHD) high-resolution stream centerline layer associated with the HUC-12 watersheds reduced to a single segment for each modeled subbasin. The delineated model (Figure D-1) consists of 104 subbasins and reaches.

There are two key dams within the SJRW that were selected for explicit inclusion in the model. The City of Fort Wayne constructed the St. Joseph River Dam near the outlet of the watershed in 1993, and the Cedarville Dam along the St. Joseph River (SJR) above the confluence of Cedar Creek in 1953. These dams were constructed to maintain water supply needs along the SJR for the city of Fort Wayne, Indiana, and these dams were included as reservoirs in the SWAT model in subbasin 3 (St. Joseph River Dam), and subbasin 31 (Cedarville Dam) based on details provided by the National Inventory of Dams as well as an historic flow gage near the outlet of Cedarville Dam (U.S. Geological Survey 04179000 SJR at Cedarville IN, daily flow recorded 1953-1982).

It is important to note that that are several low head dams in the St, Joseph River watershed which are not explicitly represented in the model because of a lack of data associated with the storage-discharge behavior of these dams. These dams are expected to impact the low flow behavior of the system. The impact of such dams are implicitly accounted in the parameterization of the model.

D-1.2 Elevation and Slope

A digital elevation model (DEM) is used by the ArcSWAT interface for a) delineation of subbasins and associated reaches, and b) computation of topographic characteristics for subbasins. A 1/3 arc second (approximately 10 meters) DEM acquired from U.S. Geological Survey-National Elevation Dataset (USGS-NED) was used for the development of the SWAT model. The vertical datum of the DEM is the North American Vertical Datum of 1988. Figure D-2 shows the elevation from sea level in the watershed, varying from 226 meters in the south to 380 meters in the north.

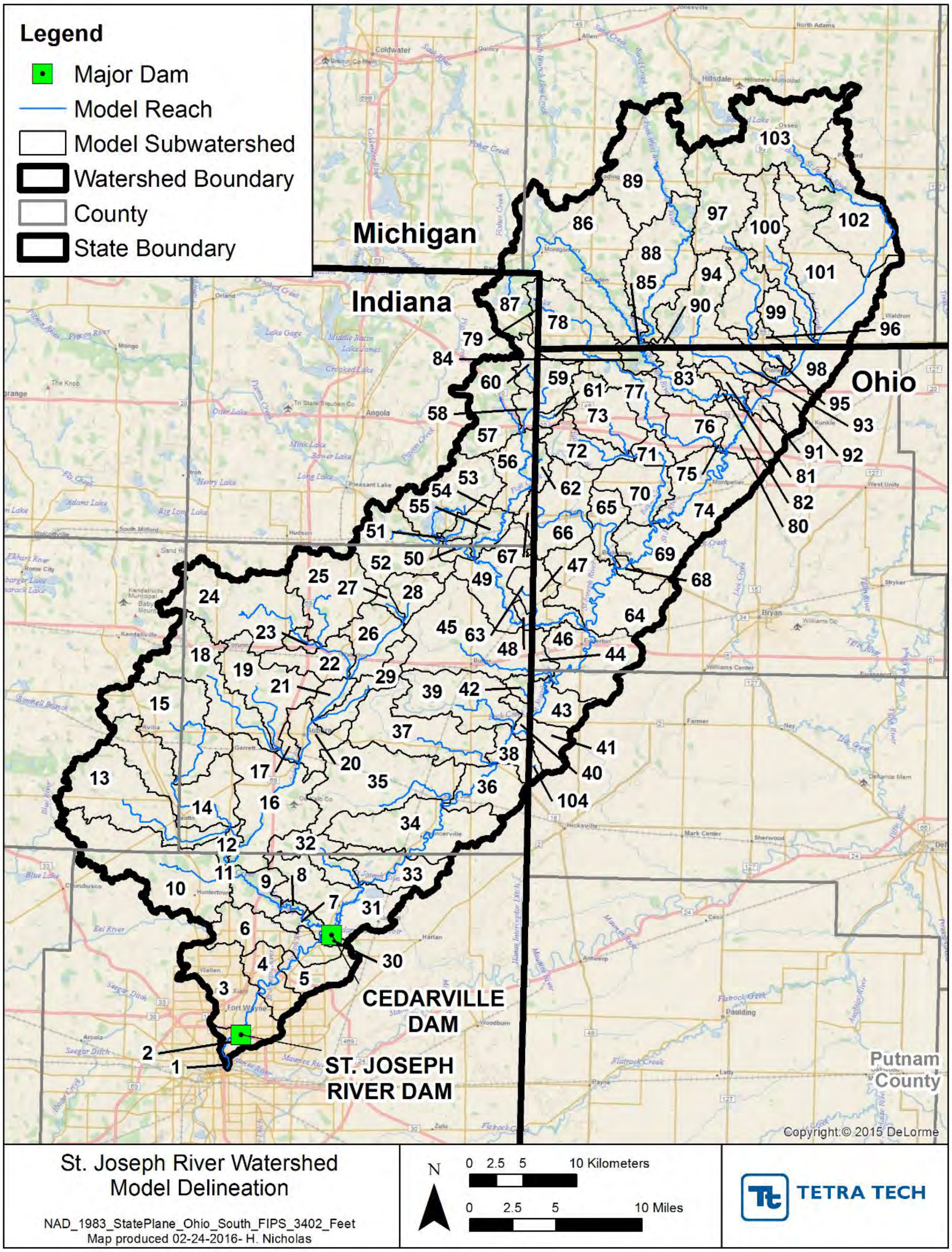


Figure D-1. Delineated subbasins and reaches for the SJRW.

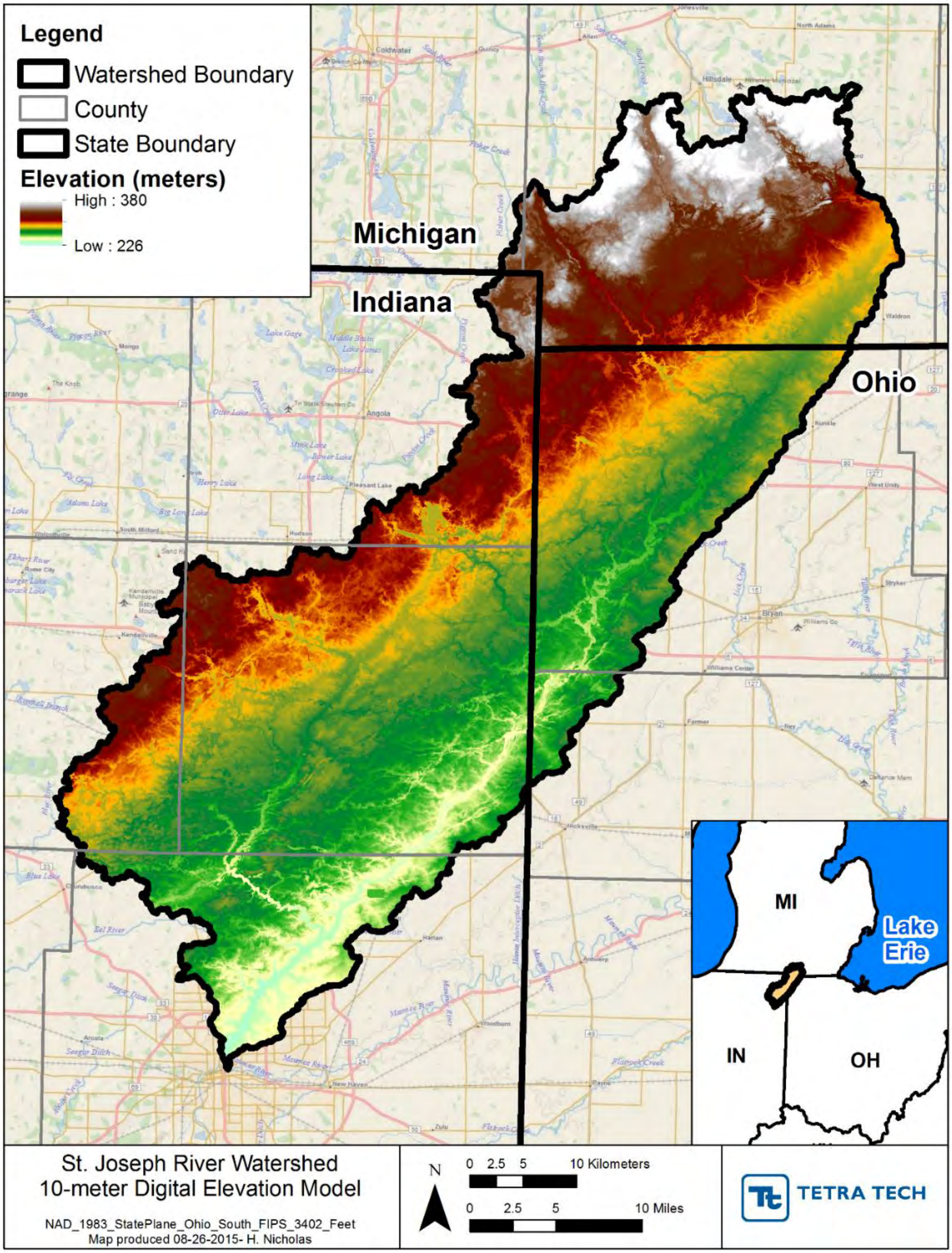


Figure D-2. Topography of the SJRW.

D-1.3 Land Use

Land use and land cover are discussed in Section 3.4 of the main report. The National Land Cover Database (NLCD) 2011 (Jin et al. 2013) was used to represent the base land use and land cover in the watershed model. Table 1 shows the area associated with each land cover class in the SJRW as per NLCD 2011. Several land use categories were aggregated for the SWAT model environment in order to provide a level of simplification that allows the model to run faster.

Table D-1. 2011 NLCD and aggregated land use classes for SWAT model development

NLCD land cover class	Area (acres)	Percent of SJRW	Aggregated land use classes	SWAT land use class
Open Water	8,615	1.23%	Open Water	WATR
Barren Land	451	0.06%	Developed, Open Space	UIDU
Developed, Open Space	40,484	5.78%		
Developed, Low Intensity	22,670	3.24%	Developed, Low Intensity	URLD
Developed, Medium Intensity	7,601	1.09%	Developed, Medium Intensity	URMD
Developed, High Intensity	2,932	0.42%	Developed, High Intensity	URHD
Deciduous Forest	76,508	10.93%	Deciduous Forest	FRSD
Evergreen Forest	1,388	0.20%		
Mixed Forest	333	0.05%		
Shrub/Scrub	3,739	0.53%	Hay/Pasture	HAY
Grassland/Herbaceous	2,392	0.34%		
Pasture/Hay	119,088	17.02%		
Cultivated Crops	361,942	51.72%	Cultivated Crops	AGRR
Woody Wetlands	48,979	7.00%	Woody Wetlands	WETL
Emergent Herbaceous Wetlands	2,742	0.39%		
Total	**699,863**	**100.00%**	*not applicable*	

Note: Areas of NLCD land cover classes vary slightly in this table versus those presented in Table 5 of Section 3.4 of the main report because different projections were used in the geographic information systems.

NLCD does not provide any information on the types of crops or crop rotation practices in the broader cultivated crops land cover class. Agricultural management practices, like tillage and fertilizer application, have significant impacts on sediment and nutrient loads generated at the landscape level. It is therefore important to classify the cultivated crops category to individual crops and associated rotation practices and to parameterize the model with their associated management operations. Section D-1.4 present the development of agricultural land use assumptions for SWAT model development.

D-1.4 Agricultural Land Use

The SJRW is 69 percent agricultural. The SWAT model was developed as a watershed-scale model that required a set of assumptions that generalize agriculture in the SJRW. These sets of assumptions were reviewed by the TMDL Workgroup, which was composed of representatives of the U.S. Environmental Protection Agency, Indiana Department of Environmental Management (IDEM), Michigan Department of Environmental Quality (Michigan DEQ), and Ohio Environmental Protection Agency (Ohio EPA), and the assumptions were reviewed by the St. Joseph River Watershed Initiatives (SJRWI). This appendix presents summaries of the development of the agricultural assumptions.

D-1.4.1 Crops

Four crops were selected to be simulated in the SJRW SWAT model: corn, soybean, winter wheat, and alfalfa hay. According to the 2012 Census of Agriculture (National Agricultural Statistics Service [NASS] 2014a; see Table C-15 in Appendix C) crops harvested over the largest acreages in six counties in the SJRW (Hillsdale, MI; Williams, OH; Allen, DeKalb, Noble, and Steuben, IN). A summation of the main six counties data indicated the following relative areas of harvested cropland (sorted largest to smallest): soybean, 45 percent; corn, 42 percent; hay, 6.3 percent; and winter wheat, 5.9 percent.

Additionally, a review of the cropland data layers (CDLs) from 2010 through 2014 (NASS 2014c, 2015) shows that these four crops are grown over the largest areas in the SJRW (Table D-2). Many more crops are grown in the SJRW but such crops are grown in acreages infinitesimal in area compared with corn, soybean, winter wheat, and alfalfa hay (Table D-2). A summation of acreages by crop across the 5 years showed the following relative areas of cropland (sorted largest to smallest): soybean, 49 percent; corn, 37 percent, winter wheat; 9.4 percent, and hay, 4.7 percent. For this SWAT model, alfalfa hay was selected because 90 percent of the hay in the SJRW is leguminous hay (Table D-2).

Table D-2. Acreages of crops in the SJRW (2010-2014 CDLs)

Crop	2010	2011	2012	2013	2014
Corn	98,931	117,081	118,210	115,725	118,873
Soybean	162,446	146,853	153,719	146,161	157,747
Winter wheat [a]	19,397	37,581	23,565	35,731	29,638
Leguminous hay [b]	13,093	13,629	14,199	13,077	12,535
Non-leguminous hay [c]	2,100	786	1,047	1,419	1,051
Fallow [d]	523	2,484	2,554	1,930	463
Other crops [e]	7,782	907	602	364	330
Non-cropland	395,613	380,565	385,988	385,477	379,248

Source:

Notes

In ArcGIS, the 2010 through 2014 raster cropland data layers were clipped to shapefile of the *St. Joseph River* hydrologic unit with hydrologic unit code 04100003.

Results were rounded to the nearest acre and do not sum to identical total annual areas due to rounding.

a. Winter wheat represents *Winter Wheat* and *Dbl Crop Win Wht/Soybeans*.

b. Leguminous hay represents *Alfalfa*.

c. Non-leguminous hay represents *Other Hay/Non Alfalfa*.

d. Fallow represents Fallow/Idle Cropland.

e. Other crops represents *Apples*, *Barley*, *Cabbage*, *Carrots*, *Christmas Trees*, *Clover/Wildflowers*, *Cucumbers*, *Dbl Crop Barley/Soybeans*, *Dry Beans*, *Grapes*, *Herbs*, *Millet*, *Misc Vegs & Fruits*, *Oats*, *Onions*, *Peppers*, *Pop or Orn Corn*, *Potatoes*, *Radishes*, *Rye*, *Sod/Grass Seed*, *Sorghum*, *Sugarbeets*, *Sunflower*, *Sweet Corn*, *Switchgrass*, and. *Tomatoes*.

D-1.4.2 Crop Rotations

Three crop rotations were selected to be simulated in the SJRW SWAT model: (1) corn-soybean, (2) corn-soybean-winter wheat, and (3) winter wheat followed by three years of alfalfa hay. Corn-soybean and corn-soybean-winter wheat will each be simulated as two sub-rotations, to yield four sub-rotations: (1) corn in year one followed by soybean in year two, (2) soybean in year one and corn in year 2, (3) corn in year one, soybean and winter wheat in year two, and (4) soybean and winter wheat in year one and corn in year two. These rotations were selected based upon analyses of the 2012 Census of Agriculture (NASS 2014a) and 2010 through 2014 CDLs (NASS 2014c, 2015), evaluation of information reported in watershed management plants for the SJRW (Loomis 2008; Quandt nd, 2015; SJRWI 2006, 2008), and upon consultation with the TMDL Workgroup[1].

[1] TMDL Workgroup conference calls regarding agricultural assumptions were held on September 11, 2015 and October 21, 2015.

D-1.4.2.1 2012 Census of Agriculture

An evaluation of the 2012 Census of Agriculture (NASS 2014a) indicated that corn and soybean across the main six counties in the SJRW tended to be harvested in an approximate 1-to-1 ratio. However, some counties have more harvested acres of corn (e.g., Noble), while others have more soybean (e.g., DeKalb) [2]. Such results indicated that corn and soybean needed to be equally present in the crop rotations selected for simulation in SWAT.

The 2012 Census of Agriculture also indicated that winter wheat and alfalfa hay were harvested across considerably less acreages. Thus, it was assumed likely that many farmers did not grow these crops and limited their rotations to corn and soybean.

D-1.4.2.2 2010-2014 Cropland Data Layers

An evaluation similar to that of the 2012 Census of Agriculture was performed for the 2010 through 2014 CDLs. The CDLs indicated that the corn-to-soybean ratio was 3:4[3], which is less than the 1:1 ratio indicated by the 2012 Census of Agriculture. Similar to the evaluation of the 2012 Census of Agriculture, it was assumed that many farmers only grew corn and soybean.

Geographic information systems (GIS) analyses were performed on the CDLs to determine the dominant crop rotations. Each year's CDL is composed of raster grid GIS data with grid cells (30 by 30 meters) that align from 2010 through 2014[4]. Thus, in GIS, 5-year crop rotations per grid cell were evaluated. The results of these analyses are summarized in the following four subsections.

D-1.4.2.3 CDL-Analysis: Pre-Processing

As the watershed-scale SJRW SWAT model was to be limited to the dominant crops (corn, soybean, winter wheat, and alfalfa hay), it was necessary re-assign CDL crop types to these four dominant crop categories. The following three rules were used for re-assignment:

1. All non-dominant crops were re-assigned to the largest dominant crop category, soybean.
2. Double-cropped soybean and winter wheat was assigned to winter wheat category
3. The hay crops were combined with fallow land and assigned to the hay category

Table D-3. Relative area for aggregated crop categories

Dominant crop category	Count	Relative area	Description
Corn	521,323	36.8%	Corn
Soybean	660,059	46.6%	Apples, Barley, Cabbage, Carrots, Christmas Trees, Clover/Wildflowers, Cucumbers, Dbl Crop Barley/Soybeans, Dry Beans, Grapes, Herbs, Millet, Misc Vegs & Fruits, Oats, Onions, Peppers, Pop or Orn Corn, Potatoes, Radishes, Rye, Sod/Grass Seed Sorghum, Soybeans, Sugarbeets, Sunflower, Sweet Corn, Switchgrass, Tomatoes
Winter wheat	160,768	11.4%	Winter Wheat, Dbl Crop Win Wht/Soybeans
Hay	73,926	5.2%	Alfalfa, Other Hay/Non Alfalfa, Fallow/Idle Cropland

Source: NASS 2014c
Note: The raster grid cell counts and relative areas are from the 2013 cropland data layer. Counts and relative areas varied by year.

[2] The corn:soybean ratio for the six counties ranged from 0.86:1 to 1.32:1.
[3] The corn:soybean ratio for the five years ranged from 0.61:1 to 0.80:1.
[4] Pre-2010 CDLs were at a coarser resolution than the 2010 through 2014 CDLs. To include pre-2010 CDLs would have required additional processing (e.g., re-sampling) that was deemed cost-ineffective for the objective of determining dominant crop rotations.

D-1.4.2.4 CDL-Analysis: Initial Results

The initial evaluation of 5-year crop rotations yielded 3,023 unique crop rotations. An issue that was immediately identified was the significant presence of non-cropland. About 44 percent of the SJRW was non-cropland from 2010 through 2014. Additionally, 2,077 of unique crop rotations included between 1 and 4 years of non-cropland. Hundreds of unique crop rotations alternated between cropland and non-cropland.

D-1.4.2.5 CDL-Analysis: Supplemental Processing

As the objective of this assessment was to determine the dominant crop rotations, the GIS analysis of 2010 through 2014 CDLs (NASS 2014c, 2015) was simplified by eliminating non-cropland from the analysis. The following rules were used to eliminate or reassign non-cropland:

1. If 3 or more years between 2010 and 2014 were originally assigned as non-cropland, the grid cells were eliminated from further analysis.
2. If 1 or 2 years between 2010 and 2014 were originally assigned as non-cropland, the 1 or 2 years of non-cropland were reassigned to a crop.
    a. If a majority of cropland cells were a single crop, then the 1 or 2 years of non-cropland were reassigned to the dominant crop.
    b. If no single crop was a majority of cropland years, the 1 or 2 years of non-cropland were reassigned to a crop present during the cropland years.
        i. If corn was present in the cropland years, the non-cropland year were reassigned to corn.
        ii. If no corn was present but soybean was present in the cropland years, the non-cropland years were reassigned to soybean.
        iii. If no corn or soybean were present but winter wheat was present in the cropland years, the non-cropland years were reassigned to winter wheat.
        iv. If no corn, soybean, or winter wheat were present but hay was present in the cropland years, the non-cropland years were reassigned to hay.

D-1.4.2.6 CDL-Analysis: Final Results

The final evaluation of 5-year crop rotations yielded 979 unique crop rotations. These rotations were evaluated and combined to determine crop rotations to simulate in the SJRW SWAT model. The results are summarized in the list below. The four dominant crops are represented by numbers (corn=1, soybean=2, winter wheat=3, hay=4) and the percentages are of cropland (i.e., excluding non-cropland that was eliminated from the analyses).

- Corn and soybean (55%)
    - 24% corn-soybean, alternating (12121, 21212)
    - 17% no pattern of 2-3 years of corn and 2-3 years of soybean
    - 10% 4 years soybean with 1 year corn (12222, 21222, 22122, 22212, 22221)
    - 4% 4 years corn with 1 year soybean (21111, 12111, 11211, 11121, 11112)
- Corn, soybean, and winter wheat (25%)
    - 4% corn-soybean-winter wheat, alternating (12312, 31231, 23123)
    - 22% no pattern of 1-3 years corn, 1-3 years soybean, and 1-3 years winter wheat
- Various (19%)
    - 2% no pattern of 2-3 years of soybean and 2-3 years of winter wheat

- 2% soybean, continuous (22222)
- 2% hay, continuous (44444)
- 2% 4 years hay with 1 year of corn, soybean, or winter wheat
- 1% corn, continuous (11111)
- 1% soybean-winter wheat, alternating (23232, 32323)
- <1% 4 years soybean with 1 year hay (24444, 42444, 44244, 44424, 44442)
- <1% 4 years winter wheat with 1 year soybean (23333, 32333, 33233, 33323, 33332)
- <1% winter wheat, continuous (33333)
- Dozens and dozens more 5-year rotations

D-1.4.2.7 Selection of Crop Rotations

The three primary crop rotations of corn-soybean, corn-soybean-winter wheat, and winter wheat followed by three years of alfalfa hay (Table D-4) were selected based upon available agricultural data from NASS, information reported in the watershed management plans (Loomis 2008; Quandt nd, 2015; SJRWI 2006, 2008), consultation with SJRWI[5], and consultation with the TMDL Workgroup[6]. Because the SWAT model for the SJRW is a watershed-scale model to support TMDL development, agricultural practices were generalized; this model was not developed for small-scale evaluations of individual tributaries or farms in the SJRW.

Table D-4. Agricultural crops and associated rotations in the SWAT model

SWAT land use class	Crop rotation	Description	Percent of SWAT land use class
AGRR	CSW	Corn-soybean-winter wheat	45%
	SWC	Soybean-winter wheat-corn	45%
	CS	Corn-soybean	5%
	SC	Soybean-corn	5%
HAY	HAY	Winter wheat- alfalfa –alfalfa - alfalfa	100%

As shown in Table D-4, two sub-rotations each of corn-soybean-winter wheat (CSW, SWC) and corn-soybean (CS, SC) were simulated. Each of these rotation options were modeled as two separate rotations in order to specify different starting crops. This way, the entire watershed is not represented with corn or soybean in a given year, but is staggered to model a crop mix across the watershed.

D-1.4.3 Tillage

Tillage practices can have a significant impact on sediment generated from agricultural and hay land. For example, a farm tilled using conventional practices will likely produce more sediment load per unit area than one that is not tilled.

In the SJRW SWAT model, tillage practices vary by crop and crop rotation (Table D-5). These practices were selected based upon analyses of the 2012 Census of Agriculture (NASS 2014b) and upon consultation with the TMDL Workgroup[7] and SJRWI, as discussed in the following subsections.

[5] Sharon Partridge-Dormer and Greg Lake, SJRWI, personal communication (via electronic mail) on September 14, 2015.
[6] TMDL Workgroup conference calls regarding agricultural assumptions were held on September 11, 2015 and October 21, 2015.
[7] TMDL Workgroup conference calls regarding agricultural assumptions were held on September 11, 2015 and October 21, 2015.

Table D-5. Crop-specified tillage operations provided by SJRW

Crop	Tillage
Corn	70% conventional, 30% conservative
Soy	85% no-till, 15% conventional
Winter Wheat	80% no-till, 20% conventional
Alfalfa	20% no-till, 80% conventional

By sub-dividing the crop rotations seen in Table D-4 based on the crop-specified tillage types seen in Table D-5, the final crop rotations that were used in the model are seen explicitly in Table D-6.

Table D-6. Crop rotation/tillage combinations for the SJRW SWAT model

SWAT land use class	Crop rotation	Initial percent of SWAT land use class	Description	Tillage Option	Percent of rotation	Final percent of SWAT land use class
AGRR	CSWA	45%	Corn – Soy – Winter Wheat	Conventional corn, no-till soy, no-till winter wheat	75%	33.75%
	CSWB			Conservation corn, conventional soy, conventional winter wheat	25%	11.25%
	SWCA	45%	Soy – Winter Wheat – Corn	Conventional corn, no-till soy, no-till winter wheat	75%	33.75%
	SWCB			Conservation corn, conventional soy, conventional winter wheat	25%	11.25%
	CSA	5%	Corn – Soy	Conventional corn, no-till soy	75%	3.75%
	CSB			Conservation corn, conventional soy	25%	1.25%
	SCA	5%	Soy – Corn	Conventional corn, no-till soy	75%	3.75%
	SCB			Conservation corn, conventional soy	25%	1.25%
HAY	HAYA	100%	Winter Wheat – Alfalfa – Alfalfa – Alfalfa	No-till winter wheat, conventional alfalfa	80%	80%
	HAYB			Conventional winter wheat, no-till alfalfa	20%	20%

D-1.4.3.1 2012 Census of Agriculture

Tillage practices are reported by county in the 2012 Census of Agriculture (2014b) by county. However, the acreage of tillage practices are not delineated by crop type (see Table C-15 in Appendix C). Additionally, tillage is reported on a farm-scale; this includes tillage on farmland other than harvested cropland. Therefore, this dataset was insufficient for which to select tillage practices for the SJRW SWAT model.

D-1.4.3.2 Tillage Practices in the Conterminous United States

Tillage practices by hydrologic unit are presented in *Tillage Practices in the Conterminous United States, 1989-2004—Datasets Aggregated by Watershed* (Baker 2011). For the SJRW (hydrologic unit code 04100003) indicate that soybean conventional tillage decreased from the late 1980s through early 2000s, while both corn and winter wheat convention tillage decreased and then increased over that timeframe. The data are summarized in Table D-7 and Figure D-3.

D-1.4.3.3 Consultation

SJRWI recommends the following tillage scheme for the SJRW SWAT model[8]:

- **Corn:** 70 percent conventional tillage and 30 percent in conservation tillage.
- **Soybean:** 85 percent no-till and 15 percent conventional tillage.
- **Winter wheat:** 80 percent no-till and 20 percent conventional tillage.
- **Alfalfa hay:** 80 percent conventional tillage and 20 percent is no till.

SJRWI further advised that that alfalfa hay that follows corn or winter wheat is tilled in the fall, while alfalfa hay following soybean is tilled in the spring. For both fall and spring tillage, about 80 percent is conventional tillage and 20 percent is no till. In the years following planting, with only harvests, there is little disturbance.

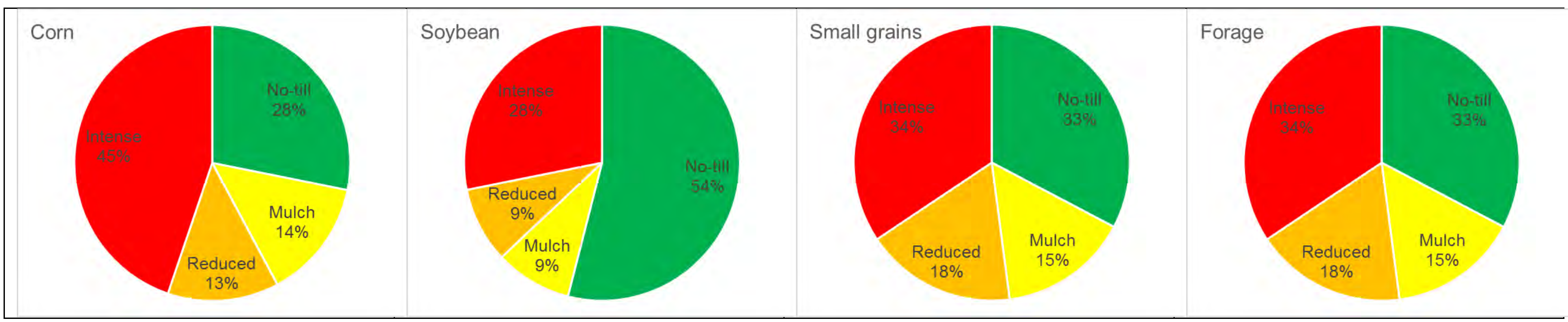
Ohio EPA stated that the majority of conventional tillage on corn fields is in the fall via chisel plow. The agency also recommended excluding no-till alfalfa hay, which is rare in northwest Ohio. Alfalfa hay typically follows winter wheat and is heavily tilled prior to planting. Alfalfa hay is harvested thrice per year without any tillage between years.

[8] Sharon Partridge-Dormer and Greg Lake, SJRWI, personal communication (via electronic mail) on September 14, 2015.

Table D-7. Tillage practices (percent) in the SJRW

Year	Corn				Soybean				Small grains [a]				Forage			
	No	Mul.	Red.	Con.	No	Mul.	Red.	Con.	No	Mul.	Red.	Con.	No	Mul.	Red.	Con.
1989	16	19	9	56	11	15	22	52	13	24	71	92	4	29	4	63
1990	18	14	11	56	13	10	11	66	17	14	42	126	9	3	6	82
1991	16	11	12	61	26	5	9	60	46	16	27	112	10	6	15	70
1992	27	14	17	42	46	8	12	33	60	28	41	71	18	4	7	71
1993	36	12	17	36	52	12	11	25	79	32	34	55	22	5	7	67
1994	40	21	18	22	68	9	10	12	87	28	18	67	16	8	9	68
1995	36	15	9	40	64	7	7	21	99	43	16	42	18	6	7	70
1996	33	18	7	41	64	6	5	25	101	24	25	48	24	0	0	76
1997	30	17	11	42	65	6	5	24	62	28	48	62	19	0	2	79
1998	26	20	8	46	73	10	4	14	62	40	39	60	23	3	5	69
1999	*no data for this year*															
2000	24	10	16	50	69	10	6	15	34	29	57	80	15	4	5	77
2001	*no data for this year*															
2002	30	10	15	45	73	9	7	11	46	18	30	106	19	3	9	69
2003	*no data for this year*															
2004	32	17	19	33	77	10	6	7	57	25	32	86	14	4	12	70

Based upon: Baker 2011
Percentages are rounded to the nearest percent.
Tillage categories are: no-till (“No”), mulch (“Mul.”), reduced “Red.”), and conventional (“Con.”). Ridge tillage was always less than 1 percent and is excluded from this table.
a. Summation of fall-seeded and spring-seeded small grains.



Based upon: Baker 2011
Note: Acreages per were summed across the 1989-2004 period and percentages were calculated.

Figure D-3. Summary of tillage in the SJRW by crop, 1989-2004.

D-1.4.4 Fertilizer Application

Fertilizers are applied to crop fields to provide the nutrients necessary for plant growth. Fertilizer application is dependent on numerous factors (e.g., soil type, soil moisture content, crop type). The dominant forms of fertilizer in the SJRW are chemical fertilizers and manure, and these practices were explicitly simulated in the SJRW SWAT model.

Land application of biosolids and septage were not explicitly simulated in the SJRW SWAT model. Due to the lack of data and assumed insignificance, the TMDL Workgroup does not believe that biosolids and septage land application need to be explicitly simulated in the SJRW SWAT model[9].

D-1.4.4.1 Chemical Fertilizers

Typical nitrogen fertilizers used are anhydrous ammonia, liquid 28 percent solution, and urea. Phosphorus-fertilizers tend to be blends or mixes with nitrogen species. In Ohio, diammonium phosphate, monoammonium phosphate, and ammonium polyphosphate are the dominant phosphorus fertilizers (Ohio EPA 2013).

In the SJRW, the following chemical fertilizers applications are typical:

- **Corn:** Farmers often apply 28-0-0 solution as a starter fertilizer during spring planting. They will then also side-dress nitrogen-fertilizers 30-days after planting. About half of the famers use anhydrous ammonia or while the other half use 28-0-0 solution.

  About 30 to 40 percent of farmers spring-apply a phosphorus fertilizer just before planting; the other 60 to 70 percent of farmers fall-apply phosphorus fertilizer.
- **Soybean:** No fertilizers are applied during the soybean portions of the crop rotations.
- **Winter wheat:** Farmers broadcast 28-0-0 solution or dry 46-0-0 in the spring after fall planting. Phosphorus-fertilizers are applied during planting in the fall.
- **Alfalfa hay:** No nitrogen-fertilizer is applied. Phosphorus-fertilizers are applied during planting in the spring.

Fertilizer application rates for the four dominant crops in the SJRW are presented in Table D-8. These rates were selected based upon evaluation of the *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalf*a (Vitosh et al. 1995) and the *Ohio Agronomic Guide* (Ohio State University Extension 2003). The rates used in the model initially were based on other SWAT models developed for TMDL support in northern Ohio but were subsequently revised based on input from local stakeholders and agricultural experts in the region.

Table D-8. Fertilizer application rates

Fertilizer	Corn	Soybean	Winter wheat	Alfalfa hay
Nitrogen (N)	190	0	90	0
Phosphorus (as P_2O_5)	50	0	50	85

Note: Fertilizer application rates are in pounds per acre.

[9] TMDL Workgroup concluded as such during the conference calls regarding agricultural assumptions that were held on September 11, 2015 and October 21, 2015.

D-1.4.4.2 Biosolids

Biosolids are composed of wastewater treatment plant (WWTP) sludge and septage transferred to WWTPs. Biosolids are land-applied in Indiana, Michigan, and Ohio. IDEM, Michigan DEQ, and Ohio EPA provided biosolids land application information. Refer to Section 4.2.2.3 of the main report for discussions of biosolids application to crop fields. Tables C-10 and C-11 summarize the available data, including the crop fields' acreages and sources of biosolids. Brief summaries by state are presented in the following subsections.

- **Michigan:** Biosolids may be land-applied to 4 crop fields in the Michigan-portion of the SJRW. The location of these fields and biosolids application rates are not available for review.
- **Ohio:** The Montpelier WWTP is authorized to land-apply biosolids to seven crop fields adjacent to or near the WWTP. Biosolids have been land applied to only one field in recent years (Ohio EPA 2015).
- **Indiana:** While biosolids were land-applied to 117 fields in the Indiana-portion of the SJRW (IDEM 2015). However, no land application has occurred since 2003. Most of the land application occurred in the 1980s and 1990s.

Upon consultation with the TMDL Workgroup[10], it was decided that biosolids were too insignificant of a source of nutrients to expend resources to investigate and attempt to simulate in the SJRW SWAT model. Therefore, biosolids land-application was not included in the SWAT model.

D-1.4.4.3 Septage

Domestic septage is pumped by companies that pump, haul, and dispose of septage. Pumped septage may be hauled to WWTPs for disposal and treatment or hauled to farms for land application to crop fields. Refer to Section 4.3.4 of the main report for discussions of septage application to crop fields.

Septage land-application was not simulated in the SJRW SWAT model because septage is not known to be land-applied in the SJRW. Michigan DEQ allows septage land-application of septage in Branch and Hillsdale counties but no land application is currently permitted in the SJRW in Michigan. Similarly, no septage land application sites are in the SJRW in Indiana (Indiana Geological Survey 2013). Information on septage application in Defiance and Williams counties in Ohio is not available.

D-1.4.4.4 Manure

Manure from livestock operations is often land-applied to crop fields. Manure may be land-applied as a liquid via draglines or as a solid using a spreader. Regulated livestock operations (e.g., concentrated animal feeding operations [CAFOs]) have requirements for manure application, especially when the livestock operator land-applied manure on their own crop fields. New regulations in Michigan require manure applicators to follow the CAFO permits when they apply manure obtained from CAFOs (Michigan DEQ 2015) and new regulations in Ohio prohibit most manure application on frozen or snow-covered ground and applications just before precipitation events in the Western Lake Erie Basin.

In the SJRW, manure is typically land-applied in the fall, after harvest, on corn and soybean fields that are planted the following spring. Manure is land-applied in July, after harvest, on winter wheat fields. Manure is land-applied during the winter when livestock operations run out of manure storage capacity. In Ohio, livestock operations must have a 6-month storage capacity, but many larger operations have a 12-month storage capacity.

[10] TMDL Workgroup conference calls regarding agricultural assumptions were held on September 11, 2015 and October 21, 2015.

Farmers often try to land-apply manure once every three years, depending on the source and application rate of the manure. Dairy manure is applied at 10,000 to 13,000 gallons per acre with a dragline while poultry manure is applied at 2 tons per acre, which is essentially a 10-year supply of phosphorus.

In the SJRW SWAT model, only manure from cattle and hog at permitted livestock operations was explicitly simulated. Due to a lack of data regarding non-permitted livestock operations and manure application, the TMDL Workgroup concluded that limiting explicit simulation of manure application to manure derived from permitted livestock operations was appropriate[11]. For manure land application to crop fields, permitted livestock operations are defined as CAFOs in Michigan and Indiana, confined feeding operations regulated by IDEM in Indiana, and confined animal feeding facilities regulated by the Ohio Department of Agriculture in Ohio.

In the model, the annual phosphorus and nitrogen production was estimated using the estimated manure production from the reported numbers of cattle or hogs at permitted livestock operations. This phosphorus and nitrogen was then distributed to cropland in the same model subbasin as the permitted livestock operation (Table D-9, Figure D-4). In cases where permitted livestock operations were near the borders of model subbasins, the phosphorus was distributed to cropland to an adjacent model subbasin too.

Manure application varies by subbasin, manure type, number of animals, and crop rotation. A total of 24 model subbasins received manure from some combination of swine, dairy, and beef sources on agricultural and hay lands. Manure production rates by animal type estimated by the American Society of Agricultural Engineers (ASAE Standards, 2005) were used to develop application rates. The total amount of manure applied to any given crop type was used to replace a fraction of the commercial fertilizer.

Hog manure was applied to corn-soybean and soybean-corn lands in the applicable subbasins before corn planting. This ensures hog manure is spread on 5 percent of agricultural land in hog waste-producing subbasins.

Dairy and beef cattle manure was applied in applicable subbasins three times per year on corn-soybean-winter wheat and soybean-winter wheat-corn rotations. Cattle manure was applied before, during, and after corn rotations, such that 45 percent of agricultural land was cattle-manure-fertilized corn at any given time in those subbasins. Cattle manure was applied once per year during the planting of alfalfa on *Hay* lands.

The volume of manure used replaced commercial fertilizer inputs based on the mineral fractions of nitrogen and phosphorus present in each manure respectively. For reference, Table D-8 details the mineral fractions of each nutrient type that manure replaced for select model subbasins. Where manure application exceeds commercial fertilizer application (occurs in very few subbasins), commercial fertilizer was set to zero.

[11] TMDL Workgroup conference call regarding agricultural assumptions were held on October 21, 2015.

Table D-9. Permitted livestock operations in the SJRW

Permitted livestock operation	Type	Animal units	Model Subbasin	Annul manure production	
				Nitrogen (kg)	Phosphorus (kg)
Michigan					
Triple T Farms (MIG010057)	CAFO	4,000 hogs	86	40,880	14,162
Ohio					
Bridgewater Dairy LLC	CAFF	3,900 dairy cattle	71 (33%) 76 (33%) 77 (33%)	640,575	111,033
Indiana					
Irish Acres Dairy LLC	CAFO	2,300 dairy cattle	45	377,775	65,481
Phillips Farm	CAFO	170 dairy calves 1,950 dairy heifers	22	89,319	14,235
Sunrise Heifer Farms LLC	CAFO	2,650 dairy heifers	19	116,070	19,345
Mark S. Rekeweg (Bull Rapids Rd)	CAFO	1,100 nursery pigs 7,000 hogs 344 sows [a]	34	82,213	27,923
Mark S. Rekeweg (Boger Rd)	CFO	2,000 hogs	31 (20%) 33 (20%)	20,440	7,081
Laub Farm LLC	CAFO	3,300 nursery pigs 3,600 hogs 750 sows	34	60,061	19,590
Brand Farms	CFO	465 dairy calves 400 dairy cattle 115 dairy heifers 120 beef cattle	52	89,752	14,155
Concord Veal	CFO	536 veal calves	35	2,935	880
Don Hook Farms Inc.	CFO	320 nursery pigs 246 sows 780 hogs	42 (50%) 43 (50%)	15,604	5,006
Haynes Dairy Farm	CFO	400 nursery pigs 264 sows 300 hogs	19	11,768	3,648
KD Carnahan Farms Inc.	CFO	70 dairy calves 204 dairy cattle 280 dairy heifers	39	47,381	7,852
Long Lane Farms Inc.	CFO	625 nursery pigs	47 (50%)	16,699	5,606

Permitted livestock operation	Type	Animal units	Model Subbasin	Annul manure production	
				Nitrogen (kg)	Phosphorus (kg)
		110 sows 1,300 hogs	63 (50%)		
R&D Malcom Farms Inc.	CFO	384 nursery pigs 125 sows 192 hogs	39	5,840	1,820
Strong Partnership	CFO	990 beef calves	36	68,657	15,899
Impressive Pork Production Inc.	CAFO	4,800 hogs	31 (10%)	49,056	16,994
John D Smith & Sons Inc. (Metz Rd)	CFO	80 beef cattle 2,800 nursery pigs 876 sows [a]	53 (30%) 57 (15%)	32,726	9,278
John D Smith & Sons Inc. (Johnson Lake Rd)	CFO	2,800 nursery pigs 876 sows [a]	52 (25%) 53 (25%)	27,178	7,994
Konger Farms LLC	CFO	1,200 hogs	10 (10%) 13 (25%)	12,264	4,249
NEI Dairy LLC	CAFO	1,620 dairy cattle	57 (20%)	266,085	46,121
Stockwell Acres Inc.	CFO	85 dairy calves 451 dairy cattle 315 dairy heifers	24 (10%) 25 (10%)	89,828	15,139

Notes
CAFF = confined animal feeding facility; CAFO = confined animal feeding operation; CFO = confined feeding operation.
a: Number of sow not provided; estimated based on number of nursing pigs.

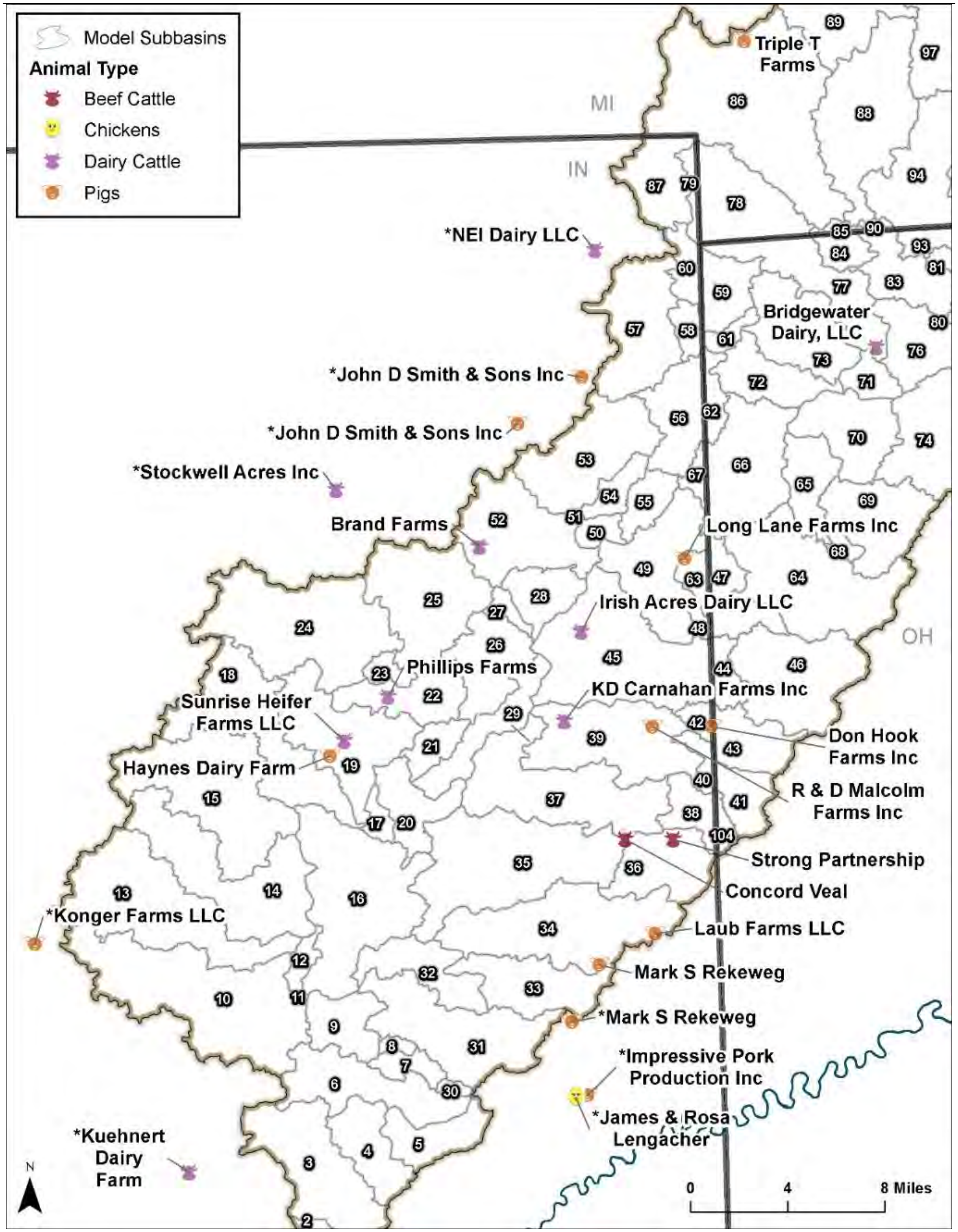


Figure D-4. Permitted livestock operations in and around the SJRW.

D-1.4.5 Crop Management Schedules

The crop management schedules to be simulated in the SJRW SWAT model are summarized in Table D-10, Table D-11, and Table D-12. The schedules combine the crop rotation (Section D-1.4.2), tillage (Section D-1.4.3), and fertilizer (Section D-1.4.4) assumptions with assumptions regarding the timing of various practices. The sequence and timing assumptions were based upon the *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa* (Vitosh et al. 1995), the *Ohio Agronomic Guide* (Ohio State University Extension 2003), *Usual Planting and Harvesting Dates for U.S. Field Crops* (NASS 2010), and consultation with the TMDL Workgroup and SJRWI. The activities were simulated using the HUSC, not the dates listed in the dates fields in Table D-10, Table D-11, and Table D-12. HUSC reflects the fraction of total base zero heat units at which each operation will take place. Using HUSC accounts for year to year variations in weather (e.g., later dates for the activities in a colder year). The harvesting dates (based upon the HUSCs) are generally earlier than those suggested by the NASS (2010) to accommodate the following crop (winter wheat, in this case).

Table D-10. Crop management schedules for corn-soybean-winter wheat and corn-soybean

Date [a]	$HUSC_{frac}$	Action	Comment
May 4	0.129	Tillage	
May 5	0.130	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
May 10	0.152	Plant corn	Heat units to maturity: 1,431
May 10	0.006	Nitrogen fertilizer	Urea: 40 lbs-N/ac, side-dress
Jun 9	0.196	Nitrogen fertilizer	Anhydrous Ammonia: 150 lbs-N/ac, side-dress
Jun 19	0.287	Phosphorus fertilizer	Elemental phosphorus: 50 lbs-P/ac, broadcast
Jun 20	0.300	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
Sep 7	1.095	Harvest & Kill corn	Allows for 10-days dry-down
Oct 1	0.800	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
May 4	0.129	Tillage	
May 10	0.152	Plant soybeans	Heat units to maturity: 1,212
Aug 28	1.000	Harvest & Kill soybeans	
Oct 11	0.898	Phosphorus fertilizer	Elemental phosphorus: 50 lb-P/ac, broadcast
Oct 12	0.902	Tillage	
Oct 13	0.905	Plant winter wheat	Heat units to maturity: 1,510
Feb 20	0.292	Nitrogen fertilizer	46-0-0: 90 lbs-N/ac, broadcast
Apr 10	0.431	Harvest & Kill winter wheat	

Notes
lb-N/ac: pounds nitrogen per acre; lb-P/ac: pounds phosphorus per acre.
a. Activities will be simulated in SWAT using the $HUSC_{frac}$; dates are provided for reference.

Table D-11. Crop management schedules for soybean-winter wheat-corn and soybean-corn

Date	$HUSC_{frac}$	Action	Comment
May 4	0.129	Tillage	
May 10	0.152	Plant soybean	Heat units to maturity: 1,212
Aug 28	1.000	Harvest & Kill soybean	
Oct 11	0.898	Phosphorus fertilizer	Elemental phosphorus: 50 lb-P/ac, broadcast
Oct 12	0.902	Tillage	
Oct 13	0.905	Plant winter wheat	Heat units to maturity: 1,510
Feb 20	0.292	Nitrogen fertilizer	46-0-0: 90 lbs-N/ac, broadcast
Apr 10	0.431	Harvest & Kill winter wheat	
May 4	0.129	Tillage	
May 5	0.130	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
May 10	0.152	Plant Corn	Heat units to maturity: 1,431
May 10	0.006	Nitrogen fertilizer	Urea: 40 lbs-N/ac, side-dress
Jun 9	0.196	Nitrogen fertilizer	Anhydrous Ammonia: 150 lbs-N/ac, side-dress
Jun 19	0.287	Phosphorus fertilizer	Elemental phosphorus: 50 lbs-P/ac, broadcast
Jun 20	0.300	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
Sep 7	1.095	Harvest & Kill Corn	Allowed for 10-days dry-down
Oct 1	0.800	Manure fertilizer	Varies by subbasin, applied by nutrient fraction

Notes
lb-N/ac: pounds nitrogen per acre; lb-P/ac: pounds phosphorus per acre.
a. Activities will be simulated in SWAT using the $HUSC_{frac}$; dates are provided for reference.

Table D-12. Crop management schedules for winter wheat followed by three years of alfalfa hay

Date	$HUSC_{frac}$	Action	Comment
Oct 11	0.898	Phosphorus fertilizer	Elemental phosphorus: 50 lb-P/ac, broadcast
Oct 12	0.902	Tillage	
Oct 13	0.905	Plant winter wheat	Heat units to maturity: 1,510
Feb 20	0.292	Nitrogen fertilizer	46-0-0: 90 lbs-N/ac, broadcast
Apr 10	0.431	Harvest & Kill winter wheat	
May 9	0.148	Tillage	
May 10	0.162	Phosphorus fertilizer	Elemental phosphorus: 85 lbs/ac, broadcast
May 10	0.152	Plant Alfalfa	Heat units to maturity: 1,448
May 15	0.200	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
Jun 24	0.611	Harvest	First Harvest
Aug 8	0.648	Harvest	Second Harvest
Sep 5	1.018	Harvest	Third Harvest
May 10	0.162	Phosphorus fertilizer	Elemental phosphorus: 85 lbs/ac, broadcast
May 15	0.200	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
Jun 24	0.611	Harvest	First Harvest
Aug 8	0.648	Harvest	Second Harvest
Sep 5	1.018	Harvest	Third Harvest
May 10	0.162	Phosphorus fertilizer	Elemental phosphorus: 85 lbs/ac, broadcast
May 15	0.200	Manure fertilizer	Varies by subbasin, applied by nutrient fraction
Jun 24	0.611	Harvest	First Harvest
Aug 8	0.648	Harvest	Second Harvest
Sep 5	1.018	Harvest & Kill Alfalfa	Third Harvest

Notes
lb-N/ac: pounds nitrogen per acre; lb-P/ac: pounds phosphorus per acre.
a. Activities will be simulated in SWAT using the $HUSC_{frac}$; dates are provided for reference.

D-1.4.6 Agricultural Tile Drains

Agricultural practices in the Midwest are frequently paired with tile drainage practices to artificially decrease soil moisture and allow for optimized crop growth. Tile drains were modeled for the SJRW on the following hydrologic soil groups: A/D, B/D, C/D, and D soils that have the land use of agriculture/row crops (AGRR) and for which slopes are less than or equal to 5 percent. These are reasonable conditions for which tile drains are generally found, and the parameters which will be set to represent these tile drains are seen below in Table D-13.

Table D-13. Tile drain parameterization for the St Joseph SWAT model.

Tile drain parameter	Definition	Initial value
GDRAIN	Tile Drain lag time (hours)	12
TDRAIN	Time to drain soil to field capacity (hours)	24
DDRAIN	Depth to sub-surface drain (mm)	1000
DEP_IMP	Depth to impervious layer (mm)	2500

D-1.5 Soil Characteristics

Soil Survey Geographic (SSURGO) database from the Natural Resources Conservation Service was used to represent soils and their associated properties in the SJRW SWAT model. A total of 446 soils are in the SJRW based on unique MUKEY identification numbers associated with each soil survey polygon. Table D-14 lists the area covered by each hydrologic soil group (HSG) in the watershed, a property of each soil type which characterizes the basic infiltration capacity of the media. When a soil is cross-listed with group D, it indicates that the soil is located with a high water table that impacts infiltration rates. A cross-listed soil will behave as its primary HSG if it is artificially drained, but if left undrained, it will behave as a D soil. For reference, Group A soils have low runoff potential and high infiltration rates (i.e. sandy soils), while D soils have high runoff potential and low infiltration rates (i.e. silty or clayey soils).

Table D-14. Soil area by HSG in the SJRW

HSG	Area (acres)	Relative area (percent)
A	34,146	4.9%
A/D	30,292	4.3%
B	34,424	4.9%
B/D	48,212	6.9%
C	116,658	16.7%
C/D	128,647	18.4%
D	307,485	43.9%
Total	**699,863**	**100%**

The following five properties are required for each soil in a SWAT model:

- Number of horizons
- Hydrologic soil group
- Maximum rooting depth
- Anion exchange capacity
- Soil cracking potential

The following 10 properties are required for the soil horizons associated with each soil:

- Depth of horizon
- Bulk density
- Available water capacity
- Hydraulic conductivity
- Percent organic carbon
- Percent sand, silt and clay
- Percent rock
- Albedo
- USLE erosivity factor
- Electrical conductivity

All the parameters listed above were available from the SSURGO database. A small fraction of required data were missing, which were addressed using the following approaches,

- If values for parameters associated with a given horizon were missing then these were filled using data from an adjacent horizon of the same soil.
- If data for all horizons were missing then the SWAT soils database was used to fill data based on the name of the soil.

D-1.6 Hydrologic Response Unit Delineation

An hydrologic response unit (HRU) is the smallest physical entity in a SWAT model for which all the land phase hydrology and water quality processes are simulated. Each HRU in a modeled subbasin is a unique combination of land use/land cover, soil and slope category. The ArcSWAT interface generates HRUs by intersecting these layers. Slope is calculated by the ArcSWAT interface during the model setup process. Two slope classes were defined for the watershed model, namely, 0 to 3 percent and 3 percent or more. Given the absence of a general guidance on the classification of slopes for HRU development, the less than 5 percent and greater than 5 percent slope categories were adopted to distinguish between low and moderate to high sloping areas, respectively. The land use/land cover and soil layers used in the watershed model have been discussed in detail in the previous sections.

The HRU setup process using the ArcSWAT interface provides a unique feature of imposing thresholds on land use, soil and slope to remove HRUs which occupy small areas in a given subbasin. Thresholds are imposed to simplify the model and reduce model run time. The area lost from removing such HRUs is re-apportioned to the remaining HRUs in a given subbasin. The use of thresholds is a standard (and sometimes necessary) process for SWAT applications to reduce computational burden. Thresholds imposed for the SJRW were 1 percent on soils, 1 percent on slopes, and none applied to land use—resulting in a total of 33,504 HRUs.

D-1.7 Meteorology

Meteorological data required for a SWAT application consist of daily precipitation, maximum and minimum daily air temperature, wind speed, relative humidity and solar radiation. Watershed modeling applications have historically relied on point measurements of meteorological parameters. Point measurements however often suffer from data gaps requiring extensive processing to address such data gaps and do not adequately represent spatial variations.

In recent years, several gridded meteorological products have been made publicly available. These products incorporate point and radar estimates of rainfall, do not have data gaps and have generally undergone extensive quality checks. PRISM (PRISM Climate Group) and NLDAS-2 (http://ldas.gsfc.nasa.gov/nldas/NLDAS2forcing.php) are two such products which are appropriate for watershed modeling applications. PRISM provides daily precipitation, and maximum and minimum temperature grids at an approximate spatial resolution of 4 kilometer (km) by 4 km for the continental United States (CONUS) from 1981 onwards. NLDAS-2 provides hourly precipitation, air temperature, wind speed, longwave and shortwave radiation, specific humidity, air pressure, and potential evapotranspiration at an approximate spatial resolution of 12 km by 12 km for the CONUS from 1979 onwards.

Precipitation and temperature data from PRISM were used because of their finer spatial resolution compared to NLDAS-2. Solar radiation, wind speed, and relative humidity (calculated using specific humidity, air pressure and temperature) from NLDAS-2 were used in the watershed model. Since both PRISM and NLDAS-2 are derived from the same historical datasets it is appropriate to *mix* these sources for meteorological forcing. The meteorological data were area-weighted to have one representative station for each HUC12 watershed.

D-1.8 Point Sources

There are 34 facilities with individual NPDES permits in the SJRW with available discharge data (Table D-15, Table D-16, and Figure D-5)[12]. Flow, sediment, and nutrient discharged by the facilities to the SJR were explicitly represented in the SWAT model. Table D-16 lists the point sources in the SJRW. There is a single large water withdrawal in the watershed which occurs in Subbasin 2, and that is the annual daily withdrawal of approximately 50 cfs for the city of Fort Wayne, Indiana. The Fort Wayne Municipal WWTP located in the lower part of the watershed discharges into the Maumee River so it is not included in this model. Also, note that the large animal operations are modeled through manure application rates rather than explicit point sources (Section D-1.4.4.4).

Major and minor point sources in Indiana and Ohio were simulated at a monthly time-step using monthly average discharge monitoring report (DMR) data provided by IDEM and sub-weekly DMR data provided by Ohio EPA. In most cases, missing monthly time-step inputs were backfilled using long-term averages of available DMR data. As the Indian Springs Recreational Campground (IN0032107) is only permitted to discharge seasonally, missing monthly time-steps were not backfilled and the lack of DMR data was assumed to indicate that no discharge occurred in a given month.

As discussed in Section 4.2.4 of the main report, Michigan's wastewater stabilization lagoons (WWSLs) covered by general permits are only permitted to discharge a few days in certain months each year. The WWSLs were simulated at a daily times-step using daily DMR data provided by Michigan DEQ. Water quality DMR data were missing for the Pittsford WWSL (MIG580006); long-term average DMR data from the other five WWSLs were used to develop the daily time-series for the Pittsford WWSL.

[12] Refer to Appendix C for information regarding all permitted point sources in the SJRW, including those without discharge data.

While several surface water withdrawals are in the SJRW, only one is of significance: the public water supply withdrawal for the city of Fort Wayne (annual average daily withdrawal of 50 cfs), which is in model subbasin #2.

Table D-15. Major point sources included in the SJRW SWAT model

State	NPDES ID	Facility name	Type	Model subbasin
Indiana	IN0020672	Auburn WWTP	Sanitary	20
Indiana	IN0022462	Butler WWTP	Sanitary	45
Indiana	IN0029969	Garrett WWTP	Sanitary	16

Table D-16. Minor point sources included in the SJRW model

State	NPDES ID	Facility name	Type	Model subbasin
Michigan	MIG580006	Pittsford SSDS WWSL	WWSL	102
Michigan	MIG580007	Waldron WWSL	WWSL	101
Michigan	MIG580008	Amboy Township WWSL	WWSL	96
Michigan	MIG580009	Reading WWSL	WWSL	86
Michigan	MIG580011	Camden WWSL	WWSL	86
Michigan	MIG580013	Amboy Township Lake Diane WWSL	WWSL	94
Ohio	OH0021164	Edgerton WWTP	sanitary	46
Ohio	OH0021831	Montpelier WWTP	sanitary	74
Ohio	OH0022535	Pioneer WWTP	sanitary	92
Ohio	OH0053376	Nettle Lake STP	sanitary	77
Ohio	OH0095141	Edon WWTP	sanitary	66
Ohio	OH0122351	Exit One	sanitary	72
Ohio	OH0138177	Montpelier WTP No. 2	WTP	74
Ohio	OH0138631	Aqua Ohio Lake Seneca WTP	WTP	83
Ohio	OH0141852	Northwest Water District WTP	WTP	72
Ohio	OH0142069	Lazy River Campground	sanitary	80
Indiana	IN0020664	Avilla WWTP	sanitary	14
Indiana	IN0020711	Waterloo WWTP	sanitary	22
Indiana	IN0032107	Indian Springs Rec Campground	sanitary	14
Indiana	IN0032981	Pickle Properties, LLC	industrial, sanitary	35
Indiana	IN0044369	Grabill Water Works	WTP	31
Indiana	IN0046761	Tower Automotive USA II	industrial	17
Indiana	IN0047473	Corunna WWTP	sanitary	18
Indiana	IN0050822	Hamilton Lake Conservancy District	sanitary	50
Indiana	IN0058611	La Otto Regional Sewer District	sanitary	13
Indiana	IN0059021	Steel Dynamics Inc.	industrial, sanitary	37
Indiana	IN0059749	Deer Track Estates WWTP	sanitary	32
Indiana	IN0060127	Dupont Water Treatment Plant - North End	WTP	3
Indiana	IN0060216	Hamilton Water Works	WTP	52
Indiana	IN0063061	Fort Wayne Utilities – Honeysuckle Site	WTP	33
Indiana	ING080271	Northcrest Shopping Center	GWPRS	3

Note: GWPRS= groundwater petroleum remediation systems; WTP = water treatment plant; WWSL = wastewater stabilization lagoon; WWTP = wastewater treatment plant.

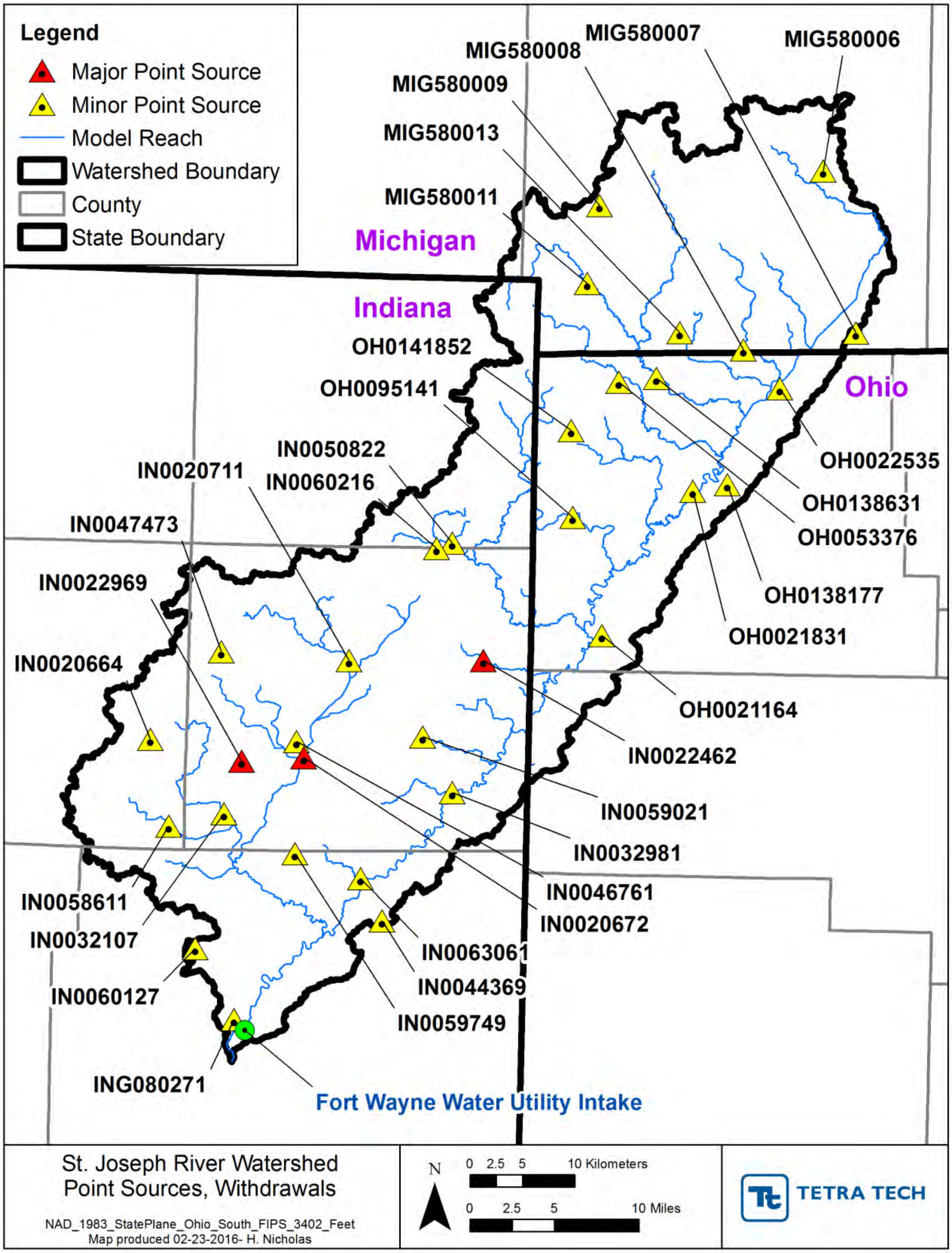


Figure D-5. Modeled point source and withdrawals in SJRW.

D-1.9 Atmospheric Deposition

Annual average atmospheric deposition of nitrate and ammonia (wet and dry) were simulated in the SWAT model. National Atmospheric Deposition Program (NADP) sites at Ann Arbor, Grand Rapids and Fort Wayne were used for wet deposition Clean Air and Trends Network (CASTNET) sites at Ann Arbor (ANA115) and Salmonie Reservoir (SAL133) were used for dry deposition.

D-2 SWAT Modeling Results

This section of the model report describes the calibration and validation of the model, first for hydrology and then for water quality.

D-2.1 Hydrology Calibration and Validation

D-2.1.1 Methods

The calibration and validation process in the SWAT model consisted of a systematic adjustment of parameters generally geared towards getting the closest match between simulated and observed flows. Water years 2010 to 2014 and 2005 to 2009 were adopted as the calibration and validation periods, respectively. The later time period was used for calibration because this period overlaps the land use coverage (NLCD 2011). There are a number of USGS and Ohio EPA flow monitoring stations within the SJRW that were used for model calibration and validation, which are detailed below (Table D-17, Figure D-6). Additional information regarding USGS flow gages and hydrology is presented in Section 3.7 of the main report.

Table D-17. Hydrology calibration and validation gage locations for SJRW

Agency	Station Name	ID	Model Subbasin	Calibration	Validation
USGS	Fish Creek at Hamilton, Indiana	04177720	51 54	X	X
USGS	Fish Creek near Artic, Indiana	04177810	49		X
USGS	St. Joseph River near Newville, Indiana	04178000	43	X	X
USGS	Cedar Creek near Cedarville, Indiana	04180000	9	X	X
USGS	St. Joseph River near Fort Wayne, Indiana	04180500	5	X	X
Ohio EPA	West Branch St. Joseph River southwest of Pioneer at Country Road 11.5	--	82	X	

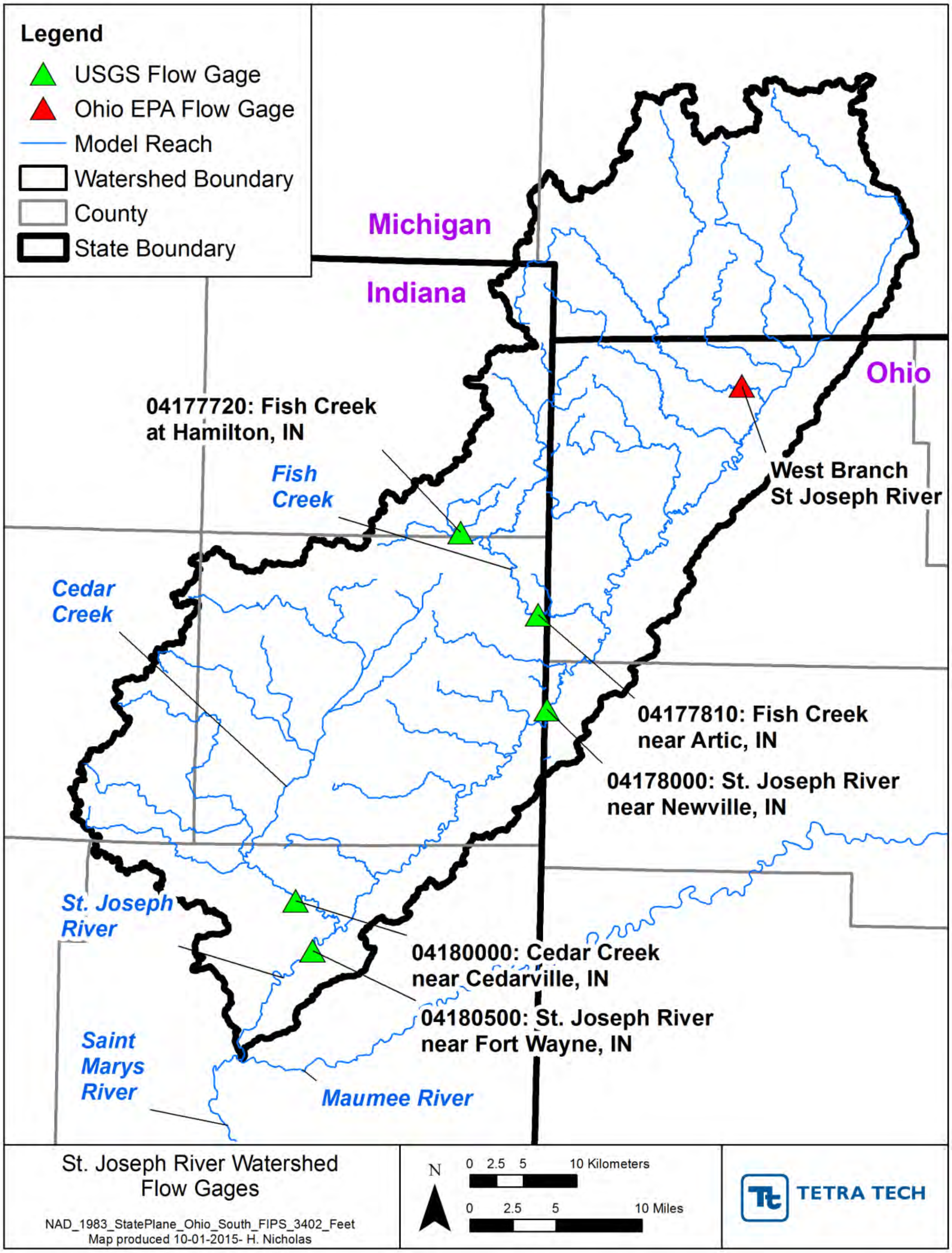


Figure D-6. Flow gages in the SJRW.

The calibration process also consisted of comparing simulated evapotranspiration to satellite based estimates at a monthly time-step from MODIS Global Evapotranspiration Project (MOD16) (http://ntsg.umt.edu/project/mod16). MOD16 is a part of a National Aeronautics and Space Agency (NASA) project to estimate global terrestrial evapotranspiration using remote sensing data. The MOD16 evapotranspiration datasets are estimated using an algorithm based on the Penman-Monteith equation as outlined in Mu *et al*. (2011).

Models are deemed acceptable when they can simulate field data within predetermined statistical measures. Model performance was generally assessed at a monthly time-step using model evaluation criteria suggested by Moriasi *et al*. (2007) (Table D-18). For the simulation of flow and pollutant loads, Moriasi *et al*. summarized recent research and recommended performance targets in terms of the Nash-Sutcliffe coefficient (NSE), root mean square error (RMSE)-observations standard deviation ratio (RSR) and the magnitude of the relative average error (RE, which Moriasi refers to as PBIAS).

The NSE is an indicator of a model's ability to predict the timing and magnitude of observed data. Values may vary from -∞ to 1.0. A value of NSE = 1.0 indicates a perfect fit between modeled and observed data, while values equal to or less than 0 indicate the model's predictions are no better than using the average of observed data.

RSR is the ratio of RMSE and standard deviation of measured data. RSR may be considered as a normalized error index statistic with values ranging from 0 to ∞. An RSR of 0 indicates a zero RMSE and hence a perfect model.

Table D-18. Performance targets for monthly average loads

Constituent	Very good	Good	Satisfactory	Unsatisfactory
Flow, Sediment and Nutrients (NSE)	> 0.75	> 0.65	> 0.5	≤ 0.5
Flow, Sediment and Nutrients (RSR)	≤ 0.5	≤ 0.6	≤ 0.7	> 0.7
Flow (RE)	< ±10	< ±15	< ±25	≥ ±25
Sediment (RE)	< ±15	< ±30	< ±55	≥ ±55
Nutrients (RE)	< ±25	< ±40	< ±70	≥ ±70

A hydrologic calibration spreadsheet was also used to determine the acceptability of modeling results on the basis of statistical criteria in Table D-19. The spreadsheet computes the relative error for various aspects of the hydrologic system. Statistical targets developed and implemented in previous studies (Lumb *et al*. 1994, Duda *et al*. 2012) were defined and met for each aspect of the system before accepting the model.

Table D-19. Hydrology calibration criteria

Statistic	Criteria
Error in total volume	≤ 10%
Error in 50% lowest flows	≤ 10%
Error in 10% highest flows	≤ 15%
Seasonal volume error (summer)	≤ 30%
Seasonal volume error (fall)	≤ 30%
Seasonal volume error (winter)	≤ 30%
Seasonal volume error (spring)	≤ 30%
Error in storm volumes	≤ 20%
Error in summer storm volumes	≤ 50%

Graphical comparison of observed and simulated flows were performed in addition to the statistical evaluation. Graphical comparisons are extremely useful for judging the results of model calibration; time-variable plots of observed versus modeled flow provide insight into the model's representation of storm hydrographs, baseflow recession, time distributions, and other pertinent factors often overlooked by statistical comparisons. The model's accuracy was assessed by interpreting these time-variable plots.

While various attempts have been made to develop auto-calibration procedures for SWAT, the results are often unsatisfactory without extensive supervision and can lead to physically unrealistic results. This occurs because SWAT, like most other watershed models, has many parameters that cannot be fully determined from external data and are strongly correlated with one another. Therefore, a manual calibration process was adopted that attempted to maximize model performance while staying within the bounds of physical reality. The parameters adjusted during the calibration and validation process are listed below. Table D-20 shows the values of these parameters in the calibrated and validated model.

a) Subbasin level parameters

- CH_N2 - Manning's *n* value for main channel
- CH_N1 - Manning's *n* value for tributary channels
- CH_K2 – effective hydraulic conductivity in main channel alluvium (millimeters per hour)
- EVRCH – reach evaporation adjustment factor
- SFTMP - snowfall temperature (degrees Celsius)
- SMTMP - snowmelt temperature (degrees Celsius)
- SMFMX - maximum melt rate for snow during the year
- SMFMN - minimum melt rate for snow during the year

b) HRU level parameters

- ESCO - soil evaporation compensation factor
- SURLAG - surface runoff lag time (days)
- GW_DELAY - groundwater delay (days)
- ALPHA_BF - baseflow alpha factor (days)
- GW_REVAP - groundwater re-evaporation co-efficient
- REVAPMN - threshold depth of water in shallow aquifer required for revap to occur (millimeters)
- RCHRG_DP – Deep aquifer percolation fraction
- SHALLST – Initial depth of water in shallow aquifer (millimeters)
- DEEPST – Initial depth of water in deep aquifer (millimeters)
- DEPIMP - Depth to impervious layer in soil profile (millimeters)
- DDRAIN - Depth to subsurface drain (millimeters)
- GDRAIN - Time to drain soil to field capacity (hour)
- TDRAIN - Drain tile lag time (hour)

Table D-20. Values of parameters in the calibrated and validated model

Parameter	Value
CH_N2	0.05
CH_N1	0.1
SFTMP	0
SMTMP	0
SMFMX	2
SMFMN	1
ESCO	0.7
SURLAG	0.2
GW_DELAY	15
ALPHA_BF	0.1
GW_REVAP	0.2
REVAPMN	0
RCHRG_DP	0
SHALLST	0.5
CH_K2	5
EVRCH	0.5
DEEPST	1,000
DEPIMP [a]	2,500
DDRAIN [a]	1,000
GDRAIN [a]	24
TDRAIN [a]	24

Note a: Applicable only for HRUs with tile-drains. Tile-drains were simulated for agricultural HRUs on low slopes (<5 percent) with soils classified as A/D, B/D, C/D or D.

D-2.1.2 Results and Discussion

Model results were first checked for realistic representation of the annual water balance. Figure D-7 shows the simulated water balance of the watershed evaluated using the SWAT Error Checker (http://swat.tamu.edu/software/swat-check/).

Sanford and Selnick (2013) have estimated evapotranspiration as a ratio of precipitation for the CONUS using regression relationships. The ratio of SWAT simulated evapotranspiration and precipitation is 0.6, which is in the lower end of the range (0.60-0.69) reported for this geographical region in Figure 13 of Sanford and Selnick (2013).

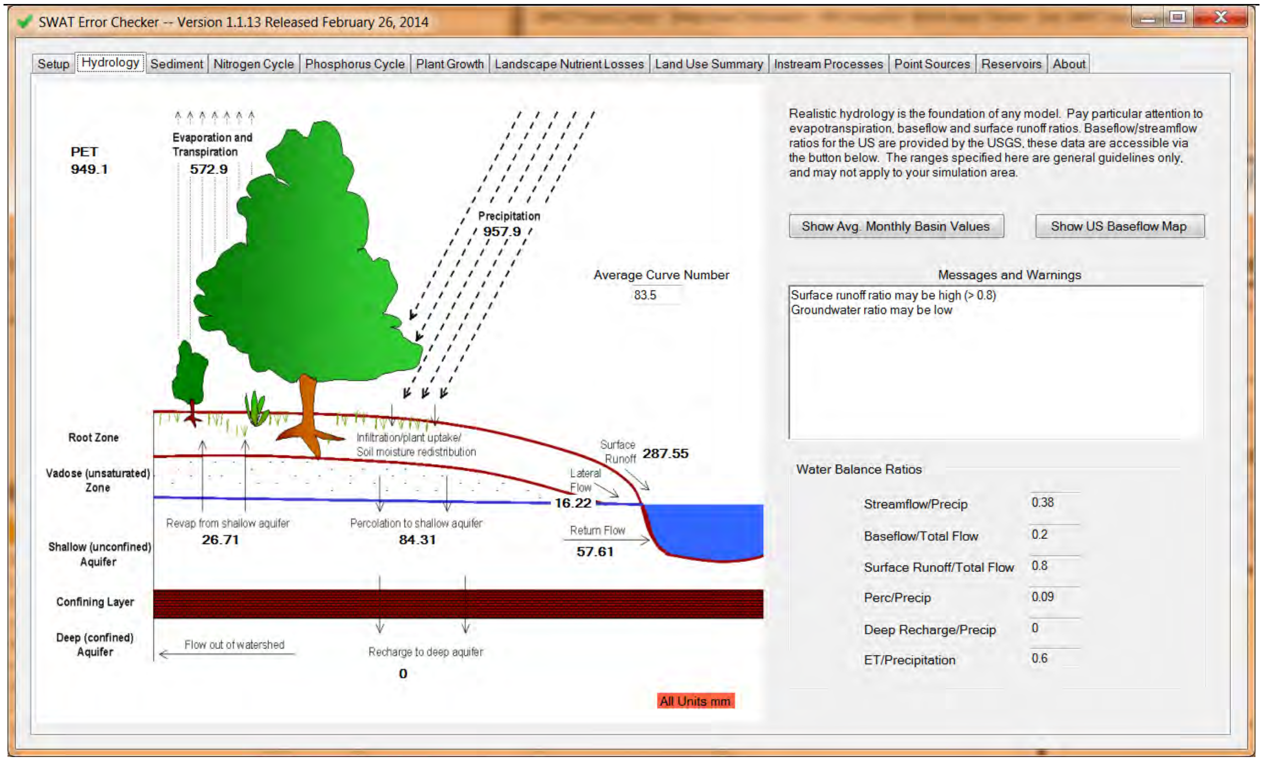
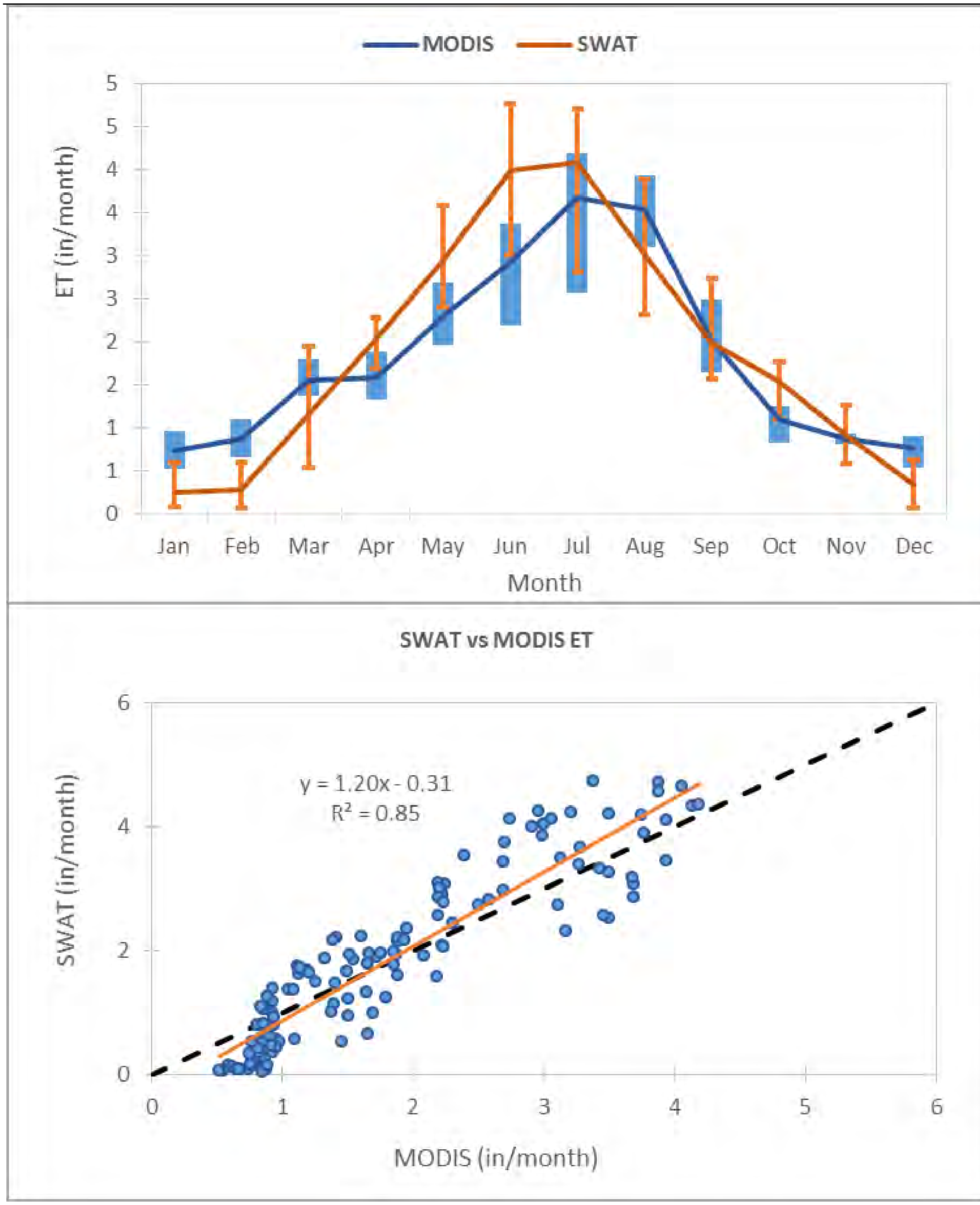


Figure D-7. SWAT simulated water balance components for the SJRW.

D-2.1.2.1 Evapotranspiration

Model evapotranspiration may be validated by comparing results with remote sensing datasets such as satellite-derived evapotranspiration estimated by NASA. The monthly simulated actual evapotranspiration matches well with the NASA instrument MODIS (Moderate Resolution Imaging Spectroradiometer) satellite-based estimates as shown in Figure D-8. The NSE, RSR, and PBIAS for simulated and estimated evapotranspiration are 0.70, 0.55 and -2.83, respectively, indicating acceptable model performance. Note that some discrepancies between satellite and model evapotranspiration may result from the fact that MODIS does not account for direct soil evaporation, and in such a heavily agricultural watershed, it is possible that SWAT may not be capturing the most representative leaf area index.



Note: The error bars on the first chart shows the range of observed and simulated monthly evapotranspiration while the solid lines show the average.

Figure D-8. Comparison of simulated evapotranspiration with satellite based estimates.

D-2.1.2.2 Streamflow

As summarized in Table D-21, the performance of the SWAT model at all the flow gages varies between good and very good for both the calibration and validation periods based on the criteria in Table D-18. The model performance in terms of relative error for low flows, high flows and seasonal flows are generally acceptable but are often greater than the criteria in Table D-19. There are a number of factors that could be responsible for such discrepancies. The magnitude and timing of low flows in the watershed are likely impacted by the presence of a large number of low head dams. These dams are not represented explicitly in the model and is likely a reason for the large errors observed during low flow periods. Some large errors associated with the winter and spring seasons are likely a result of errors in timing of snowmelt in the model. It is important to note that snowmelt in SWAT is largely simulated as a function of air temperature. More accurate estimates of snowmelt can only be achieved using an energy balance method.

Table D-21. Summary of SWAT model performance for flow calibration and validation

Period	USGS Id	Name	NSE		RSR		RE	
			Value	Performance	Value	Performance	Value	Performance
Calibration	n/a	West Branch St. Joseph River, OH	0.88	Very Good	0.35	Very Good	7.55	Very Good
	04177720	Fish Creek near Hamilton, IN	0.85	Very Good	0.39	Very Good	11.38	Good
	04177810	Fish Creek near Artic, IN	No Data					
	04180000	Cedar Creek near Cedarville, IN	0.86	Very Good	0.38	Very Good	6.47	Very Good
	04178000	St. Joseph River near Newville, IN	0.89	Very Good	0.33	Very Good	9.96	Very Good
	04180500	St. Joseph River near Fort Wayne, IN	0.90	Very Good	0.32	Very Good	6.63	Very Good
Validation	n/a	West Branch St. Joseph River, OH	No Data					
	04177720	Fish Creek near Hamilton, IN	0.77	Very Good	0.48	Very Good	9.68	Very Good
	04177810	Fish Creek near Artic, IN	0.69	Good	0.56	Good	8.68	Very Good
	04180000	Cedar Creek near Cedarville, IN	0.91	Very Good	0.30	Very Good	0.75	Very Good
	04178000	St. Joseph River near Newville, IN	0.83	Very Good	0.41	Very Good	4.81	Very Good
	04180500	St. Joseph River near Fort Wayne, IN	0.88	Very Good	0.35	Very Good	5.77	Very Good

Note: n/a = not applicable; NSE = Nash-Sutcliffe coefficient; RE = relative average error; RSR = root mean square error-observation standard deviation ratio;

D-2.1.3 Hydrology Calibration

D-2.1.3.1 West Branch St. Joseph River, OH (Ohio EPA)

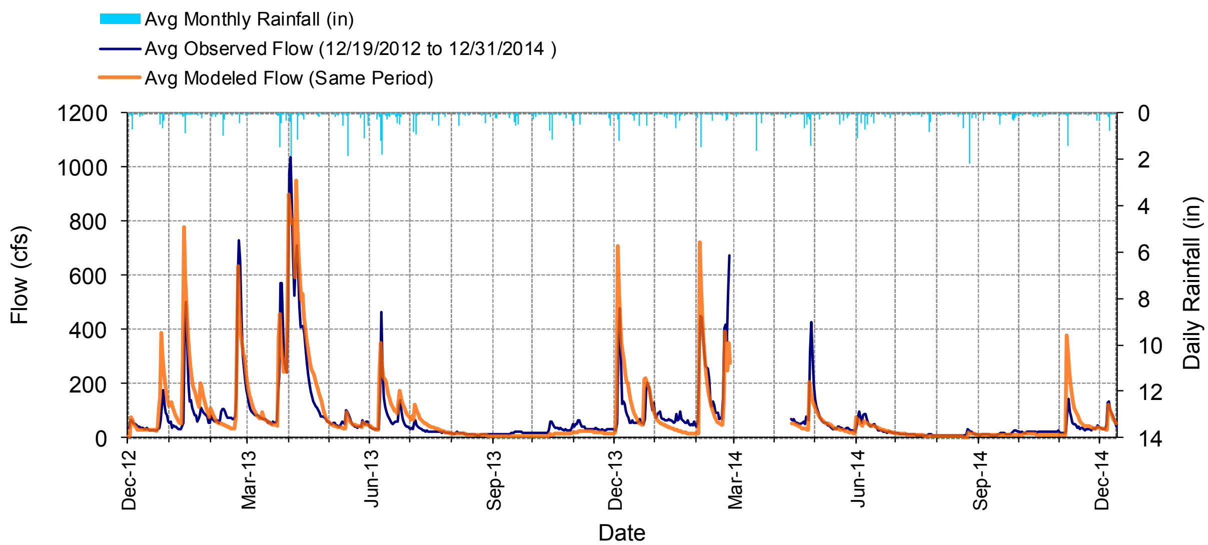


Figure D-9. Mean daily flow at WBSJR, OH.

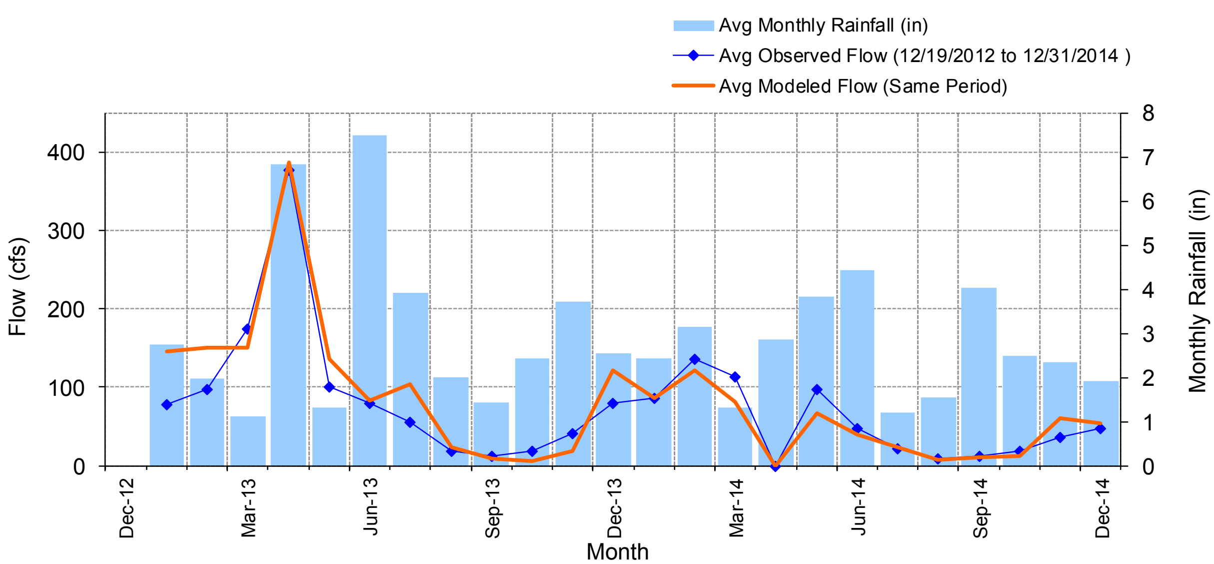


Figure D-10. Mean monthly flow at WBSJR, OH.

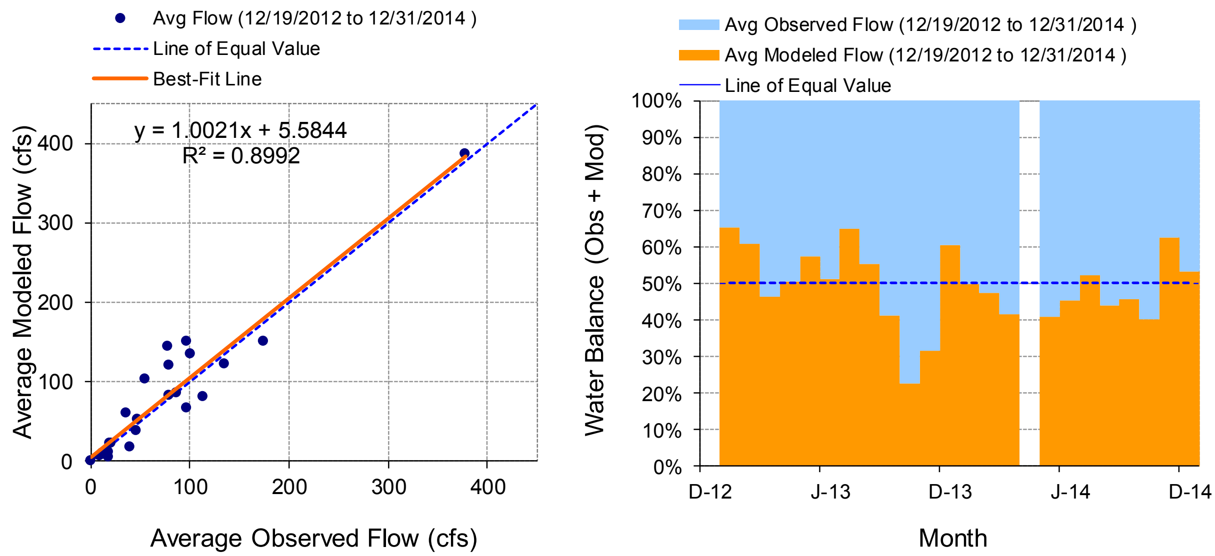


Figure D-11. Monthly flow regression and temporal variation at WBSJR, OH.

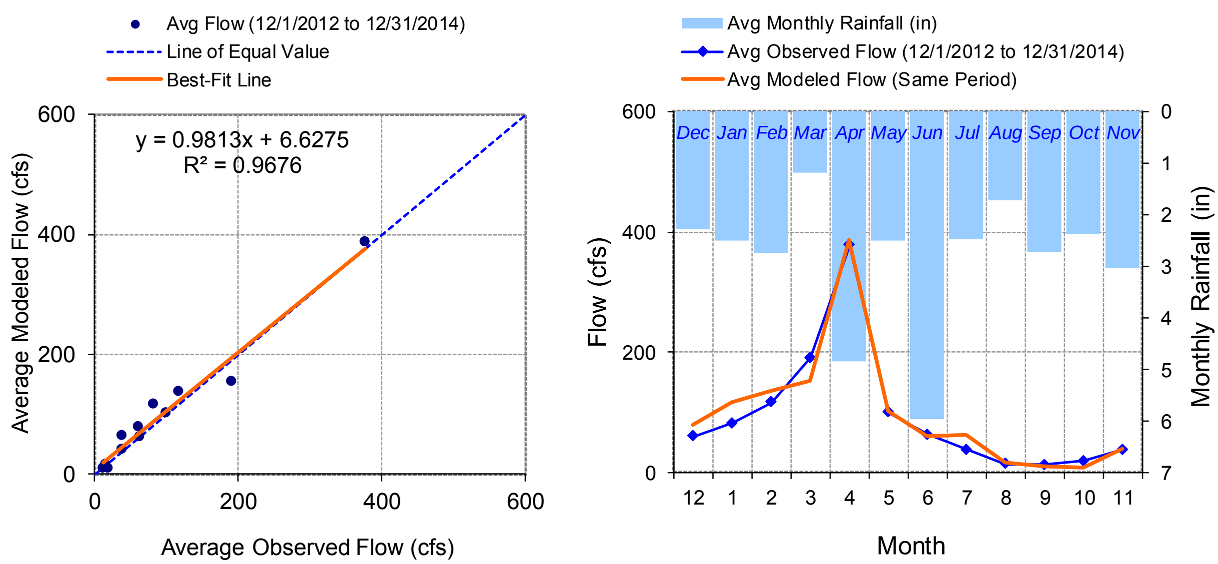


Figure D-12. Seasonal regression and temporal aggregate at WBSJR, OH.

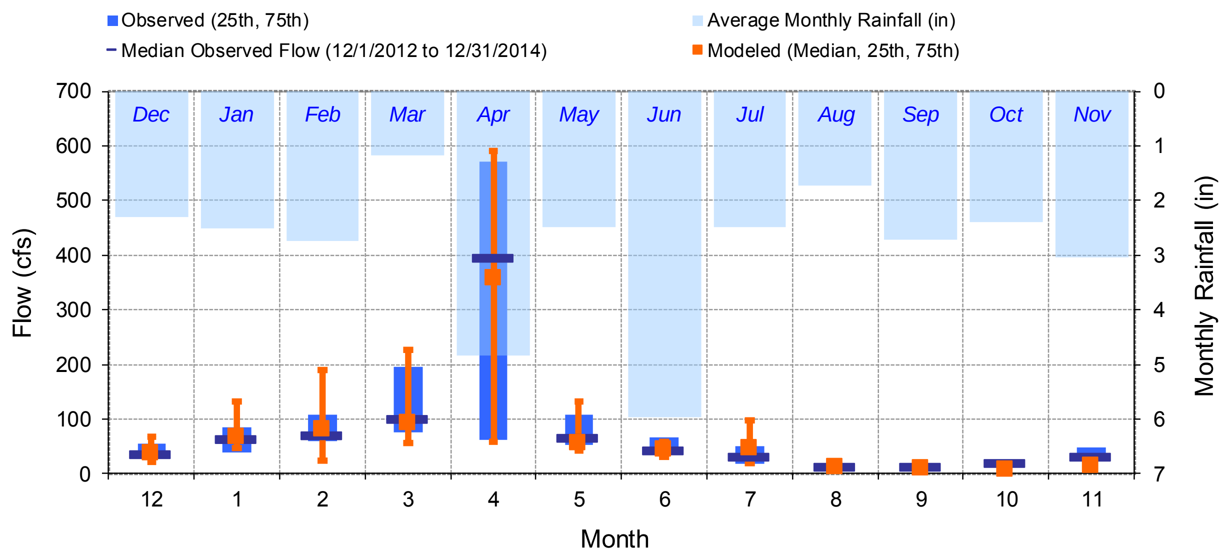


Figure D-13. Seasonal medians and ranges at WBSJR, OH.

Table D-22. Seasonal summary at WBSJR, OH

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Dec	60	36	31	55	79	37	22	68
Jan	82	63	38	85	116	69	47	132
Feb	116	70	60	108	136	82	24	190
Mar	191	99	76	196	153	93	56	227
Apr	377	396	62	572	386	359	58	592
May	99	65	53	108	101	55	43	132
Jun	63	41	34	66	61	44	31	57
Jul	38	31	19	50	63	48	19	99
Aug	14	14	9	18	15	12	7	20
Sep	12	12	11	13	9	9	7	12
Oct	19	19	16	20	9	9	5	12
Nov	38	31	22	48	40	15	12	25

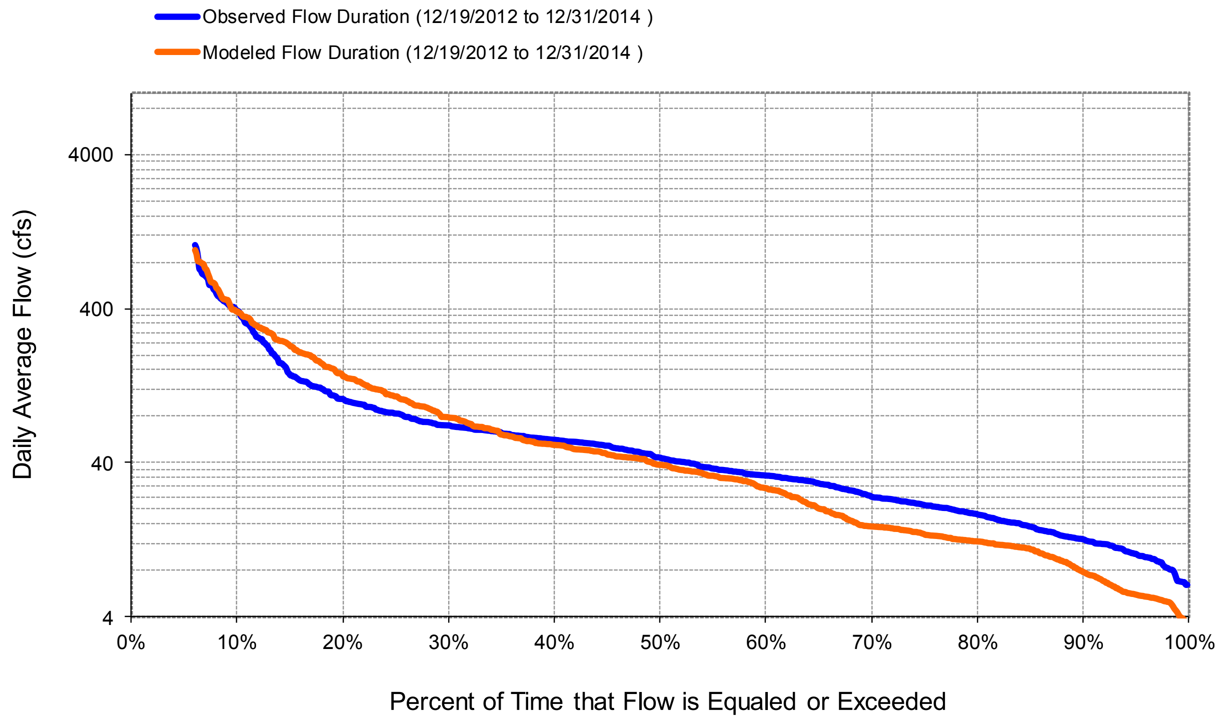


Figure D-14. Flow exceedance at WBSJR, OH.

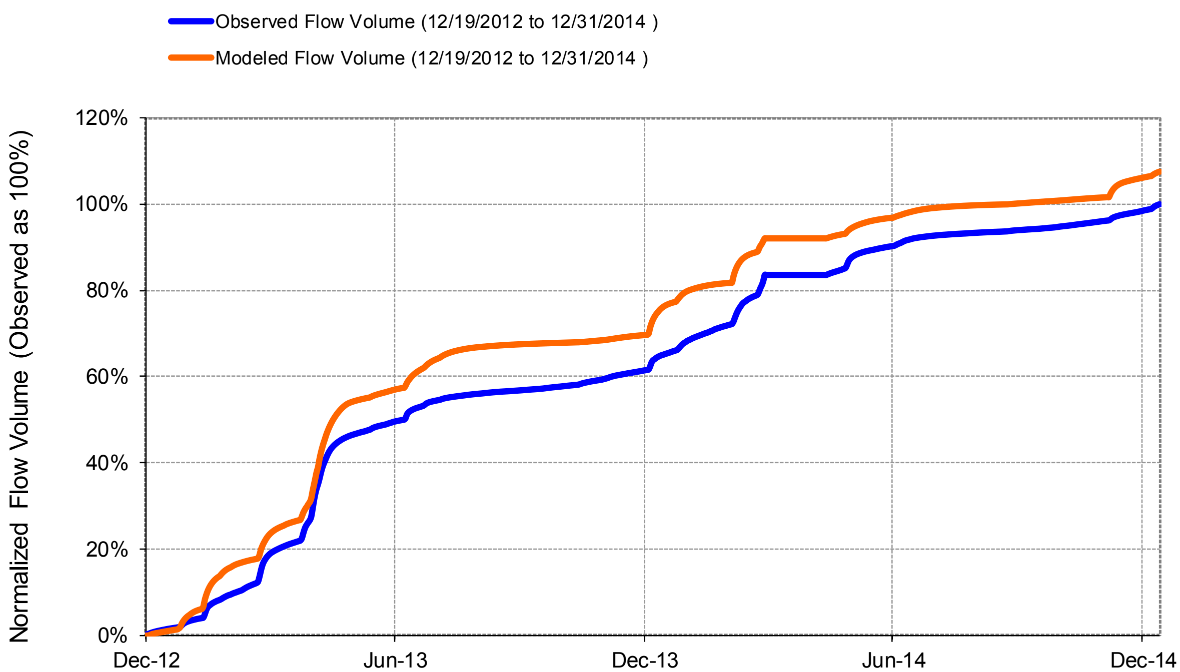


Figure D-15. Flow accumulation at WBSJR, OH.

Table D-23. Summary statistics at WBSJR, OH

SWAT Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM OUTLET 82 2.03-Year Analysis Period: 12/1/2012 - 12/31/2014 Flow volumes are (inches/year) for upstream drainage area		West Branch St. Joseph River, OH Manually Entered Data Drainage Area (sq-mi): 109		
Total Simulated In-stream Flow:	**9.70**	Total Observed In-stream Flow:		**9.02**
Total of simulated highest 10% flows:	**4.94**	Total of Observed highest 10% flows:		**4.49**
Total of Simulated lowest 50% flows:	**0.92**	Total of Observed Lowest 50% flows:		**1.26**
Simulated Summer Flow Volume (months 7-9):	**0.91**	Observed Summer Flow Volume (7-9):		**0.67**
Simulated Fall Flow Volume (months 10-12):	**1.48**	Observed Fall Flow Volume (10-12):		**1.34**
Simulated Winter Flow Volume (months 1-3):	**3.69**	Observed Winter Flow Volume (1-3):		**3.45**
Simulated Spring Flow Volume (months 4-6):	**3.61**	Observed Spring Flow Volume (4-6):		**3.56**
Total Simulated Storm Volume:	**3.14**	Total Observed Storm Volume:		**2.98**
Simulated Summer Storm Volume (7-9):	**0.14**	Observed Summer Storm Volume (7-9):		**0.12**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	7.55	10		
Error in 50% lowest flows:	-27.09	10		
Error in 10% highest flows:	9.91	15		
Seasonal volume error - Summer:	36.39	30		
Seasonal volume error - Fall:	10.92 >>	30	Clear	
Seasonal volume error - Winter:	7.04	30		
Seasonal volume error - Spring:	1.35	30		
Error in storm volumes:	5.17	20		
Error in summer storm volumes:	17.45	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.772	Model accuracy increases		
Baseline adjusted coefficient (Garrick), E':	0.561	as E or E' approaches 1.0		
Monthly NSE	0.880			

D-2.1.3.2 Fish Creek near Hamilton, IN (USGS 04177720)

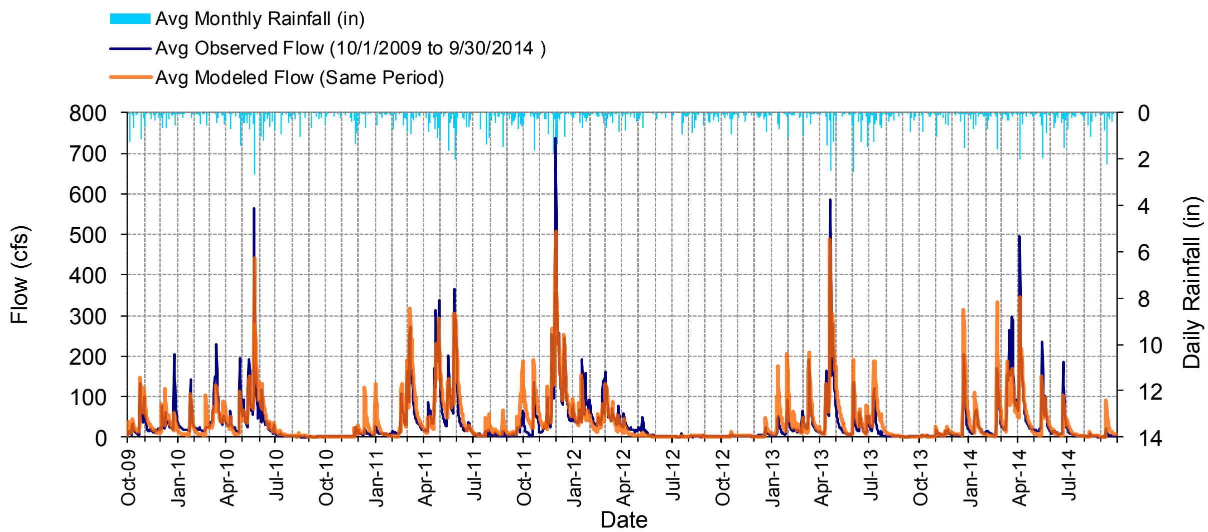


Figure D-16. Mean daily flow at Fish Creek near Hamilton, IN (USGS 04177720).

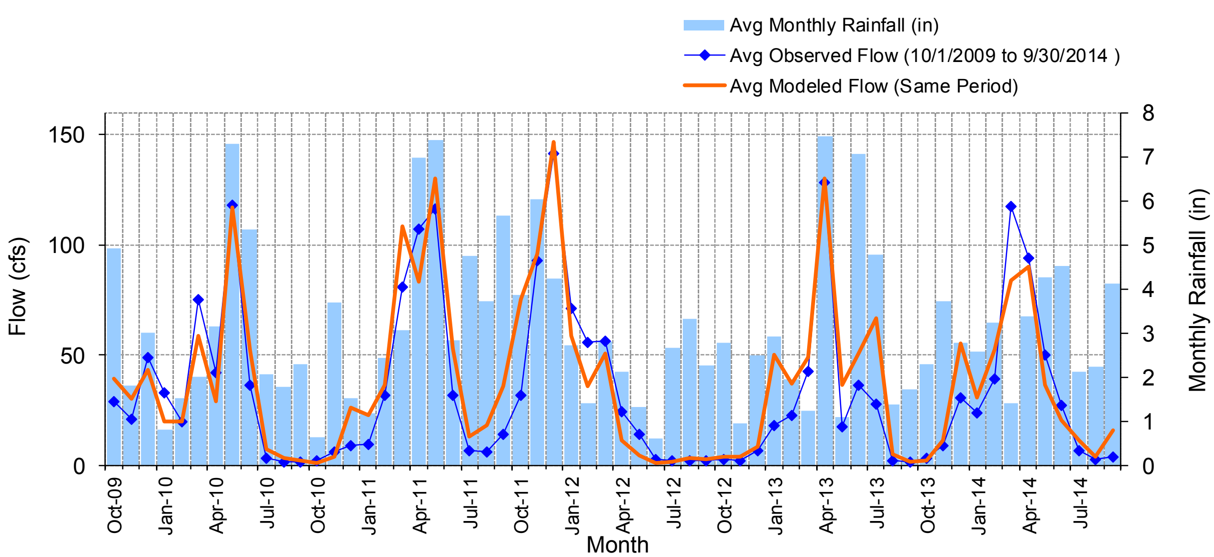


Figure D-17. Mean monthly flow at Fish Creek near Hamilton, IN (USGS 04177720).

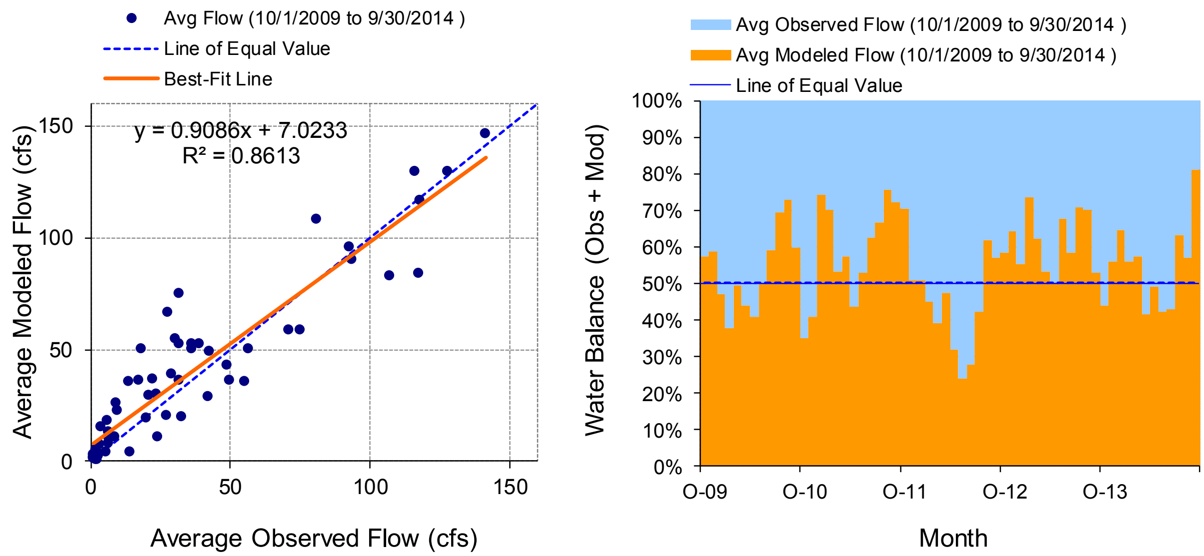


Figure D-18. Monthly flow regression and temporal variation at Fish Creek near Hamilton, IN (USGS 04177720).

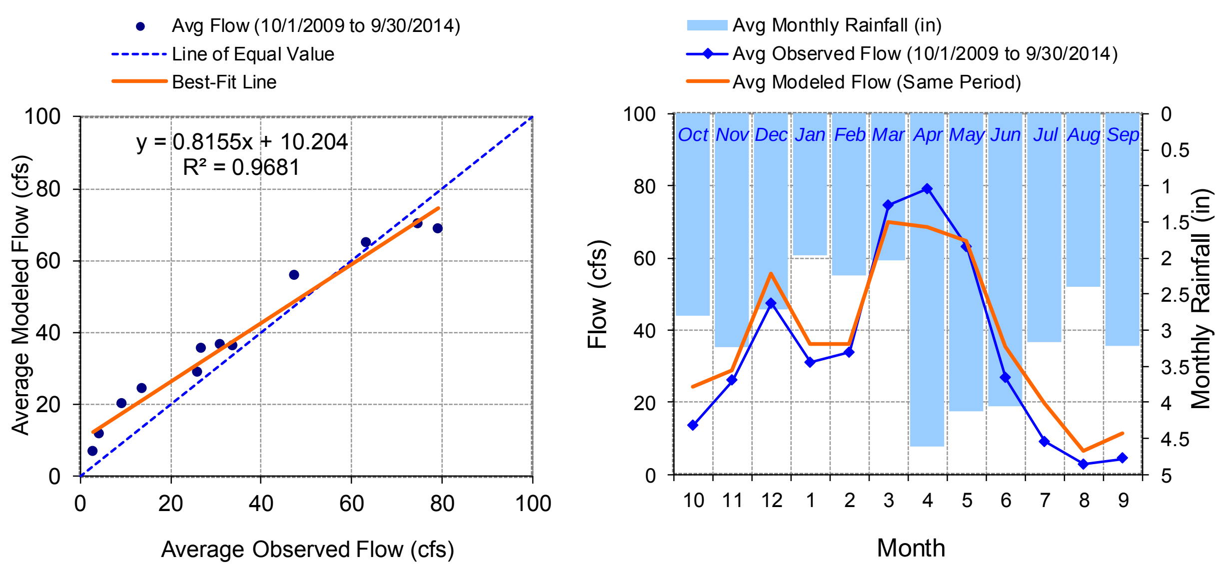


Figure D-19. Seasonal regression and temporal aggregate at Fish Creek near Hamilton, IN (USGS 04177720).

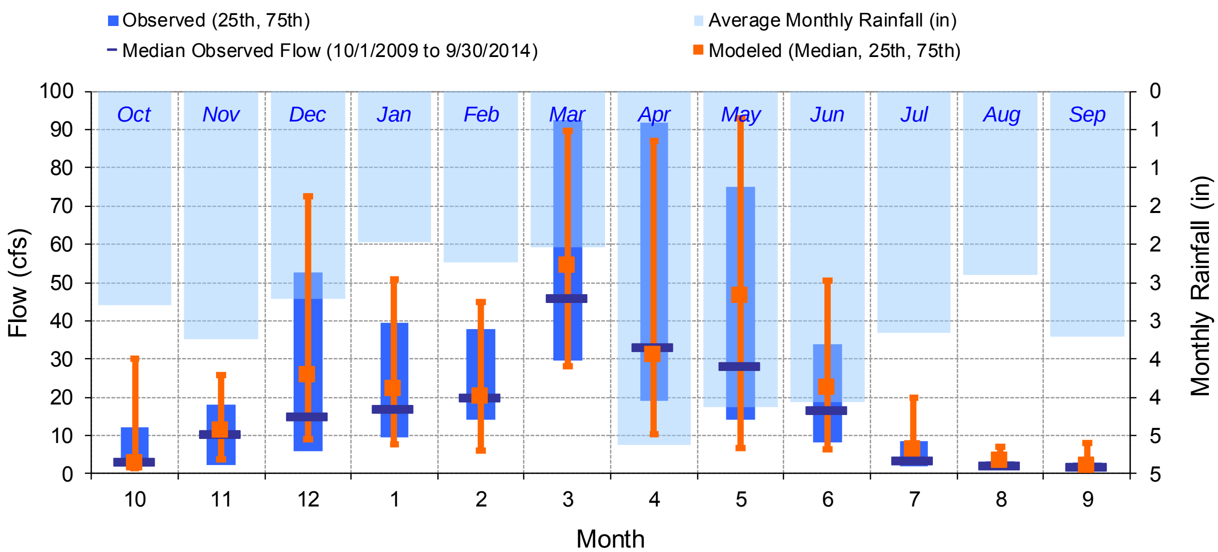


Figure D-20. Seasonal medians and ranges at Fish Creek near Hamilton, IN (USGS 04177720).

Table D-24. Seasonal summary at Fish Creek near Hamilton, IN (USGS 04177720).

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	14	3	2	12	24	3	2	30
Nov	26	11	2	18	29	11	4	26
Dec	47	15	6	53	56	26	9	73
Jan	31	17	10	40	36	22	8	51
Feb	34	20	14	38	36	20	6	45
Mar	75	46	30	93	70	54	28	90
Apr	79	33	19	92	69	31	10	87
May	63	28	14	75	65	46	7	93
Jun	27	17	8	34	35	22	7	50
Jul	9	3	2	8	20	6	4	20
Aug	3	2	1	3	7	4	3	7
Sep	4	2	1	3	11	2	2	8

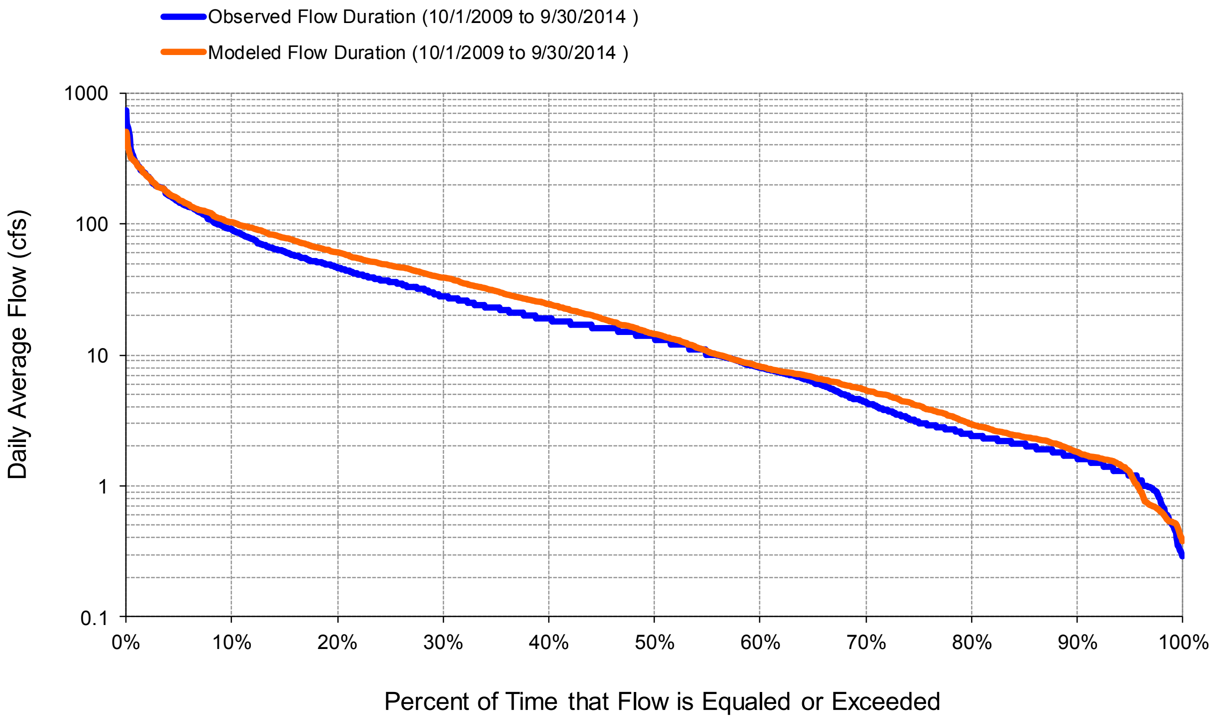


Figure D-21. Flow exceedance at Fish Creek near Hamilton, IN (USGS 04177720).

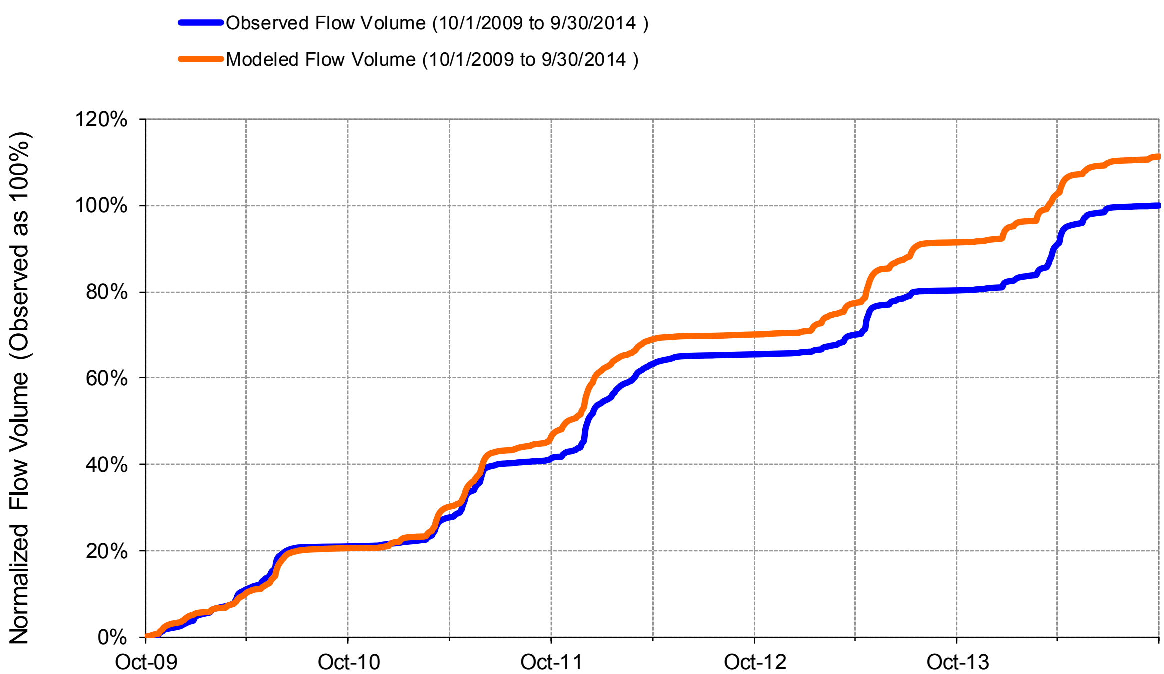


Figure D-22. Flow accumulation at Fish Creek near Hamilton, IN (USGS 04177720).

Table D-25. Summary statistics at Fish Creek near Hamilton, IN (USGS 04177720).

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET(S) 51, 54 5-Year Analysis Period: 10/1/2009 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		USGS 04177720 FISH CREEK AT HAMILTON, IN Hydrologic Unit Code: 4100003 Latitude: 41.53227275 Longitude: -84.9035726 Drainage Area (sq-mi): 37.5	
Total Simulated In-stream Flow:	**13.85**	Total Observed In-stream Flow:	**12.43**
Total of simulated highest 10% flows:	**6.51**	Total of Observed highest 10% flows:	**6.58**
Total of Simulated lowest 50% flows:	**0.92**	Total of Observed Lowest 50% flows:	**0.84**
Simulated Summer Flow Volume (months 7-9):	**1.16**	Observed Summer Flow Volume (7-9):	**0.49**
Simulated Fall Flow Volume (months 10-12):	**3.32**	Observed Fall Flow Volume (10-12):	**2.65**
Simulated Winter Flow Volume (months 1-3):	**4.29**	Observed Winter Flow Volume (1-3):	**4.20**
Simulated Spring Flow Volume (months 4-6):	**5.08**	Observed Spring Flow Volume (4-6):	**5.09**
Total Simulated Storm Volume:	**4.22**	Total Observed Storm Volume:	**4.32**
Simulated Summer Storm Volume (7-9):	**0.31**	Observed Summer Storm Volume (7-9):	**0.17**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*
Error in total volume:	11.38	10
Error in 50% lowest flows:	9.76	10
Error in 10% highest flows:	-1.21	15
Seasonal volume error - Summer:	133.71	30
Seasonal volume error - Fall:	25.29	30
Seasonal volume error - Winter:	2.17	30
Seasonal volume error - Spring:	-0.15	30
Error in storm volumes:	-2.23	20
Error in summer storm volumes:	83.73	50
Nash-Sutcliffe Coefficient of Efficiency, E:	0.801	Model accuracy increases as E or E' approaches 1.0
Baseline adjusted coefficient (Garrick), E':	0.582	
Monthly NSE	0.848	

>> Clear

D-2.1.3.3 Cedar Creek near Cedarville, IN (USGS 04180000)

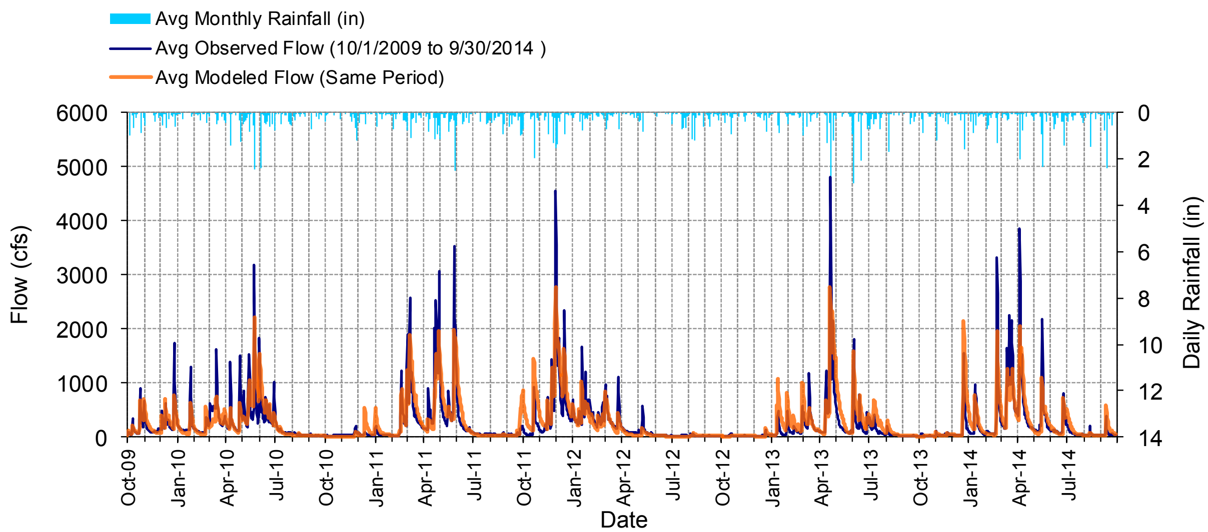


Figure D-23. Mean daily flow at Cedar Creek near Cedarville, IN (USGS 04180000).

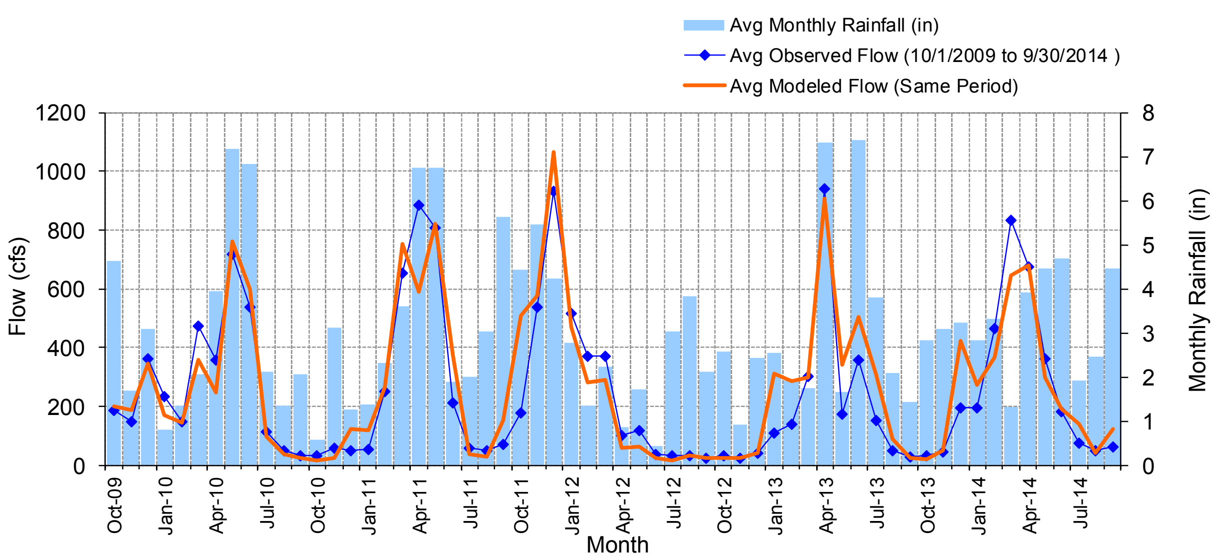


Figure D-24. Mean monthly flow at Cedar Creek near Cedarville, IN (USGS 04180000).

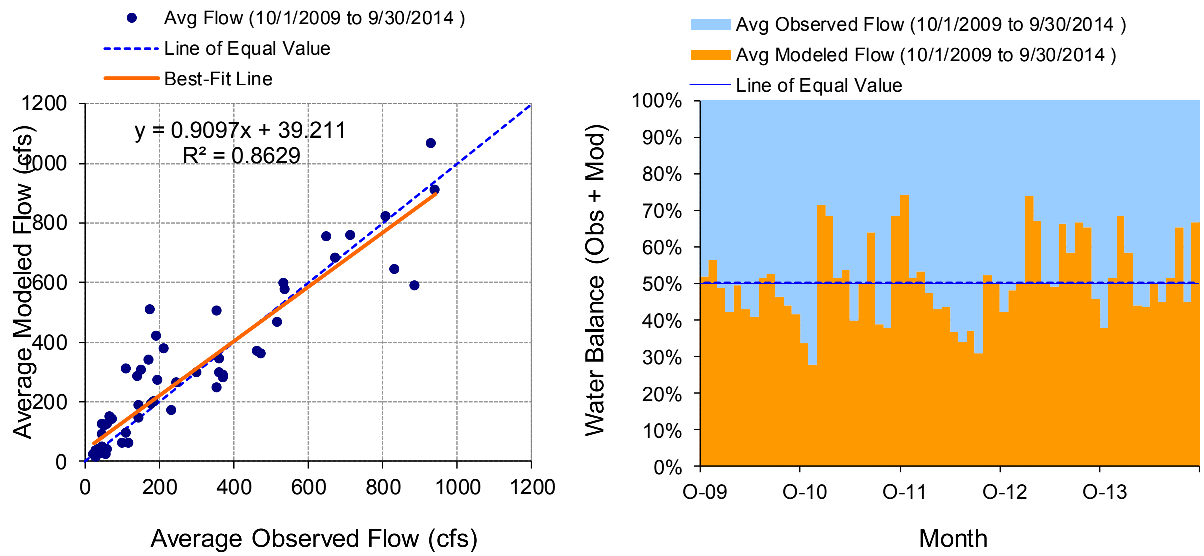


Figure D-25. Monthly flow regression and temporal variation at Cedar Creek near Cedarville, IN (USGS 04180000).

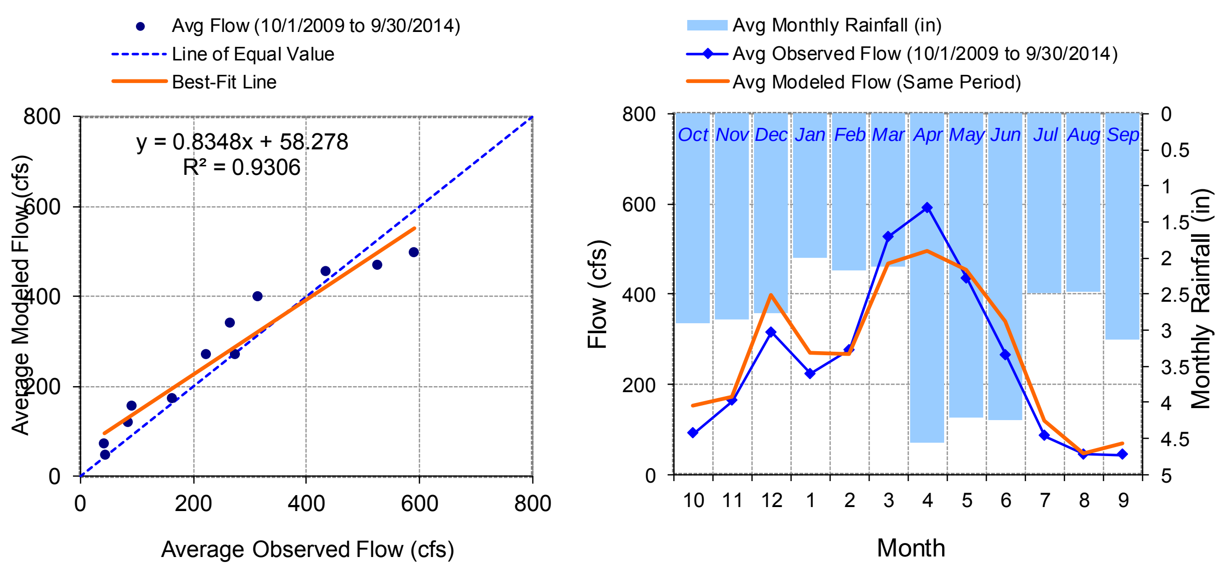


Figure D-26. Seasonal regression and temporal aggregate at Cedar Creek near Cedarville, IN (USGS 04180000).

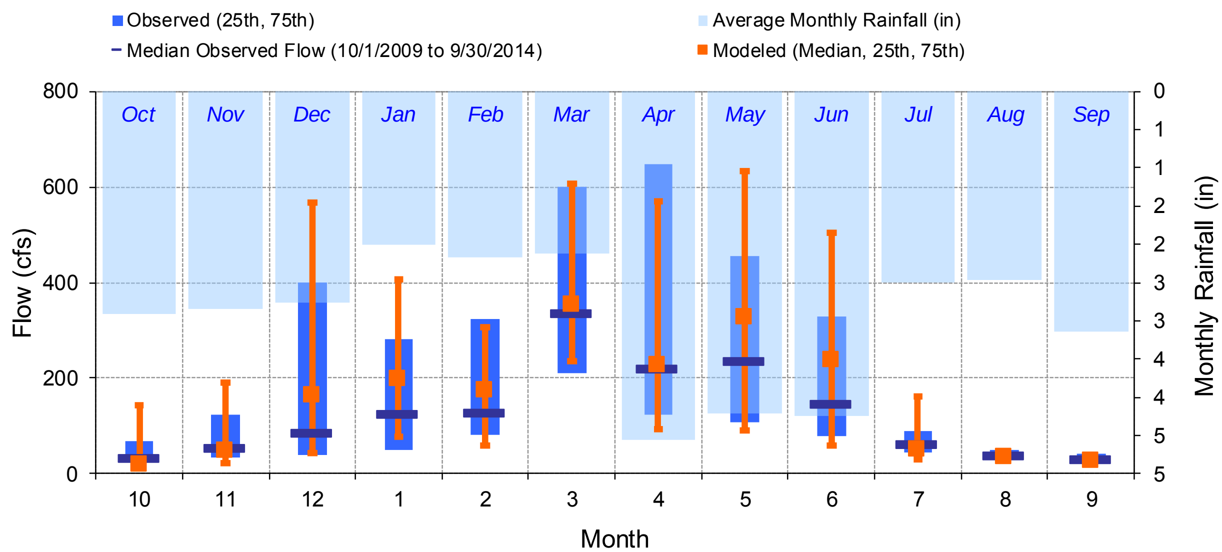


Figure D-27. Seasonal medians and ranges at Cedar Creek near Cedarville, IN (USGS 04180000).

Table D-26. Seasonal summary at Cedar Creek near Cedarville, IN (USGS 04180000)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	91	34	29	70	153	20	18	142
Nov	163	54	34	123	172	49	23	191
Dec	315	85	38	399	399	165	42	567
Jan	223	126	51	283	269	200	76	407
Feb	276	127	81	325	268	175	60	308
Mar	527	336	212	600	469	353	236	606
Apr	592	221	124	647	497	228	94	571
May	436	236	108	455	455	327	90	634
Jun	265	146	79	328	339	237	59	505
Jul	86	62	45	90	119	52	29	162
Aug	45	39	33	49	46	36	29	43
Sep	43	31	26	42	69	26	22	32

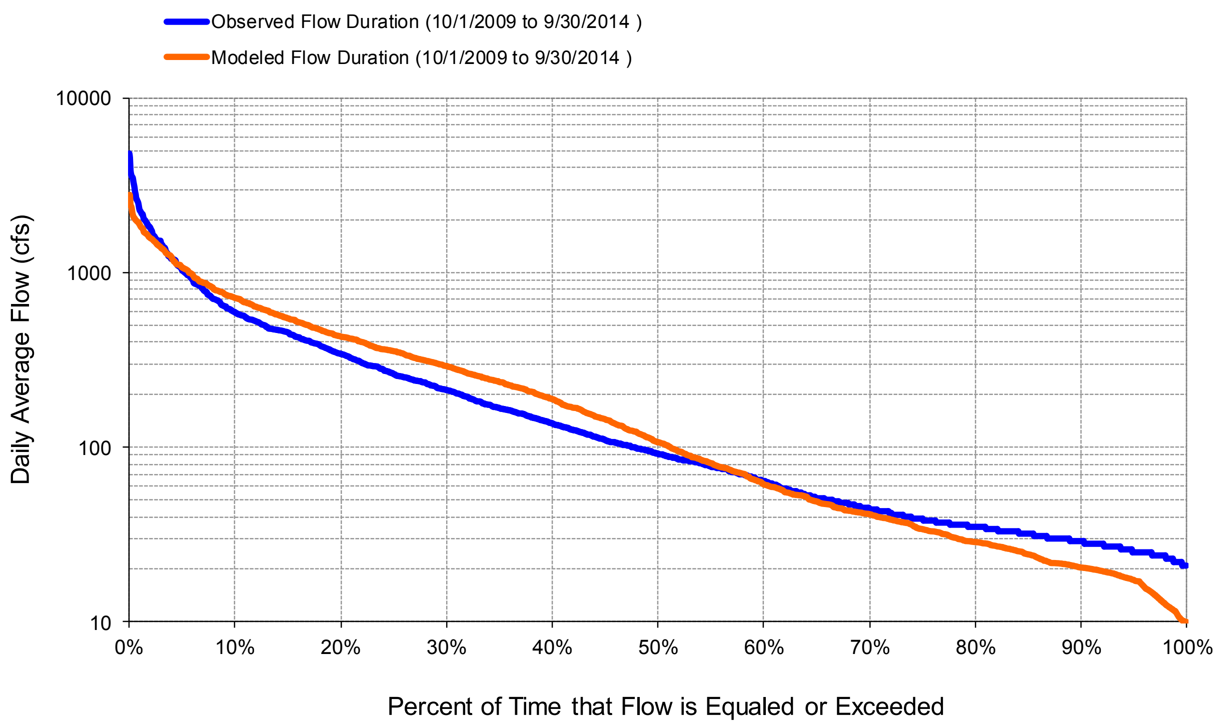


Figure D-28. Flow exceedance at Cedar Creek near Cedarville, IN (USGS 04180000).

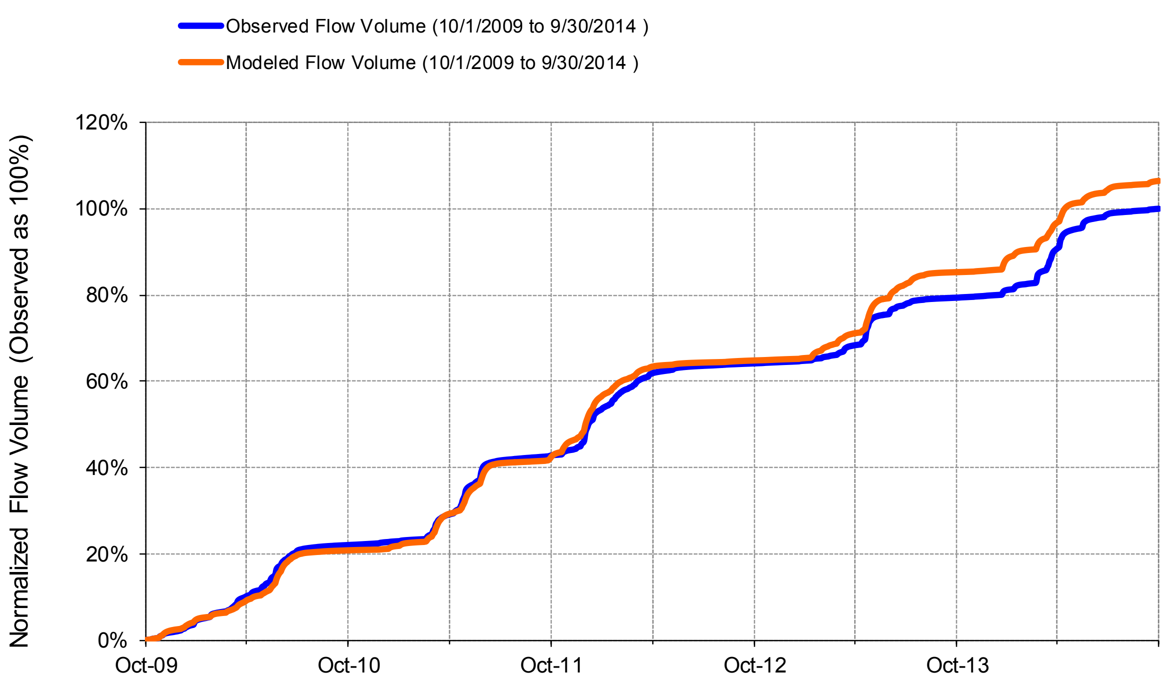


Figure D-29. Flow accumulation at Cedar Creek near Cedarville, IN (USGS 04180000).

Table D-27. Summary statistics at Cedar Creek near Cedarville, IN (USGS 04180000)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 9 5-Year Analysis Period: 10/1/2009 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		USGS 04180000 CEDAR CREEK NEAR CEDARVILLE, IN Hydrologic Unit Code: 4100003 Latitude: 41.218938 Longitude: -85.0763589 Drainage Area (sq-mi): 270	
Total Simulated In-stream Flow:	**13.64**	Total Observed In-stream Flow:	**12.82**
Total of simulated highest 10% flows:	**6.12**	Total of Observed highest 10% flows:	**6.64**
Total of Simulated lowest 50% flows:	**1.05**	Total of Observed Lowest 50% flows:	**1.14**
Simulated Summer Flow Volume (months 7-9):	**0.99**	Observed Summer Flow Volume (7-9):	**0.74**
Simulated Fall Flow Volume (months 10-12):	**3.07**	Observed Fall Flow Volume (10-12):	**2.41**
Simulated Winter Flow Volume (months 1-3):	**4.19**	Observed Winter Flow Volume (1-3):	**4.27**
Simulated Spring Flow Volume (months 4-6):	**5.40**	Observed Spring Flow Volume (4-6):	**5.40**
Total Simulated Storm Volume:	**4.82**	Total Observed Storm Volume:	**5.84**
Simulated Summer Storm Volume (7-9):	**0.29**	Observed Summer Storm Volume (7-9):	**0.18**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	6.47	10	
Error in 50% lowest flows:	-8.56	10	
Error in 10% highest flows:	-7.87	15	
Seasonal volume error - Summer:	34.40	30	
Seasonal volume error - Fall:	27.49 >>	30	Clear
Seasonal volume error - Winter:	-1.91	30	
Seasonal volume error - Spring:	-0.09	30	
Error in storm volumes:	-17.37	20	
Error in summer storm volumes:	59.74	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.746	Model accuracy increases as E or E' approaches 1.0	
Baseline adjusted coefficient (Garrick), E':	0.569		
Monthly NSE	0.857		

D-2.1.3.4 St. Joseph River near Newville, IN (USGS 04178000)

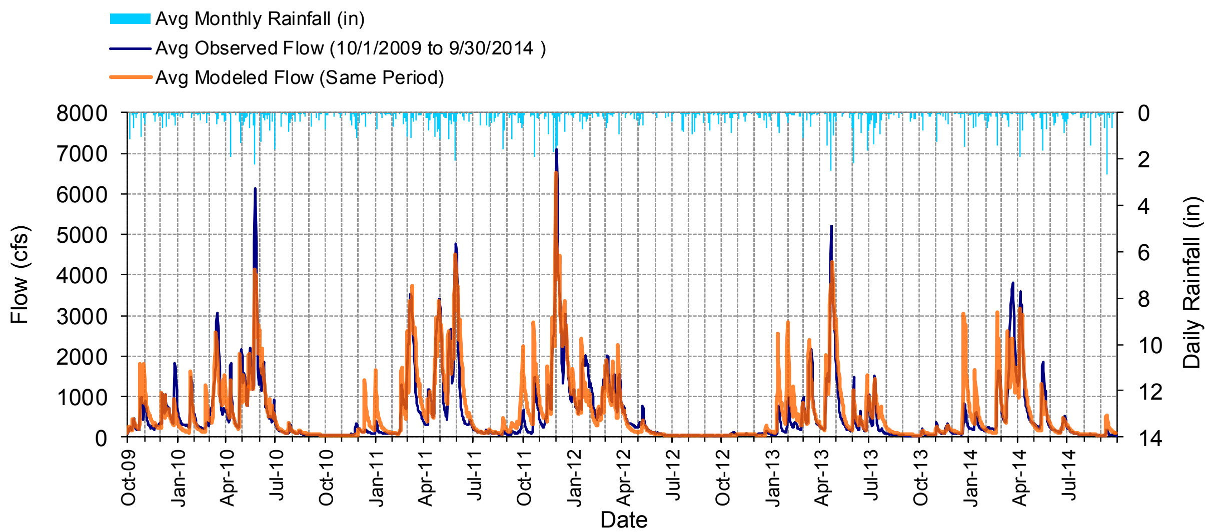


Figure D-30. Mean daily flow at SJR near Newville, IN (USGS 04178000).

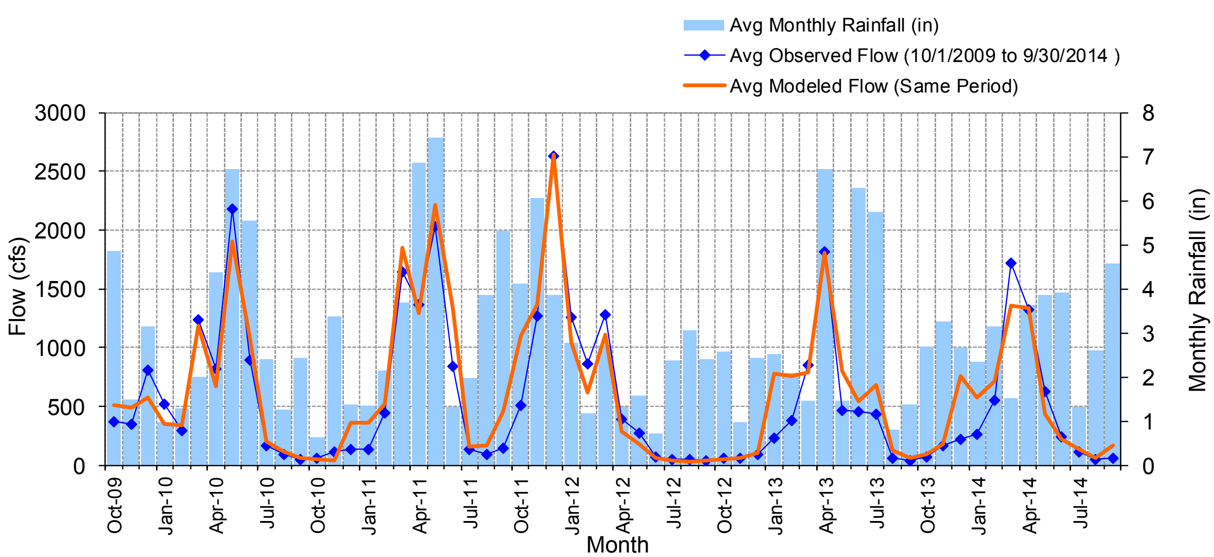


Figure D-31. Mean monthly flow at SJR near Newville, IN (USGS 04178000).

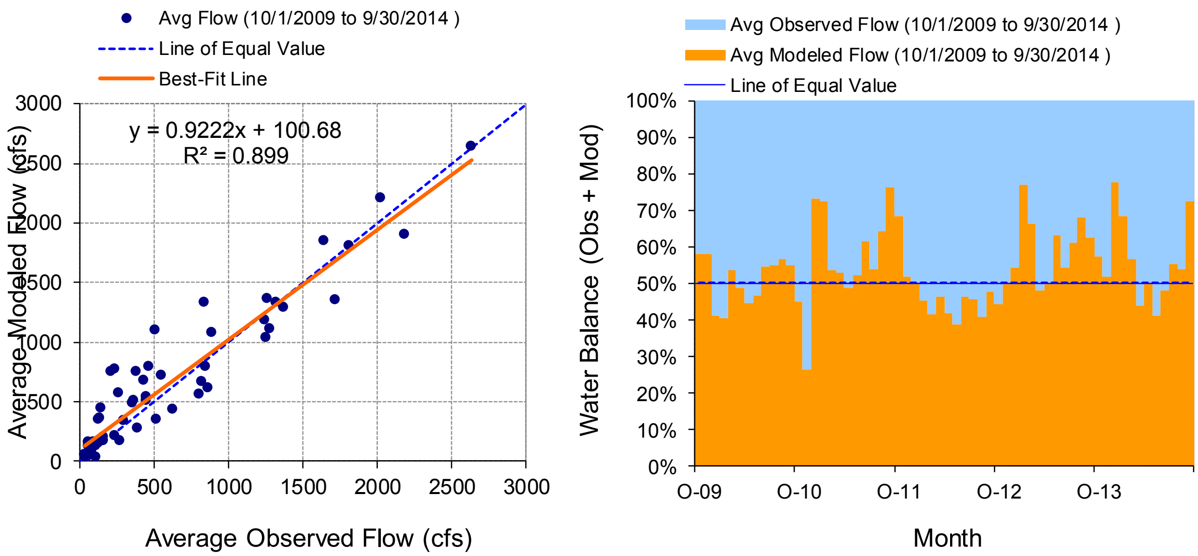


Figure D-32. Monthly flow regression and temporal variation at SJR near Newville, IN (USGS 04178000).

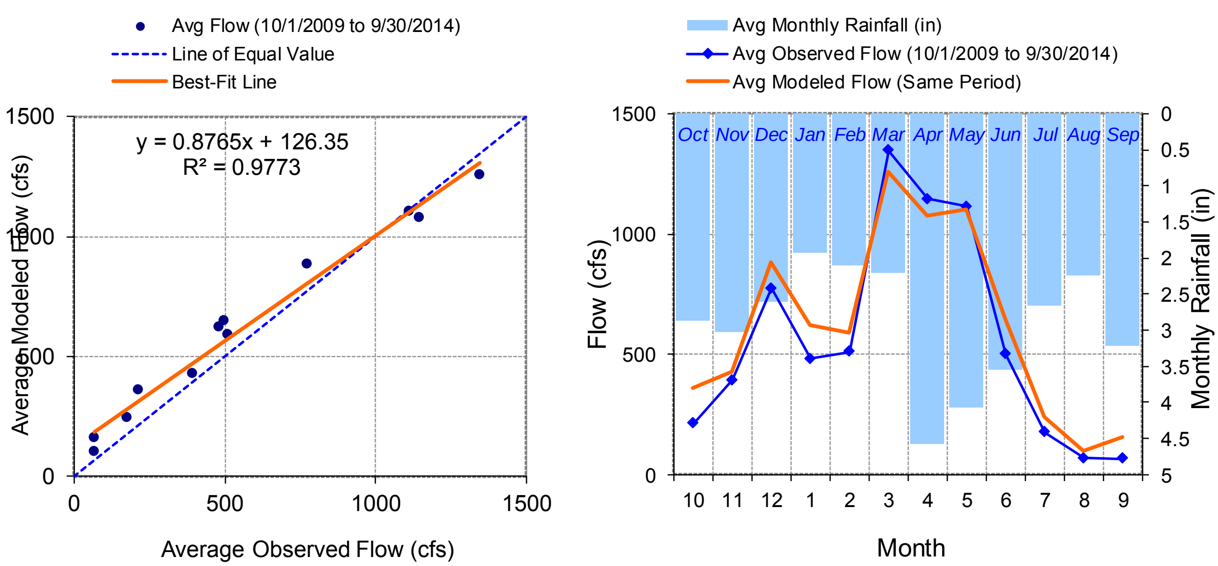


Figure D-33. Seasonal regression and temporal aggregate at SJR near Newville, IN (USGS 04178000).

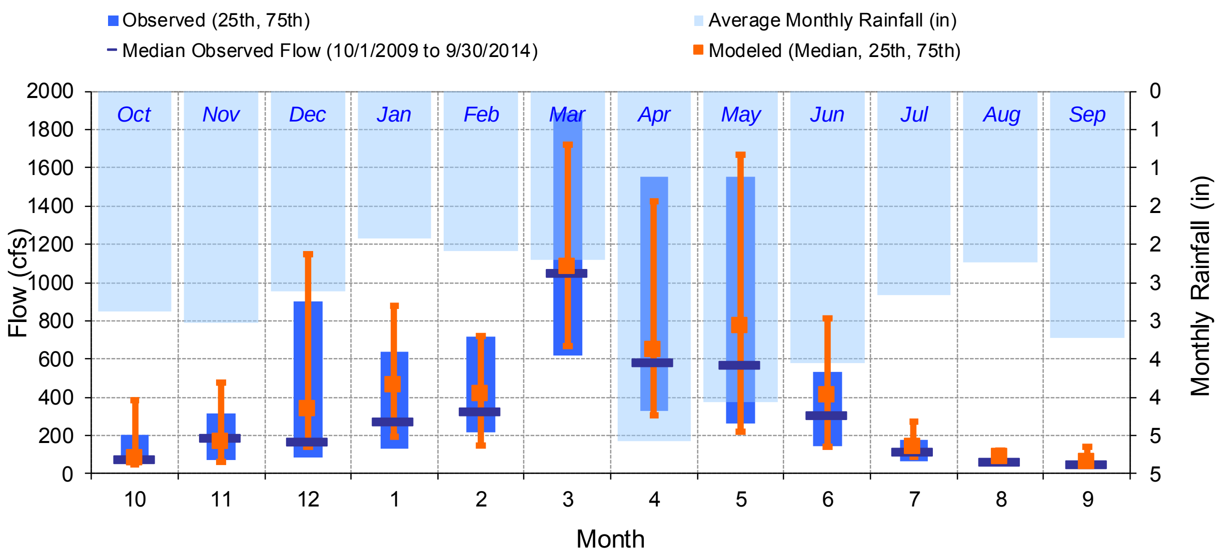


Figure D-34. Seasonal medians and ranges at SJR near Newville, IN (USGS 04178000).

Table D-28. Seasonal summary at SJR near Newville, IN (USGS 04178000)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	212	75	53	202	359	80	49	386
Nov	392	187	69	313	426	168	63	477
Dec	775	168	86	904	885	340	138	1149
Jan	481	274	134	640	619	462	195	879
Feb	509	326	216	716	589	418	146	722
Mar	1347	1050	616	1890	1258	1081	668	1719
Apr	1144	581	330	1555	1077	647	307	1423
May	1113	571	262	1555	1103	776	218	1671
Jun	499	305	147	531	648	412	138	812
Jul	176	116	67	175	241	144	86	272
Aug	68	59	49	78	100	90	58	120
Sep	67	48	40	61	156	62	51	142

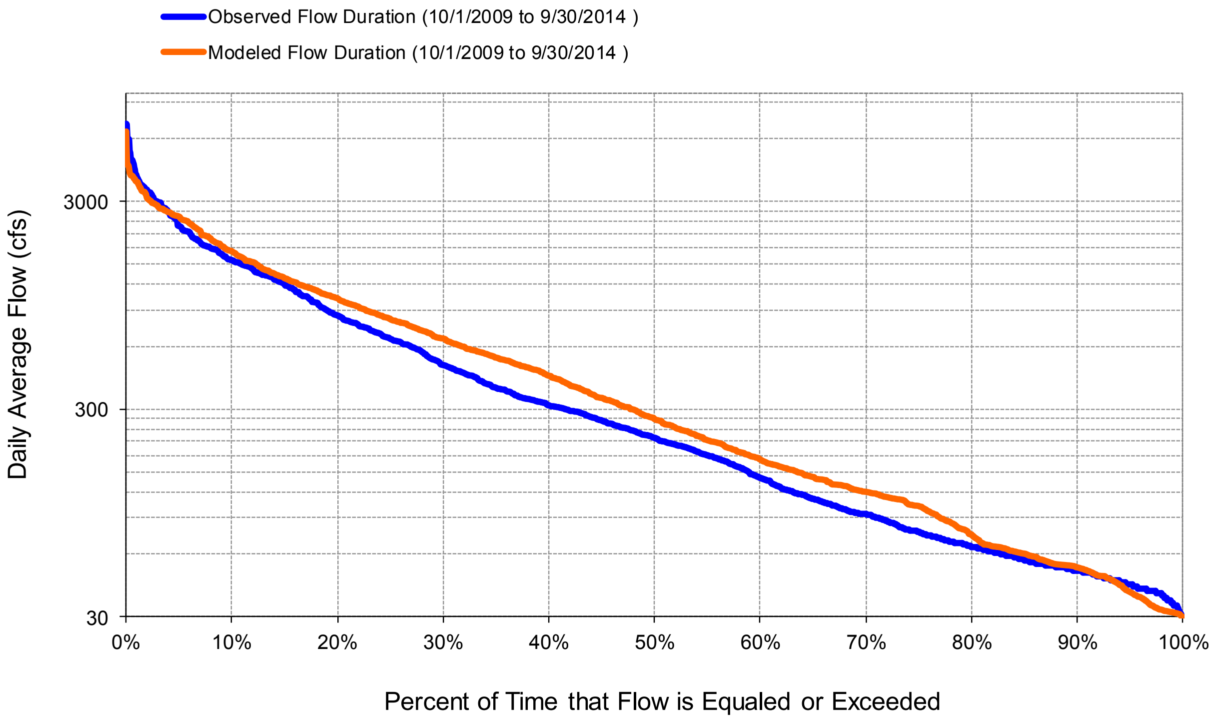


Figure D-35. Flow exceedance at SJR near Newville, IN (USGS 04178000).

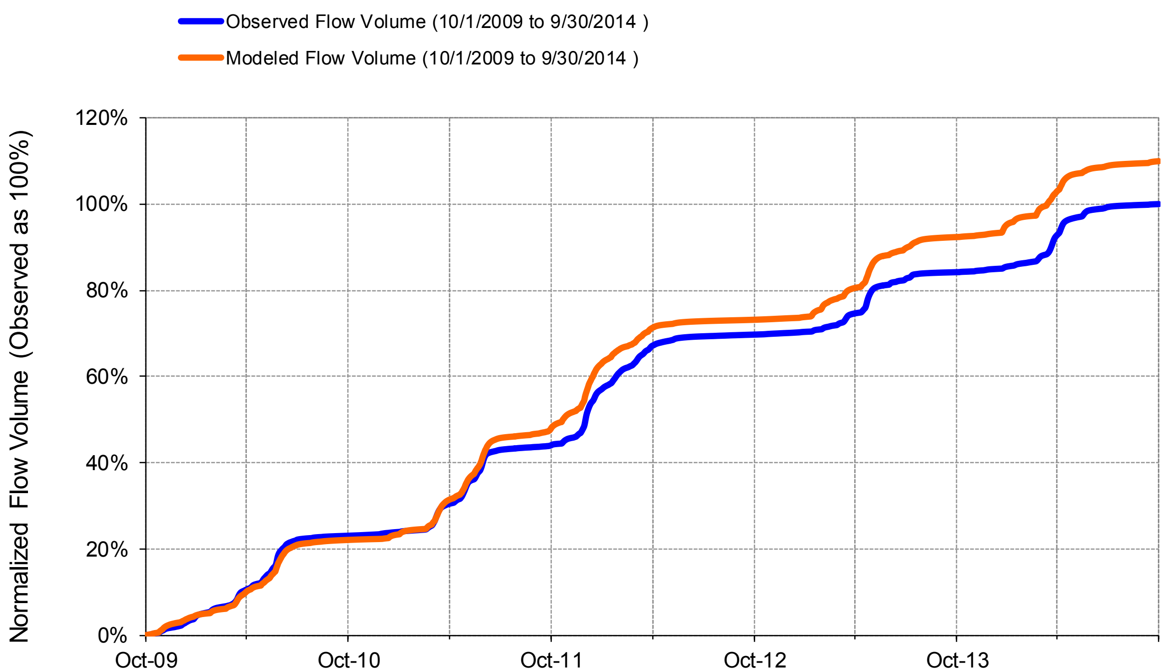


Figure D-36. Flow accumulation at SJR near Newville, IN (USGS 04178000).

Table D-29. Summary statistics at SJR near Newville, IN (USGS 04178000)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 43 5-Year Analysis Period: 10/1/2009 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		USGS 04178000 ST. JOSEPH RIVER NEAR NEWVILLE, IN Hydrologic Unit Code: 4100003 Latitude: 41.3853283 Longitude: -84.8016259 Drainage Area (sq-mi): 610	
Total Simulated In-stream Flow:	**13.86**	Total Observed In-stream Flow:	**12.61**
Total of simulated highest 10% flows:	**5.92**	Total of Observed highest 10% flows:	**5.99**
Total of Simulated lowest 50% flows:	**1.25**	Total of Observed Lowest 50% flows:	**1.05**
Simulated Summer Flow Volume (months 7-9):	**0.93**	Observed Summer Flow Volume (7-9):	**0.58**
Simulated Fall Flow Volume (months 10-12):	**3.13**	Observed Fall Flow Volume (10-12):	**2.58**
Simulated Winter Flow Volume (months 1-3):	**4.56**	Observed Winter Flow Volume (1-3):	**4.33**
Simulated Spring Flow Volume (months 4-6):	**5.24**	Observed Spring Flow Volume (4-6):	**5.11**
Total Simulated Storm Volume:	**4.23**	Total Observed Storm Volume:	**4.02**
Simulated Summer Storm Volume (7-9):	**0.22**	Observed Summer Storm Volume (7-9):	**0.16**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	9.96	10	
Error in 50% lowest flows:	19.09	10	
Error in 10% highest flows:	-1.07	15	
Seasonal volume error - Summer:	59.38	30	
Seasonal volume error - Fall:	21.24	30	
Seasonal volume error - Winter:	5.29	30	
Seasonal volume error - Spring:	2.58	30	
Error in storm volumes:	5.31	20	
Error in summer storm volumes:	35.15	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.772	Model accuracy increases as E or E' approaches 1.0	
Baseline adjusted coefficient (Garrick), E':	0.608		
Monthly NSE	0.890		

D-2.1.3.5 St. Joseph River near Fort Wayne, IN (USGS 04180500)

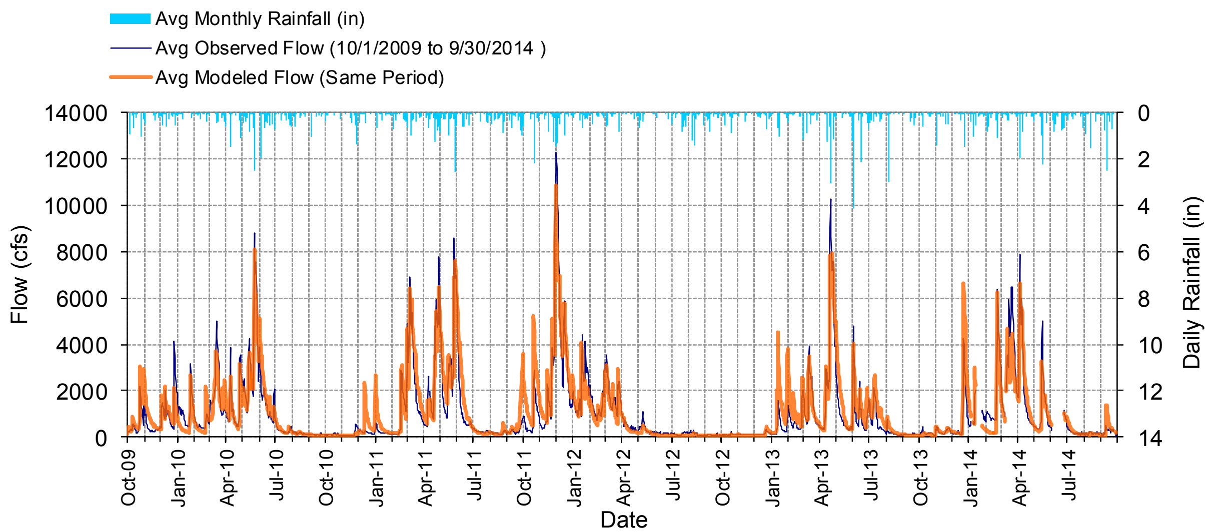


Figure D-37. Mean daily flow at SJR near Fort Wayne, IN USGS 04180500).

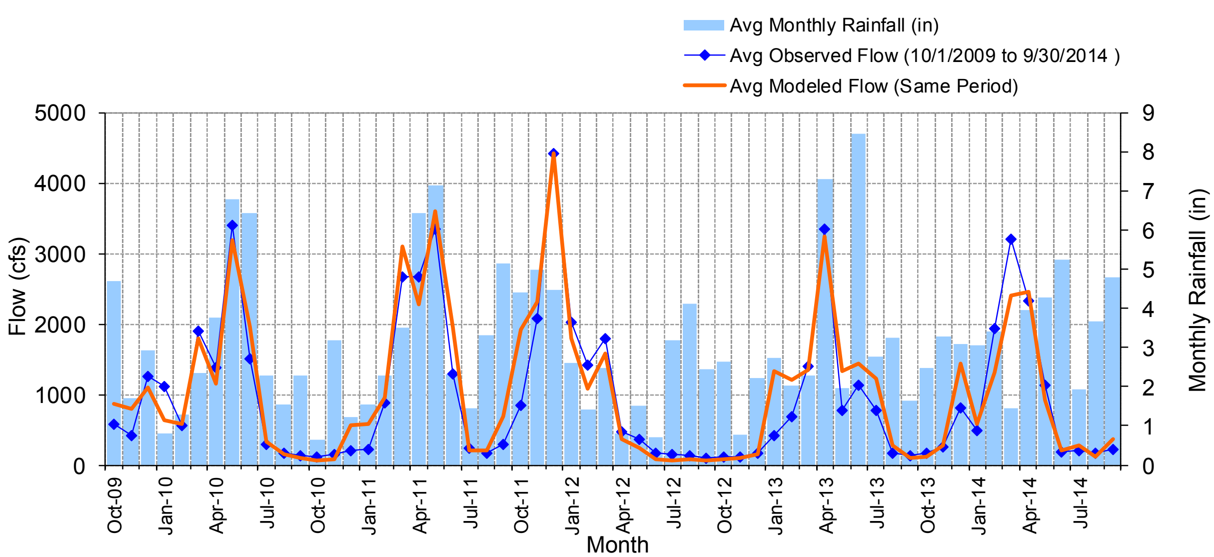


Figure D-38. Mean monthly flow at SJR near Fort Wayne, IN USGS 04180500).

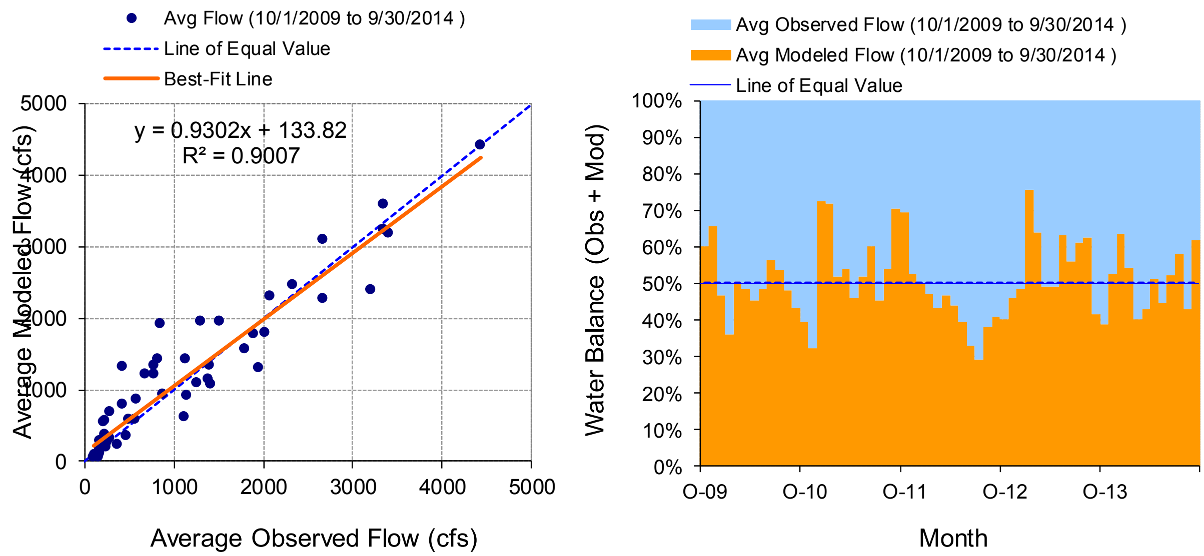


Figure D-39. Monthly flow regression and temporal variation at SJR near Fort Wayne, IN USGS 04180500).

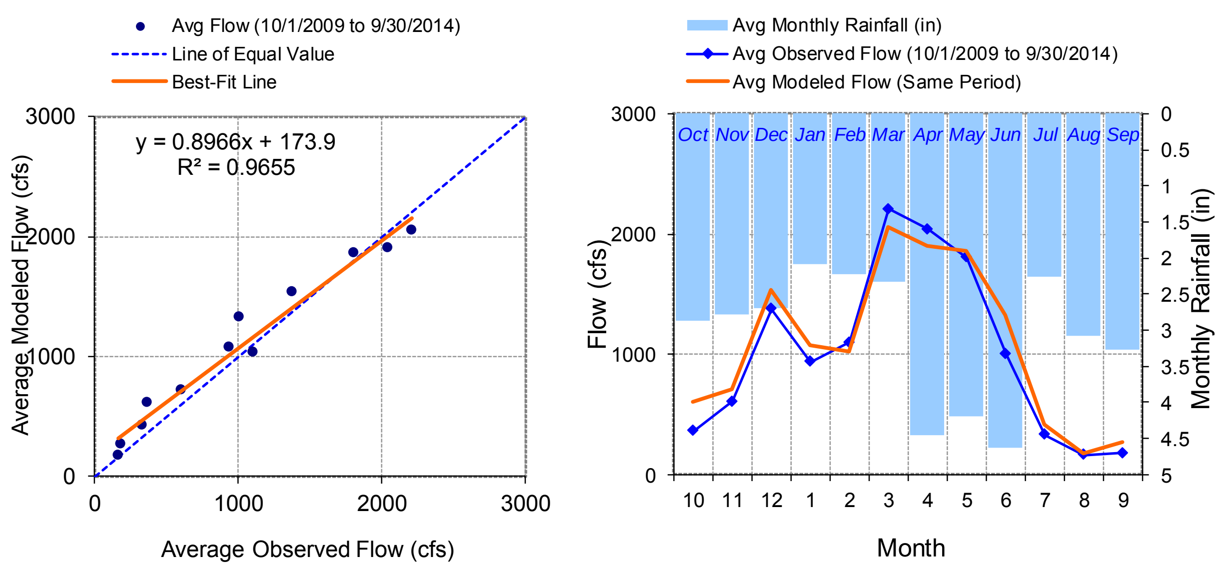


Figure D-40. Seasonal regression and temporal aggregate at SJR near Fort Wayne, IN USGS 04180500).

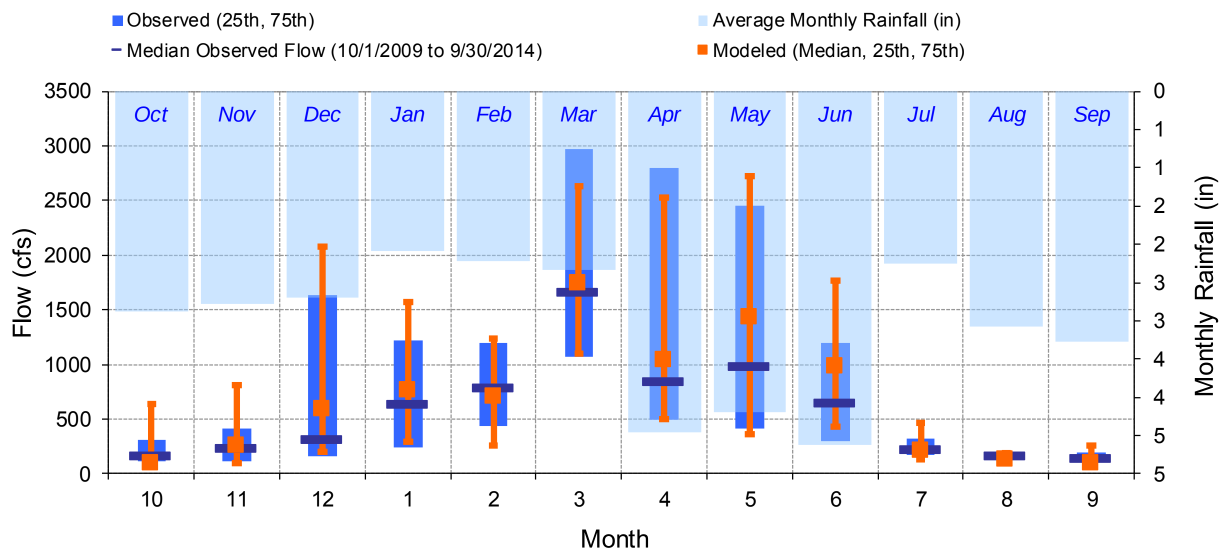


Figure D-41. Seasonal medians and ranges at SJR near Fort Wayne, IN USGS 04180500).

Table D-30. Seasonal summary at SJR near Fort Wayne, IN USGS 04180500)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	364	167	117	306	609	103	71	635
Nov	605	241	111	414	711	255	94	815
Dec	1377	316	158	1630	1536	589	204	2077
Jan	935	633	239	1218	1076	770	293	1577
Feb	1101	783	436	1200	1026	705	253	1239
Mar	2205	1660	1073	2970	2053	1750	1098	2636
Apr	2042	841	500	2798	1898	1041	500	2534
May	1807	989	420	2450	1857	1432	356	2726
Jun	1006	648	304	1203	1322	979	426	1765
Jul	332	225	176	323	420	216	130	466
Aug	164	162	124	192	172	133	106	185
Sep	177	140	109	200	268	95	90	259

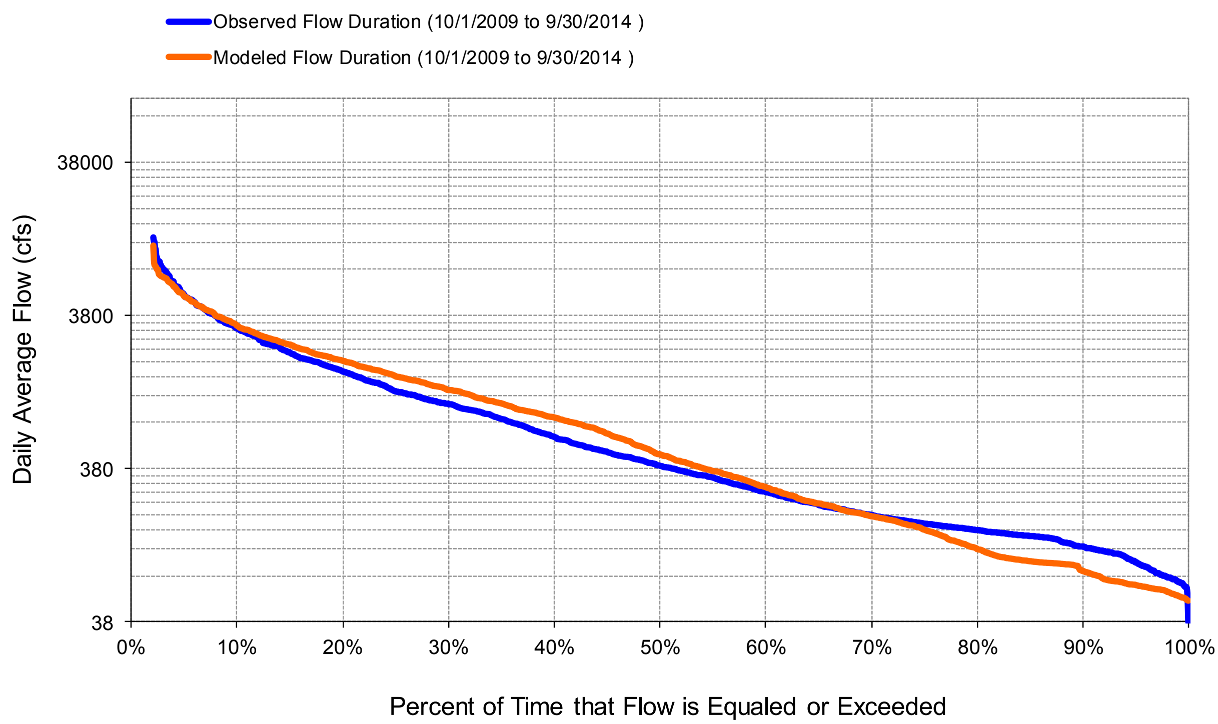


Figure D-42. Flow exceedance at SJR near Fort Wayne, IN USGS 04180500).

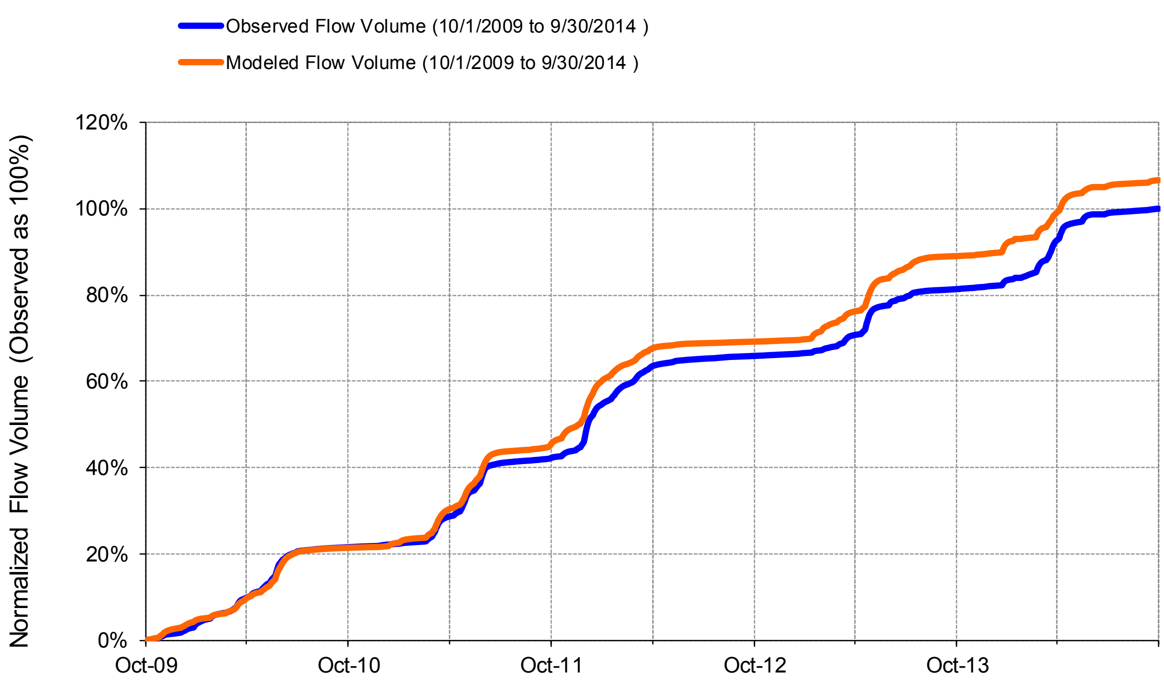


Figure D-43. Flow accumulation at SJR near Fort Wayne, IN USGS 04180500).

Table D-31. Summary statistics at SJR near Fort Wayne, IN USGS 04180500)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 5 5-Year Analysis Period: 10/1/2009 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		St. Joseph River near Fort Wayne Manually Entered Data Drainage Area (sq-mi): 1060	
Total Simulated In-stream Flow:	**13.52**	Total Observed In-stream Flow:	**12.68**
Total of simulated highest 10% flows:	**5.80**	Total of Observed highest 10% flows:	**6.01**
Total of Simulated lowest 50% flows:	**1.11**	Total of Observed Lowest 50% flows:	**1.17**
Simulated Summer Flow Volume (months 7-9):	**0.92**	Observed Summer Flow Volume (7-9):	**0.72**
Simulated Fall Flow Volume (months 10-12):	**3.08**	Observed Fall Flow Volume (10-12):	**2.53**
Simulated Winter Flow Volume (months 1-3):	**4.31**	Observed Winter Flow Volume (1-3):	**4.40**
Simulated Spring Flow Volume (months 4-6):	**5.21**	Observed Spring Flow Volume (4-6):	**5.02**
Total Simulated Storm Volume:	**5.64**	Total Observed Storm Volume:	**5.84**
Simulated Summer Storm Volume (7-9):	**0.32**	Observed Summer Storm Volume (7-9):	**0.26**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	6.63	10		
Error in 50% lowest flows:	-4.64	10		
Error in 10% highest flows:	-3.60	15		
Seasonal volume error - Summer:	27.54	30		
Seasonal volume error - Fall:	21.83 >>	30	Clear	
Seasonal volume error - Winter:	-2.24	30		
Seasonal volume error - Spring:	3.72	30		
Error in storm volumes:	-3.32	20		
Error in summer storm volumes:	23.80	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.841	Model accuracy increases		
Baseline adjusted coefficient (Garrick), E':	0.642	as E or E' approaches 1.0		
Monthly NSE	0.896			

D-2.1.4 Hydrology Validation

D-2.1.4.1 Fish Creek near Hamilton, IN (USGS 04177720)

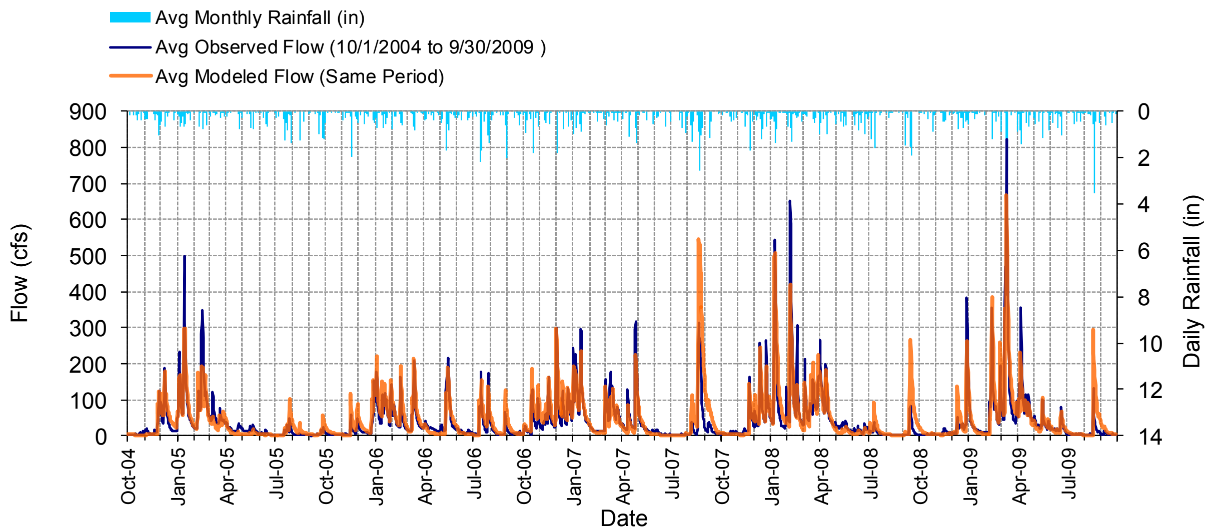


Figure D-44. Mean daily flow at Fish Creek near Hamilton, IN (USGS 04177720).

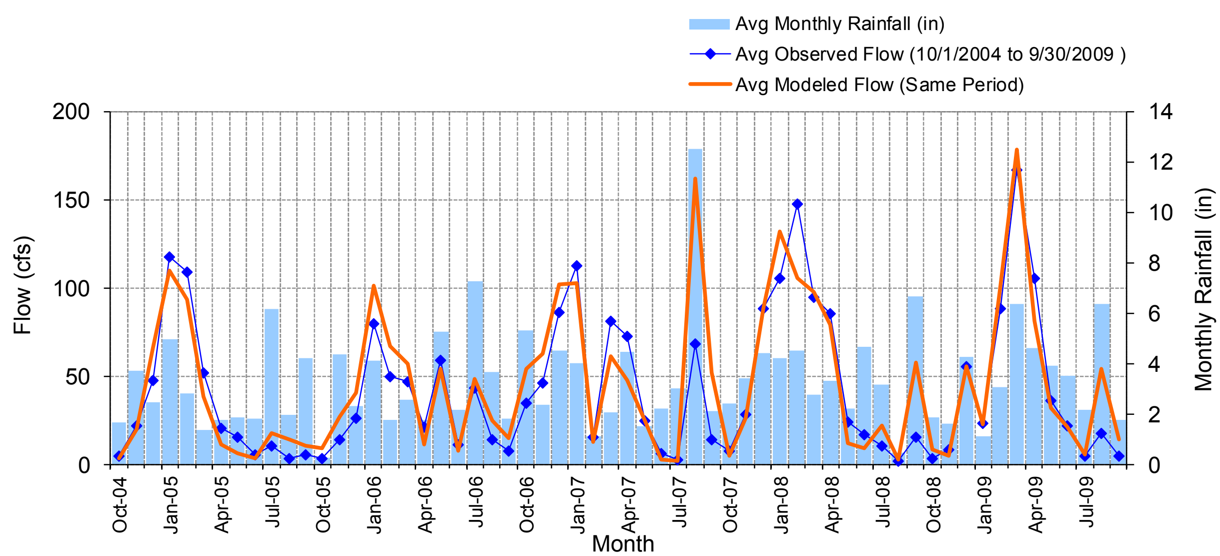


Figure D-45. Mean monthly flow at Fish Creek near Hamilton, IN (USGS 04177720).

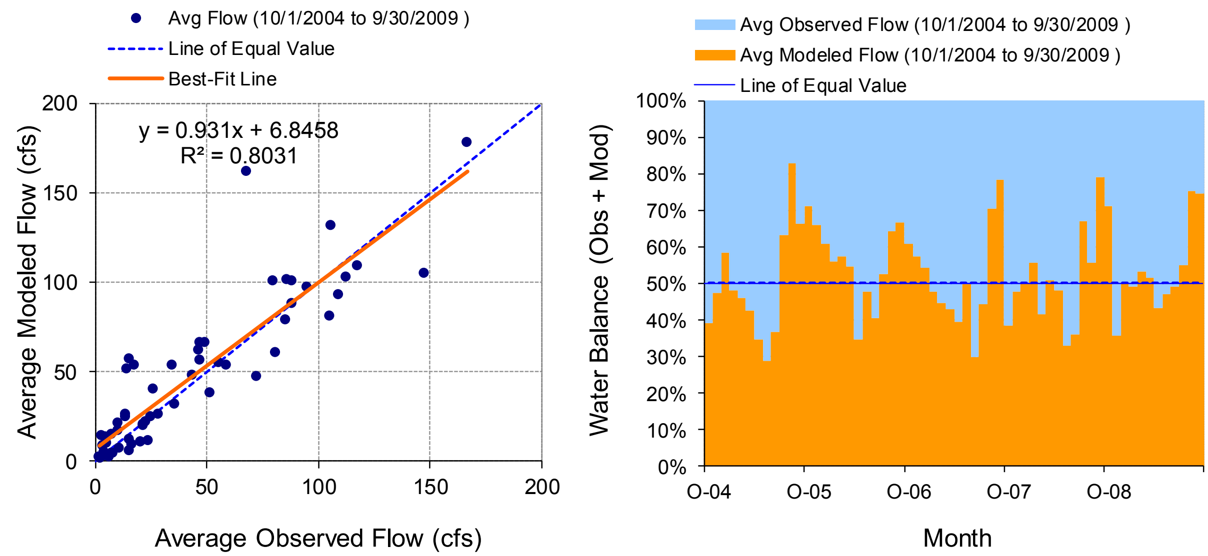


Figure D-46. Monthly flow regression and temporal variation at Fish Creek near Hamilton, IN (USGS 04177720).

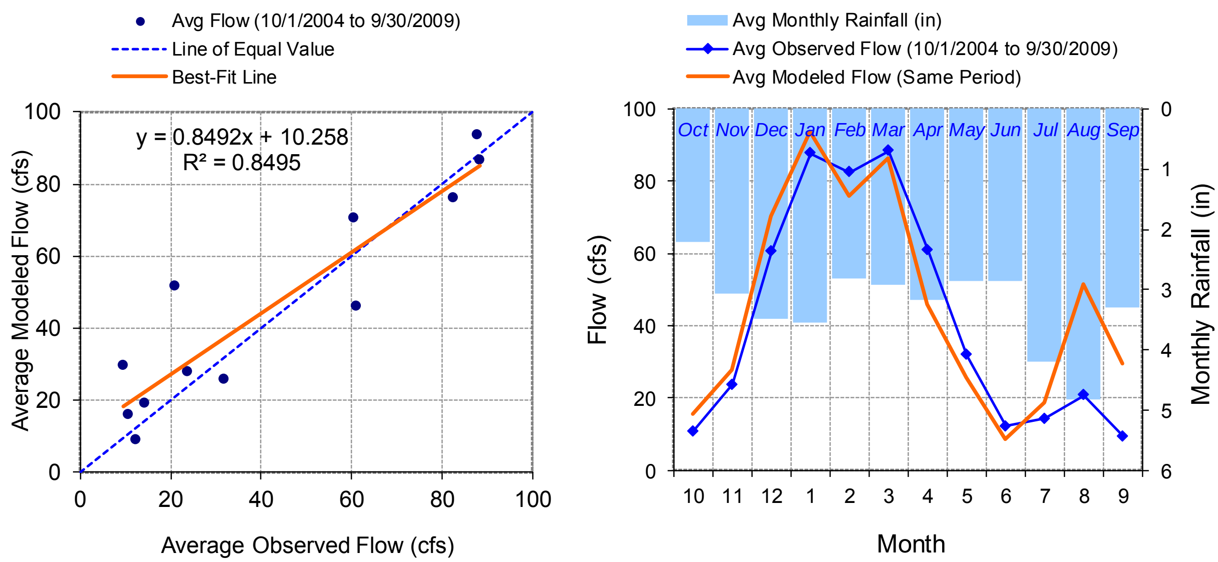


Figure D-47. Seasonal regression and temporal aggregate at Fish Creek near Hamilton, IN (USGS 04177720).

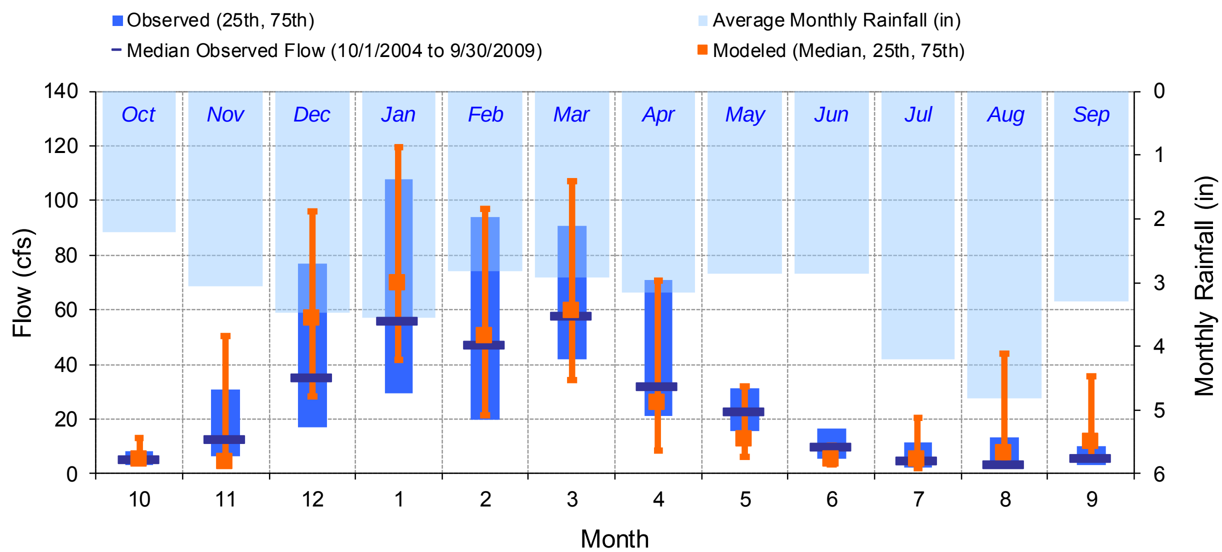


Figure D-48. Seasonal medians and ranges at Fish Creek near Hamilton, IN (USGS 04177720).

Table D-32. Seasonal summary at Fish Creek near Hamilton, IN (USGS 04177720)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	11	5	3	8	16	5	4	13
Nov	24	13	6	31	28	5	3	51
Dec	61	35	17	77	70	57	28	96
Jan	88	56	30	108	94	70	42	120
Feb	82	47	20	94	76	50	21	97
Mar	88	58	42	91	86	59	34	107
Apr	61	32	21	71	46	26	8	71
May	32	23	16	32	26	12	6	32
Jun	12	10	5	17	9	5	3	10
Jul	14	5	2	12	19	5	2	20
Aug	21	3	2	14	51	8	3	44
Sep	9	6	3	10	30	12	6	36

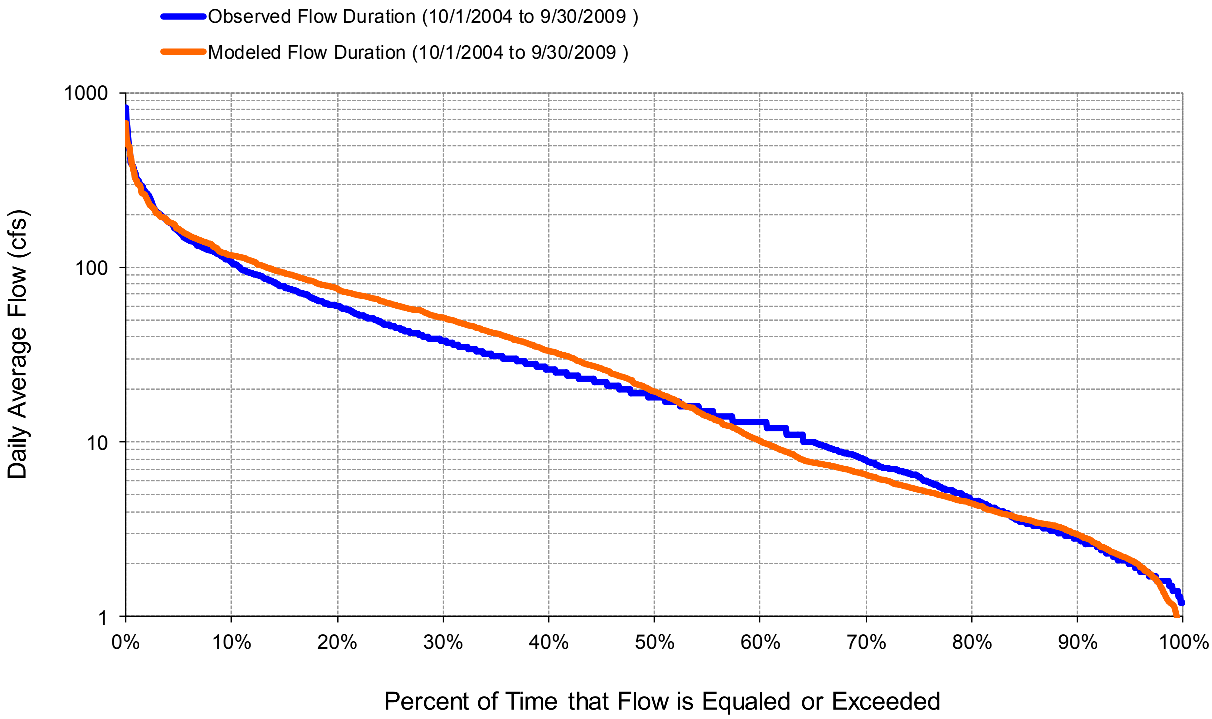


Figure D-49. Flow exceedance at Fish Creek near Hamilton, IN (USGS 04177720).

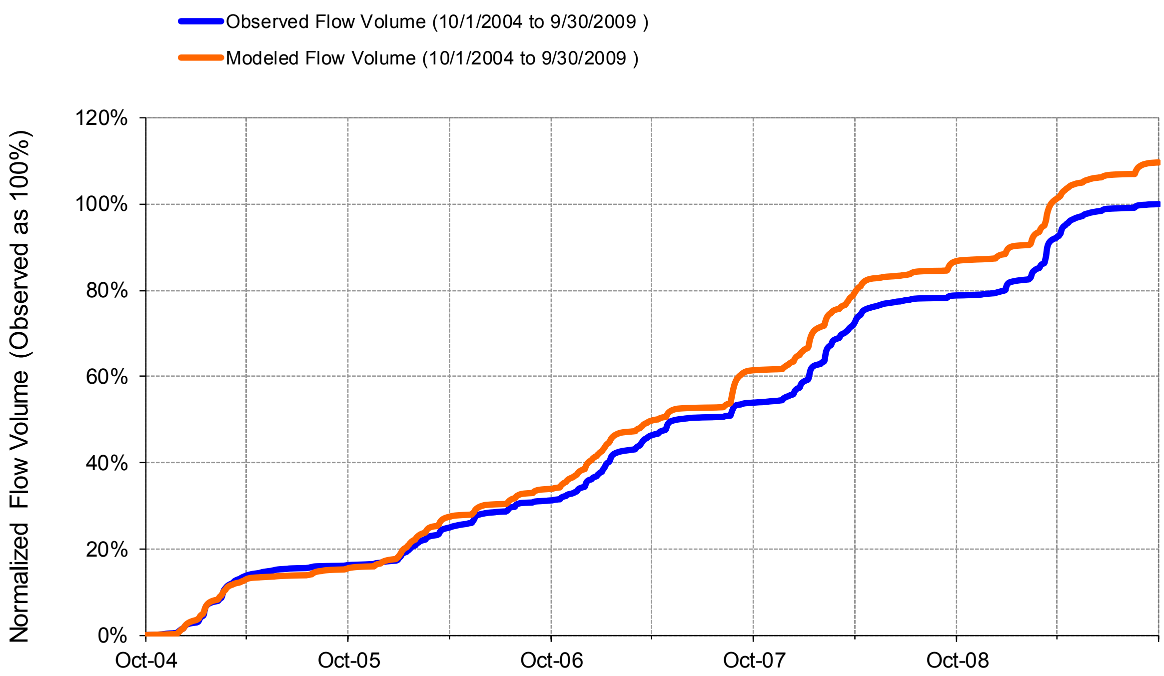


Figure D-50. Flow accumulation at Fish Creek near Hamilton, IN (USGS 04177720).

Table D-33. Summary statistics at Fish Creek near Hamilton, IN (USGS 04177720)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET(S) 51, 54 5-Year Analysis Period: 10/1/2004 - 9/30/2009 Flow volumes are (inches/year) for upstream drainage area		USGS 04177720 FISH CREEK AT HAMILTON, IN Hydrologic Unit Code: 4100003 Latitude: 41.53227275 Longitude: -84.9035726 Drainage Area (sq-mi): 37.5	
Total Simulated In-stream Flow:	**16.60**	Total Observed In-stream Flow:	**15.13**
Total of simulated highest 10% flows:	**7.27**	Total of Observed highest 10% flows:	**7.31**
Total of Simulated lowest 50% flows:	**1.21**	Total of Observed Lowest 50% flows:	**1.35**
Simulated Summer Flow Volume (months 7-9):	**3.04**	Observed Summer Flow Volume (7-9):	**1.36**
Simulated Fall Flow Volume (months 10-12):	**3.48**	Observed Fall Flow Volume (10-12):	**2.90**
Simulated Winter Flow Volume (months 1-3):	**7.66**	Observed Winter Flow Volume (1-3):	**7.72**
Simulated Spring Flow Volume (months 4-6):	**2.42**	Observed Spring Flow Volume (4-6):	**3.16**
Total Simulated Storm Volume:	**5.17**	Total Observed Storm Volume:	**5.47**
Simulated Summer Storm Volume (7-9):	**0.96**	Observed Summer Storm Volume (7-9):	**0.56**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	9.68	10		
Error in 50% lowest flows:	-10.02	10		
Error in 10% highest flows:	-0.57	15		
Seasonal volume error - Summer:	123.99	30		
Seasonal volume error - Fall:	20.11 >>	30		Clear
Seasonal volume error - Winter:	-0.75	30		
Seasonal volume error - Spring:	-23.53	30		
Error in storm volumes:	-5.55	20		
Error in summer storm volumes:	72.10	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.759	Model accuracy increases as E or E' approaches 1.0		
Baseline adjusted coefficient (Garrick), E':	0.579			
Monthly NSE	0.773			

D-2.1.4.2 Fish Creek near Artic, IN (USGS 04177810)

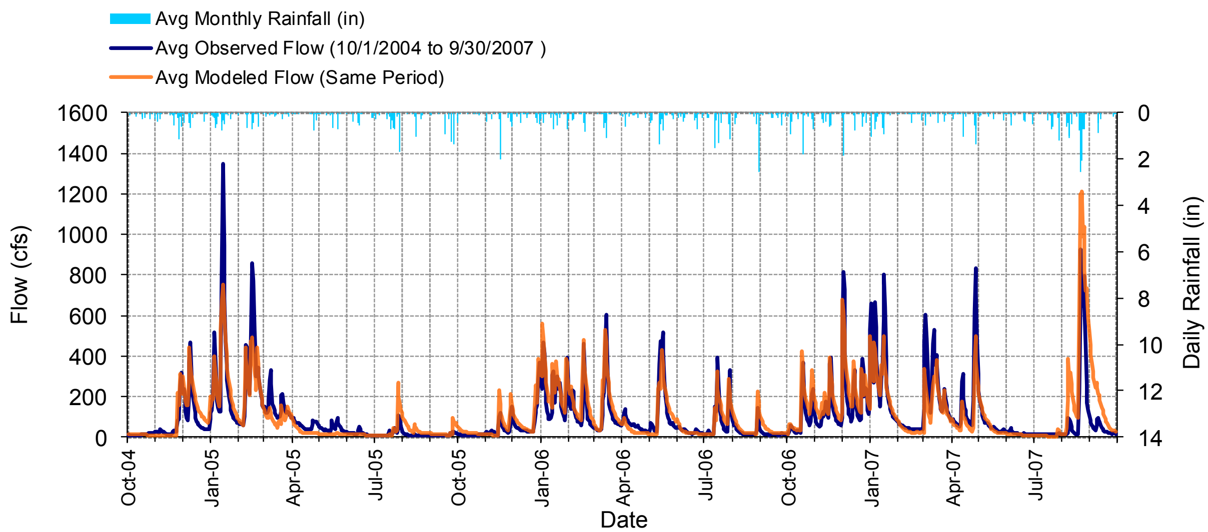


Figure D-51. Mean daily flow at Fish Creek near Artic, IN (USGS 04177810).

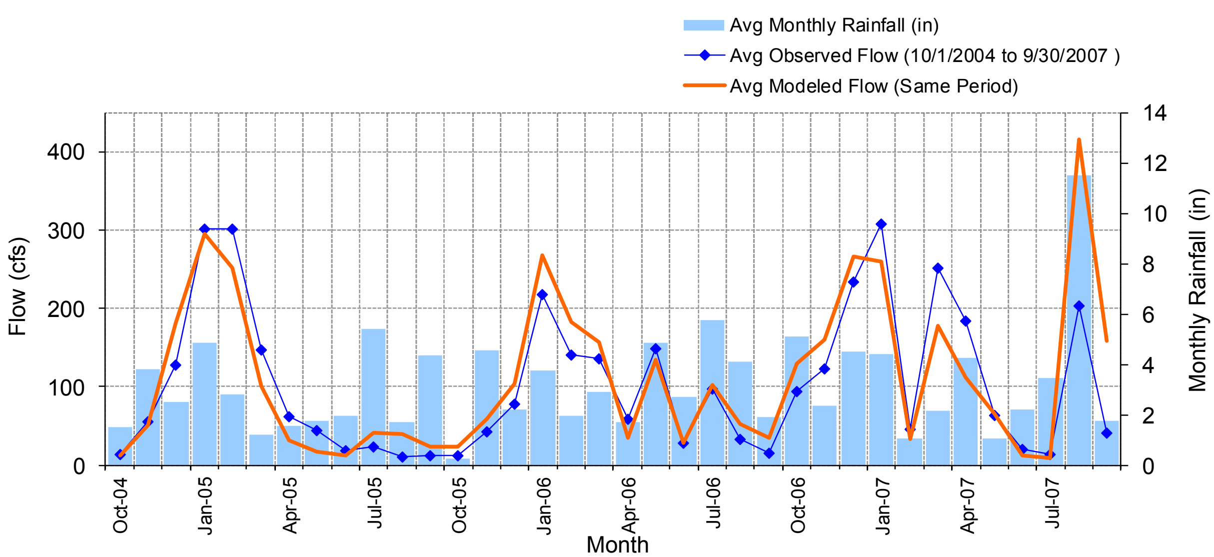


Figure D-52. Mean monthly flow at Fish Creek near Artic, IN (USGS 04177810).

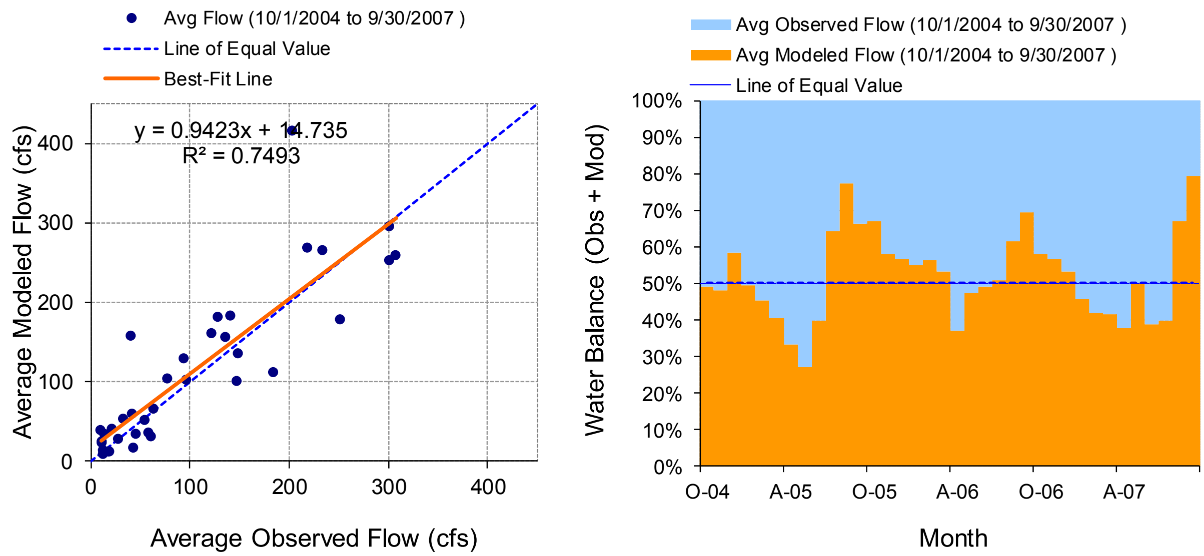


Figure D-53. Monthly flow regression and temporal variation at Fish Creek near Artic, IN (USGS 04177810).

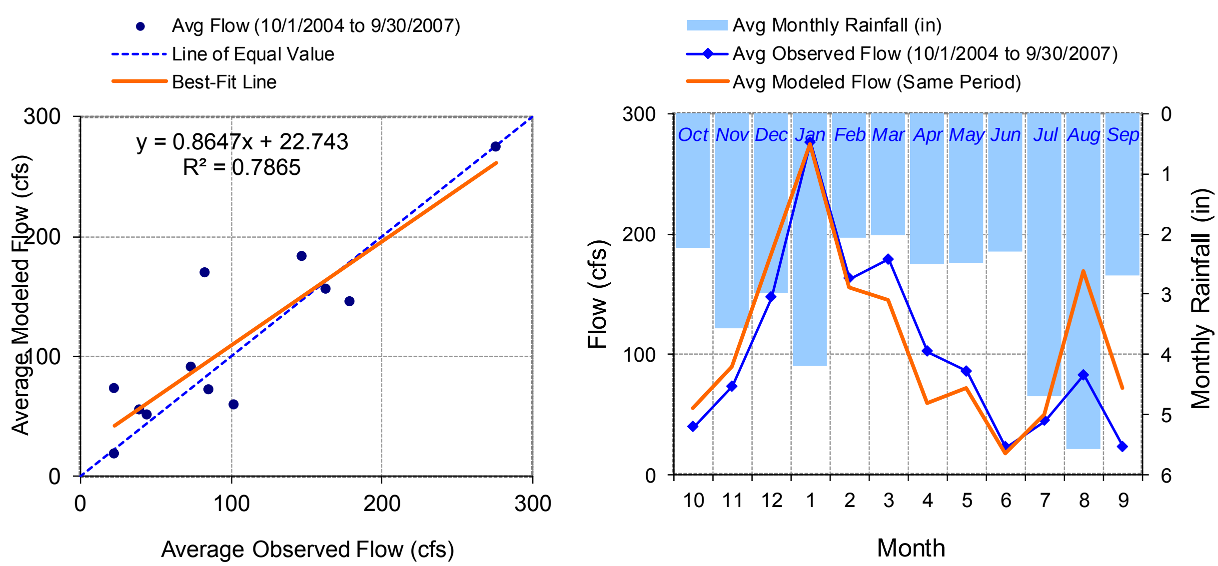


Figure D-54. Seasonal regression and temporal aggregate at Fish Creek near Artic, IN (USGS 04177810).

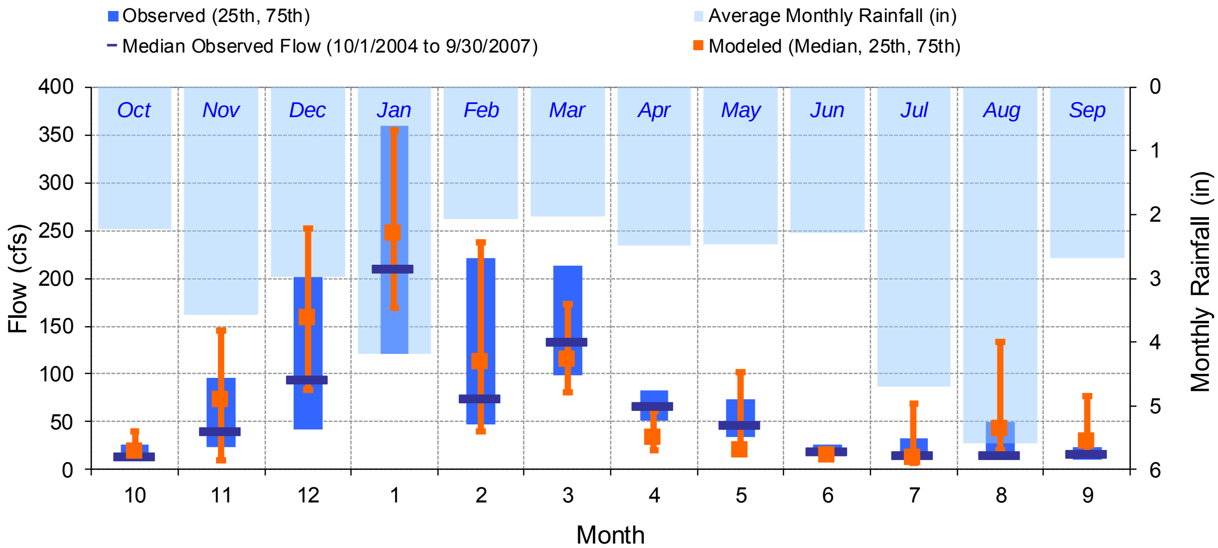


Figure D-55. Seasonal medians and ranges at Fish Creek near Artic, IN (USGS 04177810).

Table D-34. Seasonal summary at Fish Creek near Artic, IN (USGS 04177810).

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	40	14	10	26	55	19	14	40
Nov	73	40	24	96	90	73	10	145
Dec	147	94	42	202	183	159	83	252
Jan	276	210	121	360	274	247	169	354
Feb	163	75	48	222	156	113	39	238
Mar	179	134	99	213	145	115	81	173
Apr	102	66	51	83	59	33	20	61
May	86	47	34	73	72	20	17	102
Jun	22	19	16	26	18	14	11	18
Jul	45	15	13	33	50	12	7	69
Aug	83	15	12	50	169	43	20	134
Sep	23	16	11	24	72	29	18	76

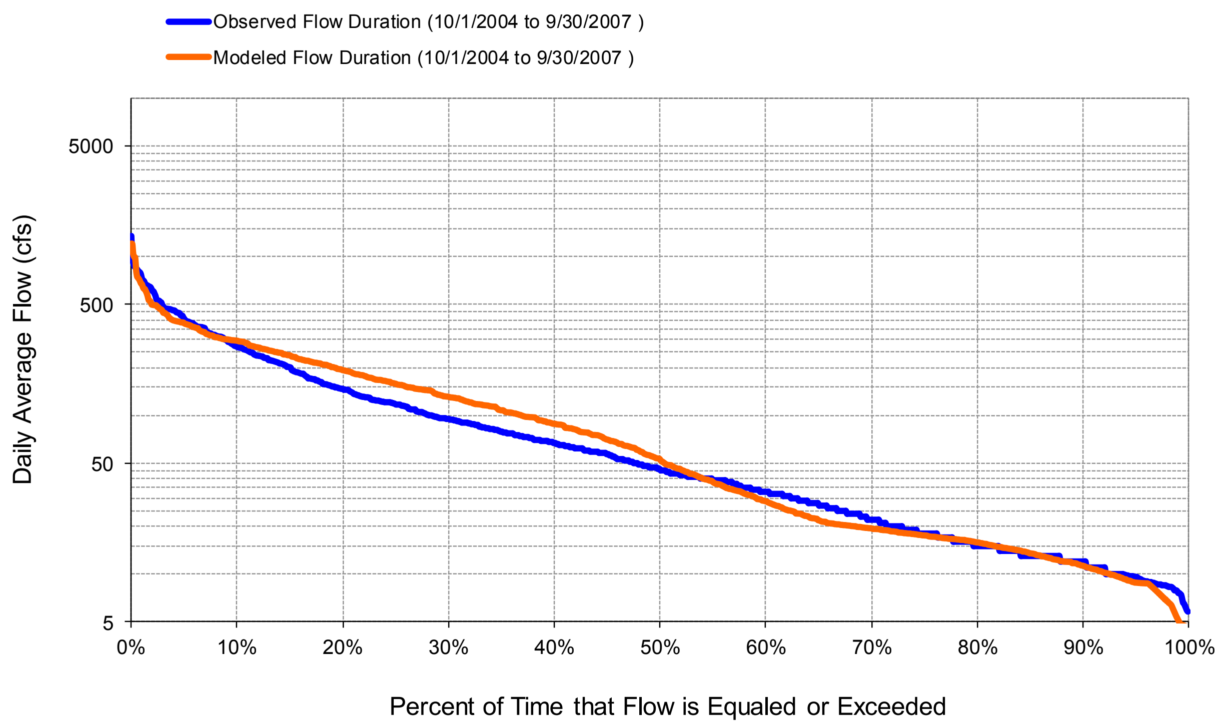


Figure D-56. Flow exceedance at Fish Creek near Artic, IN (USGS 04177810).

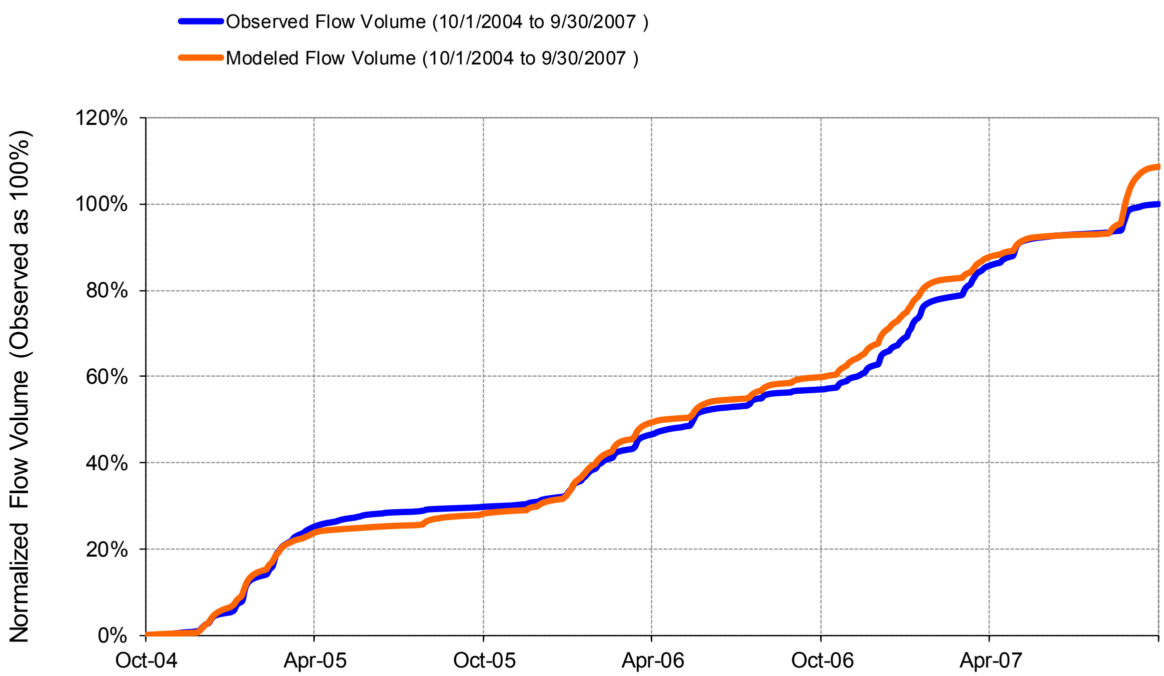


Figure D-57. Flow accumulation at Fish Creek near Artic, IN (USGS 04177810).

Table D-35. Summary statistics at Fish Creek near Artic, IN (USGS 04177810)

SWAT Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM OUTLET 49 3-Year Analysis Period: 10/1/2004 - 9/30/2007 Flow volumes are (inches/year) for upstream drainage area		USGS 04177810 FISH CREEK NR ARTIC Hydrologic Unit Code: 4100003 Latitude: 41.3853283 Longitude: -84.8016259 Drainage Area (sq-mi): 610		
Total Simulated In-stream Flow:	**15.54**	Total Observed In-stream Flow:		**14.30**
Total of simulated highest 10% flows:	**6.17**	Total of Observed highest 10% flows:		**6.56**
Total of Simulated lowest 50% flows:	**1.41**	Total of Observed Lowest 50% flows:		**1.50**
Simulated Summer Flow Volume (months 7-9):	**3.40**	Observed Summer Flow Volume (7-9):		**1.76**
Simulated Fall Flow Volume (months 10-12):	**3.83**	Observed Fall Flow Volume (10-12):		**3.03**
Simulated Winter Flow Volume (months 1-3):	**6.59**	Observed Winter Flow Volume (1-3):		**7.09**
Simulated Spring Flow Volume (months 4-6):	**1.72**	Observed Spring Flow Volume (4-6):		**2.42**
Total Simulated Storm Volume:	**4.01**	Total Observed Storm Volume:		**4.85**
Simulated Summer Storm Volume (7-9):	**0.87**	Observed Summer Storm Volume (7-9):		**0.65**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	8.68	10		
Error in 50% lowest flows:	-6.00	10		
Error in 10% highest flows:	-5.90	15		
Seasonal volume error - Summer:	93.32	30		
Seasonal volume error - Fall:	26.23 >>	30		Clear
Seasonal volume error - Winter:	-6.97	30		
Seasonal volume error - Spring:	-28.95	30		
Error in storm volumes:	-17.31	20		
Error in summer storm volumes:	35.35	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.687	Model accuracy increases as E or E' approaches 1.0		
Baseline adjusted coefficient (Garrick), E':	0.542			
Monthly NSE	0.690			

D-2.1.4.3 Cedar Creek near Cedarville, IN (USGS 04180000)

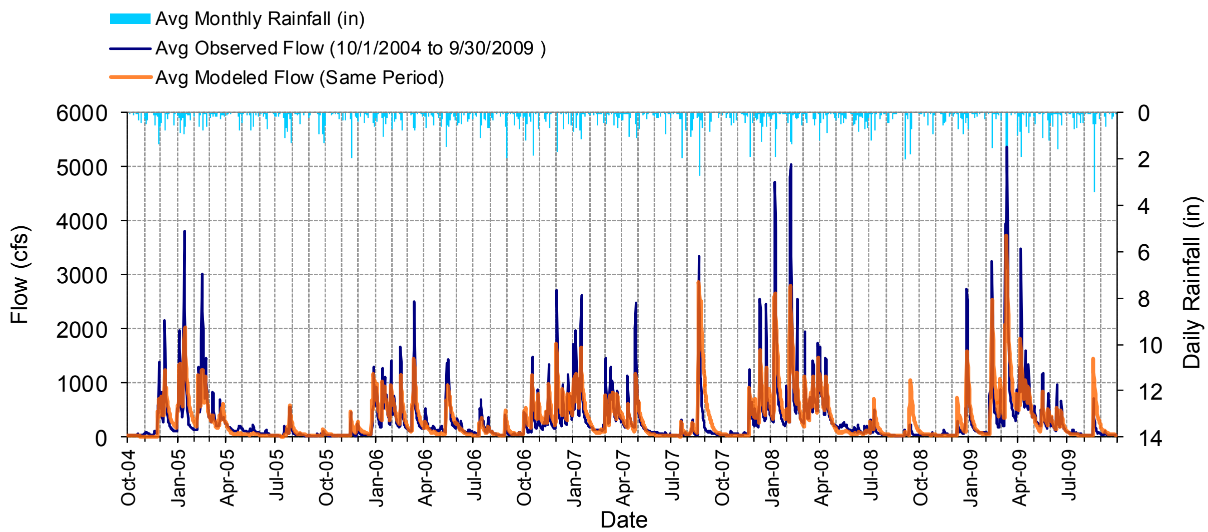


Figure D-58. Mean daily flow at Cedar Creek near Cedarville, IN (USGS 04180000).

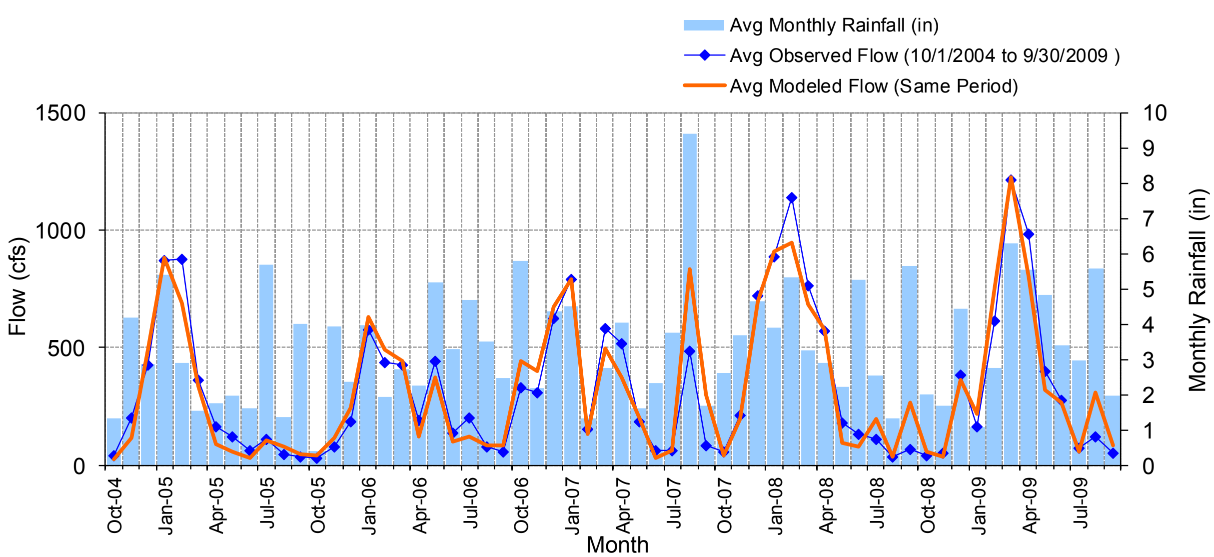


Figure D-59. Mean monthly flow at Cedar Creek near Cedarville, IN (USGS 04180000).

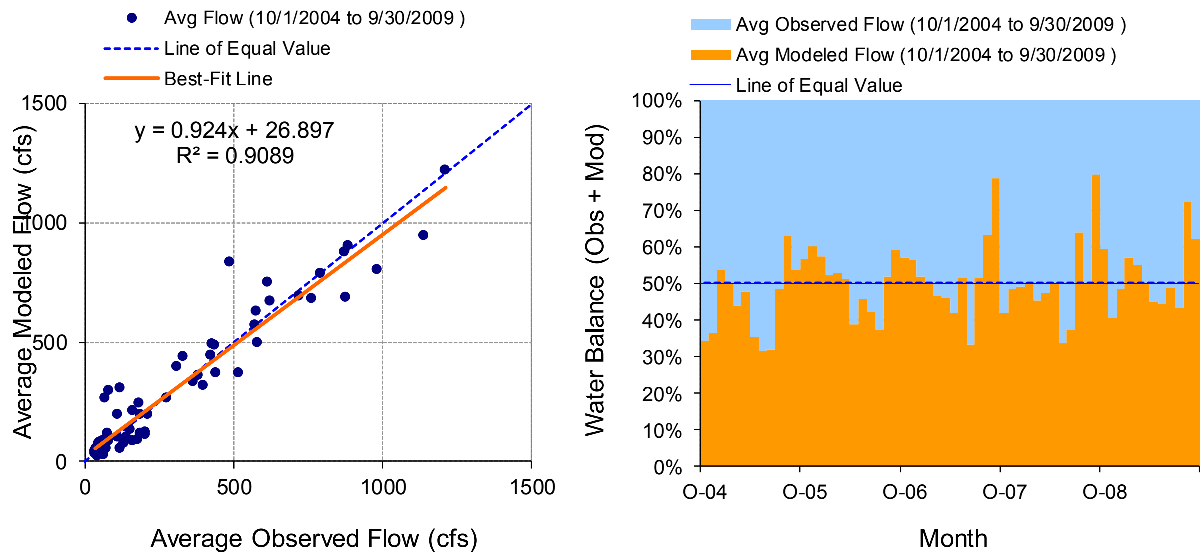


Figure D-60. Monthly flow regression and temporal variation at Cedar Creek near Cedarville, IN (USGS 04180000).

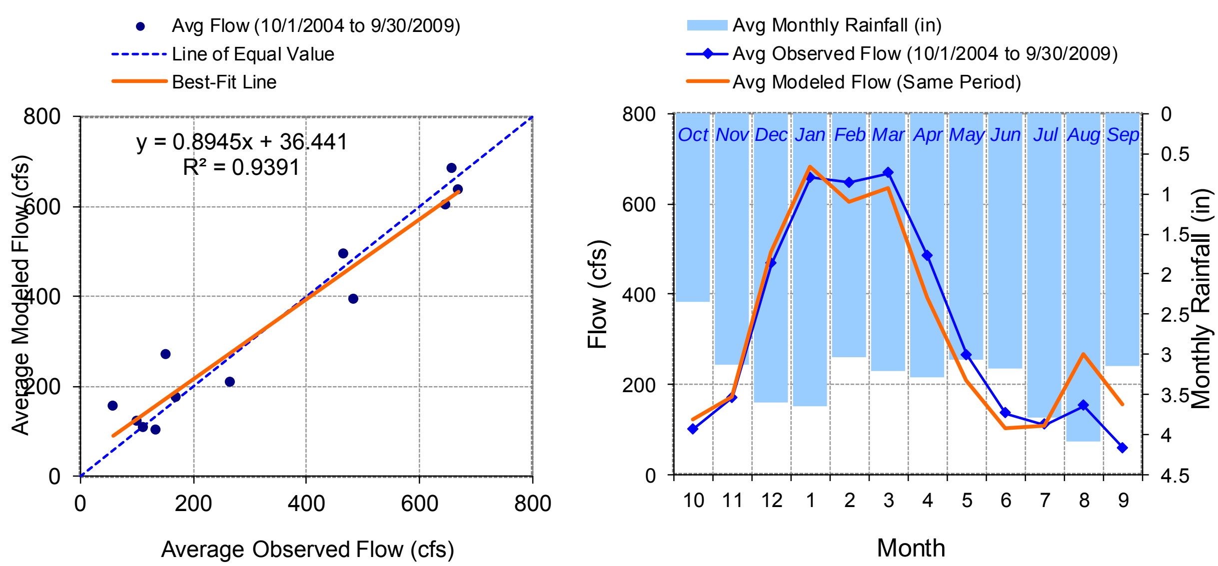


Figure D-61. Seasonal regression and temporal aggregate at Cedar Creek near Cedarville, IN (USGS 04180000).

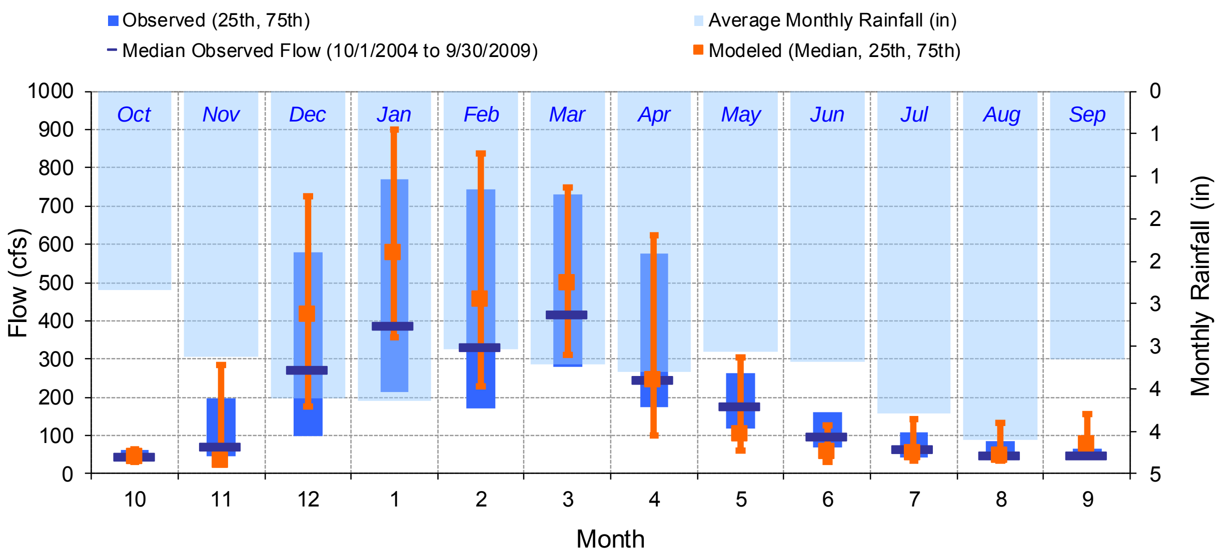


Figure D-62. Seasonal medians and ranges at Cedar Creek near Cedarville, IN (USGS 04180000).

Table D-36. Seasonal summary at Cedar Creek near Cedarville, IN (USGS 04180000)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	100	44	34	62	121	44	32	65
Nov	171	72	47	199	173	35	26	283
Dec	467	273	99	581	494	415	175	724
Jan	658	388	213	771	684	576	357	899
Feb	647	332	170	745	604	456	228	838
Mar	668	417	280	731	636	498	311	750
Apr	484	245	174	575	392	245	101	625
May	265	177	120	264	207	104	60	303
Jun	135	96	67	162	101	57	31	127
Jul	111	65	44	110	108	55	33	144
Aug	153	46	37	85	268	48	34	133
Sep	59	49	38	65	155	76	47	155

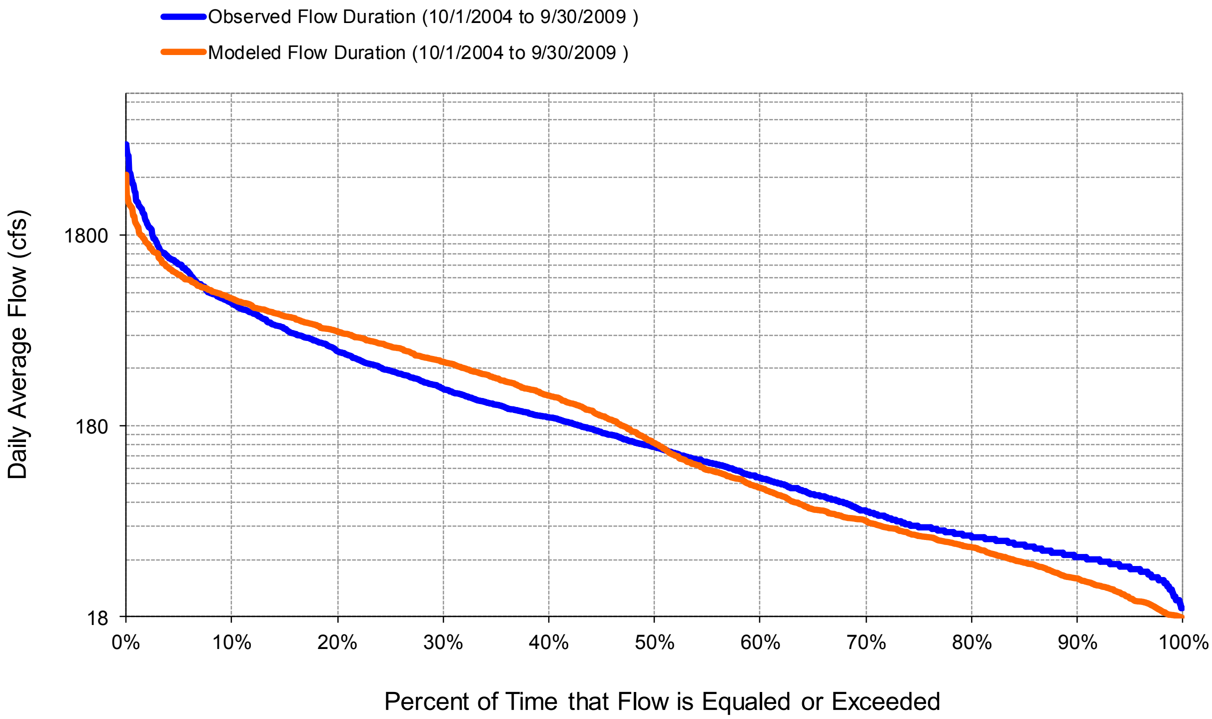


Figure D-63. Flow exceedance at Cedar Creek near Cedarville, IN (USGS 04180000).

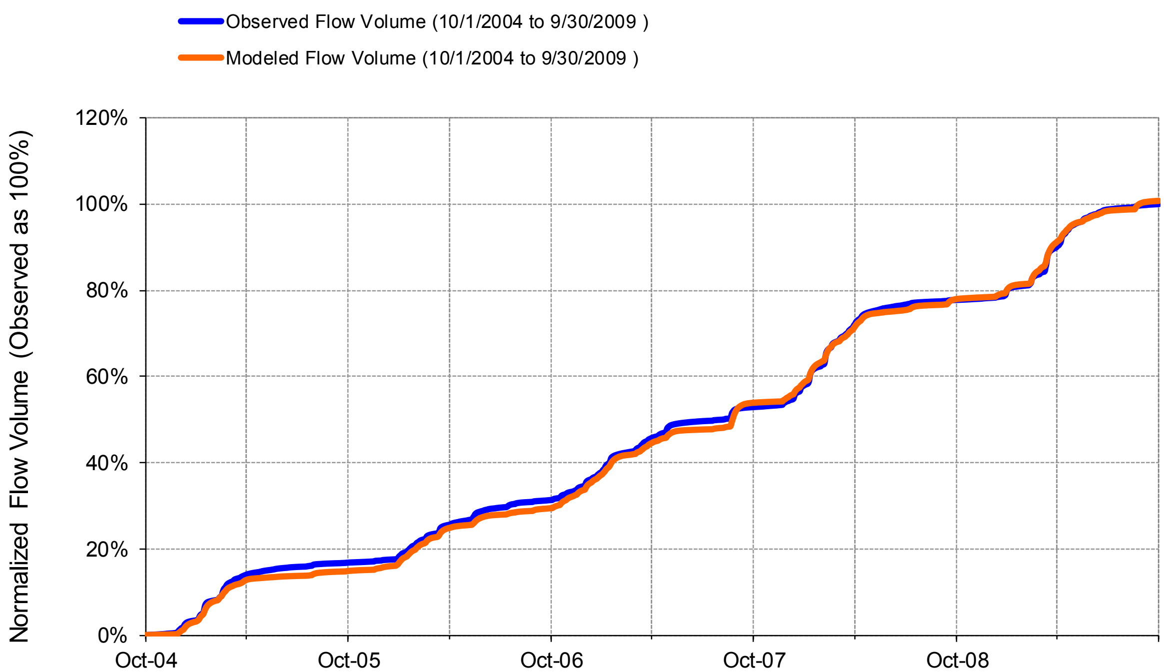


Figure D-64. Flow accumulation at Cedar Creek near Cedarville, IN (USGS 04180000).

Table D-37. Summary statistics at Cedar Creek near Cedarville, IN (USGS 04180000)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 9 5-Year Analysis Period: 10/1/2004 - 9/30/2009 Flow volumes are (inches/year) for upstream drainage area		USGS 04180000 CEDAR CREEK NEAR CEDARVILLE, IN Hydrologic Unit Code: 4100003 Latitude: 41.218938 Longitude: -85.0763589 Drainage Area (sq-mi): 270	
Total Simulated In-stream Flow:	**16.49**	Total Observed In-stream Flow:	**16.37**
Total of simulated highest 10% flows:	**6.63**	Total of Observed highest 10% flows:	**7.95**
Total of Simulated lowest 50% flows:	**1.44**	Total of Observed Lowest 50% flows:	**1.64**
Simulated Summer Flow Volume (months 7-9):	**2.25**	Observed Summer Flow Volume (7-9):	**1.37**
Simulated Fall Flow Volume (months 10-12):	**3.34**	Observed Fall Flow Volume (10-12):	**3.13**
Simulated Winter Flow Volume (months 1-3):	**7.98**	Observed Winter Flow Volume (1-3):	**8.18**
Simulated Spring Flow Volume (months 4-6):	**2.92**	Observed Spring Flow Volume (4-6):	**3.69**
Total Simulated Storm Volume:	**5.81**	Total Observed Storm Volume:	**7.86**
Simulated Summer Storm Volume (7-9):	**0.87**	Observed Summer Storm Volume (7-9):	**0.64**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	0.75	10		
Error in 50% lowest flows:	-12.53	10		
Error in 10% highest flows:	-16.60	15		
Seasonal volume error - Summer:	64.07	30		
Seasonal volume error - Fall:	6.72 >>	30	Clear	
Seasonal volume error - Winter:	-2.40	30		
Seasonal volume error - Spring:	-20.81	30		
Error in storm volumes:	-25.99	20		
Error in summer storm volumes:	36.73	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.752	Model accuracy increases as E or E' approaches 1.0		
Baseline adjusted coefficient (Garrick), E':	0.586			
Monthly NSE	0.909			

D-2.1.4.4 St. Joseph River near Newville, IN (USGS 04178000)

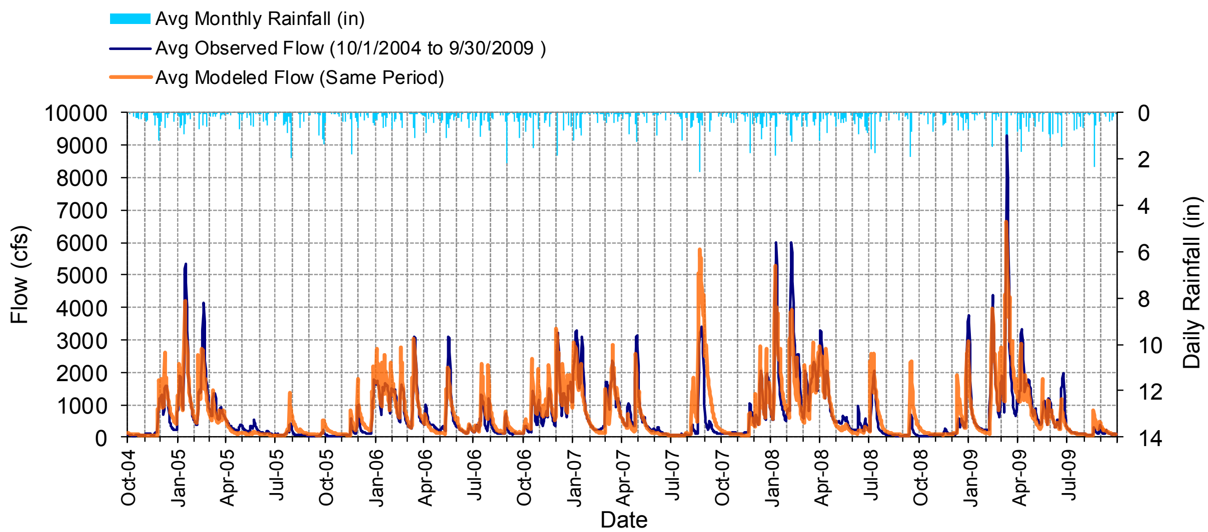


Figure D-65. Mean daily flow at SJR near Newville, IN (USGS 04178000).

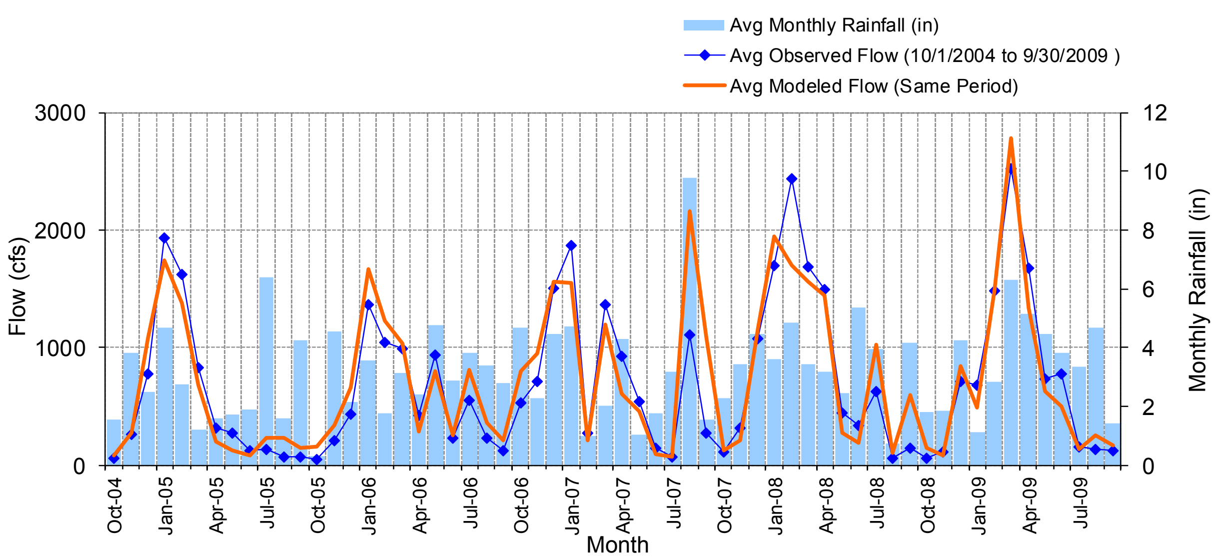


Figure D-66. Mean monthly flow at SJR near Newville, IN (USGS 04178000).

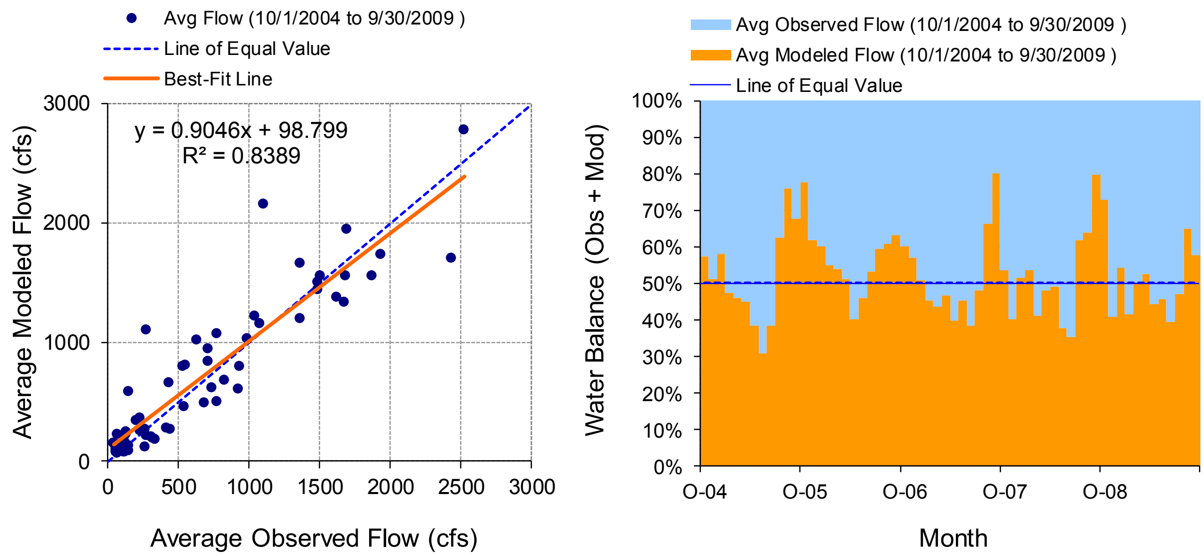


Figure D-67. Monthly flow regression and temporal variation at SJR near Newville, IN (USGS 04178000).

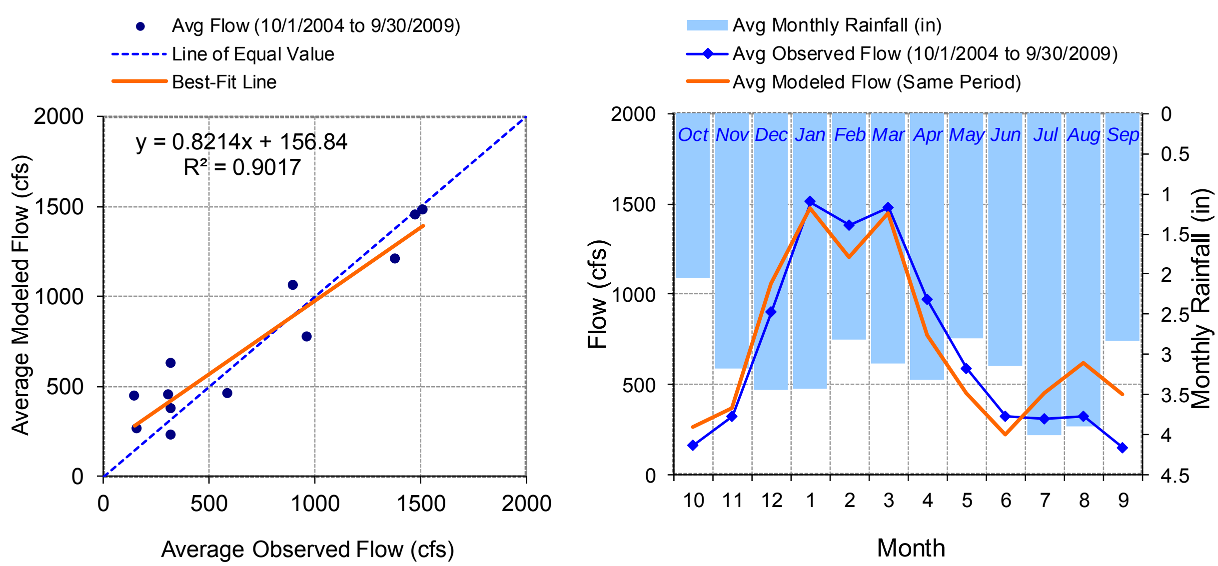


Figure D-68. Seasonal regression and temporal aggregate at SJR near Newville, IN (USGS 04178000).

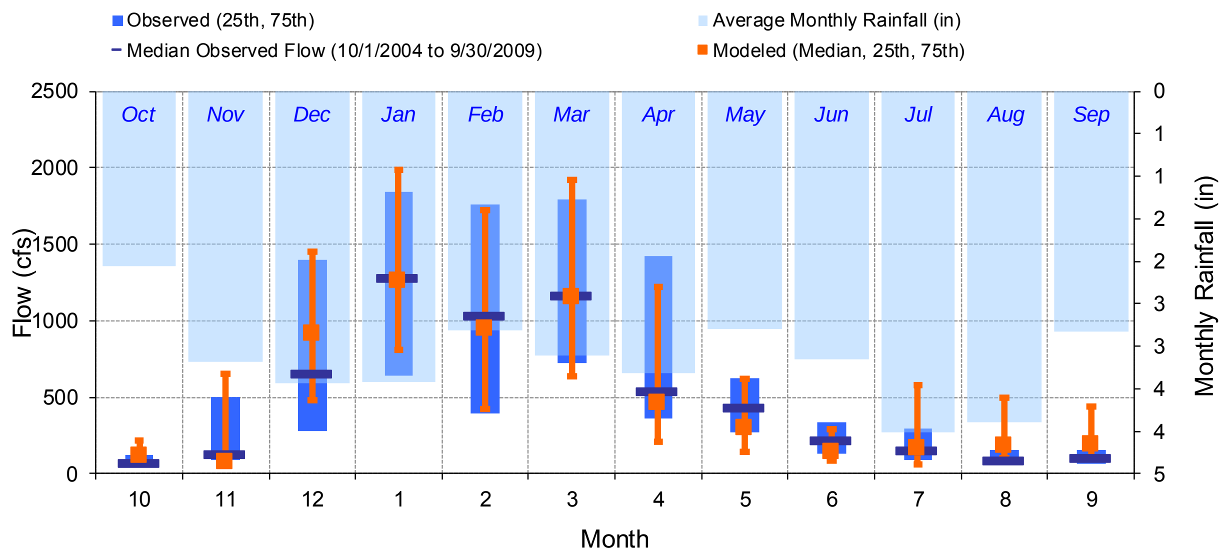


Figure D-69. Seasonal medians and ranges at SJR near Newville, IN (USGS 04178000).

Table D-38. Seasonal summary at SJR near Newville, IN (USGS 04178000)

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	161	67	48	123	262	121	96	220
Nov	322	128	90	499	369	79	67	654
Dec	901	652	277	1395	1056	920	481	1456
Jan	1510	1280	638	1845	1478	1265	814	1990
Feb	1381	1030	396	1760	1207	947	425	1727
Mar	1478	1160	722	1795	1449	1159	636	1924
Apr	966	539	364	1420	773	461	209	1224
May	587	433	267	626	454	301	144	624
Jun	322	215	132	336	223	141	87	291
Jul	308	148	86	299	451	166	61	577
Aug	320	87	64	160	621	181	100	495
Sep	148	105	69	154	443	189	98	442

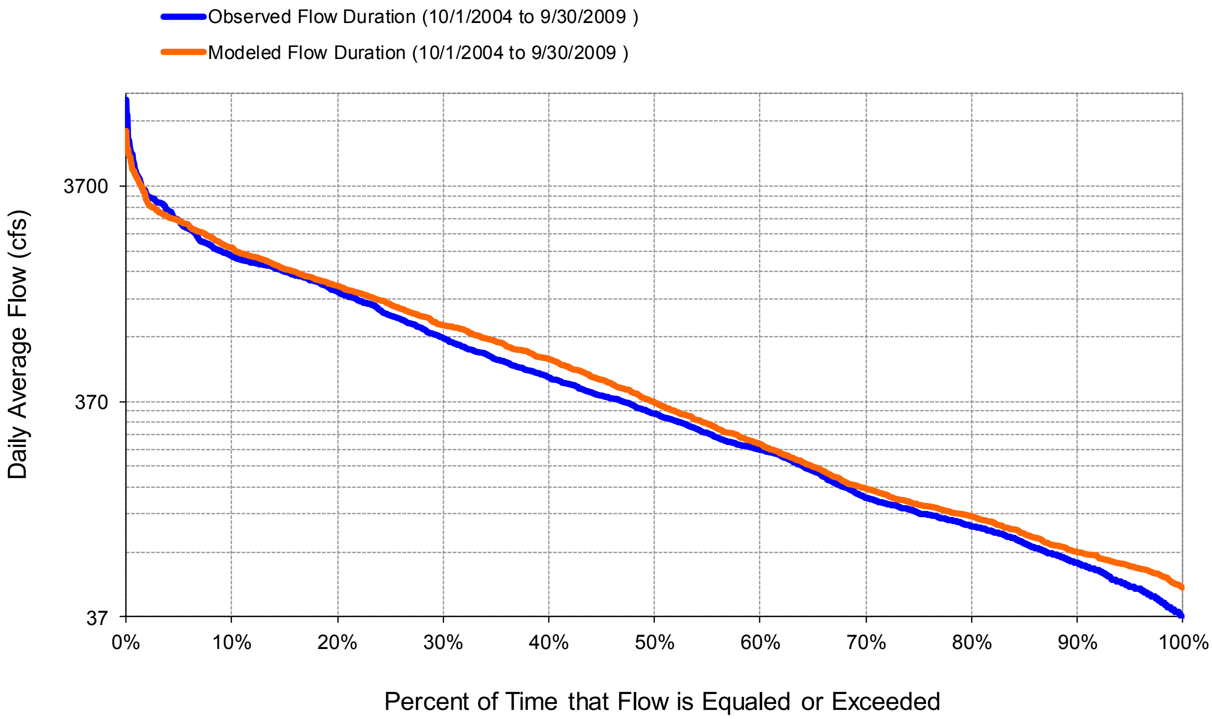


Figure D-70. Flow exceedance at SJR near Newville, IN (USGS 04178000).

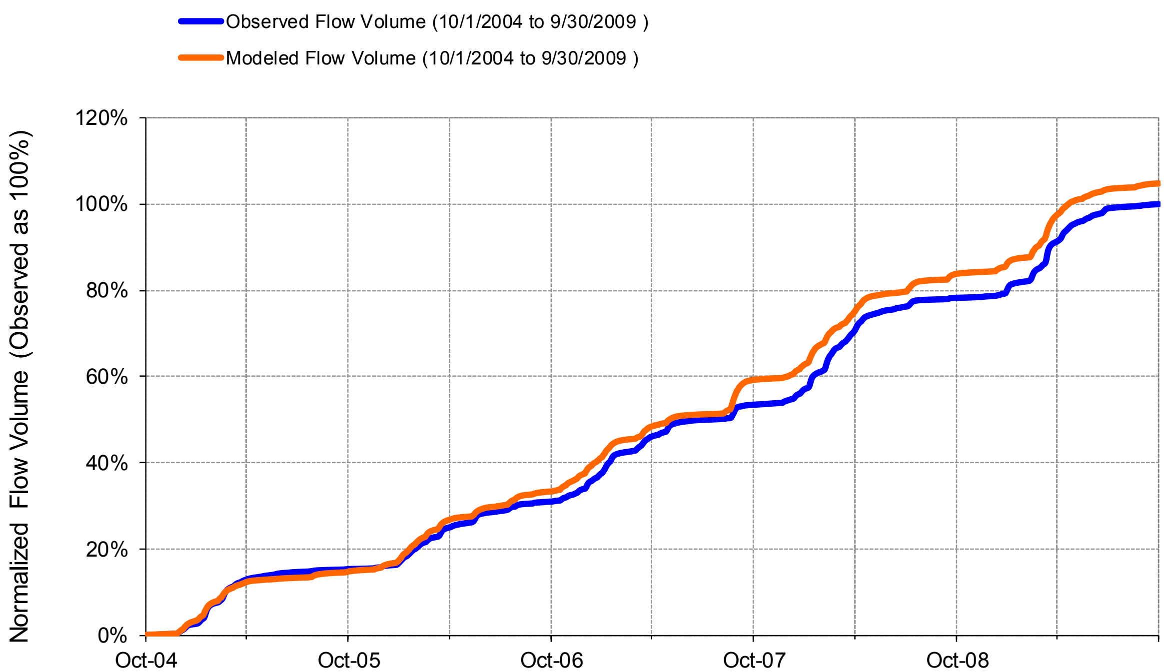


Figure D-71. Flow accumulation at SJR near Newville, IN (USGS 04178000).

Table D-39. Summary statistics at SJR near Newville, IN (USGS 04178000)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 43 5-Year Analysis Period: 10/1/2004 - 9/30/2009 Flow volumes are (inches/year) for upstream drainage area		USGS 04178000 ST. JOSEPH RIVER NEAR NEWVILLE, IN Hydrologic Unit Code: 4100003 Latitude: 41.3853283 Longitude: -84.8016259 Drainage Area (sq-mi): 610	
Total Simulated In-stream Flow:	**16.29**	Total Observed In-stream Flow:	**15.54**
Total of simulated highest 10% flows:	**6.24**	Total of Observed highest 10% flows:	**6.43**
Total of Simulated lowest 50% flows:	**1.69**	Total of Observed Lowest 50% flows:	**1.54**
Simulated Summer Flow Volume (months 7-9):	**2.84**	Observed Summer Flow Volume (7-9):	**1.46**
Simulated Fall Flow Volume (months 10-12):	**3.17**	Observed Fall Flow Volume (10-12):	**2.59**
Simulated Winter Flow Volume (months 1-3):	**7.61**	Observed Winter Flow Volume (1-3):	**8.02**
Simulated Spring Flow Volume (months 4-6):	**2.68**	Observed Spring Flow Volume (4-6):	**3.46**
Total Simulated Storm Volume:	**5.32**	Total Observed Storm Volume:	**5.46**
Simulated Summer Storm Volume (7-9):	**0.95**	Observed Summer Storm Volume (7-9):	**0.56**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*
Error in total volume:	4.81	10
Error in 50% lowest flows:	9.71	10
Error in 10% highest flows:	-2.96	15
Seasonal volume error - Summer:	94.49	30
Seasonal volume error - Fall:	22.01	30
Seasonal volume error - Winter:	-5.19	30
Seasonal volume error - Spring:	-22.69	30
Error in storm volumes:	-2.68	20
Error in summer storm volumes:	69.83	50
Nash-Sutcliffe Coefficient of Efficiency, E:	0.735	Model accuracy increases as E or E' approaches 1.0
Baseline adjusted coefficient (Garrick), E':	0.590	
Monthly NSE	0.831	

>> Clear

D-2.1.4.5 St. Joseph River near Fort Wayne, IN (USGS 04180500)

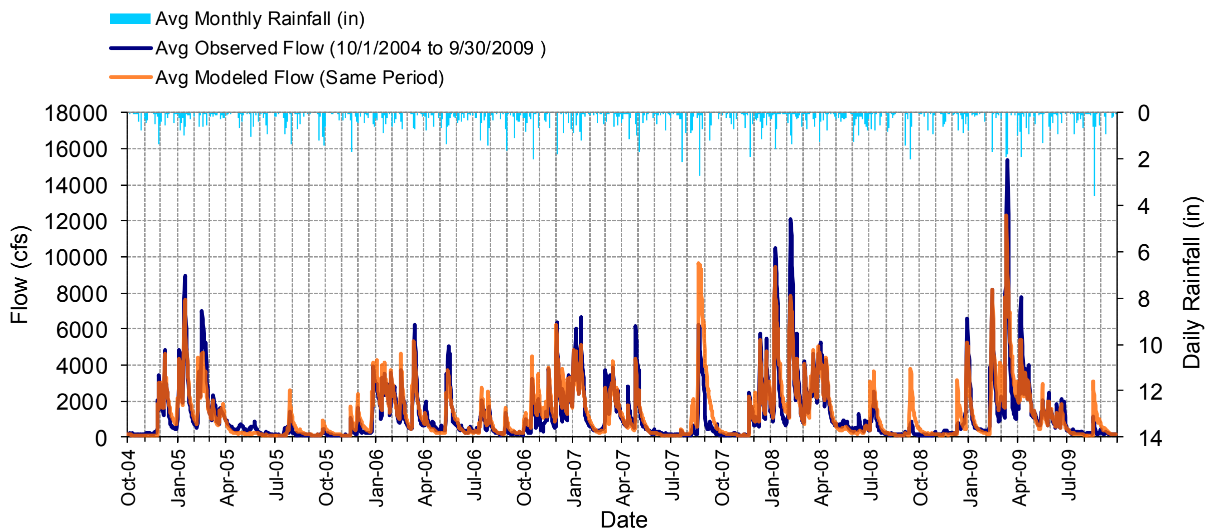


Figure D-72. Mean daily flow at SJR near Fort Wayne, IN (USGS 04180500).

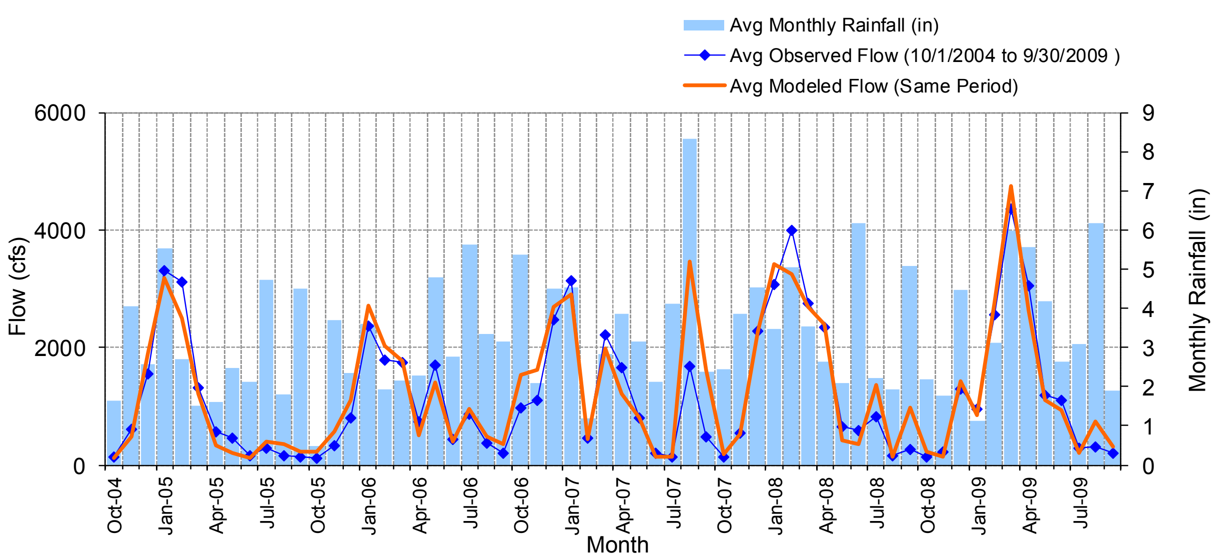


Figure D-73. Mean monthly flow at SJR near Fort Wayne, IN (USGS 04180500).

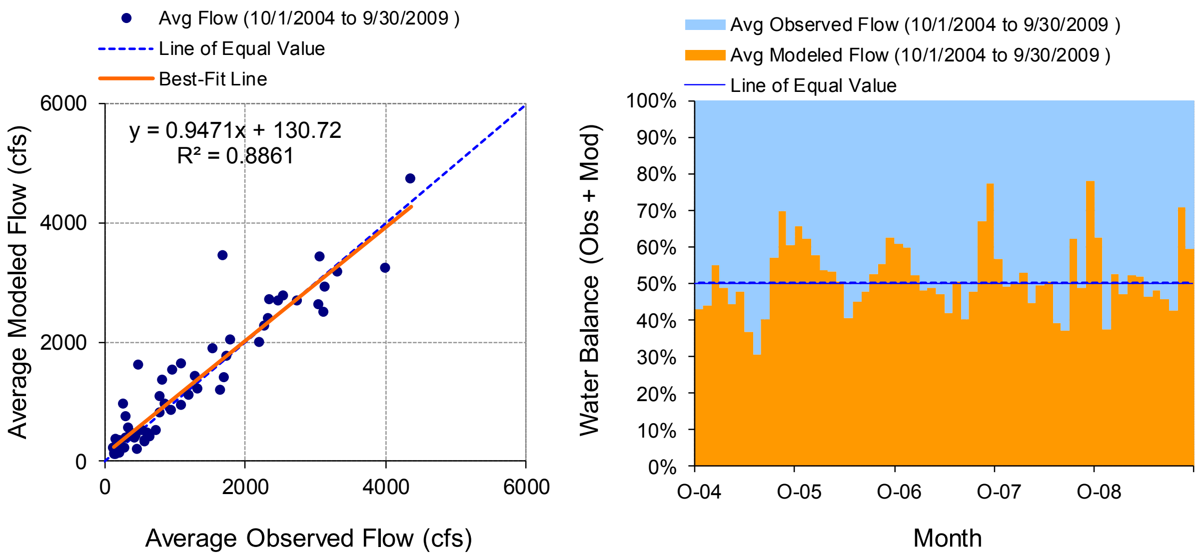


Figure D-74. Monthly flow regression and temporal variation at SJR near Fort Wayne, IN (USGS 04180500).

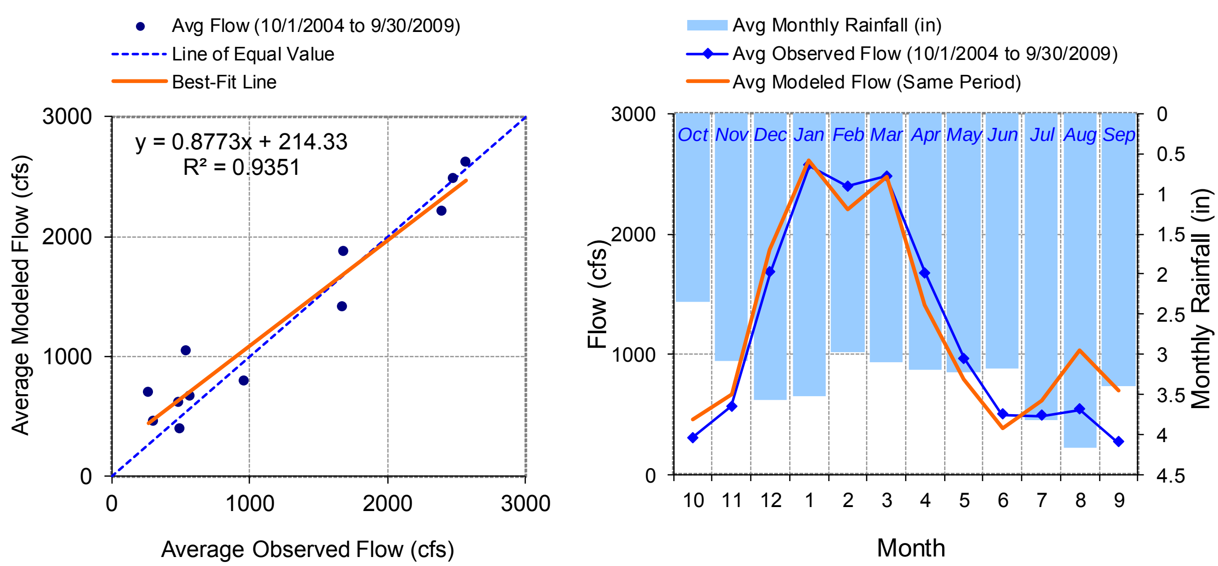


Figure D-75. Seasonal regression and temporal aggregate at SJR near Fort Wayne, IN (USGS 04180500).

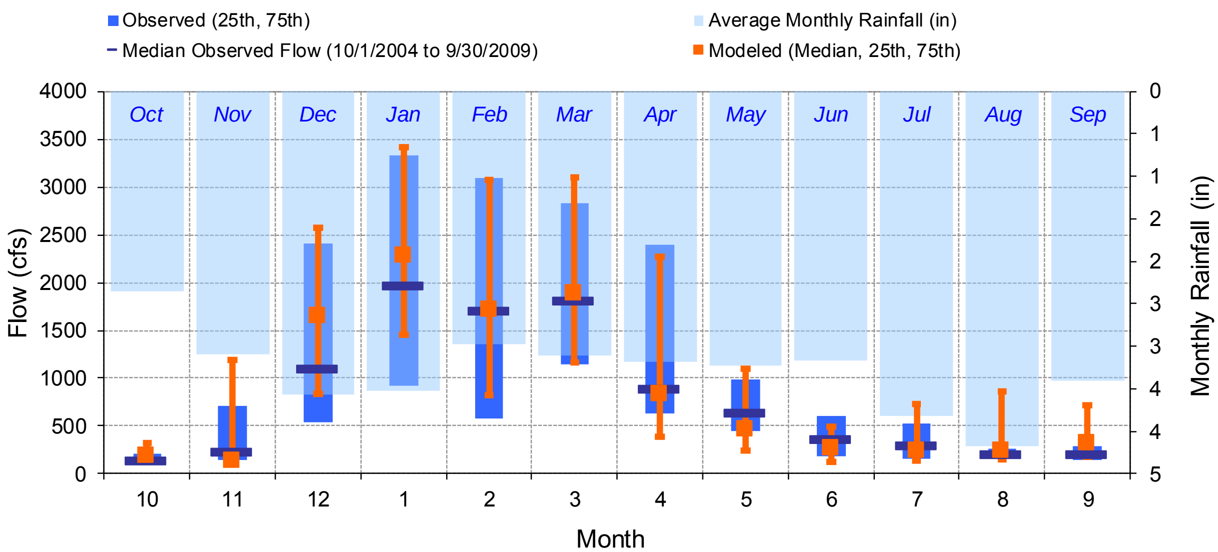


Figure D-76. Seasonal medians and ranges at SJR near Fort Wayne, IN (USGS 04180500).

Table D-40. Seasonal summary at SJR near Fort Wayne, IN (USGS 04180500).

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	306	140	115	206	458	187	144	326
Nov	565	235	147	715	666	134	107	1189
Dec	1681	1100	544	2415	1872	1650	836	2576
Jan	2569	1970	918	3325	2613	2283	1454	3418
Feb	2395	1710	580	3100	2205	1714	828	3071
Mar	2479	1810	1140	2830	2480	1893	1165	3099
Apr	1675	883	625	2398	1413	836	393	2265
May	964	639	443	983	789	469	247	1094
Jun	499	360	189	600	385	263	125	493
Jul	486	291	153	525	612	244	135	734
Aug	539	199	153	264	1036	244	153	863
Sep	265	198	149	292	695	327	171	718

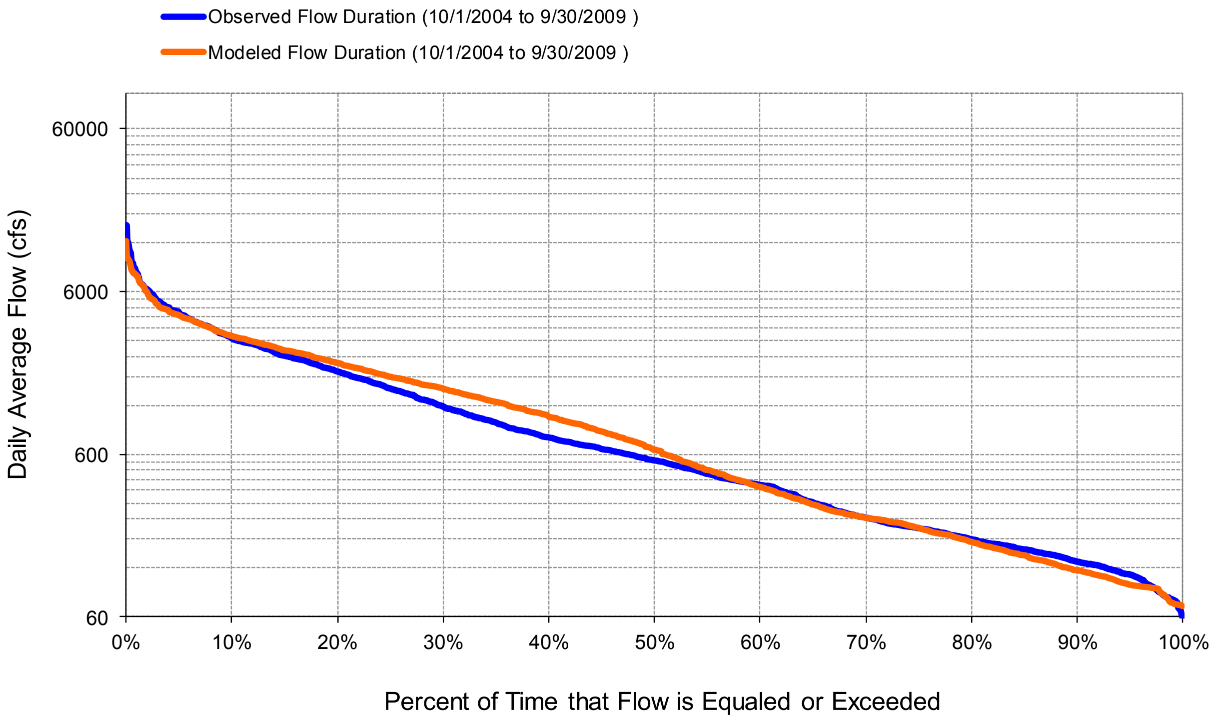


Figure D-77. Flow exceedance at SJR near Fort Wayne, IN (USGS 04180500).

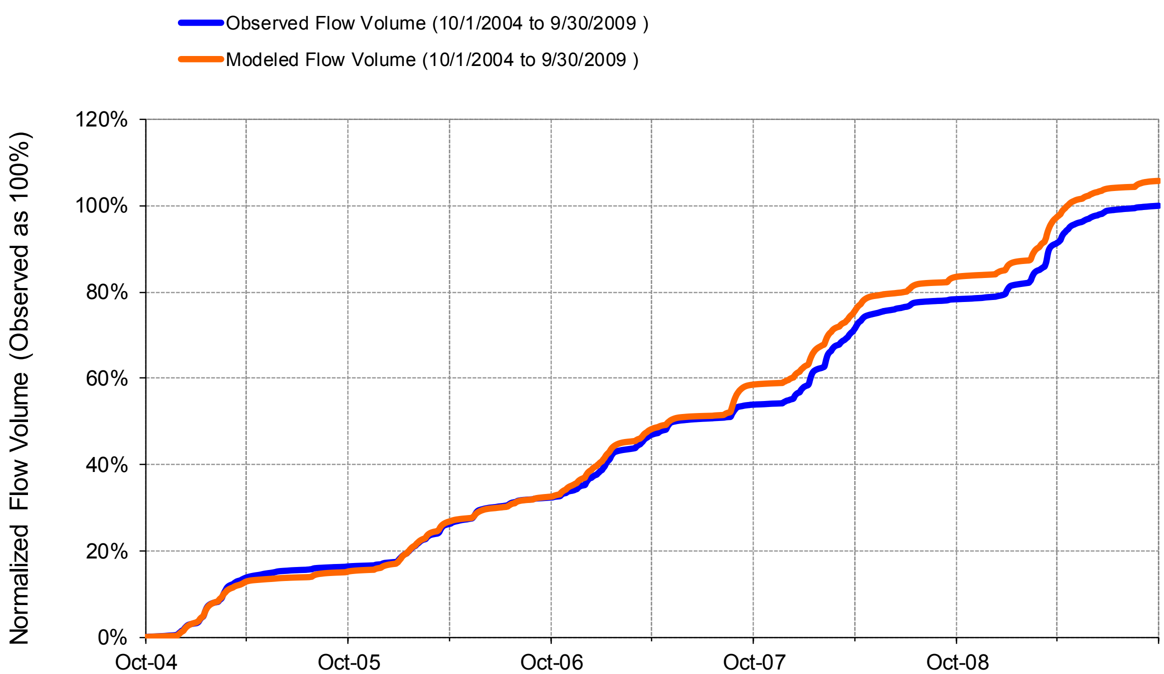


Figure D-78. Flow accumulation at SJR near Fort Wayne, IN (USGS 04180500).

Table D-41. Summary statistics at SJR near Fort Wayne, IN (USGS 04180500)

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 5 5-Year Analysis Period: 10/1/2004 - 9/30/2009 Flow volumes are (inches/year) for upstream drainage area		St. Joseph River near Fort Wayne, IN Manually Entered Data Drainage Area (sq-mi): 1060	
Total Simulated In-stream Flow:	**16.23**	Total Observed In-stream Flow:	**15.35**
Total of simulated highest 10% flows:	**6.25**	Total of Observed highest 10% flows:	**6.60**
Total of Simulated lowest 50% flows:	**1.59**	Total of Observed Lowest 50% flows:	**1.60**
Simulated Summer Flow Volume (months 7-9):	**2.52**	Observed Summer Flow Volume (7-9):	**1.39**
Simulated Fall Flow Volume (months 10-12):	**3.24**	Observed Fall Flow Volume (10-12):	**2.76**
Simulated Winter Flow Volume (months 1-3):	**7.72**	Observed Winter Flow Volume (1-3):	**7.86**
Simulated Spring Flow Volume (months 4-6):	**2.75**	Observed Spring Flow Volume (4-6):	**3.34**
Total Simulated Storm Volume:	**7.02**	Total Observed Storm Volume:	**7.69**
Simulated Summer Storm Volume (7-9):	**1.19**	Observed Summer Storm Volume (7-9):	**0.70**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	5.77	10		
Error in 50% lowest flows:	-0.05	10		
Error in 10% highest flows:	-5.27	15		
Seasonal volume error - Summer:	81.10	30		
Seasonal volume error - Fall:	17.43 >>	30	Clear	
Seasonal volume error - Winter:	-1.78	30		
Seasonal volume error - Spring:	-17.53	30		
Error in storm volumes:	-8.69	20		
Error in summer storm volumes:	70.40	50		
Nash-Sutcliffe Coefficient of Efficiency, E:	0.809	Model accuracy increases		
Baseline adjusted coefficient (Garrick), E':	0.648	as E or E' approaches 1.0		
Monthly NSE	0.878			

D-2.2 Water Quality Calibration and Validation

D-2.2.1 Methods

Water quality calibration and validation primarily focused on total suspended solids (TSS) and total phosphorus (TP). While calibration was also carried out for nitrogen and its species, these were deemed less important since the TMDLs are for TSS and TP.

Water quality data was available at gage locations monitored by the City of Fort Wayne, Ohio EPA, and Indiana Department of Environmental Management (IDEM). Water years 2009 to 2014 were used for calibration and water years 2005 to 2008 were used for validation. The locations of the water quality sites are used for calibration and validation shown in Table D-42 and Figure D-79.

Table D-42. Water quality calibration and validation sites in the SJRW

Agency	Site description	Station ID	Paired flow gage	Model subbasin	Data date range	Calibration	Validation
Ohio EPA	East Branch St. Joseph River, OH	PK08K29	*none*	92	2012-2014	X	
Ohio EPA	West Branch St. Joseph River, OH	PK08S21	Ohio EPA WBSJR	82	2012-2014	X	
Ohio EPA	Nettle Creek, OH	P08S06	*none*	76	2012-2014	X	
Ohio EPA	St. Joseph River, OH	P08S17	*none*	69	2012-2014	X	
IDEM	St. Joseph River, IN	LEJ050-0006	*none*	56	2004-2014	X	X
IDEM	Fish Creek near Artic, IN	LEJ050-0007	USGS 04177810	49	2004-2014	X	X
USGS		04177810			2004-2007		X
Ohio EPA	Fish Creek, OH	P08S20	*none*	47	2012-2014	X	
Ohio EPA	St Joseph River near Newville, IN	510220	USGS 04178000	43	2005-2014	X	X
IDEM	St. Joseph River, IN	LEJ060-0006	*none*	38	2004-2014	X	X
IDEM	Cedar Creek near Cedarville, IN	LEJ090-0026	USGS 04180000	9	2004-2014	X	X
IDEM	St Joseph River near Fort Wayne, IN	LEJ100-0002	USGS 04180500	5	2004-2011	X	X
City of Fort Wayne		Mayhew Road			2004-2014		
IDEM	St Joseph River near outlet	LEJ100-0003	*none*	2	2004-2014	X	X
City of Fort Wayne		Tennessee Avenue			2004-2014	X	X

Note: IDEM = Indiana Department of Environmental Management; Ohio EPA = Ohio Environmental Protection Agency; USGS = U.S. Geological Survey.

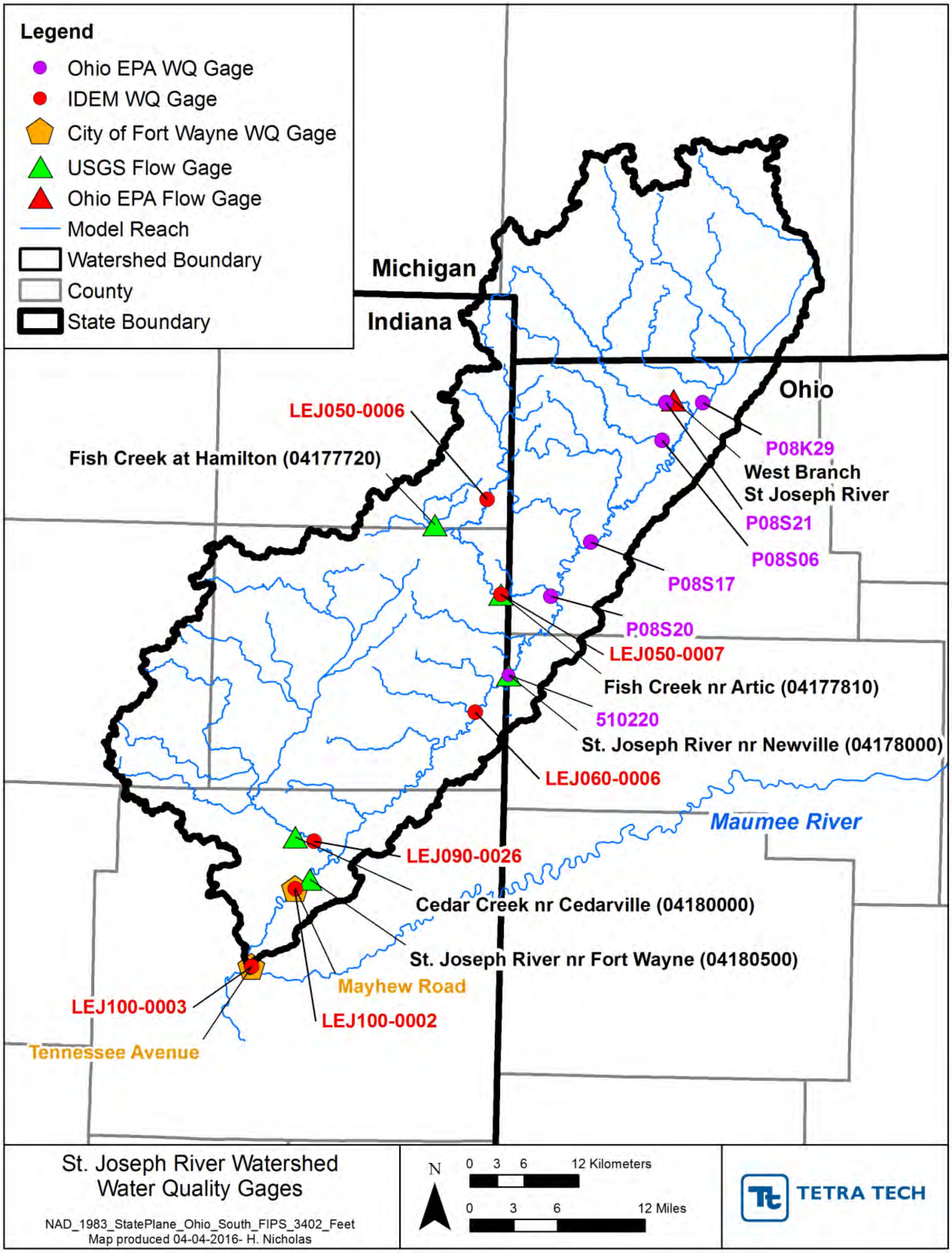


Figure D-79. Water quality calibration and validation sites in the SJRW.

Consistent with recommendations of Moriasi et al. (2007), evaluation of SWAT water quality calibration focused on replicating monthly loads. For simulation of pollutant loads, Moriasi et al. (2007) summarized recent research and recommended performance targets. Refer back to Table D-18 in Section D-2.1.1for the performance criteria for nutrients and sediment.

Moriasi et al. (2007) note that these comparisons are most appropriate for evaluating water quality simulations when a nearly complete measured time-series exists. Alternatively, when only scattered grab samples are available, "comparison of frequency distributions and/or percentiles…may be more appropriate than the quantitative statistics guidelines" (page 892). Comparison of model results to monthly loads presents challenges because monthly loads are not observed. Instead, monthly loads must be estimated from scattered concentration grab samples and continuous flow records. As a result, the monthly load calibration is inevitably based on comparing two uncertain numbers.

The USGS program LOADEST (Runkel *et al.*, 2004) was used to generate time-series of water quality constituents using regression techniques at locations with continuous flow data. The load comparisons were supported by detailed examinations of the relationships of flows to loads and concentrations and the distribution of concentration prediction errors versus flow, time, and season, as well as standard time-series plots.

A regression approach was not possible for water quality gages without continuous flow monitoring data. As a result, calibration and validation at such locations consisted of paired comparison of comparing simulated and observed sediment and nutrient concentrations.

Water quality calibration was conducted manually and the parameters adjusted during the calibration and validation process are listed below. Table D-43 shows the values of these parameters in the calibrated and validated model.

a) Basin level parameters
   - PRF - Peak rate adjustment factor for sediment routing in the main channel
   - SPCON - Linear parameter for calculating the maximum amount of sediment that can be re-entrained during channel sediment routing
   - CDN - Denitrification exponential rate coefficient
   - SDNCO - Denitrification threshold water content
   - NPERCO - Nitrogen percolation coefficient
   - PPERCO - Phosphorus percolation coefficient
   - PHOSKD - Phosphorus soil partitioning coefficient
   - PSP - Phosphorus sorption coefficient

b) HRU level parameters
   - ERORGN - Organic nitrogen enrichment ratio
   - ERORGP - Organic phosphorus enrichment ratio
   - LAT_ORGN - Organic nitrogen in baseflow (mg/l)
   - USLE_P - USLE equation support practice factor

Table D-43. Values of parameters in the model

Parameter	Value
PRF	0.8
SPCON	0.0001 – 0.0007
CDN	0.3
SDNCO	1
NPERCO	0.5
PPERCO	10
PHOSKD	200
PSP	0.2
ERORGN	2
ERORGP	0.25
LAT_ORGN	2
USLE_P	0.5,1

D-2.2.2 Results and Discussion

D-2.2.2.1 Load Comparison

SWAT simulated monthly sediment and nutrient loads were compared against regression loads generated using LOADEST. The SWAT model performance for TSS and TP for the calibration and validation periods vary between satisfactory and very good. The performance is unsatisfactory for TSS at the Fish Creek gage. The model performance for TN varies between satisfactory and very good depending on the location. While model performance for TKN varies between satisfactory and very good, the model performance for NOx is unsatisfactory. It is important to note that nitrate loads are often strongly associated with groundwater and do not show a correlation with streamflow. Regression is not likely the ideal approach to estimate NOx loads under such conditions. However, nitrogen-species calibration and validation is of less of a concern because TMDLs and linkage analyses were only developed for TP and TSS.

In the figures in Section D-2.2.2.1.1 through Section D-2.2.2.1.4, the error bars represent the standard error of prediction associated with each regression data point.

D-2.2.2.1.1 LEJ050-0007 - Fish Creek at Artic, IN (SWAT Subbasin # 49)

Table D-44. Evaluation of SWAT model performance at Fish Creek near Artic, IN

Statistic		TSS		TP		TKN		NOX		TN	
		Cal	Val	Cal	Val	Cal	Val	Cal	Val	Cal	Val
NSE	Value	No flow data for regression	0.14	No flow data for regression	0.78	No flow data for regression	0.63	No flow data for regression	0.46	No flow data for regression	0.68
	Performance		U		VG		S		U		G
RSR	Value		0.93		0.47		0.61		0.74		0.57
	Performance		U		VG		S		U		G
RE	Value		-14.1%		-7.0%		-5.2%		15.8%		-1.3%
	Performance		VG		VG		VG		VG		VG

Notes
Cal = calibration; G = good; NOx = nitrate plus nitrite; NSE = Nash-Sutcliffe coefficient; RE = relative average error; RSR = root mean square error-observation standard deviation ratio; S = satisfactory; TKN = total Kjeldahl nitrogen; TP = total phosphorus; TSS = total suspended solids; U = unsatisfactory; Val = validation; VG = very good.
Evaluation of SWAT model performance for water quality constituent loads at a monthly time-step for the calibration and validation periods (negative indicates over-prediction).

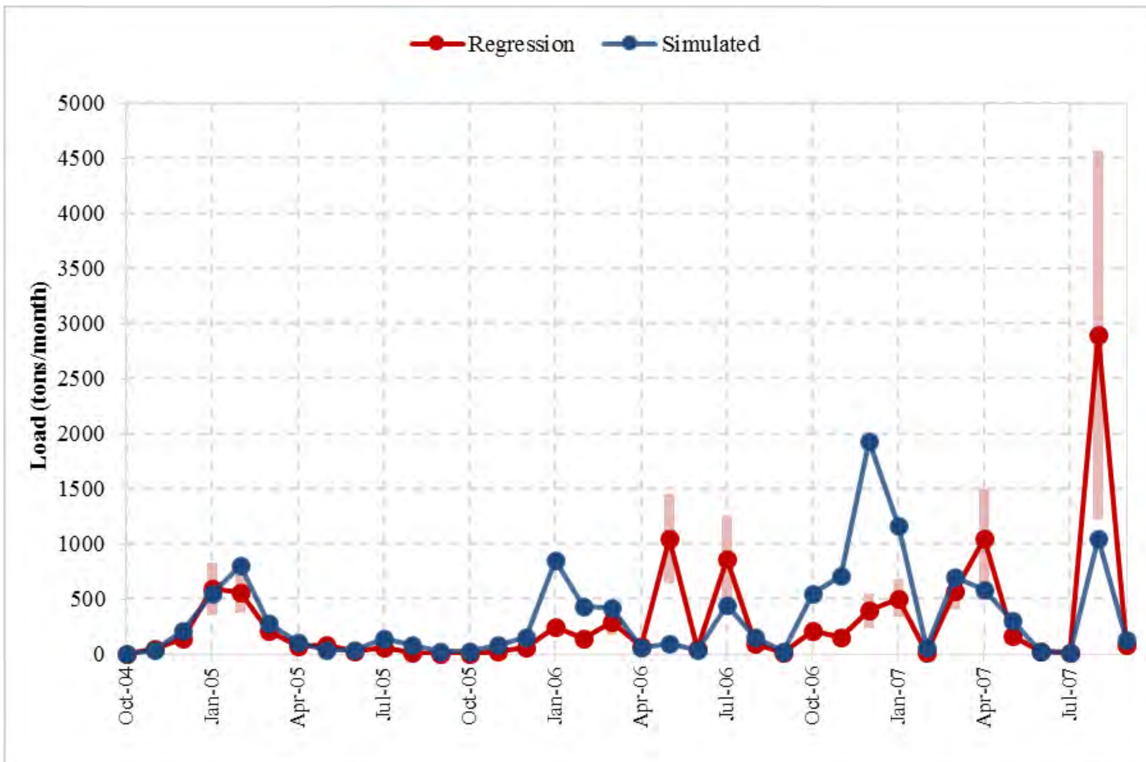


Figure D-80. Monthly simulated and regression TSS loads at LEJ050-0007 (validation period).

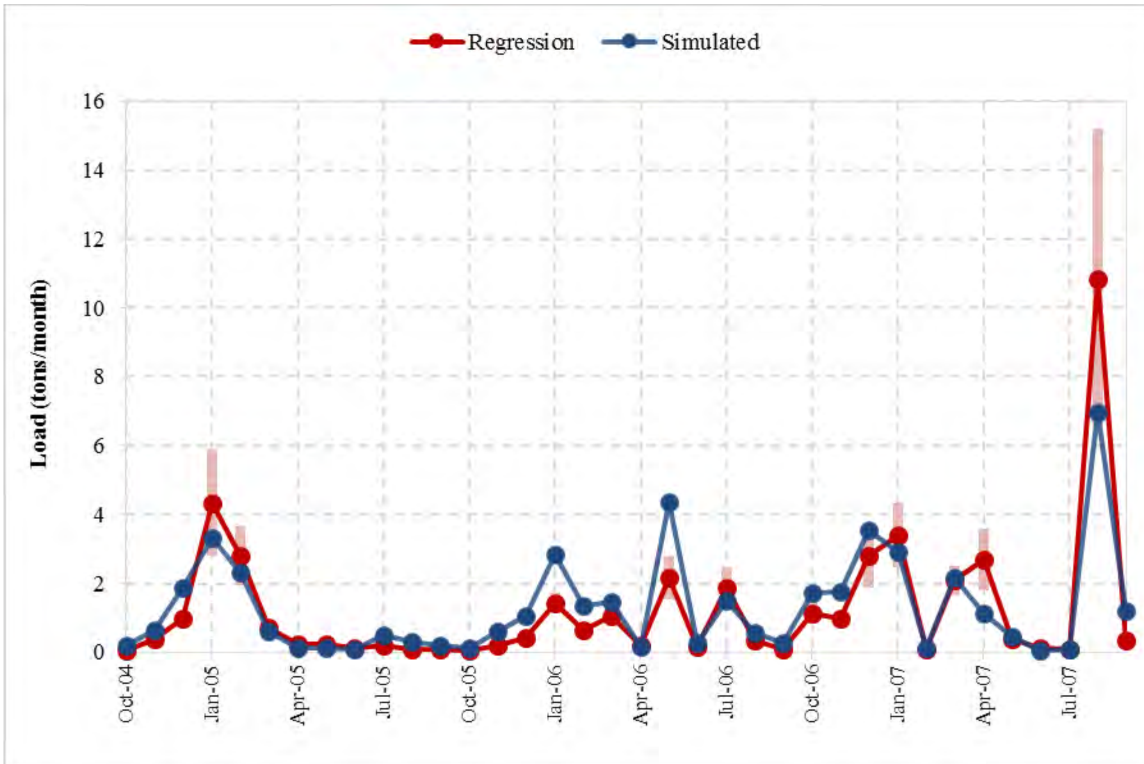


Figure D-81. Monthly simulated and regression TP loads at LEJ050-0007 (validation period).

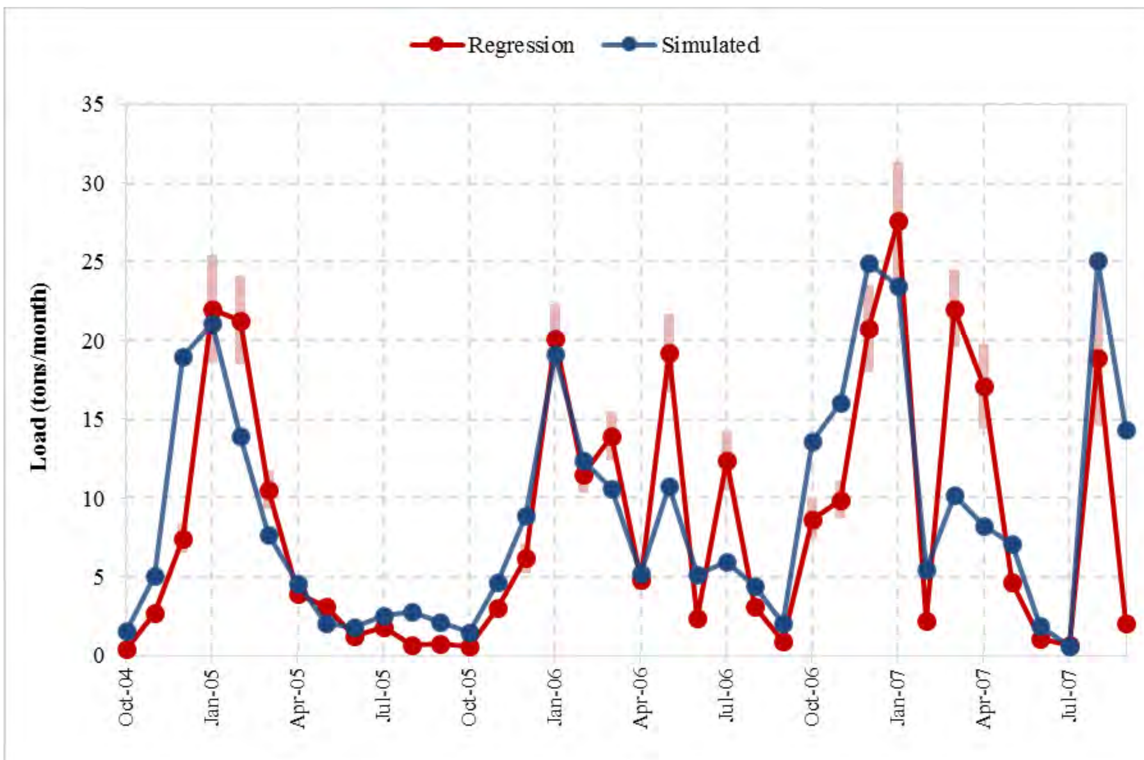


Figure D-82. Monthly simulated and regression TKN loads at LEJ050-0007 (validation period).

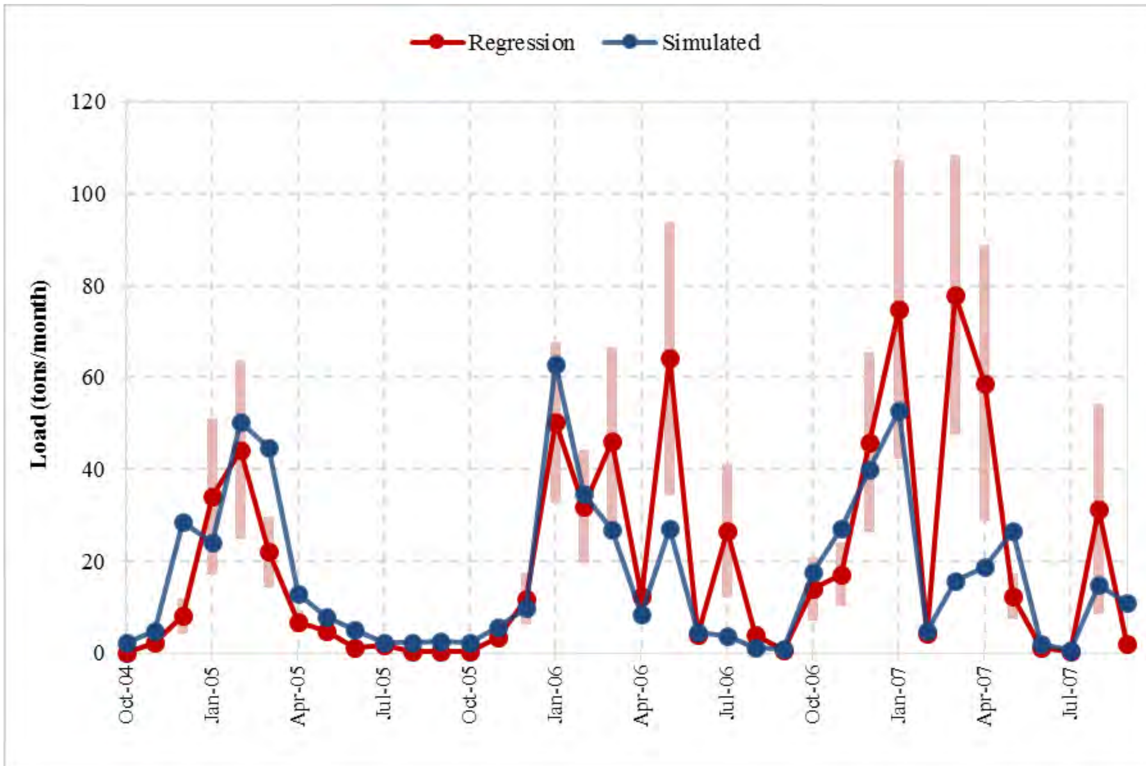


Figure D-83. Monthly simulated and regression NOX loads at LEJ050-0007 (validation period).

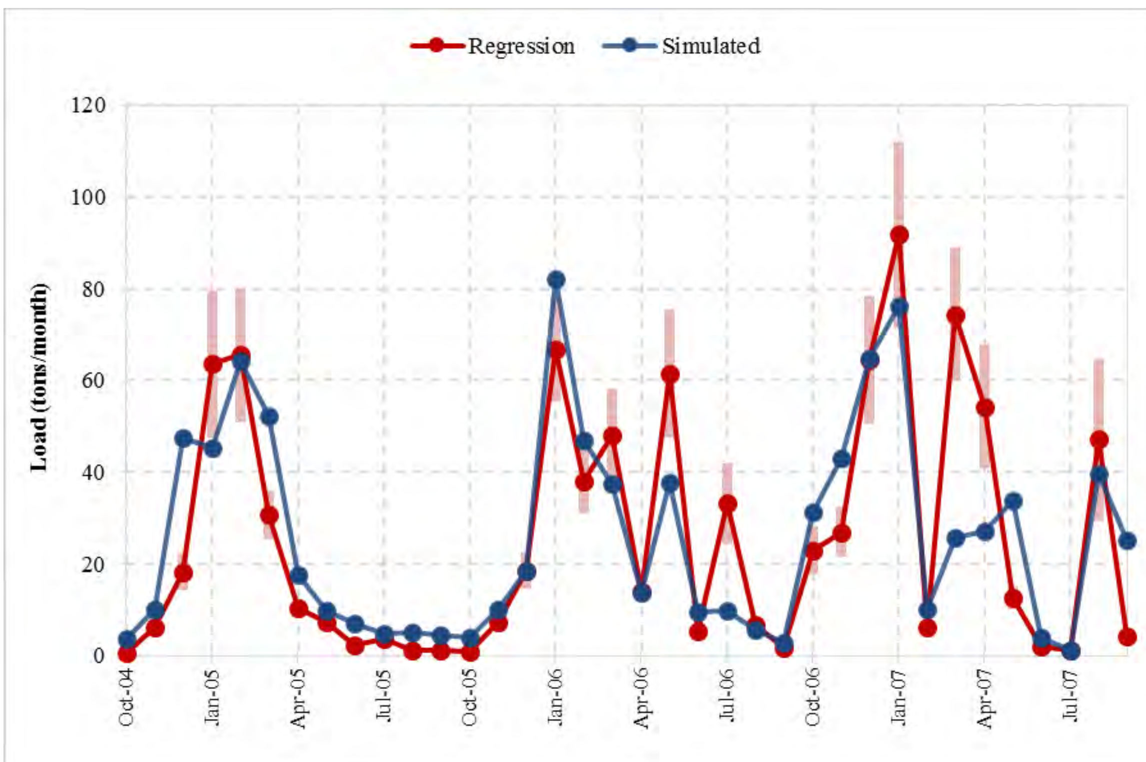


Figure D-84. Monthly simulated and regression TN loads at LEJ050-0007 (validation period).

D-2.2.2.1.2 LEJ090-0026 - Cedar Creek near Cedarville, IN (SWAT Subbasin # 9)

Table D-45. Evaluation of SWAT model performance at Cedar Creek near Cedarville, IN

Statistic		TSS		TP		TKN		NOX		TN	
		Cal	Val	Cal	Val	Cal	Val	Cal	Val	Cal	Val
NSE	Value	0.58	0.53	0.78	0.83	0.77	0.68	0.37	0.40	0.53	0.51
	Performance	S	S	VG	VG	VG	G	U	U	S	S
RSR	Value	0.65	0.69	0.47	0.41	0.48	0.56	0.79	0.78	0.69	0.70
	Performance	S	S	VG	VG	VG	G	U	U	S	S
RE	Value	16.1%	27.4%	-13.2%	3.8%	8.4%	21.0%	39.4%	40.2%	31.5%	35.4%
	Performance	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG

Notes

Cal = calibration; G = good; NOx = nitrate plus nitrite; NSE = Nash-Sutcliffe coefficient; RE = relative average error; RSR = root mean square error-observation standard deviation ratio; S = satisfactory; TKN = total Kjeldahl nitrogen; TP = total phosphorus; TSS = total suspended solids; U = unsatisfactory; Val = validation; VG = very good.

Evaluation of SWAT model performance for water quality constituent loads at a monthly time-step for the calibration and validation periods (negative indicates over-prediction).

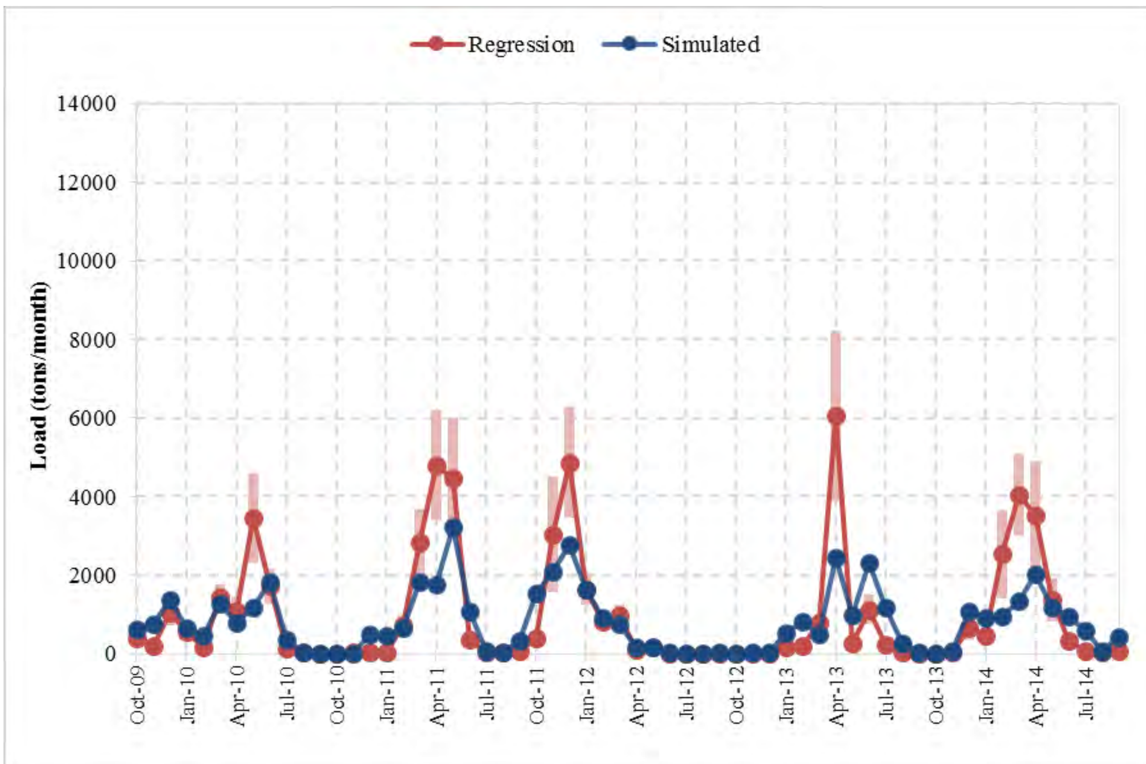


Figure D-85. Monthly simulated and regression TSS loads at LEJ090-0026 (calibration period).

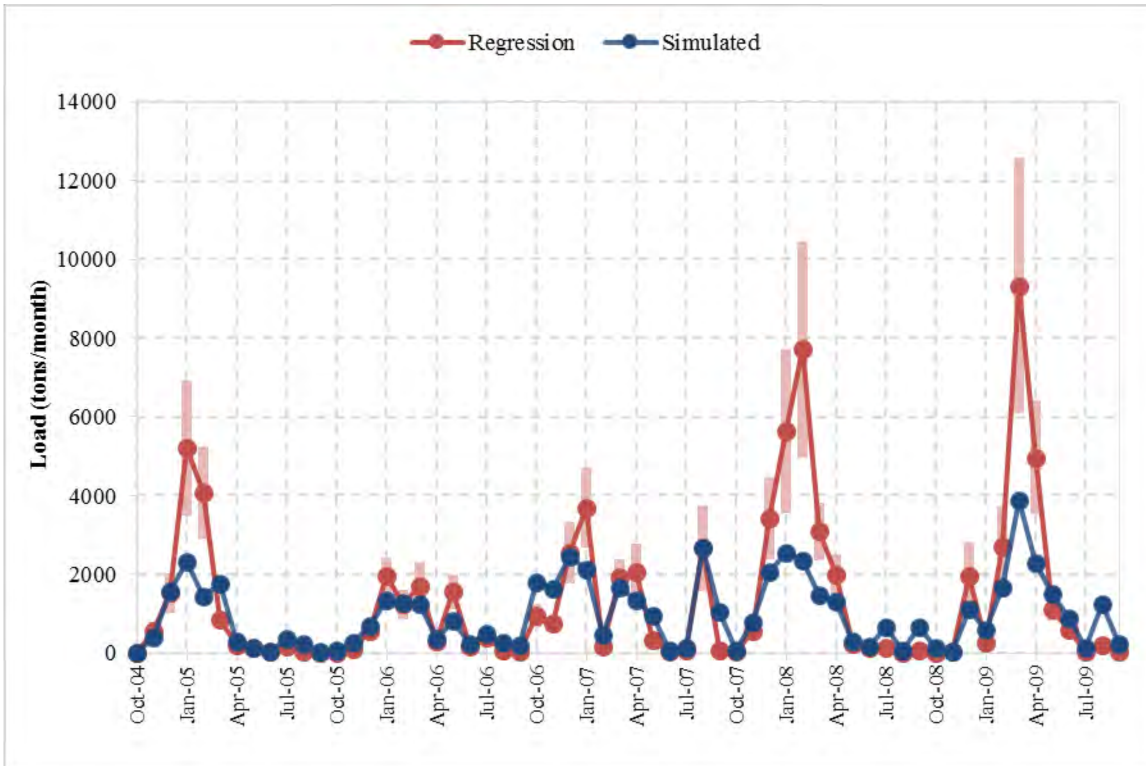


Figure D-86. Monthly simulated and regression TSS loads at LEJ090-0026 (validation period).

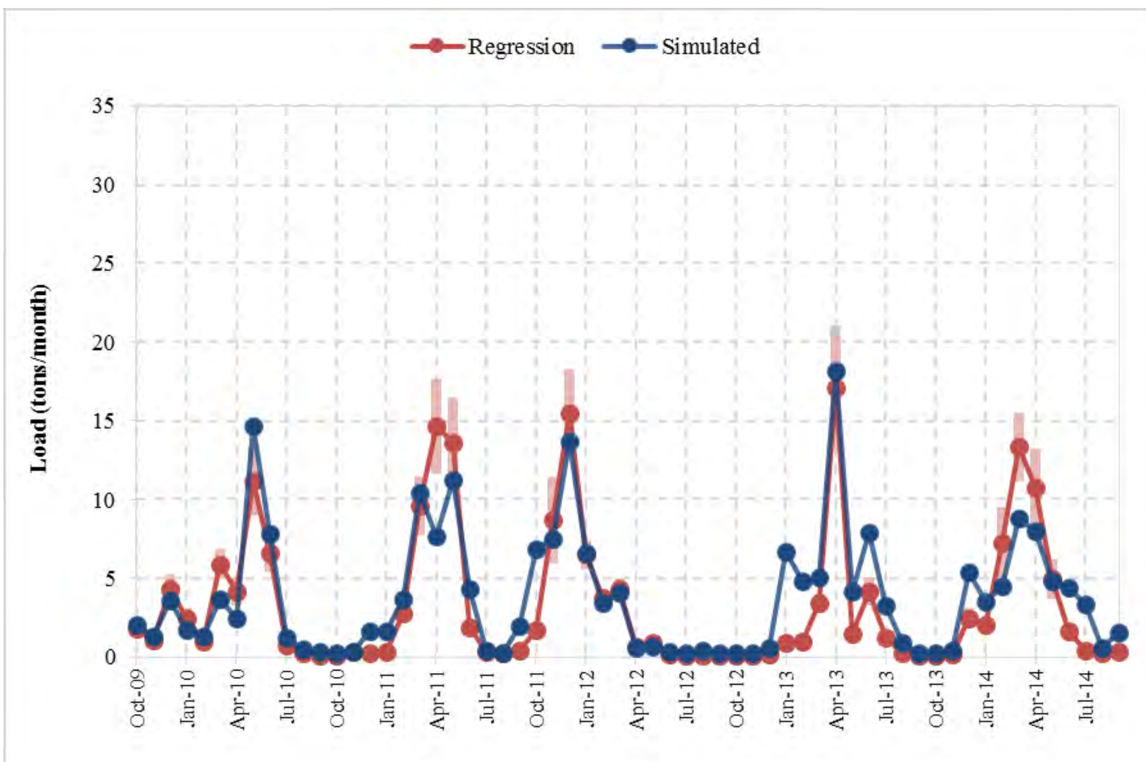


Figure D-87. Monthly simulated and regression TP loads at LEJ090-0026 (calibration period).

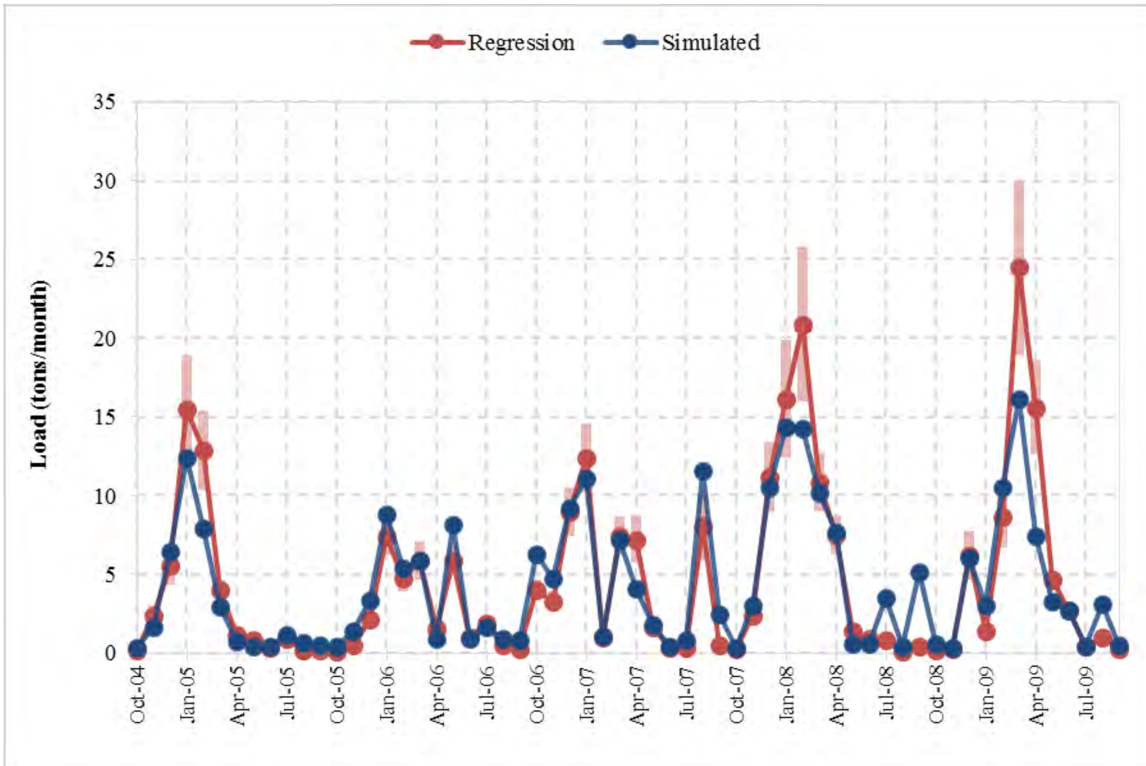


Figure D-88. Monthly simulated and regression TP loads at LEJ090-0026 (validation period).

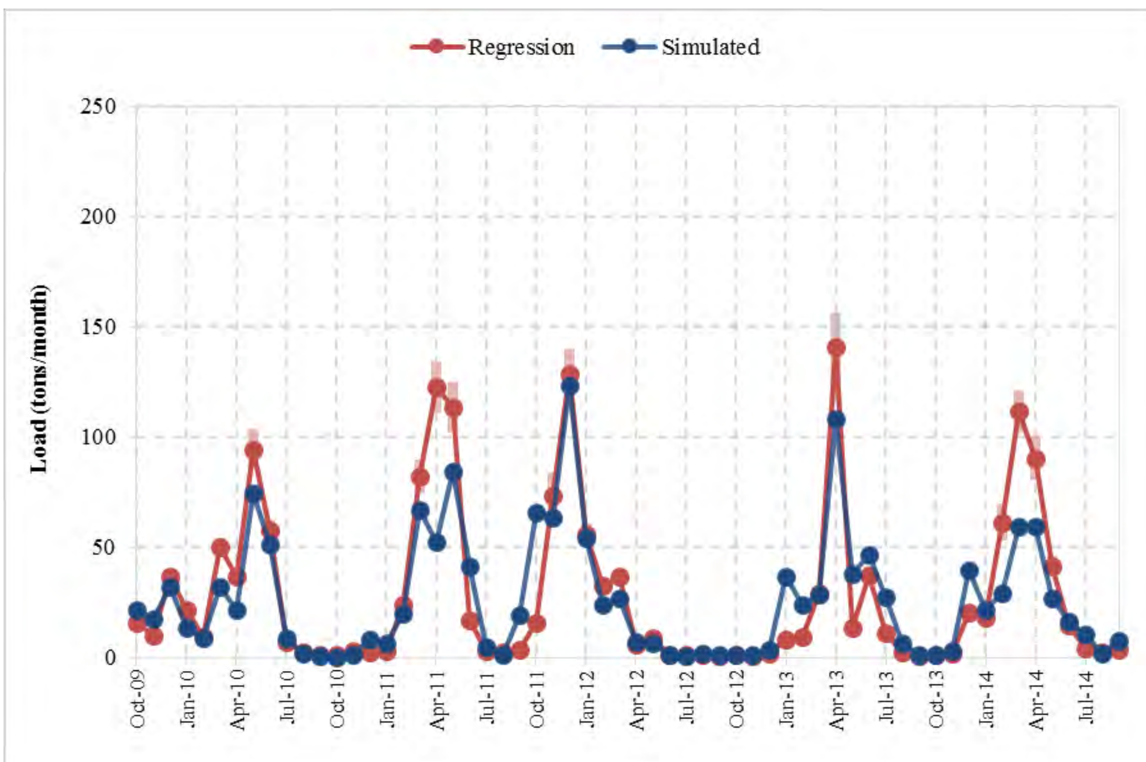


Figure D-89. Monthly simulated and regression TKN loads at LEJ090-0026 (calibration period).

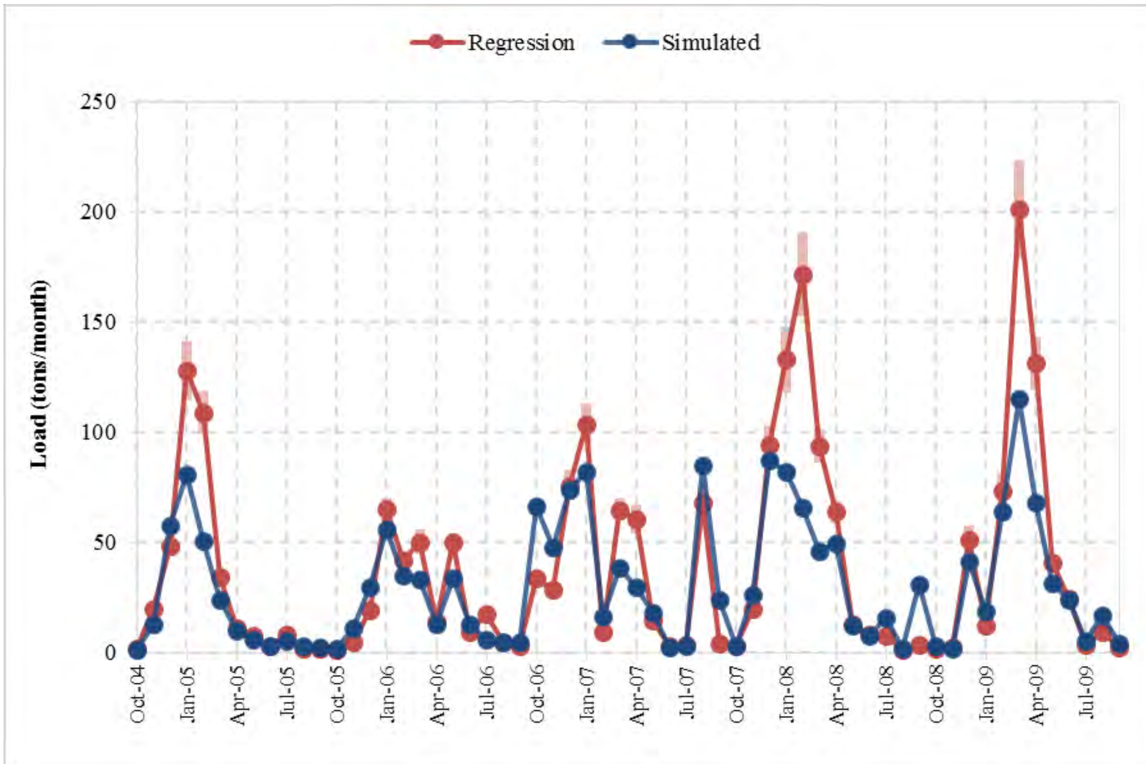


Figure D-90. Monthly simulated and regression TKNP loads at LEJ090-0026 (validation period).

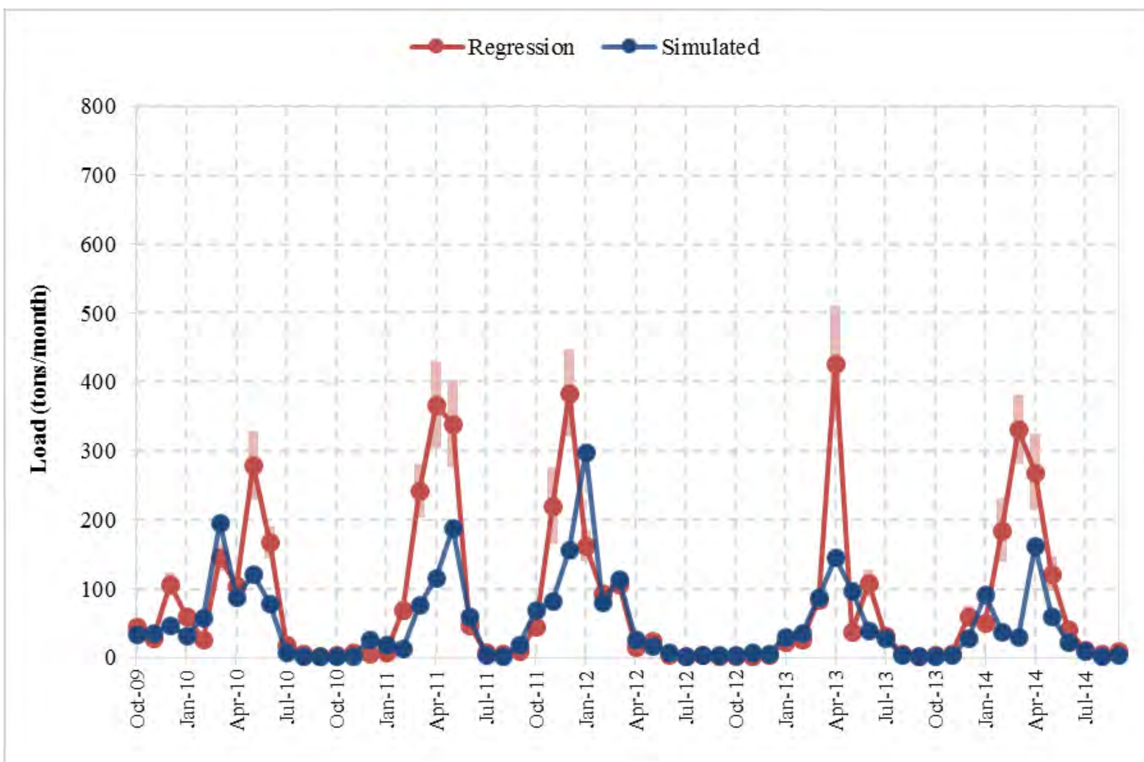


Figure D-91. Monthly simulated and regression NOX loads at LEJ090-0026 (calibration period).

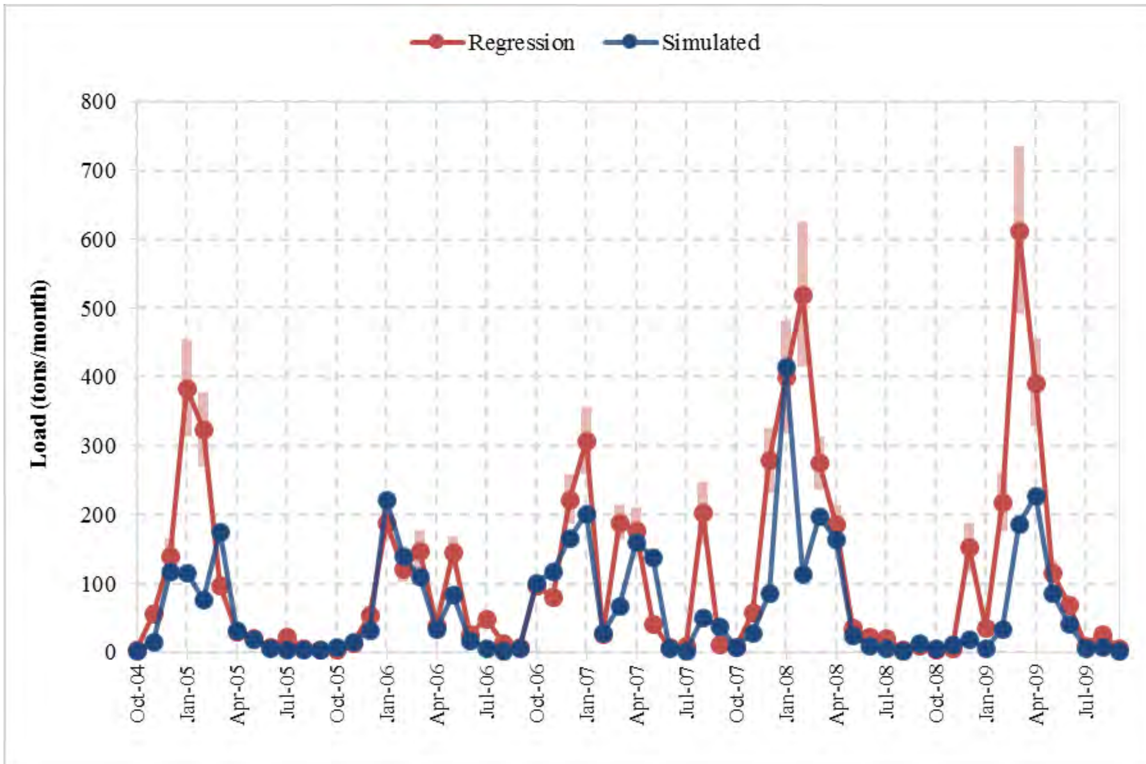


Figure D-92. Monthly simulated and regression NOX loads at LEJ090-0026 (validation period).

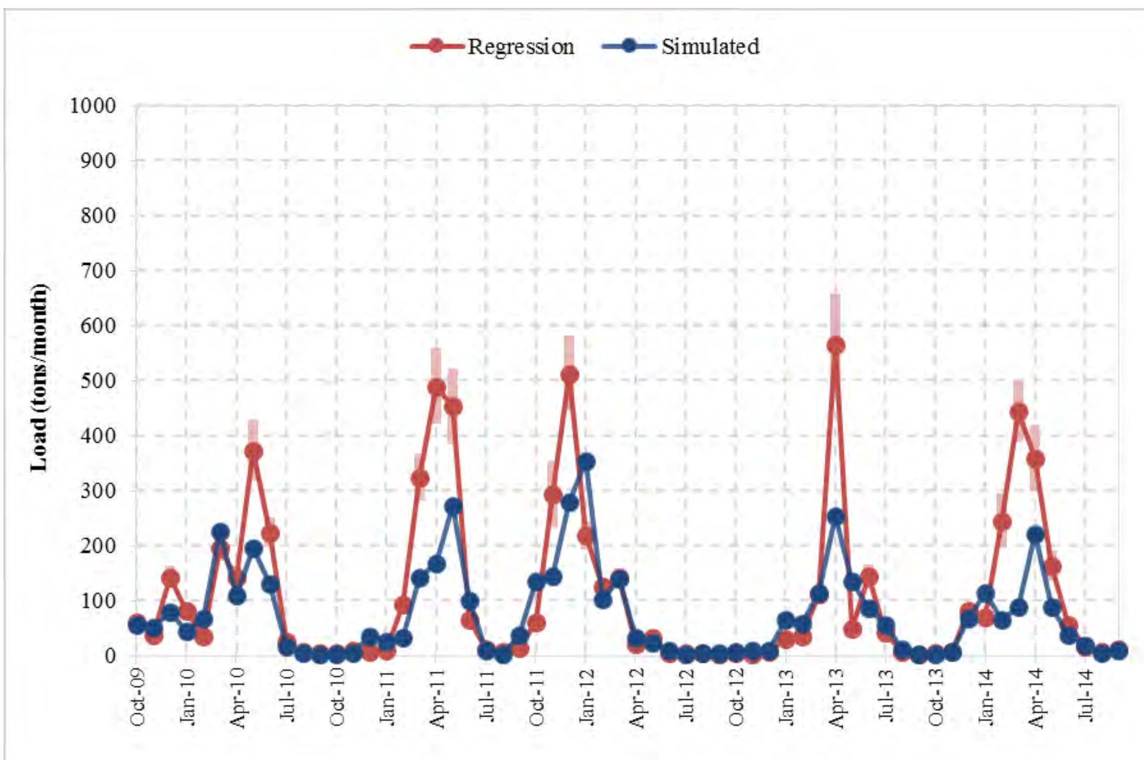


Figure D-93. Monthly simulated and regression TN loads at LEJ090-0026 (calibration period).

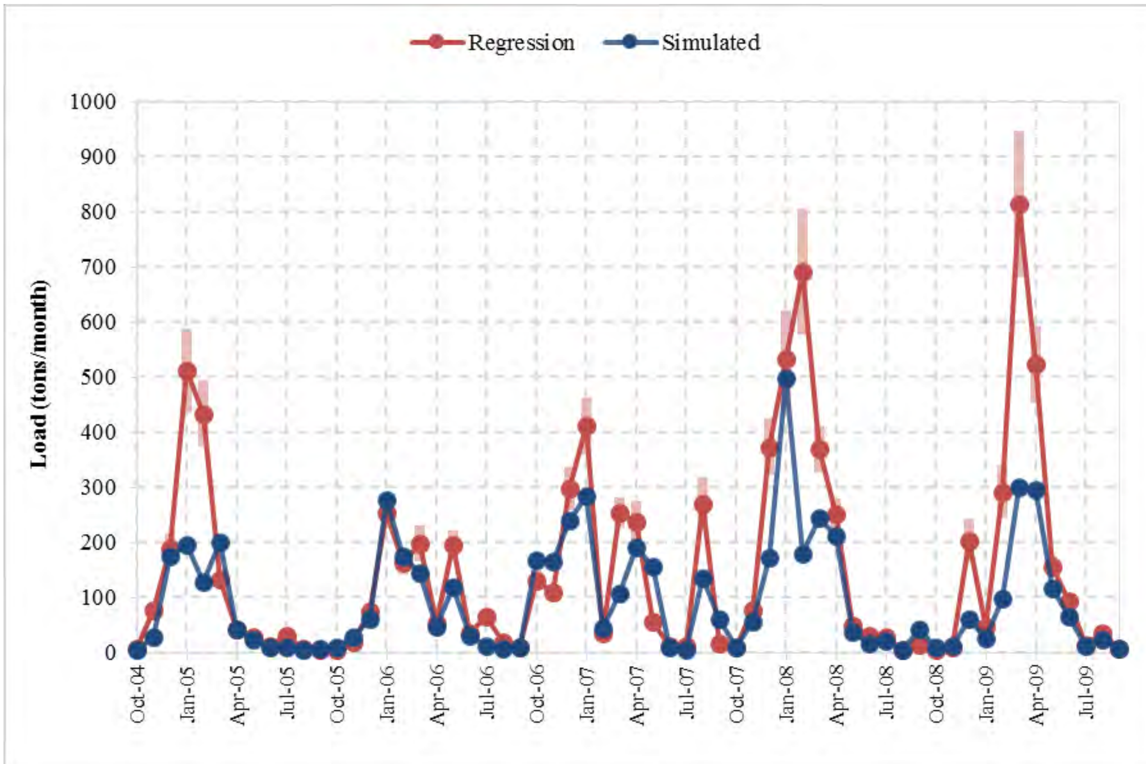


Figure D-94. Monthly simulated and regression TN loads at LEJ090-0026 (validation period).

D-2.2.2.1.3 510220 - St. Joseph River near Newville, IN (SWAT Subbasin # 43)

Table D-46. Evaluation of SWAT model performance at St. Joseph River near Newville, IN

Statistic		TSS		TP		TKN		NOX		TN	
		Cal	Val	Cal	Val	Cal	Val	Cal	Val	Cal	Val
NSE	Value	0.73	0.56	0.76	0.59	0.82	0.75	0.68	0.55	0.76	0.67
	Performance	G	S	VG	S	VG	G	G	S	VG	G
RSR	Value	0.52	0.66	0.49	0.64	0.43	0.50	0.57	0.67	0.49	0.58
	Performance	G	S	VG	S	VG	G	G	S	VG	G
RE	Value	16.1%	2.9%	-18.3%	-10.4%	-4.1%	5.3%	9.5%	15.5%	2.4%	9.4%
	Performance	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG

Notes

Cal = calibration; G = good; NOx = nitrate plus nitrite; NSE = Nash-Sutcliffe coefficient; RE = relative average error; RSR = root mean square error-observation standard deviation ratio; S = satisfactory; TKN = total Kjeldahl nitrogen; TP = total phosphorus; TSS = total suspended solids; U = unsatisfactory; Val = validation; VG = very good.

Evaluation of SWAT model performance for water quality constituent loads at a monthly time-step for the calibration and validation periods (negative indicates over-prediction).

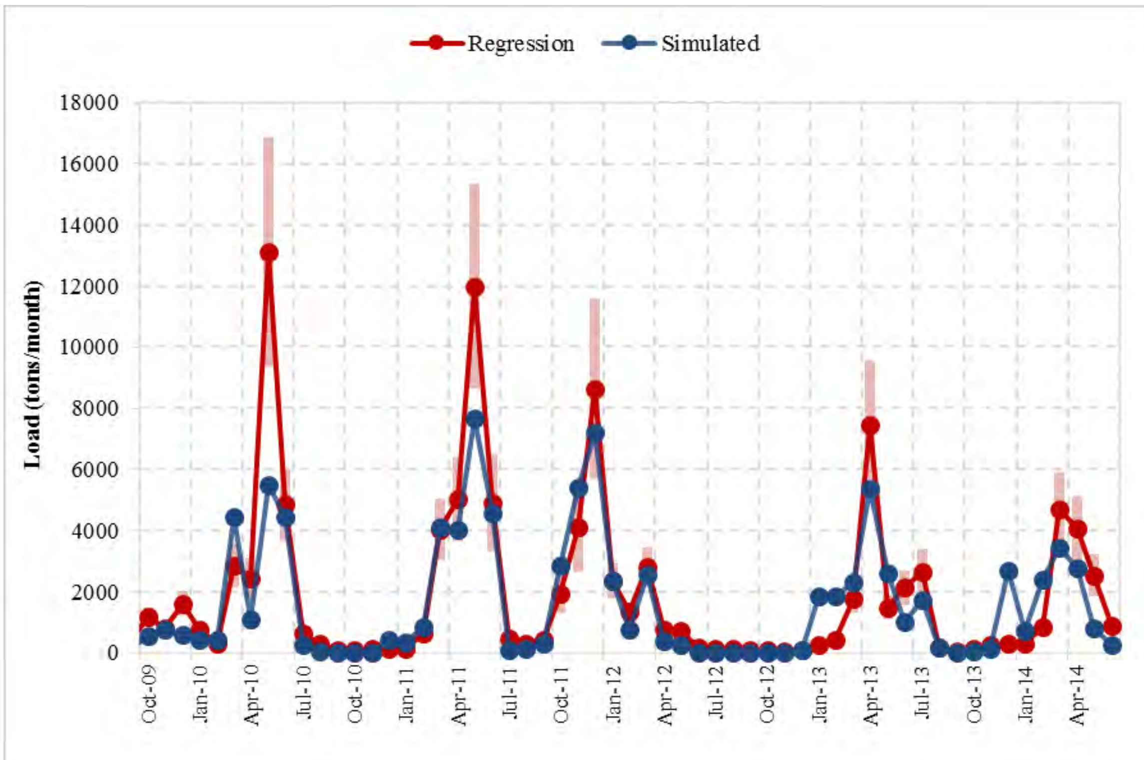


Figure D-95. Monthly simulated and regression TSS loads at 510220 (calibration period).

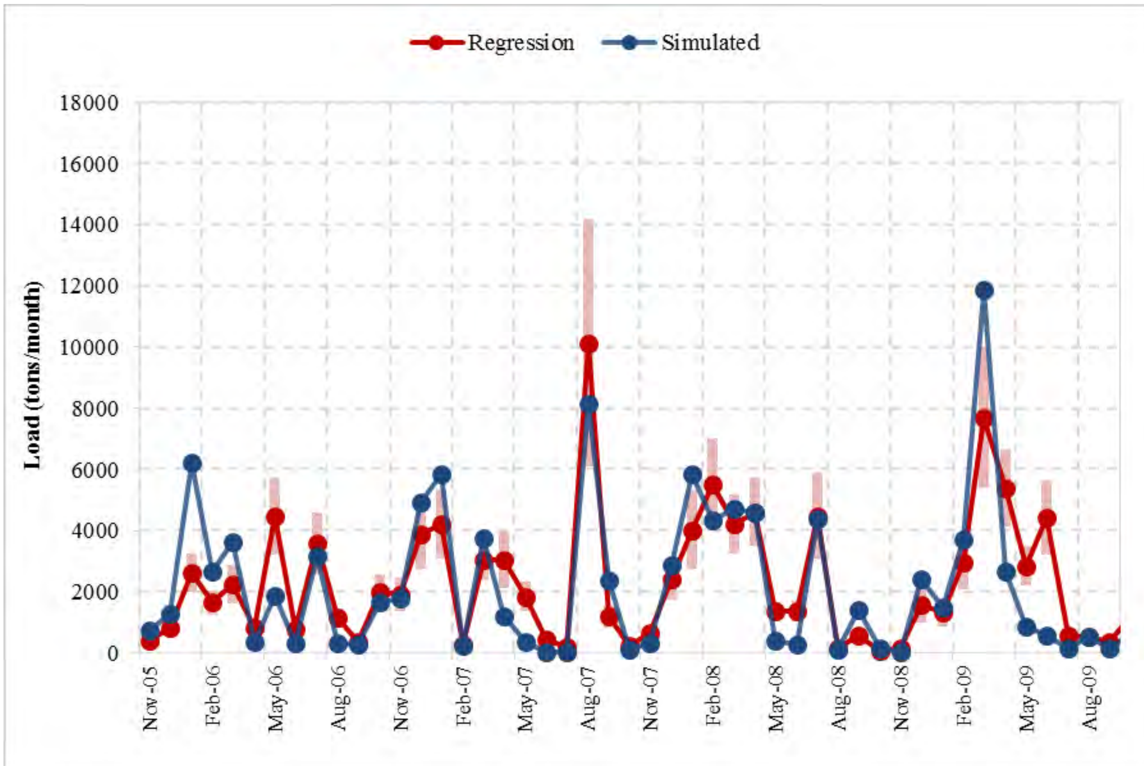


Figure D-96. Monthly simulated and regression TSS loads at 510220 (validation period).

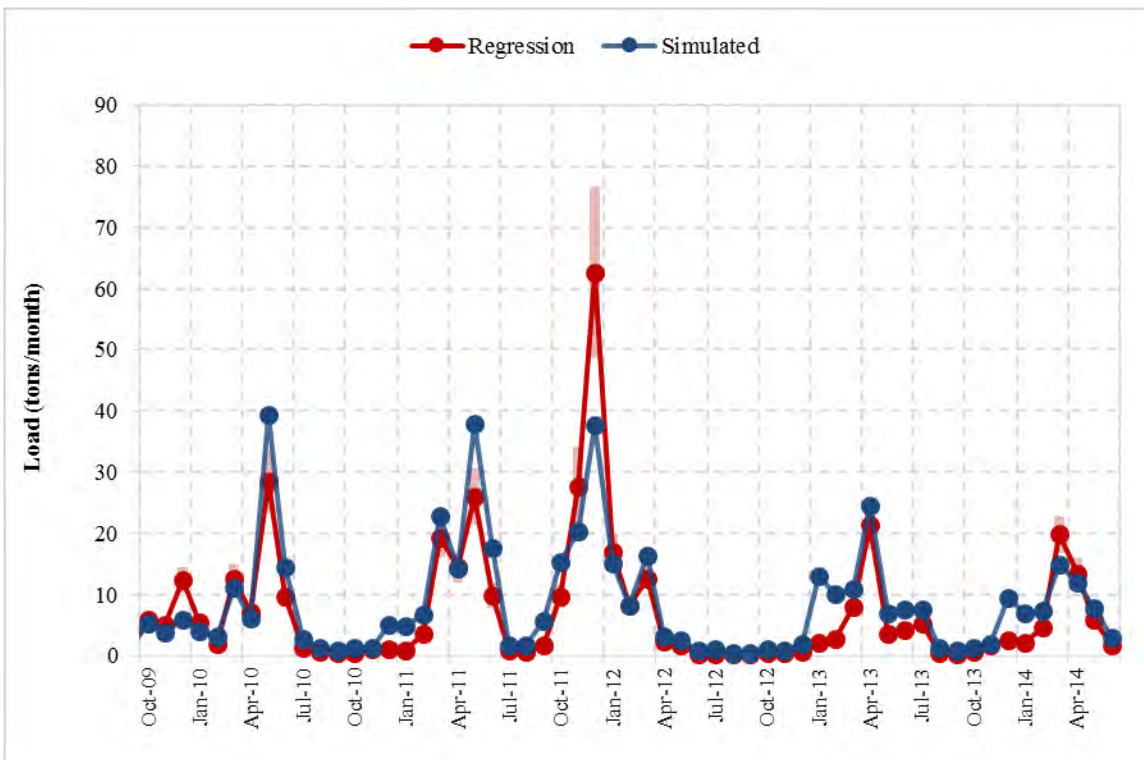


Figure D-97. Monthly simulated and regression TP loads at 510220 (calibration period).

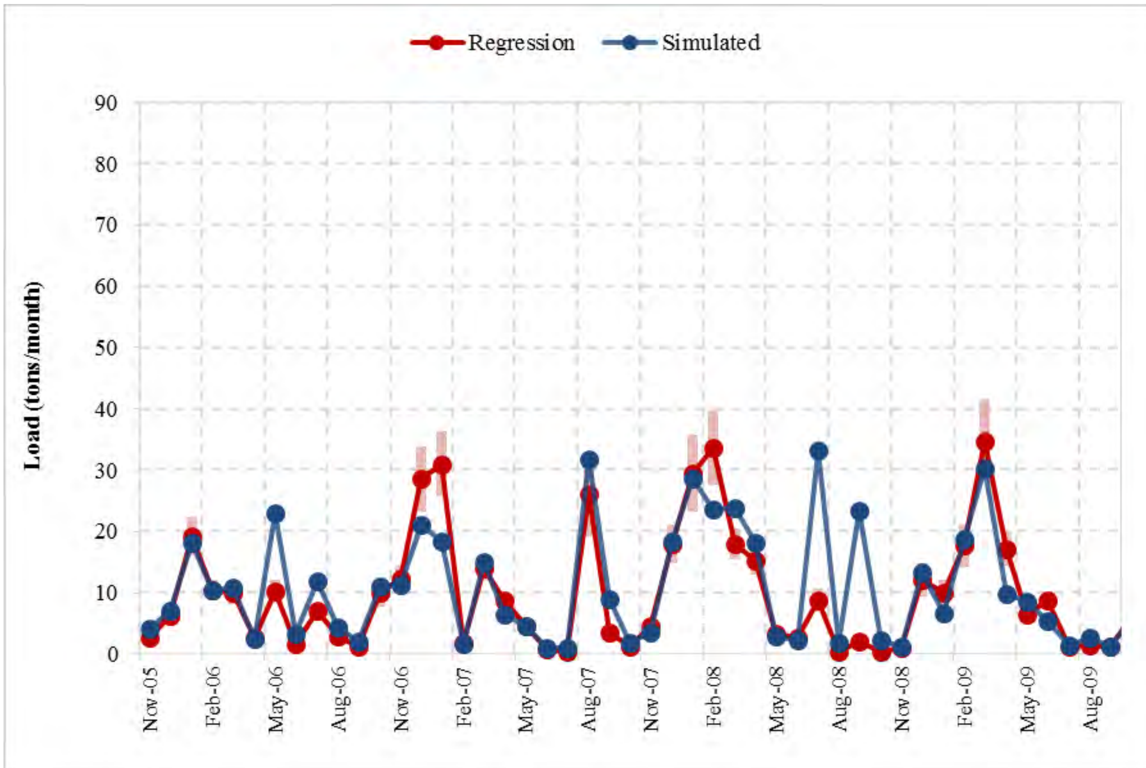


Figure D-98. Monthly simulated and regression TP loads at 510220 (validation period).

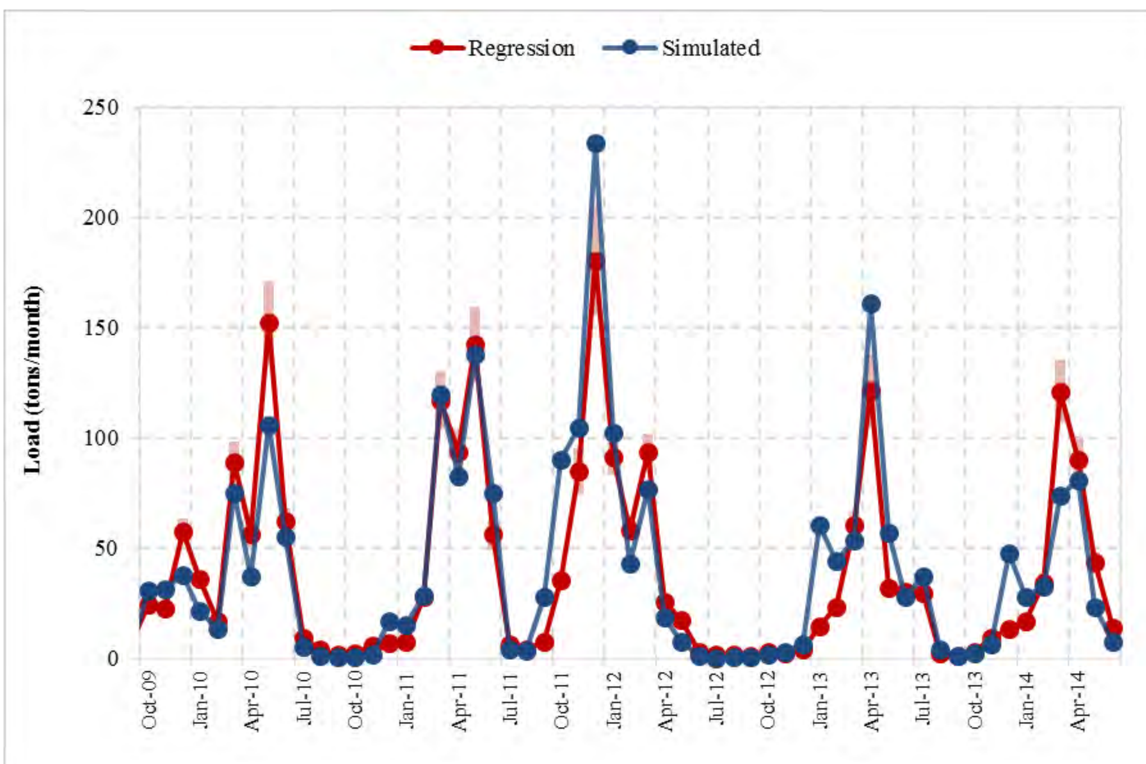


Figure D-99. Monthly simulated and regression TKN loads at 510220 (calibration period).

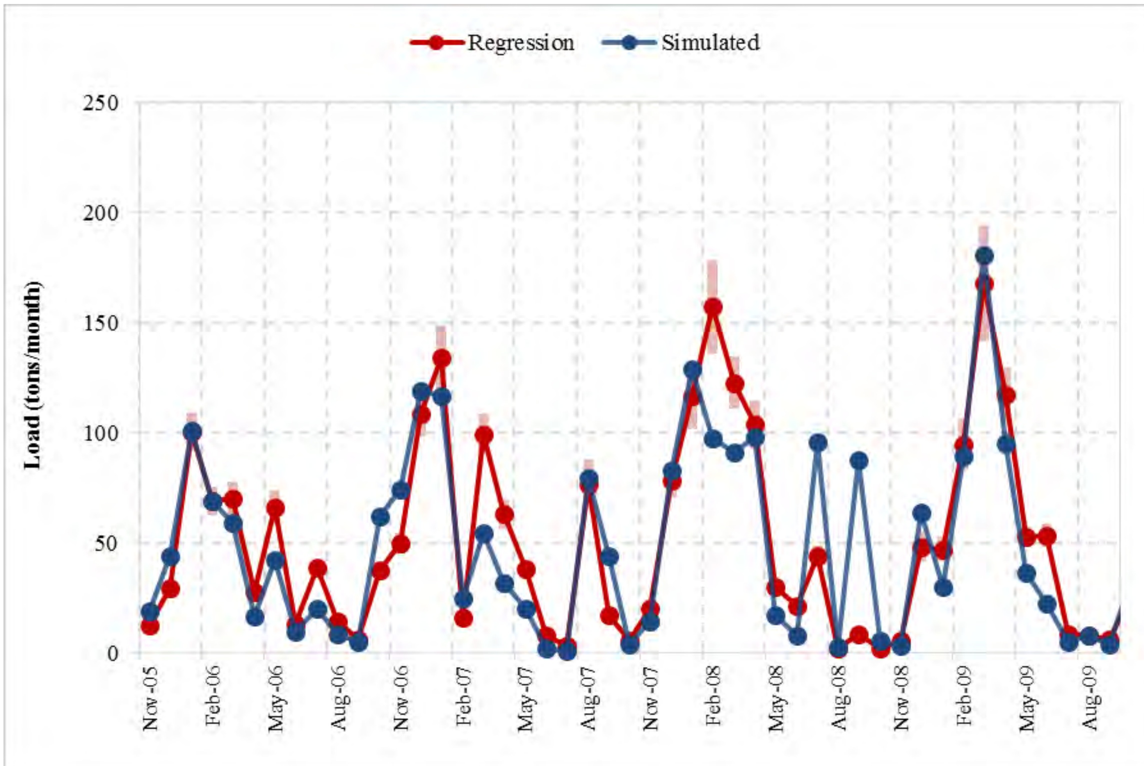


Figure D-100. Monthly simulated and regression TKN loads at 510220 (validation period).

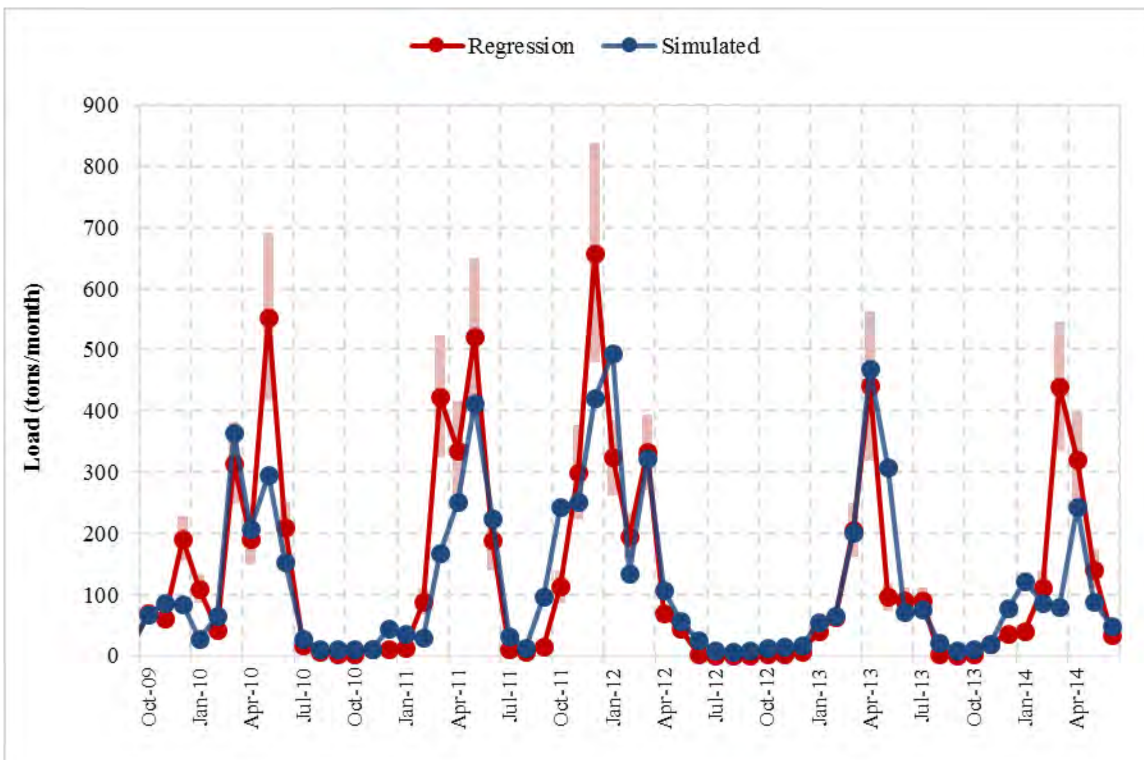


Figure D-101. Monthly simulated and regression NOX loads at 510220 (calibration period).

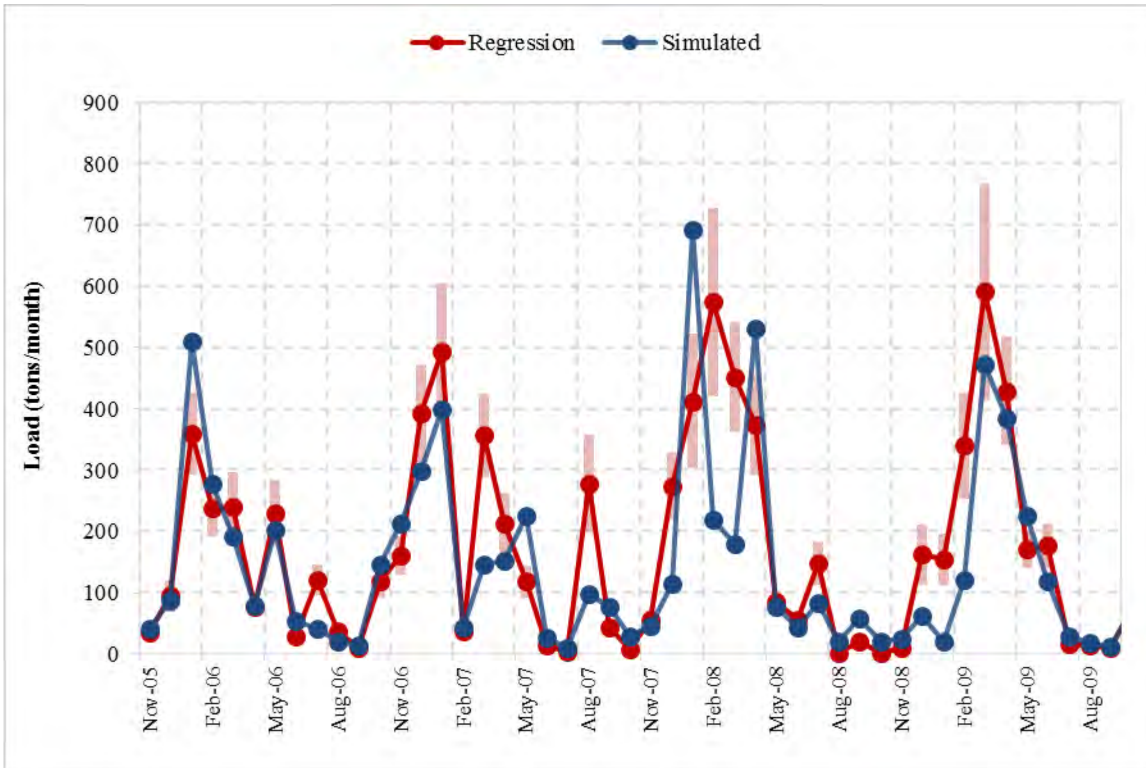


Figure D-102. Monthly simulated and regression NOX loads at 510220 (validation period).

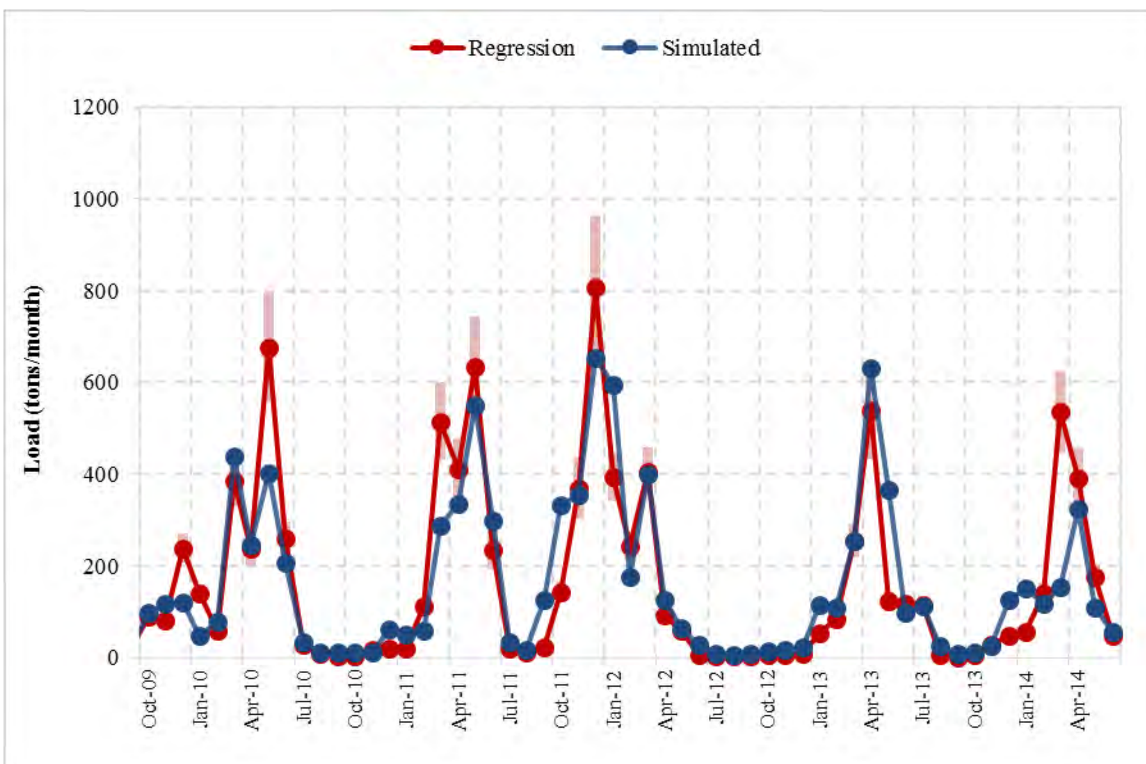


Figure D-103. Monthly simulated and regression TN loads at 510220 (calibration period).

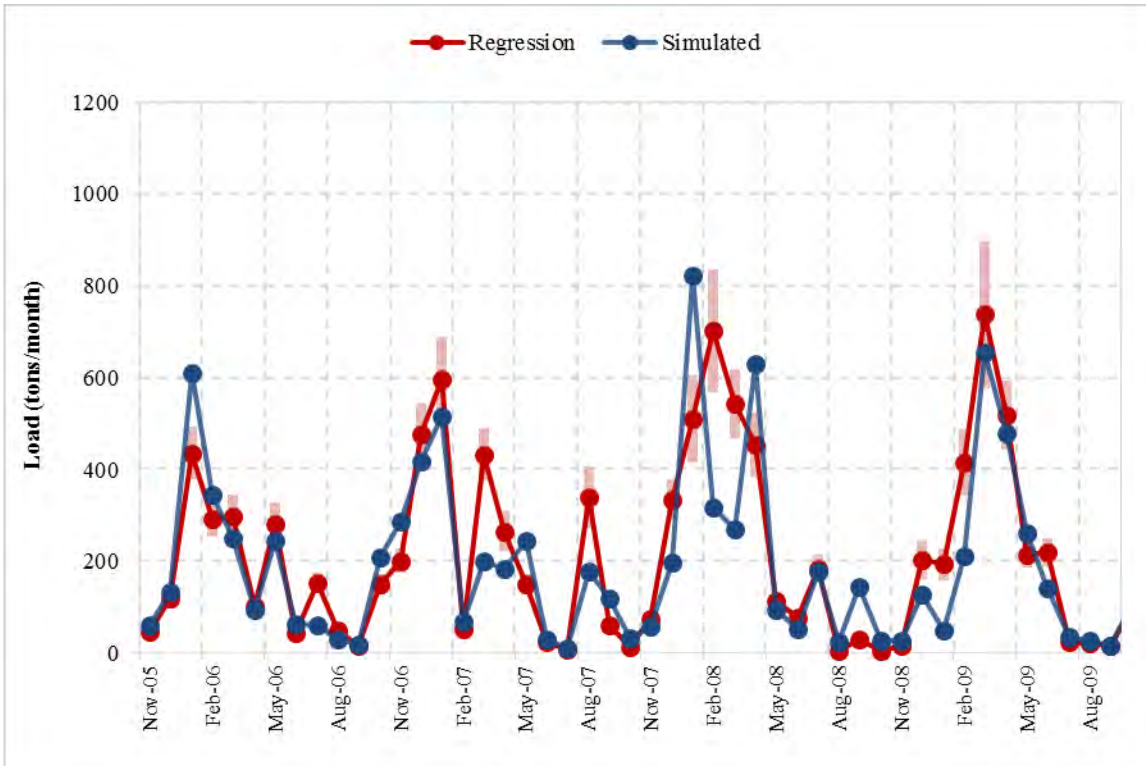


Figure D-104. Monthly simulated and regression TN loads at 510220 (validation period).

D-2.2.2.1.4 LEJ100-0002 - St. Joseph River near Fort Wayne, IN (SWAT Subbasin # 5)[13]

Table D-47. Evaluation of SWAT model performance at St. Joseph River near Newville, IN

Statistic		TSS		TP		TKN		NOX		TN	
		Cal	Val	Cal	Val	Cal	Val	Cal	Val	Cal	Val
NSE	Value	0.77	0.81	0.84	0.71	0.81	0.57	0.30	0.40	0.57	0.60
	Performance	VG	VG	VG	G	VG	S	U	U	S	S
RSR	Value	0.48	0.44	0.41	0.54	0.43	0.66	0.84	0.77	0.65	0.63
	Performance	VG	VG	VG	G	VG	S	U	U	S	S
RE	Value	21.3%	25.5%	-6.3%	25.3%	15.3%	40.2%	38.3%	7.3%	23.9%	16.0%
	Performance	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG

Notes

Cal = calibration; G = good; NOx = nitrate plus nitrite; NSE = Nash-Sutcliffe coefficient; RE = relative average error; RSR = root mean square error-observation standard deviation ratio; S = satisfactory; TKN = total Kjeldahl nitrogen; TP = total phosphorus; TSS = total suspended solids; U = unsatisfactory; Val = validation; VG = very good.

Evaluation of SWAT model performance for water quality constituent loads at a monthly time-step for the calibration and validation periods (negative indicates over-prediction).

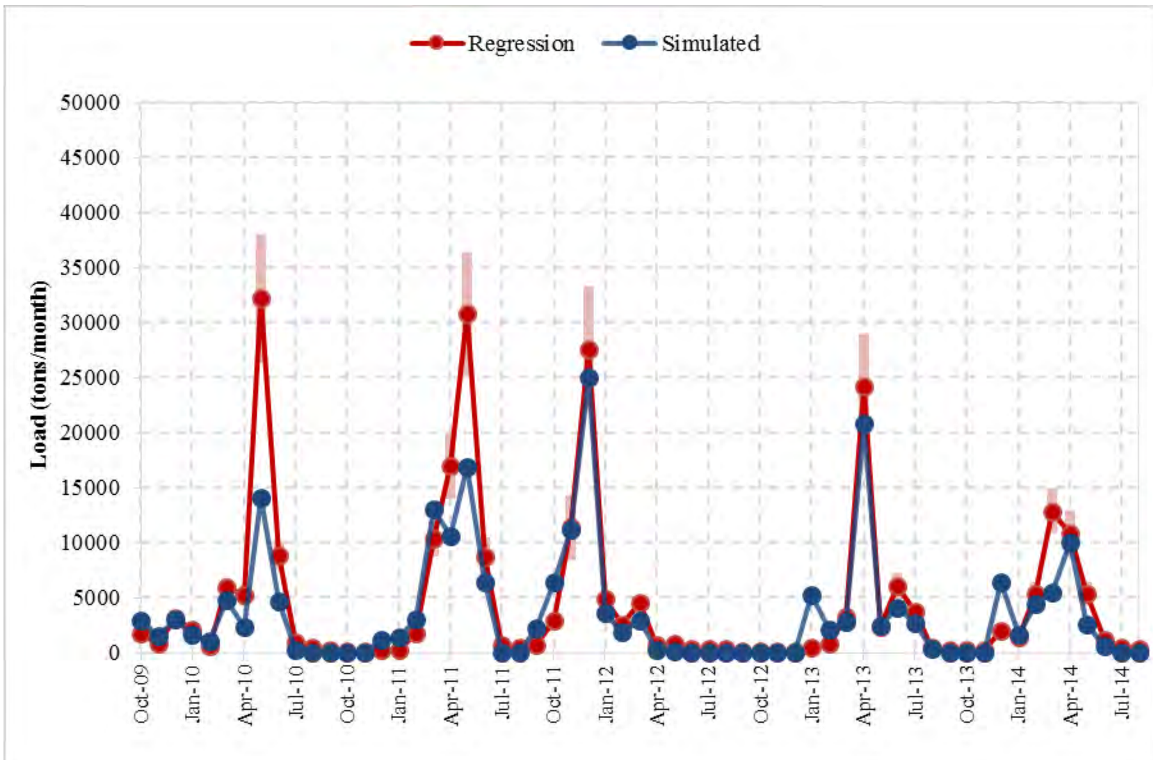


Figure D-105. Monthly simulated and regression TSS loads at LEJ100-0002 (calibration period).

[13] Includes the city of Fort Wayne's water quality data collected at Mayhew Road.

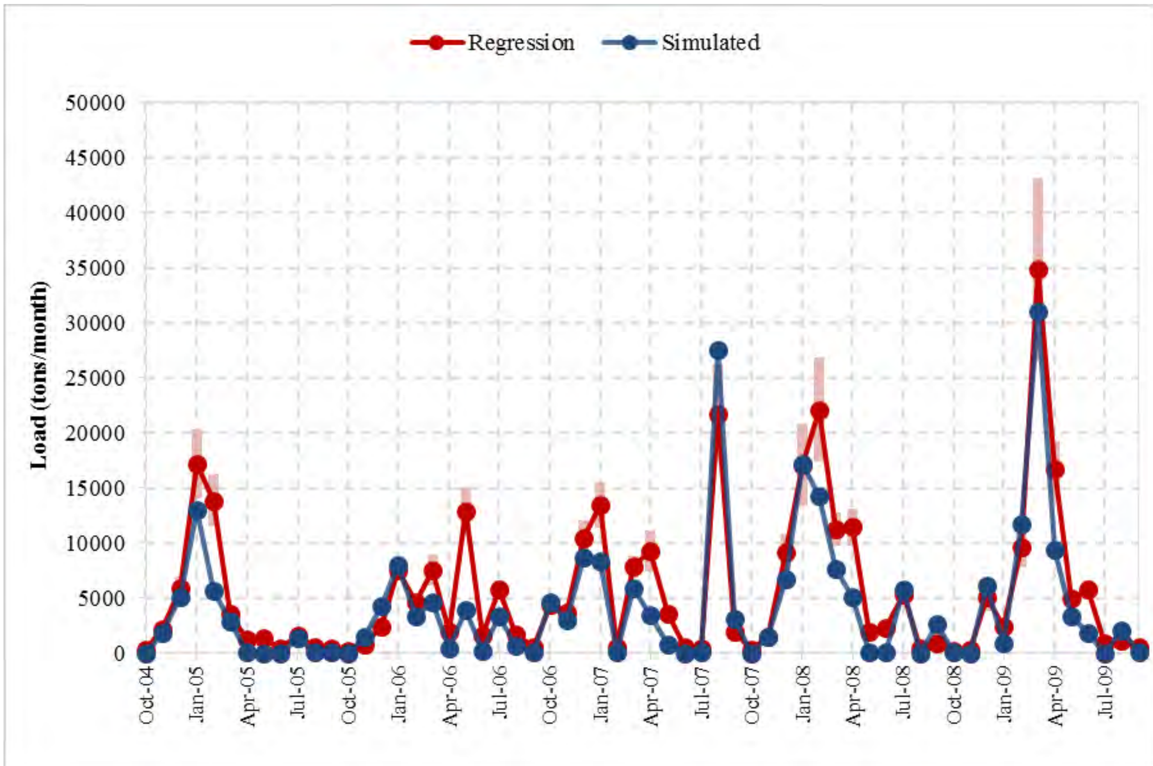


Figure D-106. Monthly simulated and regression TSS loads at LEJ100-0002 (validation period).

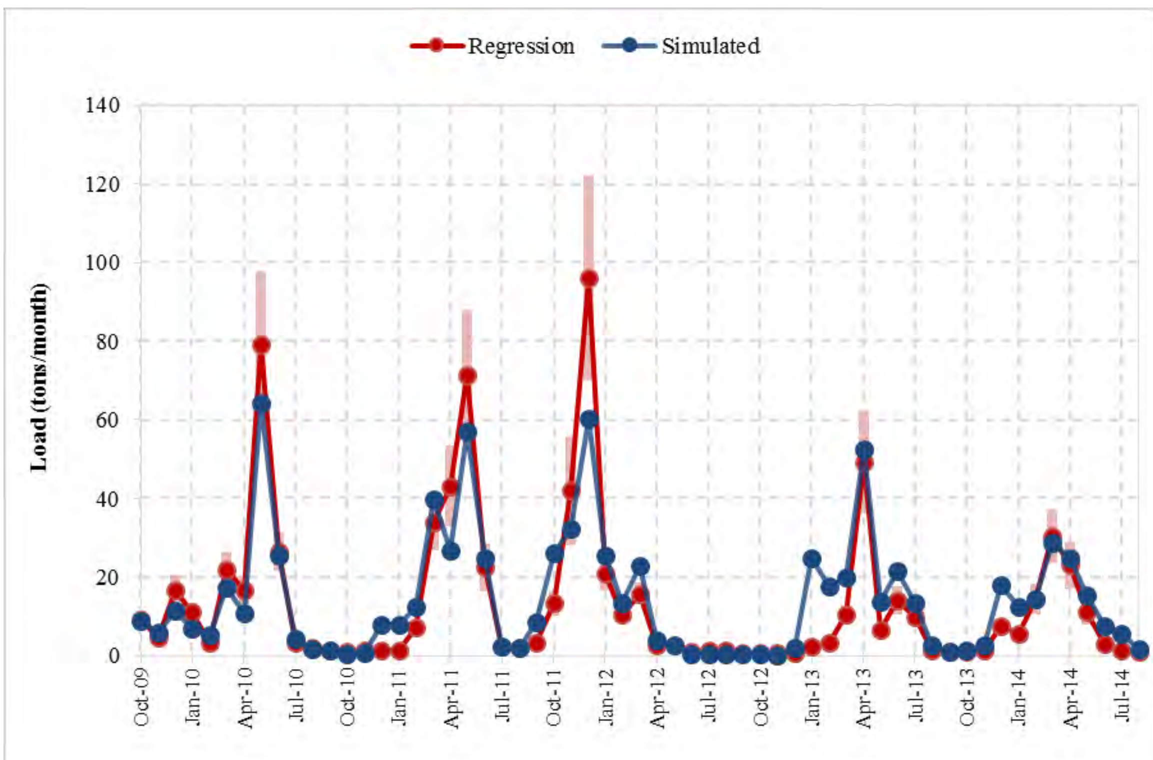


Figure D-107. Monthly simulated and regression TP loads at LEJ100-0002 (calibration period).

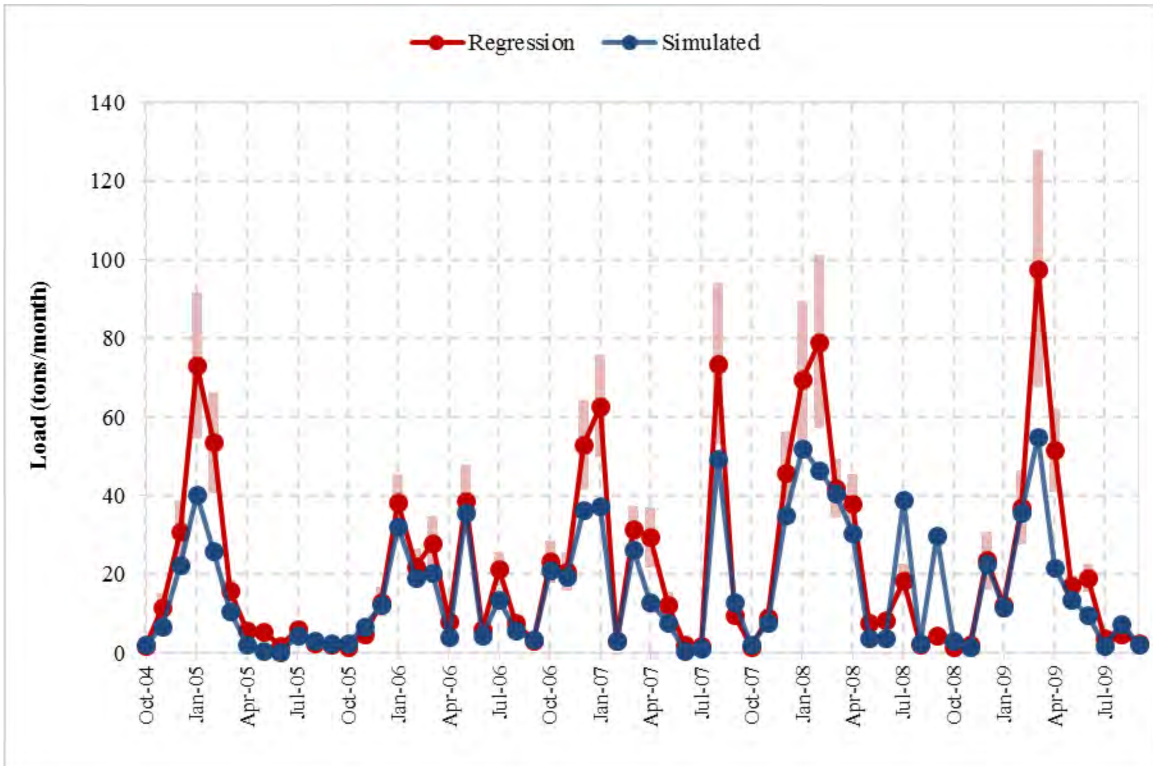


Figure D-108. Monthly simulated and regression TP loads at LEJ100-0002 (validation period).

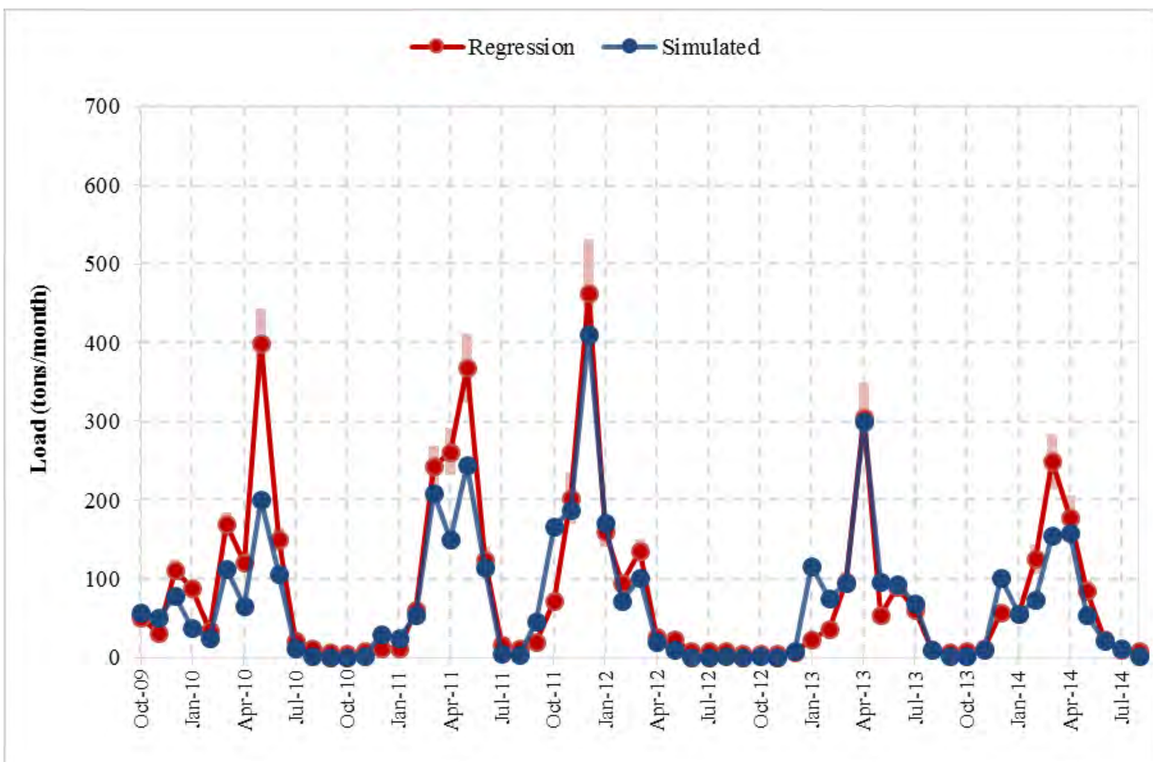


Figure D-109. Monthly simulated and regression TKN loads at LEJ100-0002 (calibration period).

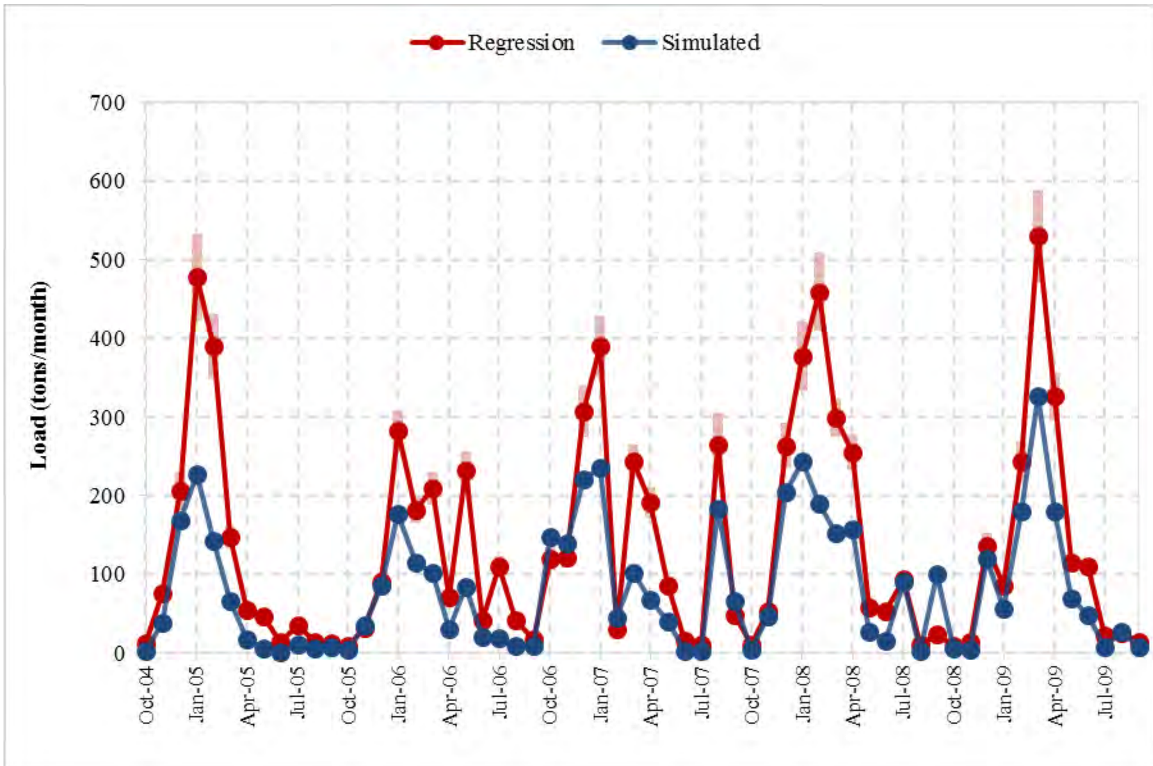


Figure D-110. Monthly simulated and regression TKN loads at LEJ100-0002 (validation period).

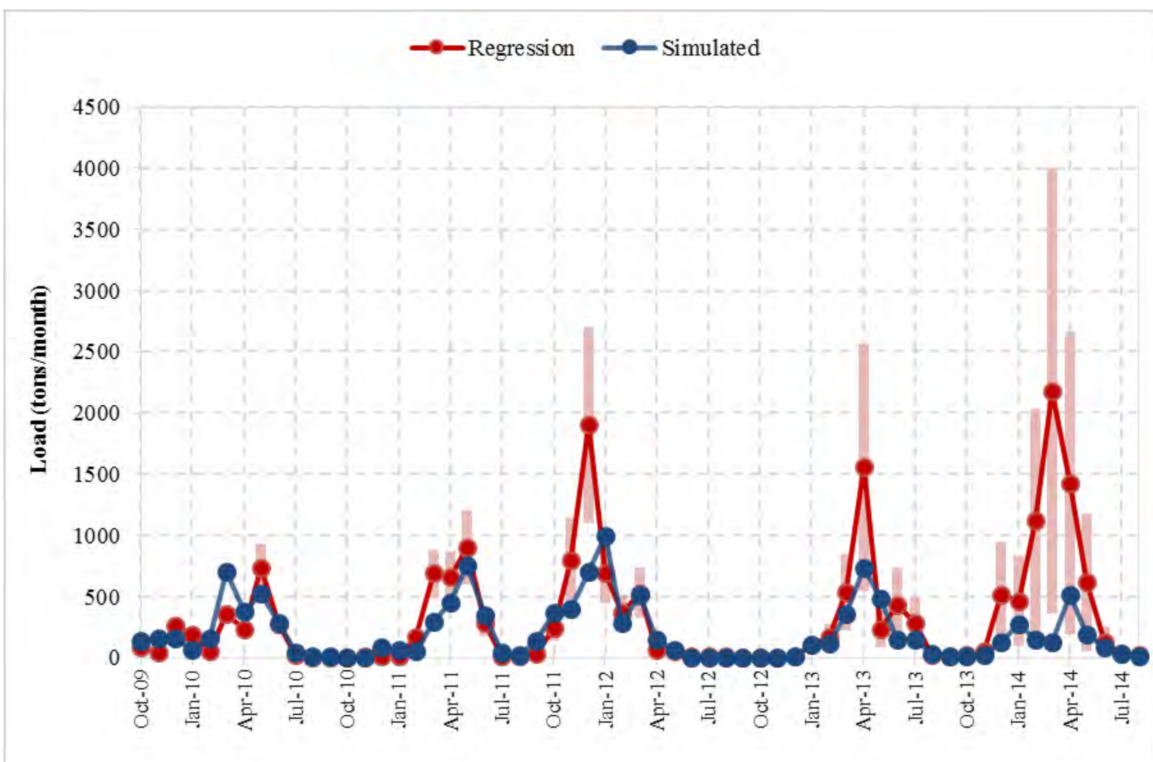


Figure D-111. Monthly simulated and regression NOX loads at LEJ100-0002 (calibration period).

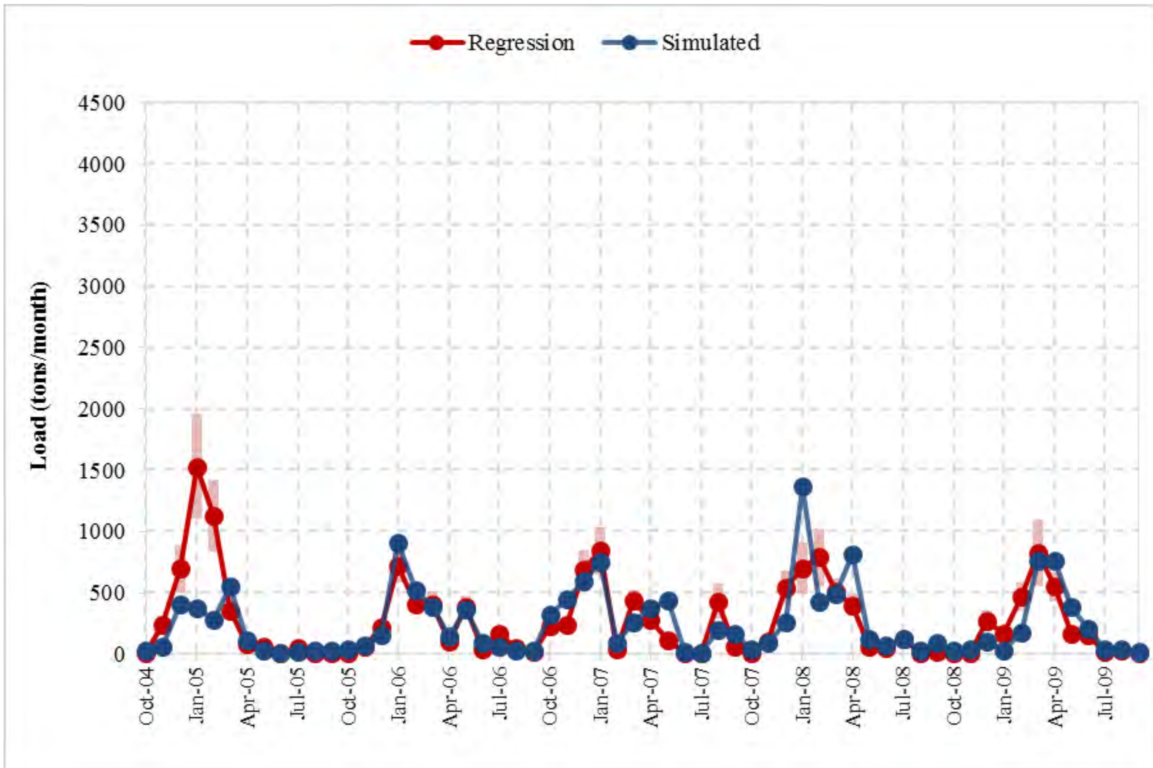


Figure D-112. Monthly simulated and regression NOX loads at LEJ100-0002 (validation period).

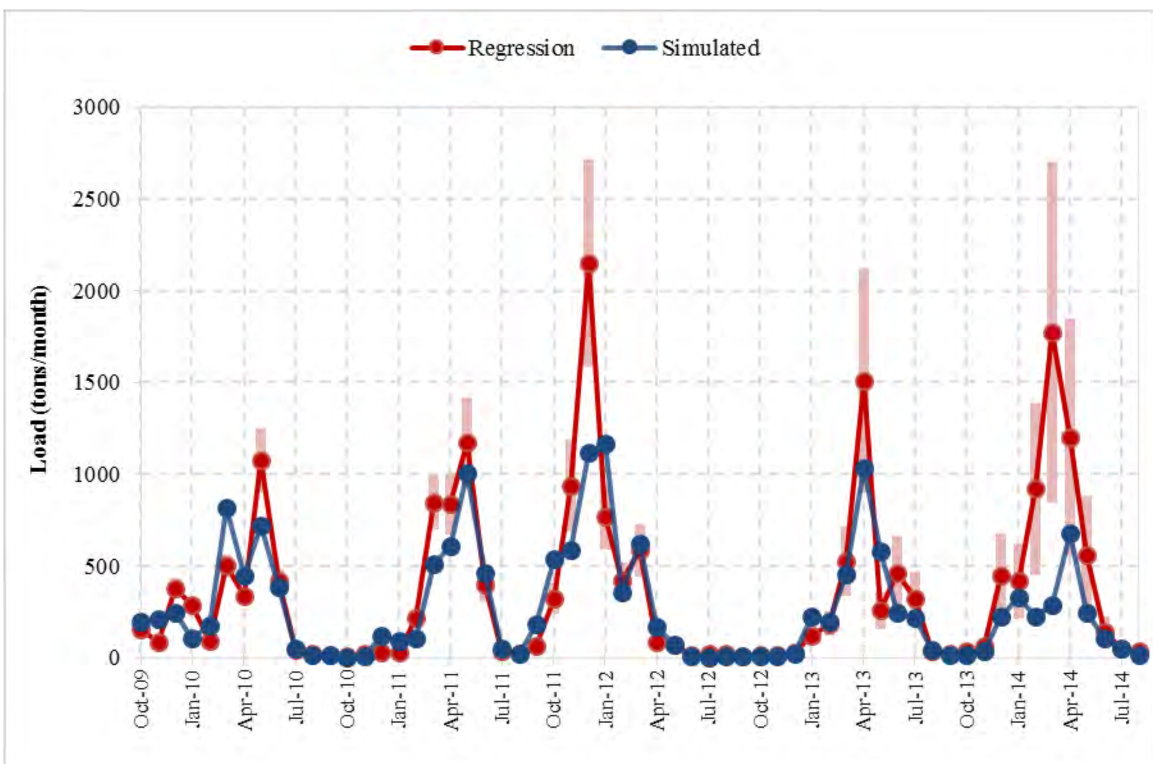


Figure D-113. Monthly simulated and regression TN loads at LEJ100-0002 (calibration period).

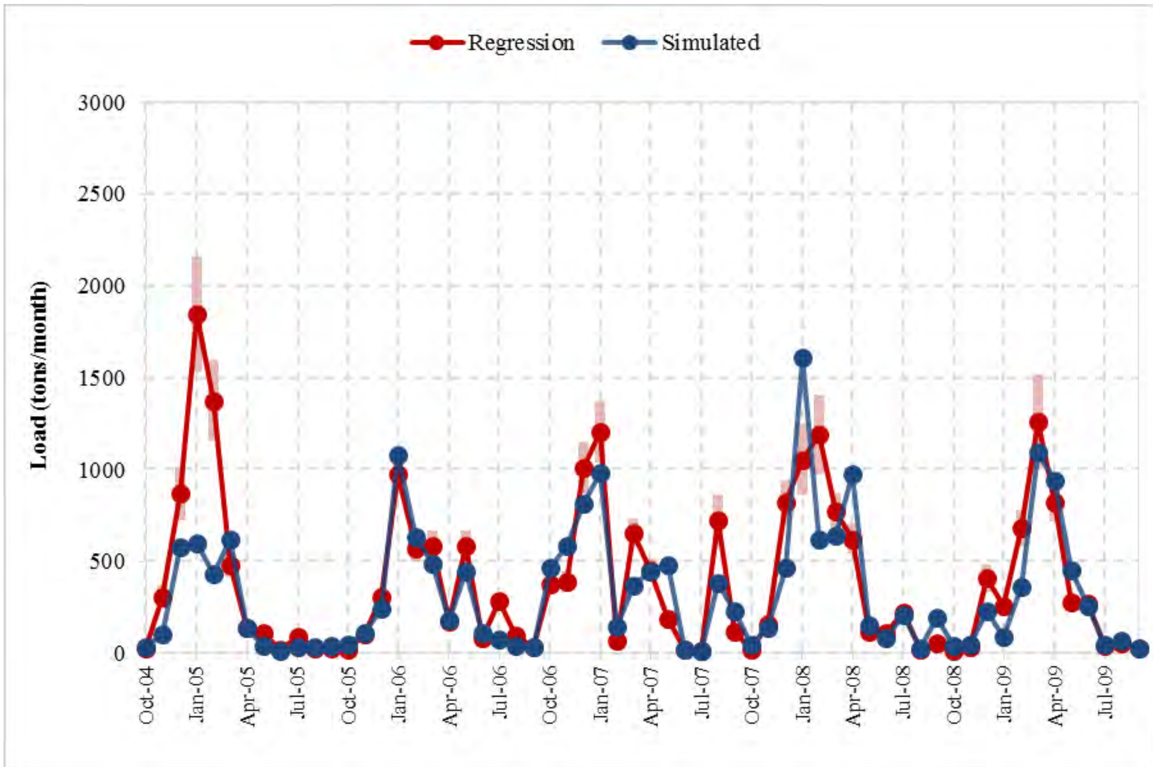


Figure D-114. Monthly simulated and regression TN loads at LEJ100-0002 (validation period).

D-2.2.2.1 Concentration Comparison

The model performance based on concentration varies by location and constituent. It is important to note that some of the sampling locations are downstream of point source dischargers and there is considerable uncertainty associated with point source loads. Point source flow, sediment and nutrient data are often available at a monthly time-step. In addition, several nutrient species are often not reported and assumptions are made for their discharge concentrations. As a result, daily constituent load time-series for point sources are often based on observations at a coarser time-step or assumptions and may have considerable uncertainties associated with them. In addition, some locations have very few samples (less than 20), which makes true evaluation of model performance difficult.

It is also important to note that historic applications of SWAT have generally consisted of calibrating and validating the model performance against monthly load time-series. SWAT was designed to simulate watershed loading and is not an ideal tool for simulating in-stream concentrations. In light of these limitations, the St. Joseph River SWAT model was generally able to simulate the trends in the observed samples. The average errors are quite large in certain instances but they are generally on account of the inability of the model to simulate some atypically high concentrations. The simulated concentrations were however generally in the same range as the observed. The summary of model performance at each of these locations is provided in the following sections.

D-2.2.2.1.1 P08K29 - East Branch St. Joseph River (Ohio EPA) (SWAT Subbasin # 92)

Table D-48. Evaluation of SWAT model performance on paired observed and simulated concentrations at P08K29

	Observed				Simulated					
Constituent	Mean	Min	Median	Max	Mean	Min	Median	Max	RE	n
TSS	30.83	2.50	21.00	92.00	54.04	6.24	30.49	161.86	-75.3%	12
TP	0.09	0.02	0.07	0.23	0.14	0.05	0.12	0.41	-51.2%	12
TKN	0.76	0.10	0.64	1.55	1.61	0.76	1.11	4.69	-112.2%	12
NOx	1.89	0.05	0.68	7.22	1.79	0.26	1.23	4.63	5.3%	12
TN	2.65	0.44	1.32	8.30	3.40	1.02	2.88	9.32	-28.3%	12

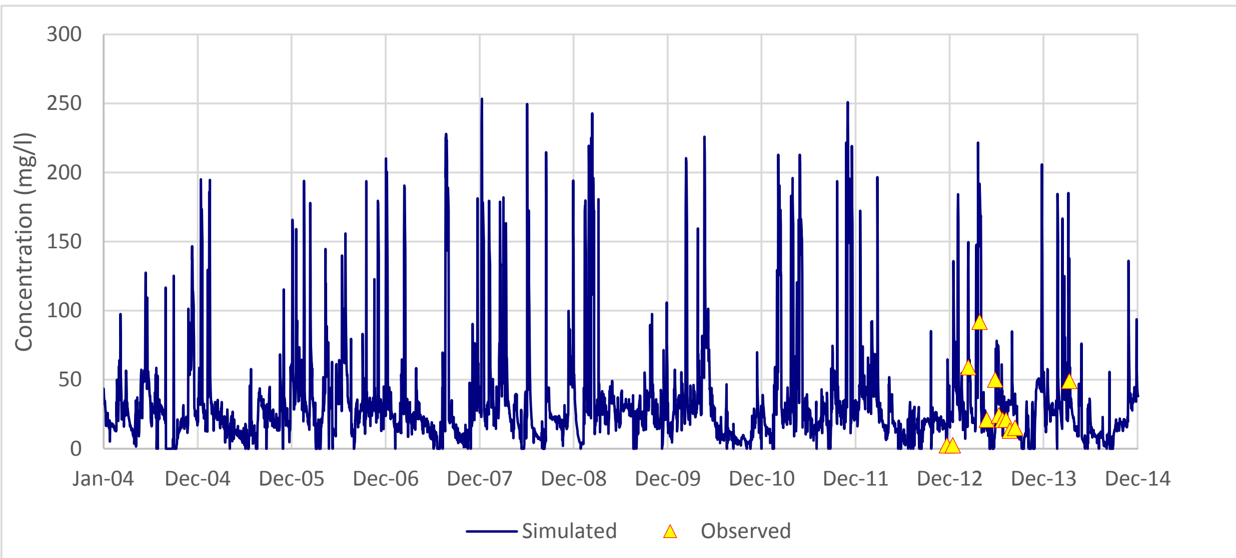


Figure D-115. Time series of observed and simulated TSS concentrations at P08K29.

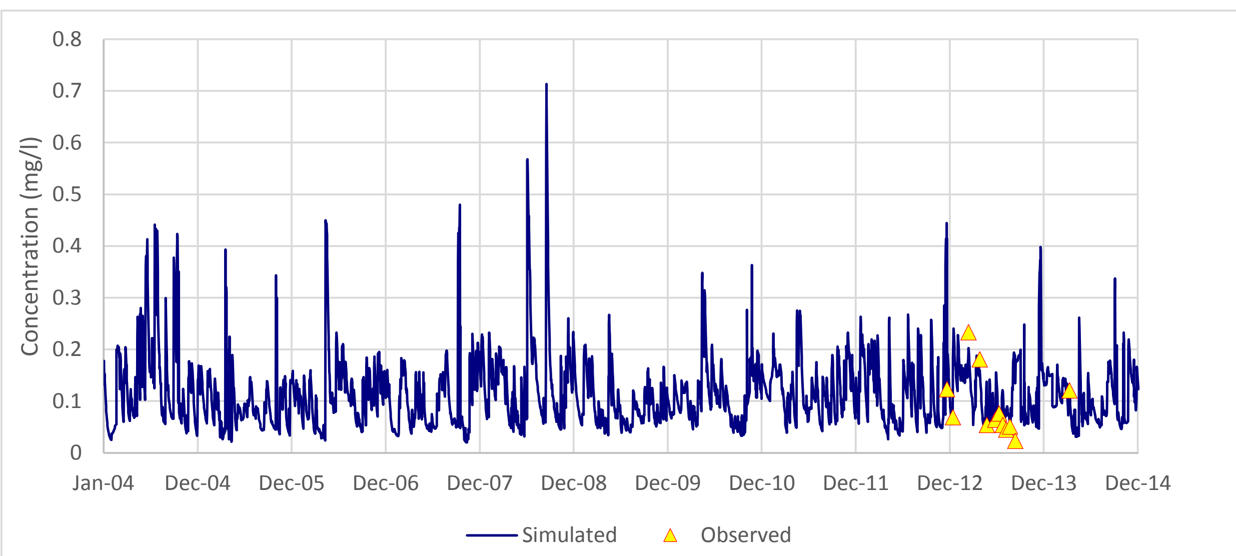


Figure D-116. Time series of observed and simulated TP concentrations at P08K29.

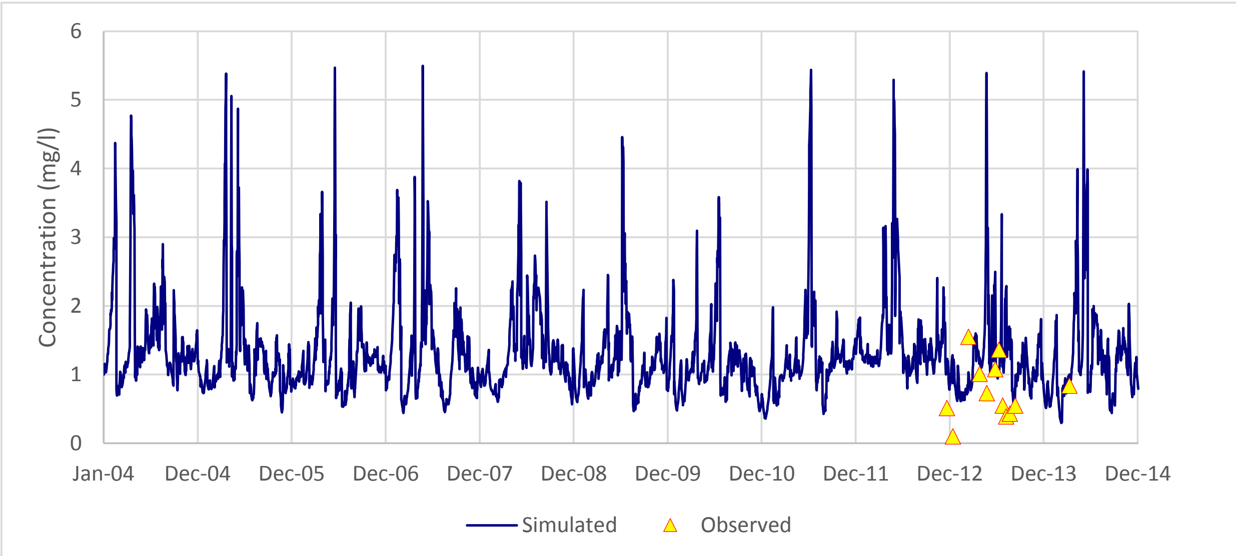


Figure D-117. Time series of observed and simulated TKN concentrations at P08K29.

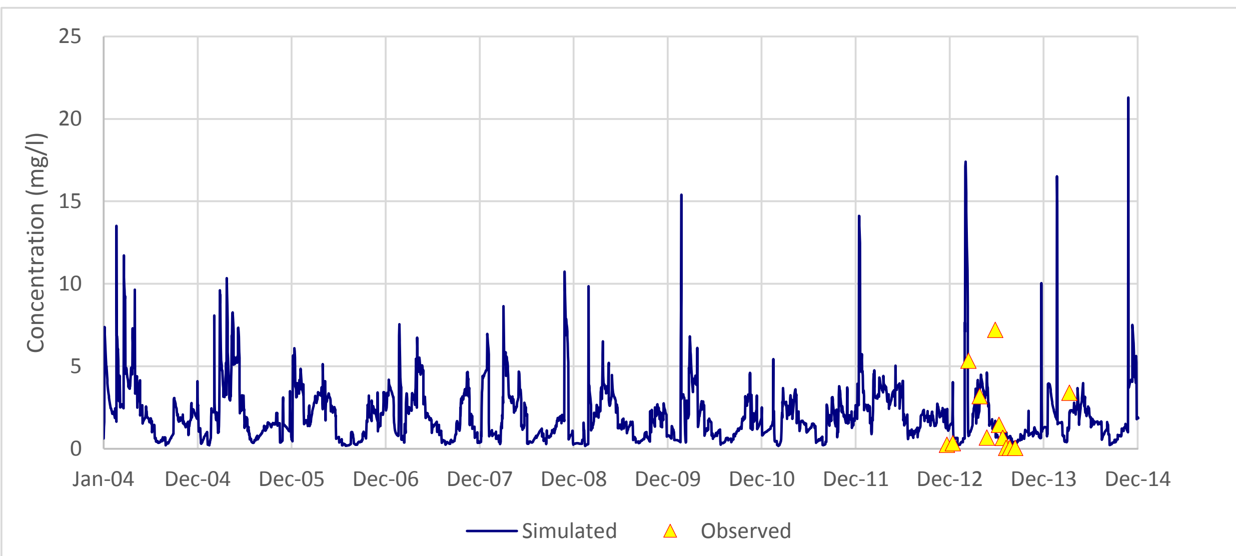


Figure D-118. Time series of observed and simulated NOx concentrations at P08K29.

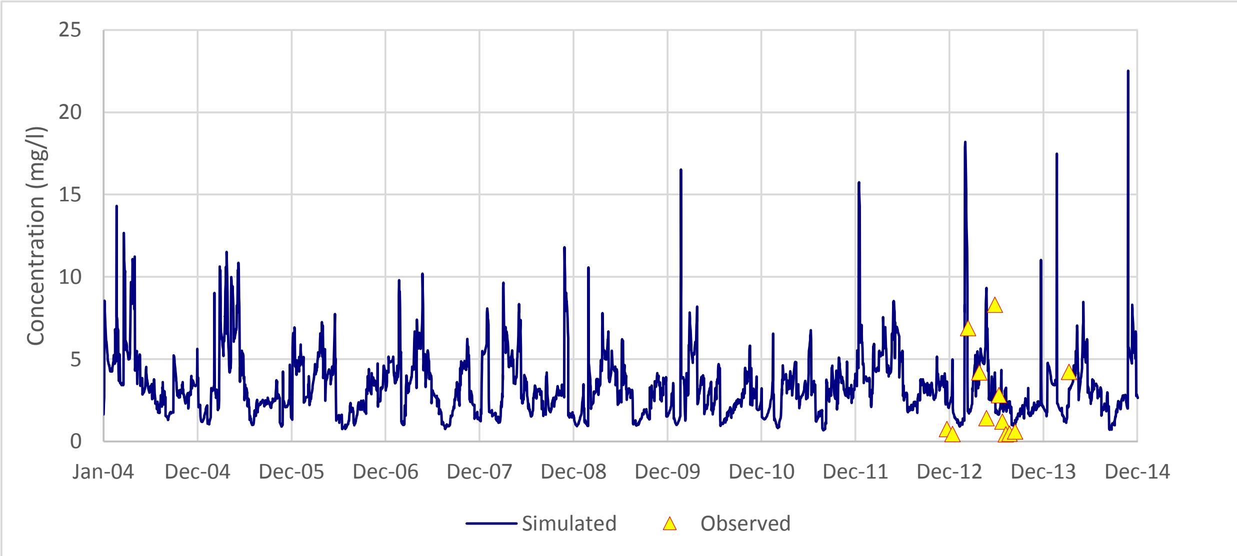


Figure D-119. Time series of observed and simulated TN concentrations at P08K29.

D-2.2.2.1.2 P08S21 - West Branch St. Joseph River (Ohio EPA) (SWAT Subbasin # 82)

Table D-49. Evaluation of SWAT model performance on paired observed and simulated concentrations at P08S21

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	27.93	2.50	29.50	61.00	20.05	0.02	0.41	237.19	28.2%	14
TP	0.06	0.01	0.05	0.18	0.09	0.01	0.07	0.17	-48.6%	14
TKN	0.69	0.27	0.64	1.12	1.67	0.77	1.23	3.75	-141.1%	14
NOx	1.03	0.10	0.38	3.81	1.90	0.58	1.50	4.62	-84.9%	14
TN	1.72	0.38	0.98	4.93	3.56	1.59	3.31	8.37	-107.5%	14

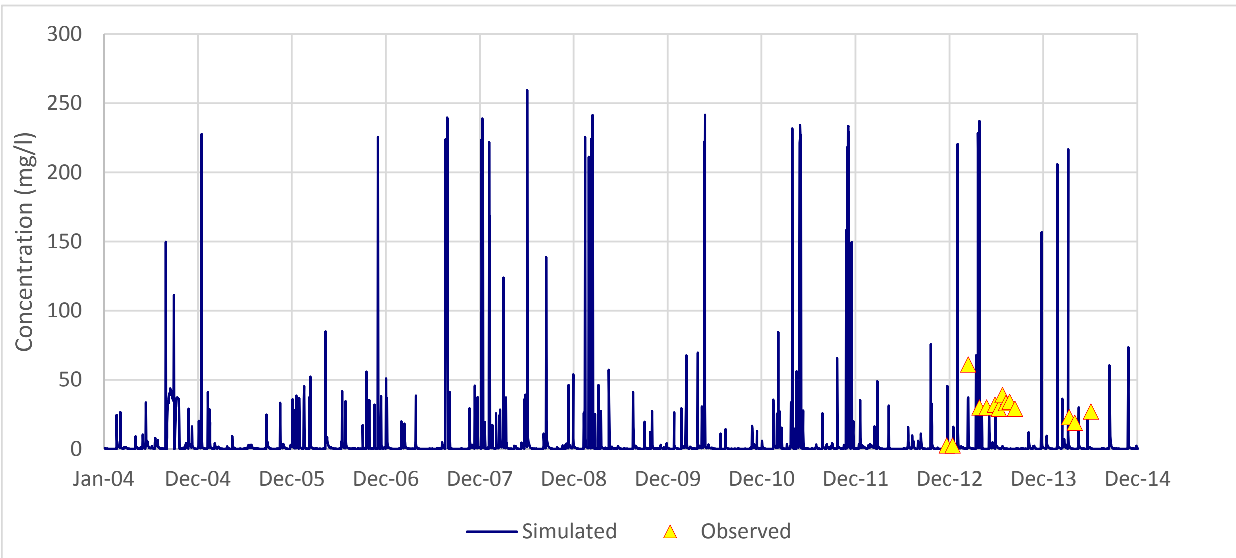


Figure D-120. Time series of observed and simulated TSS concentrations at P08S21.

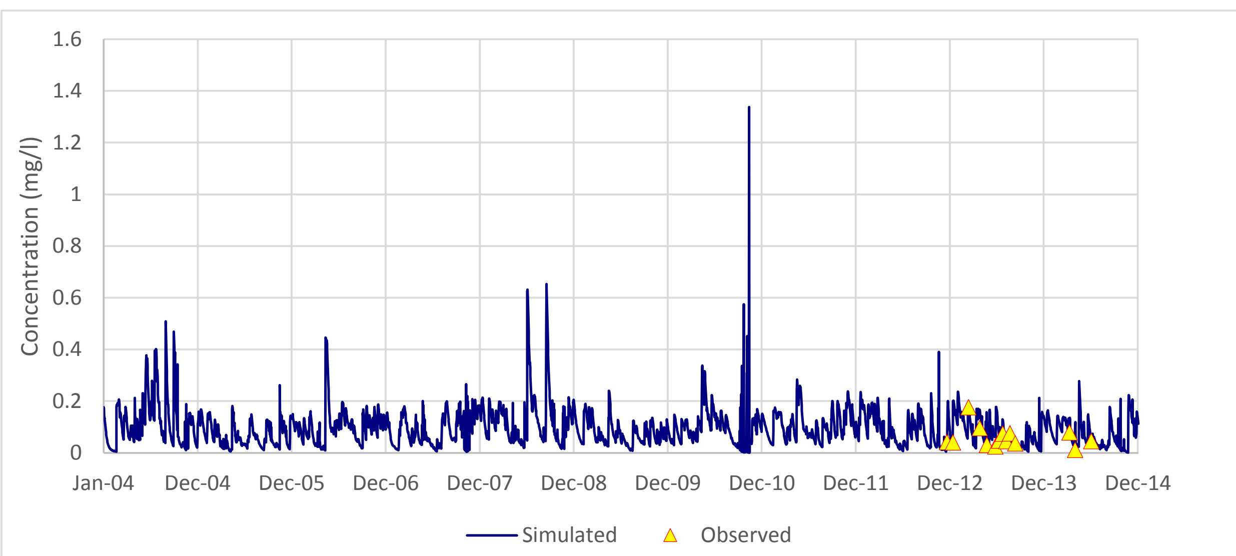


Figure D-121. Time series of observed and simulated TP concentrations at P08S21.

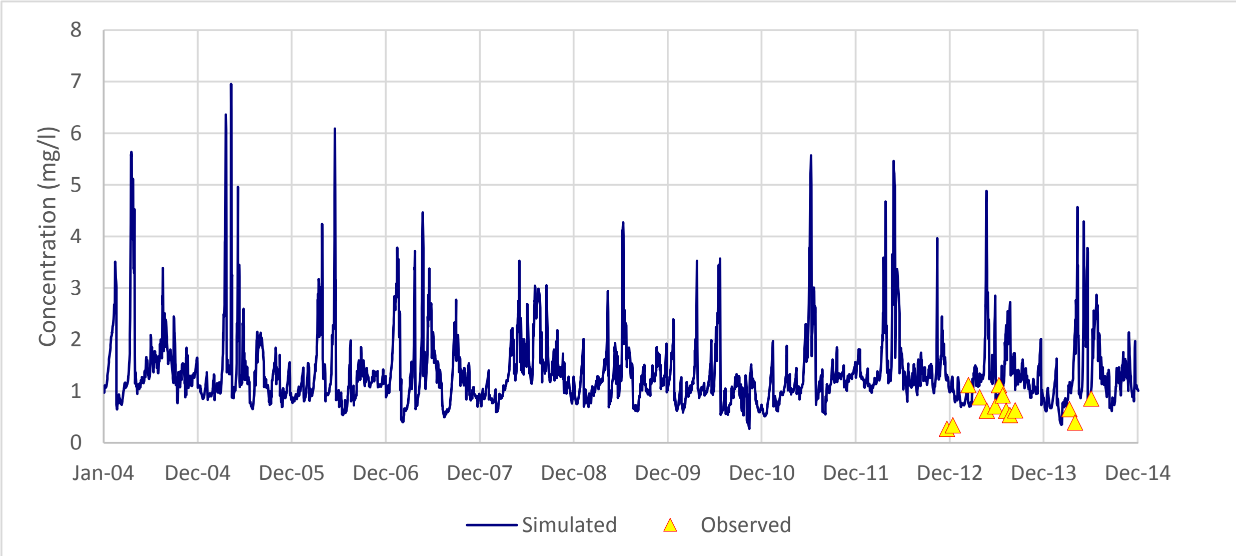


Figure D-122. Time series of observed and simulated TKN concentrations at P08S21.

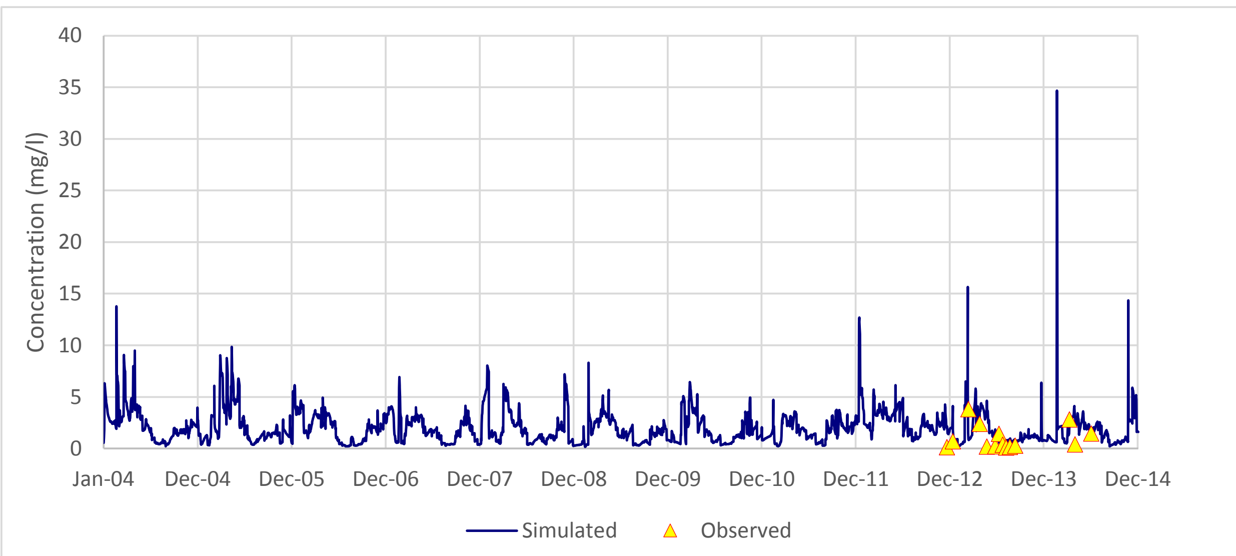


Figure D-123. Time series of observed and simulated NOx concentrations at P08S21.

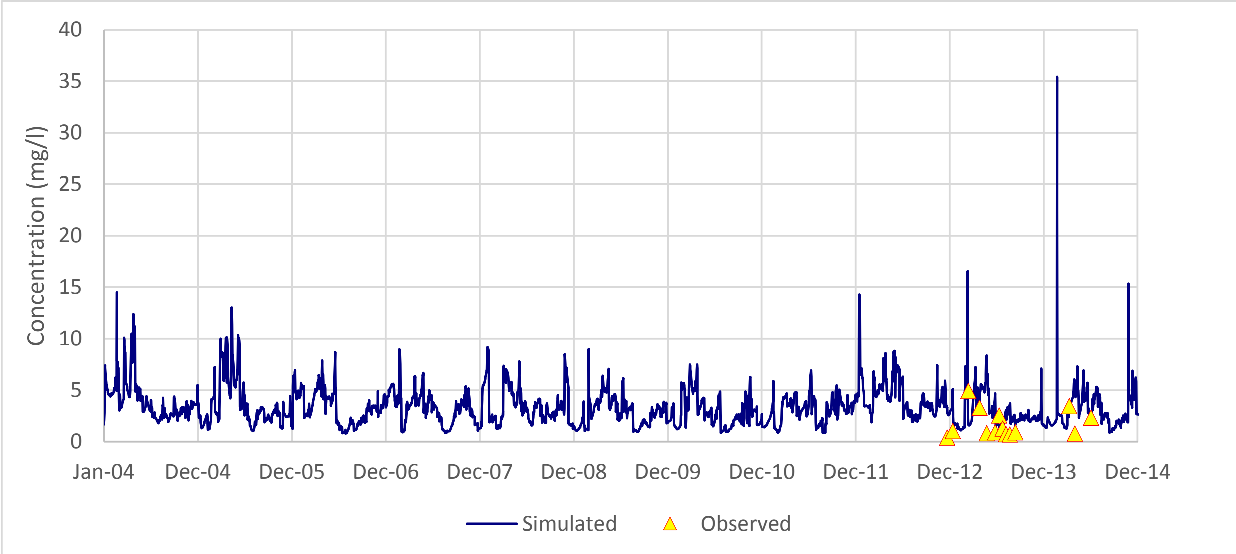


Figure D-124. Time series of observed and simulated TN concentrations at P08S21.

D-2.2.2.1.3 P08S06 - Nettle Creek (Ohio EPA) (SWAT Subbasin # 76)

Table D-50. Evaluation of SWAT model performance on paired observed and simulated concentrations at P08S06

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	48.92	2.50	29.00	162.00	12.19	4.36	10.16	24.10	75.1%	12
TP	0.10	0.02	0.06	0.25	0.17	0.09	0.15	0.45	-64.5%	12
TKN	0.90	0.48	0.85	1.52	1.50	0.82	1.46	2.39	-67.0%	12
NOx	1.80	0.05	1.11	6.83	2.40	0.65	1.83	6.43	-33.5%	12
TN	2.70	0.76	2.21	8.04	3.90	1.98	3.30	8.82	-44.7%	12

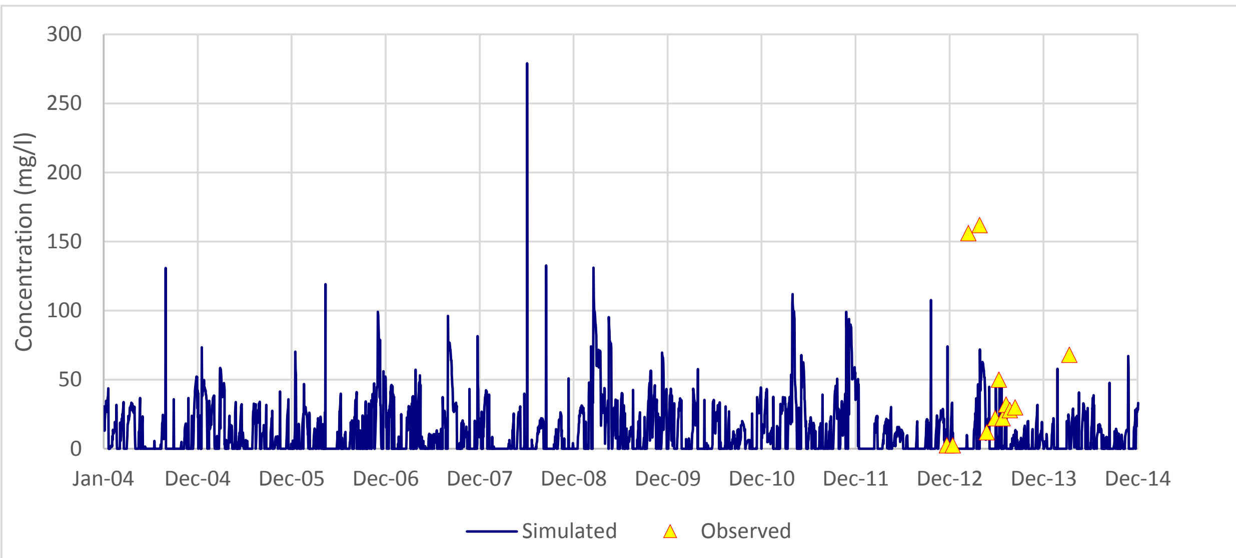


Figure D-125. Time series of observed and simulated TSS concentrations at P08S06.

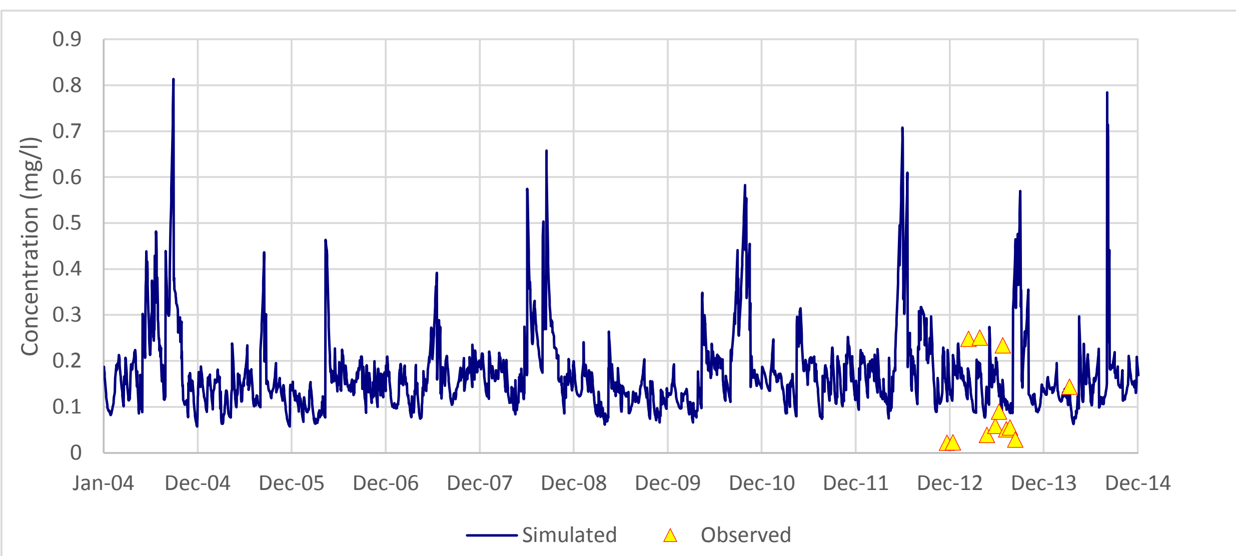


Figure D-126. Time series of observed and simulated TP concentrations at P08S06.

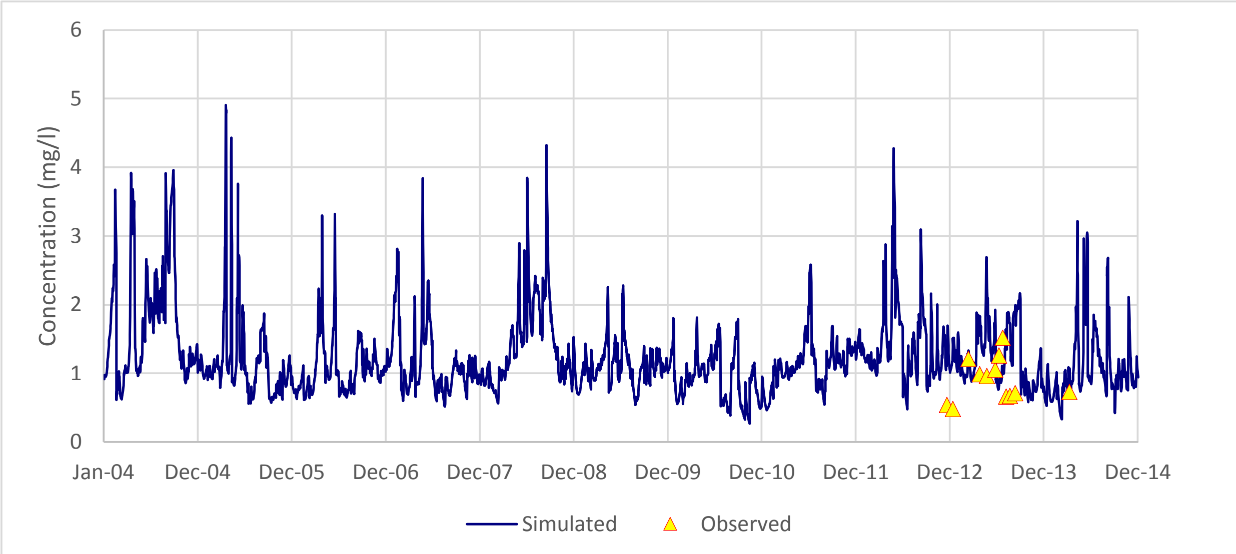


Figure D-127. Time series of observed and simulated TKN concentrations at P08S06.

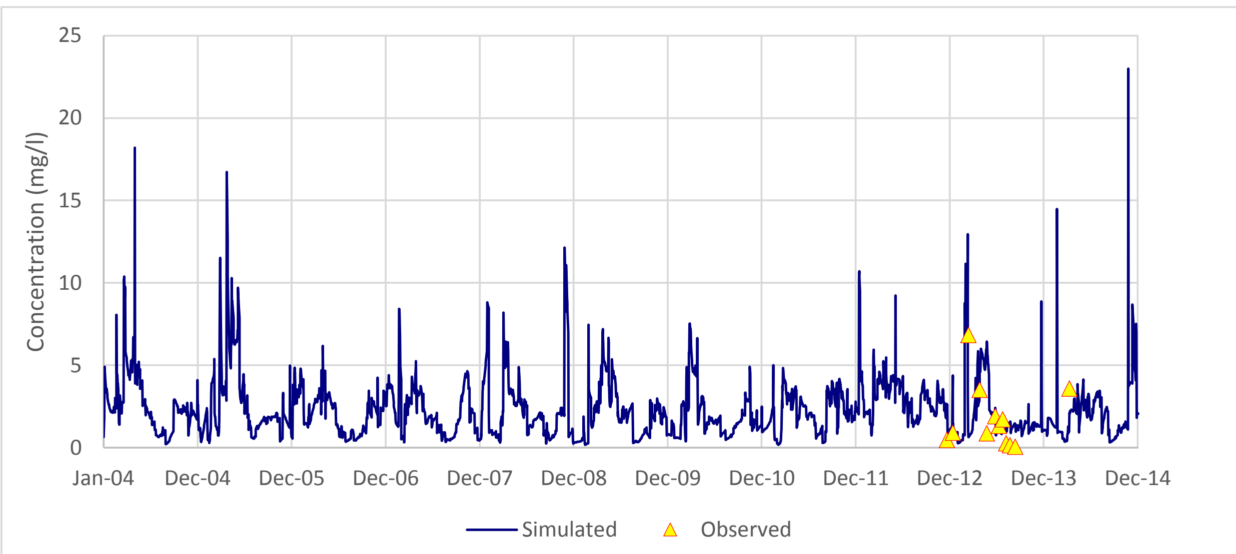


Figure D-128. Time series of observed and simulated NOx concentrations at P08S06.

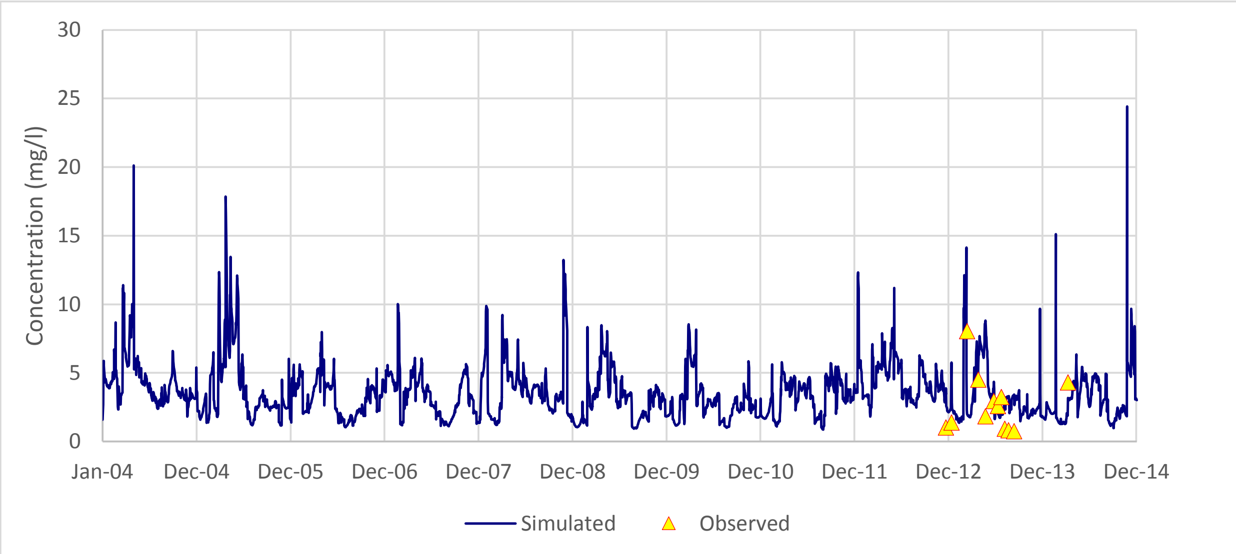


Figure D-129. Time series of observed and simulated TN concentrations at P08S06.

D-2.2.2.1.4 P08S17 - St. Joseph River (Ohio EPA) (SWAT Subbasin # 69)

Table D-51. Evaluation of SWAT model performance on paired observed and simulated concentrations at P08S17

	Observed				Simulated					
Constituent	Mean	Min	Median	Max	Mean	Min	Median	Max	RE	n
TSS	40.71	2.50	33.00	100.00	12.89	5.26	12.05	21.61	68.3%	12
TP	0.11	0.04	0.11	0.27	0.15	0.09	0.13	0.26	-35.8%	12
TKN	0.67	0.18	0.61	1.28	0.76	0.25	0.78	1.12	-14.3%	12
NOx	1.60	0.18	0.73	5.85	2.21	0.87	1.81	5.63	-38.0%	12
TN	2.27	0.68	1.35	7.13	2.97	1.52	2.44	6.75	-31.0%	12

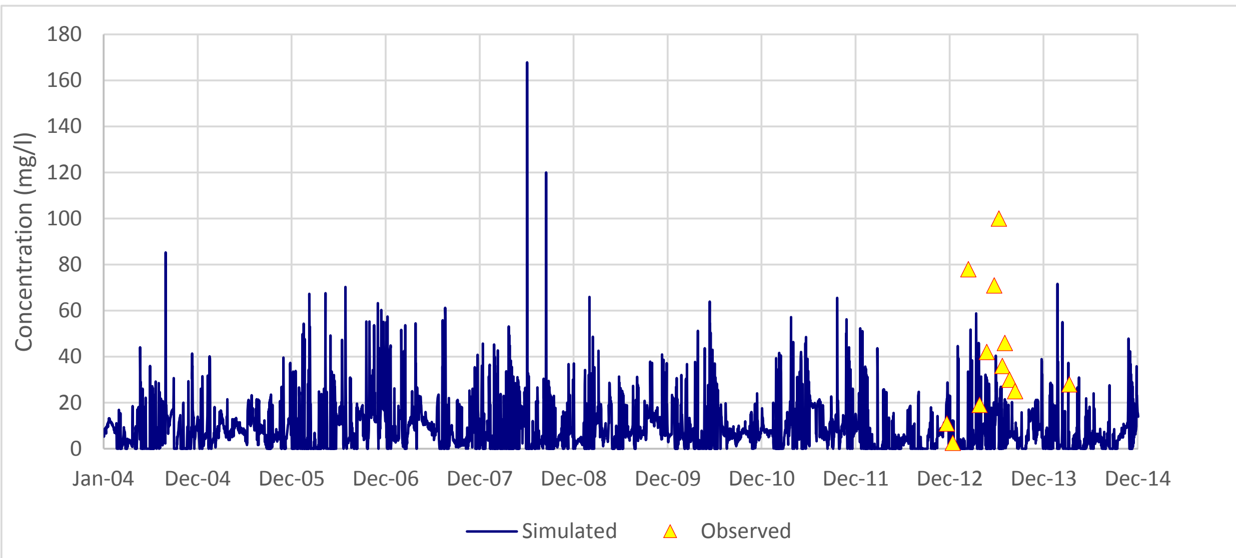


Figure D-130. Time series of observed and simulated TSS concentrations at P08S17.

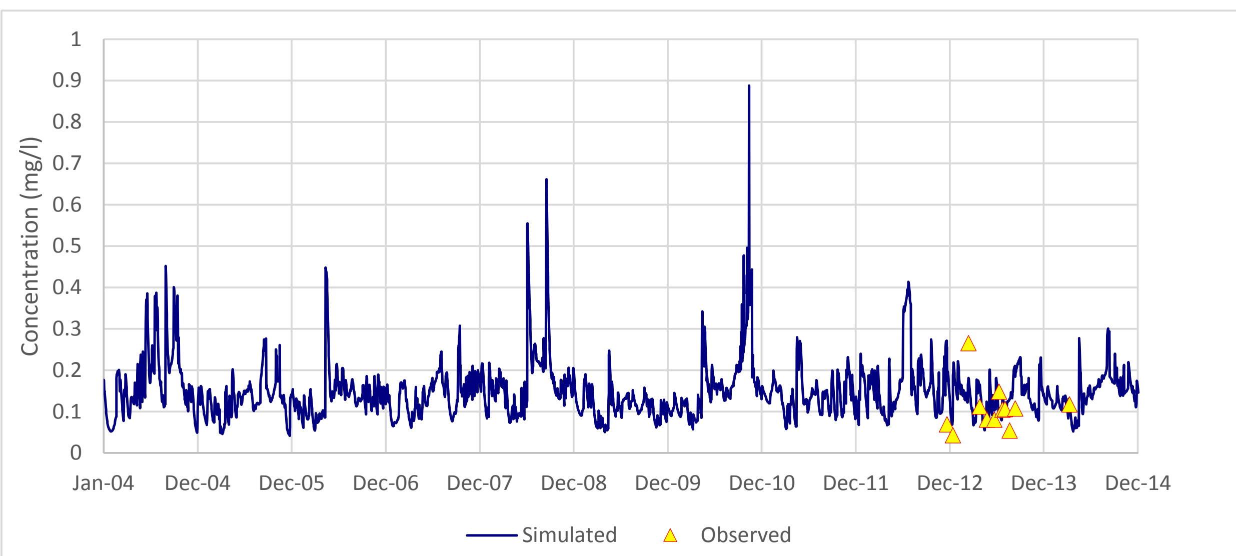


Figure D-131. Time series of observed and simulated TP concentrations at P08S17.

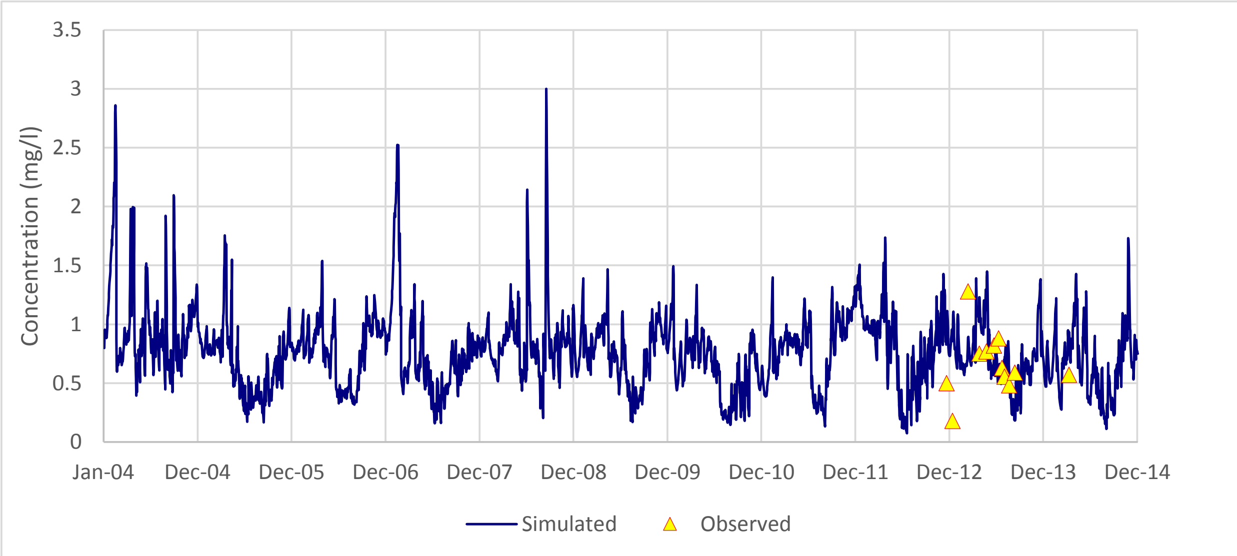


Figure D-132. Time series of observed and simulated TKN concentrations at P08S17.

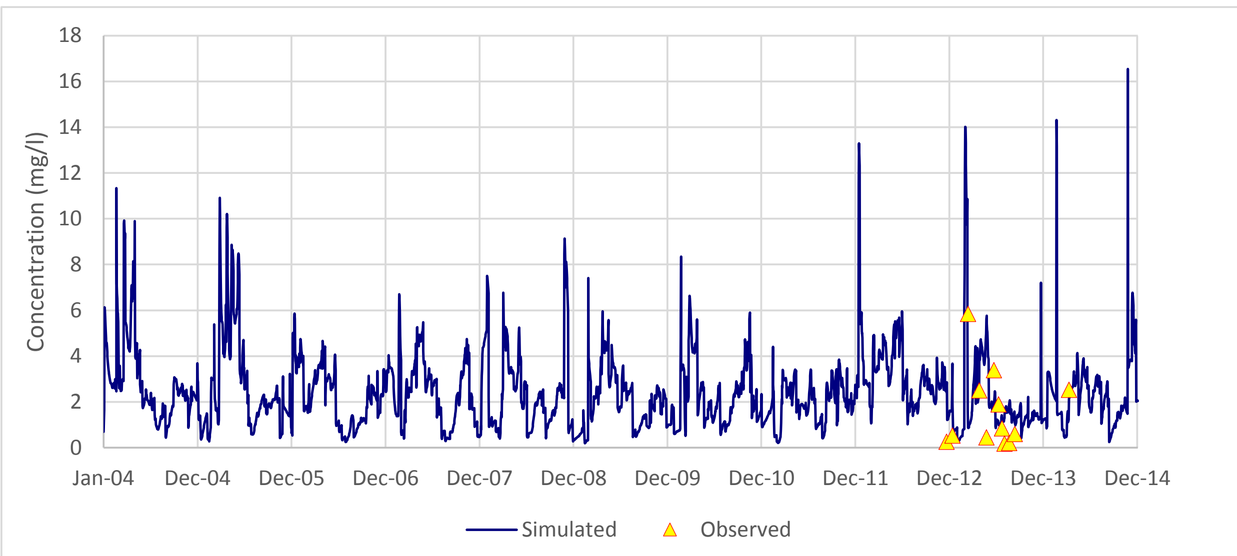


Figure D-133. Time series of observed and simulated NOx concentrations at P08S17.

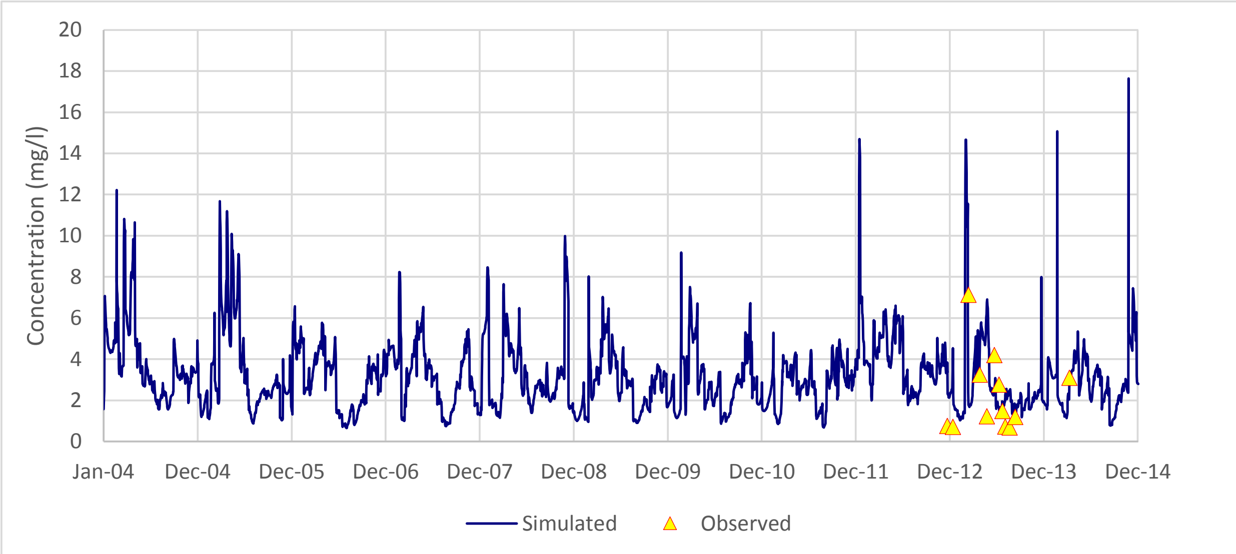


Figure D-134. Time series of observed and simulated TN concentrations at P08S17.

D-2.2.2.1.5 LEJ050-0006 - Fish Creek (IDEM) (SWAT Subbasin # 56)

Table D-52. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ050-0006

	Observed				Simulated					
Constituent	Mean	Min	Median	Max	Mean	Min	Median	Max	RE	n
TSS	19.94	2.00	8.00	256.00	25.31	1.55	24.08	85.38	-26.9%	104
TP	0.11	0.02	0.07	1.80	0.09	0.00	0.07	0.26	18.2%	104
TKN	0.84	0.30	0.70	5.40	1.43	0.46	1.27	5.75	-70.4%	104
NOx	1.19	0.05	0.90	6.20	2.41	0.19	1.98	14.42	-102.3%	104
TN	2.03	0.35	1.70	8.20	3.84	0.79	3.40	15.29	-89.1%	104

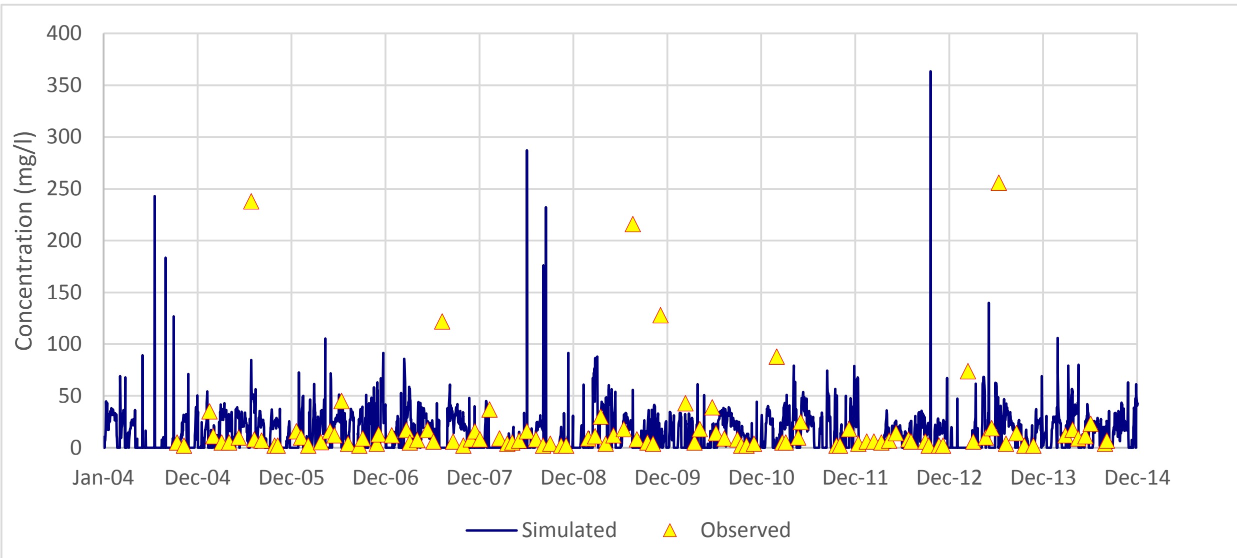


Figure D-135. Time series of observed and simulated TSS concentrations at LEJ050-0006.

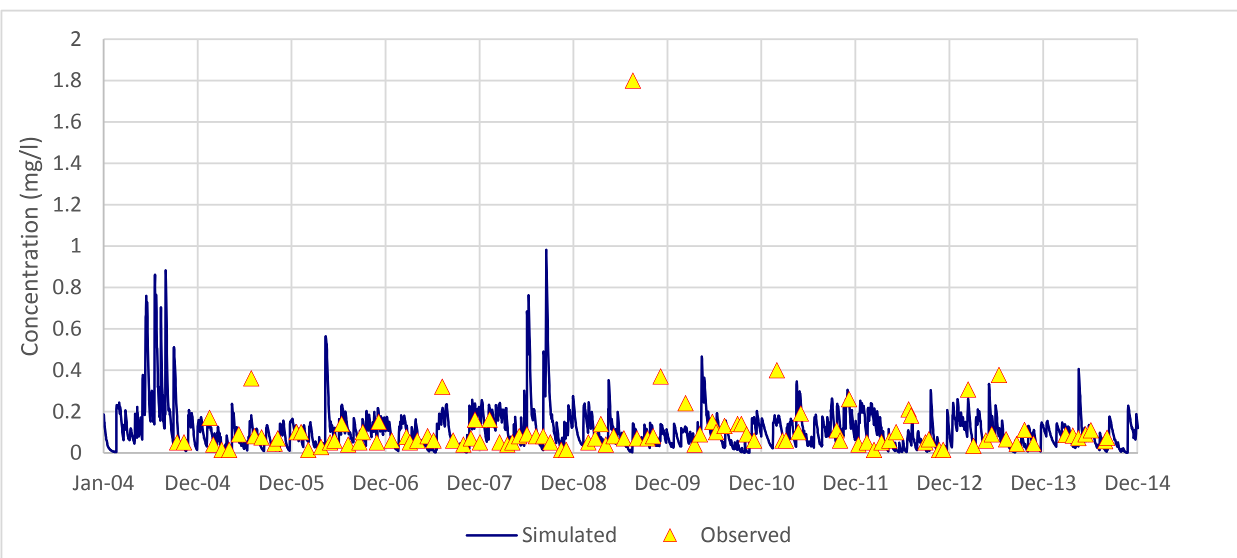


Figure D-136. Time series of observed and simulated TP concentrations at LEJ050-0006.

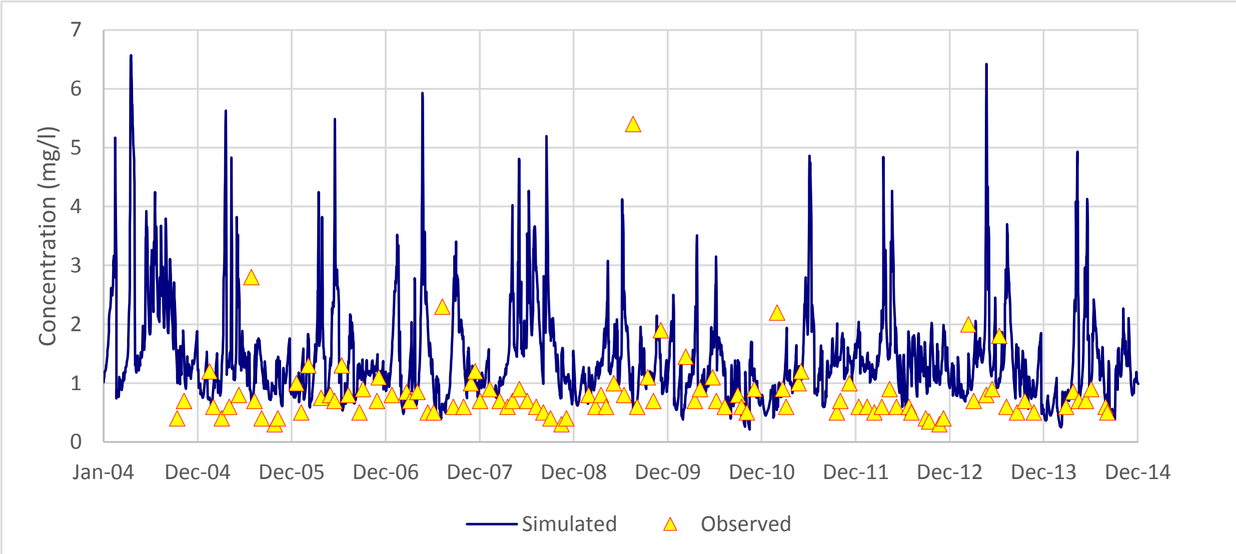


Figure D-137. Time series of observed and simulated TKN concentrations at LEJ050-0006.

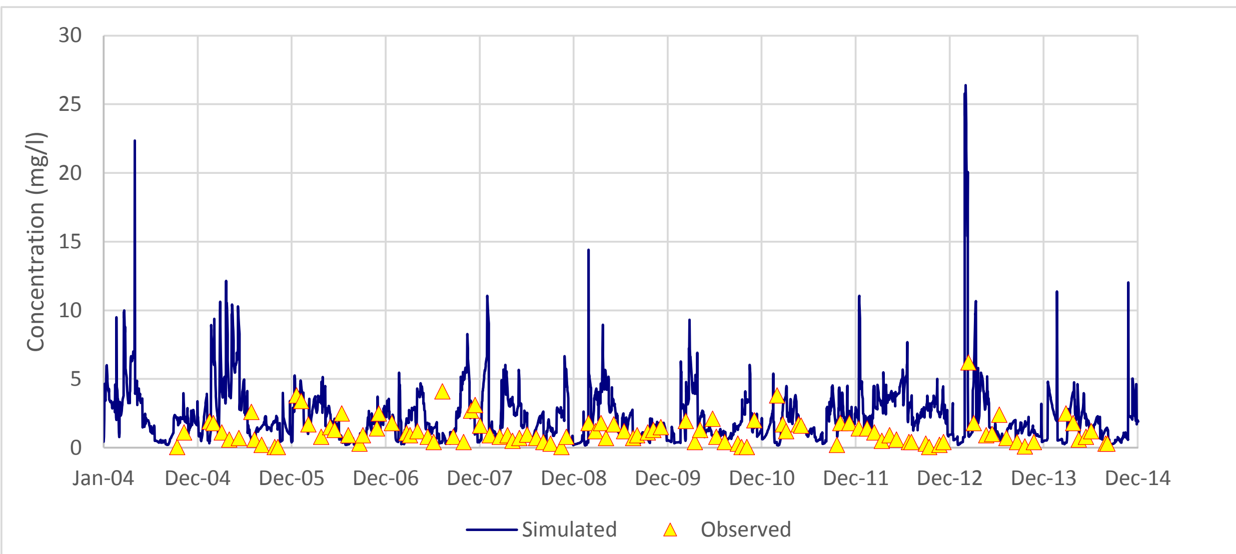


Figure D-138. Time series of observed and simulated NOx concentrations at LEJ050-0006.

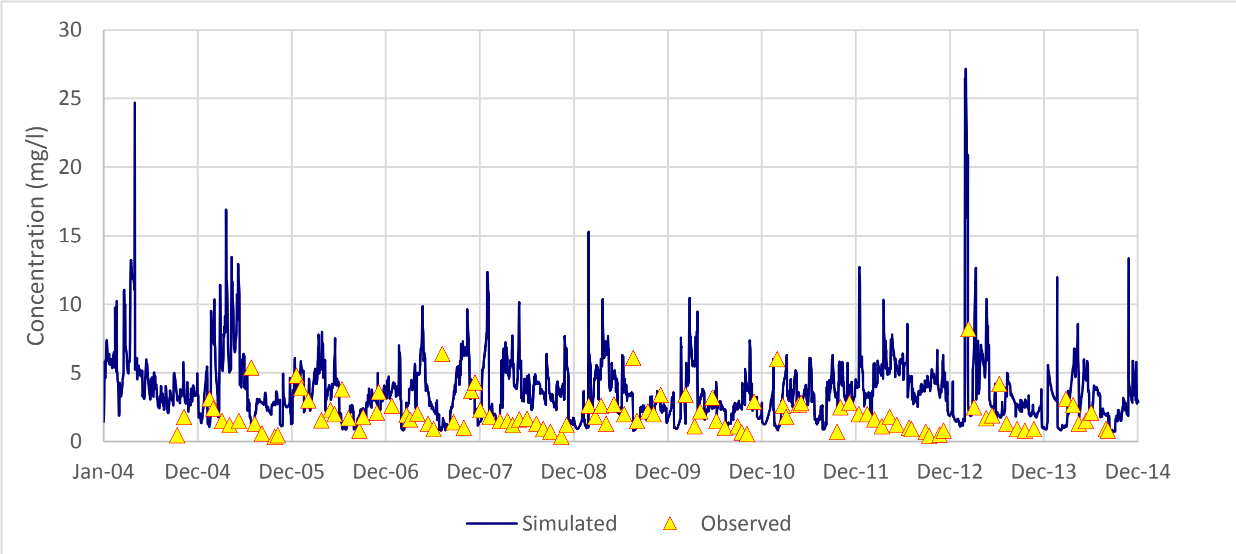


Figure D-139. Time series of observed and simulated TN concentrations at LEJ050-0006.

D-2.2.2.1.6 LEJ050-0007 - Fish Creek (IDEM) (SWAT Subbasin # 49)

Table D-53. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ050-0007

	Observed				Simulated					
Constituent	Mean	Min	Median	Max	Mean	Min	Median	Max	RE	n
TSS	17.25	2.00	8.00	280.00	36.12	1.41	28.70	161.14	-109.4%	115
TP	0.08	0.02	0.06	0.42	0.10	0.02	0.08	0.26	-26.3%	115
TKN	0.78	0.20	0.75	2.10	1.32	0.45	1.18	5.08	-68.0%	115
NOx	1.09	0.03	0.90	6.00	2.27	0.18	1.92	12.19	-108.7%	115
TN	1.87	0.23	1.60	7.80	3.59	0.85	3.25	13.04	-91.7%	115

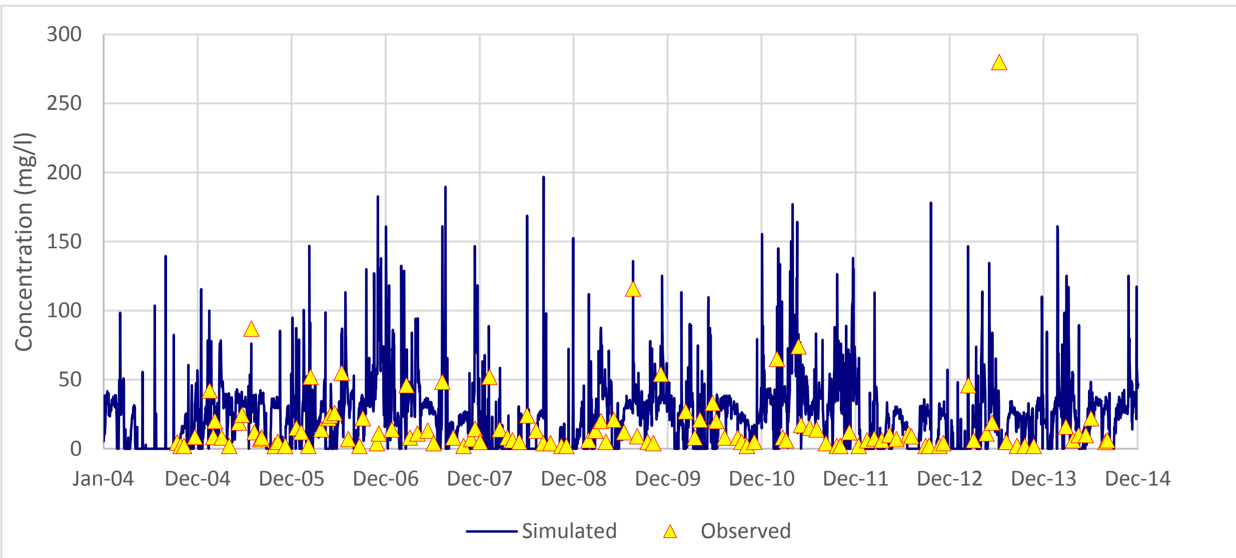


Figure D-140. Time series of observed and simulated TSS concentrations at LEJ050-0007.

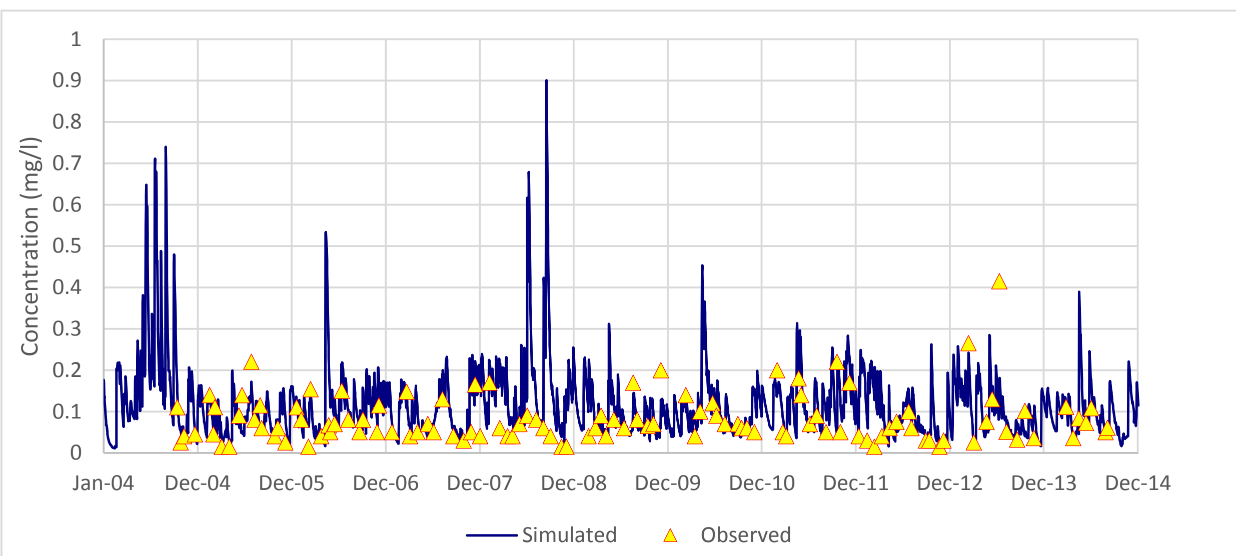


Figure D-141. Time series of observed and simulated TP concentrations at LEJ050-0007.

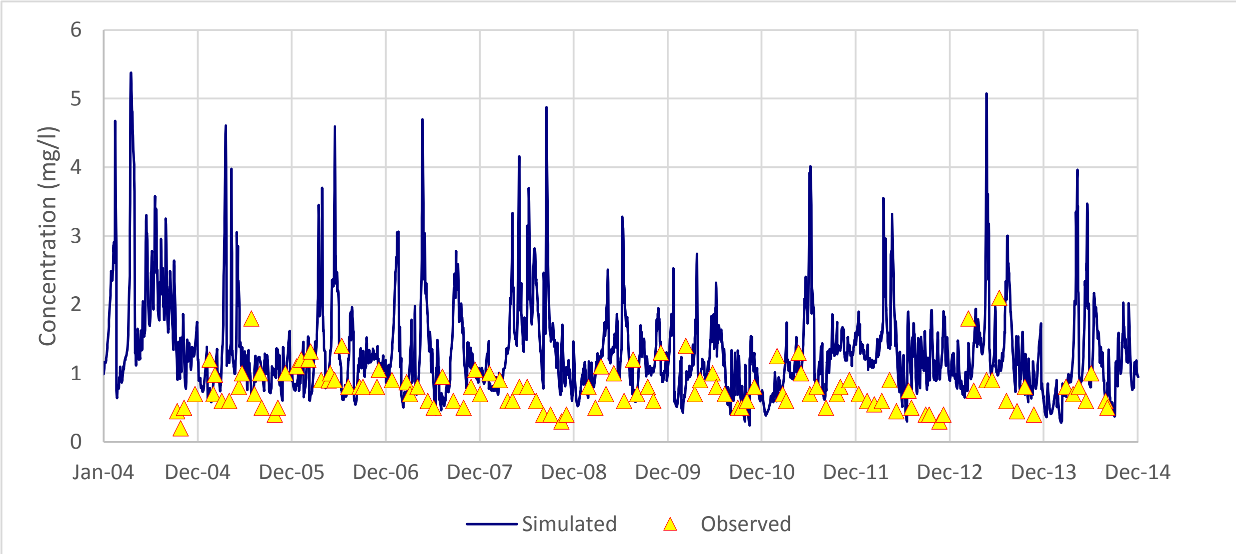


Figure D-142. Time series of observed and simulated TKN concentrations at LEJ050-0007.

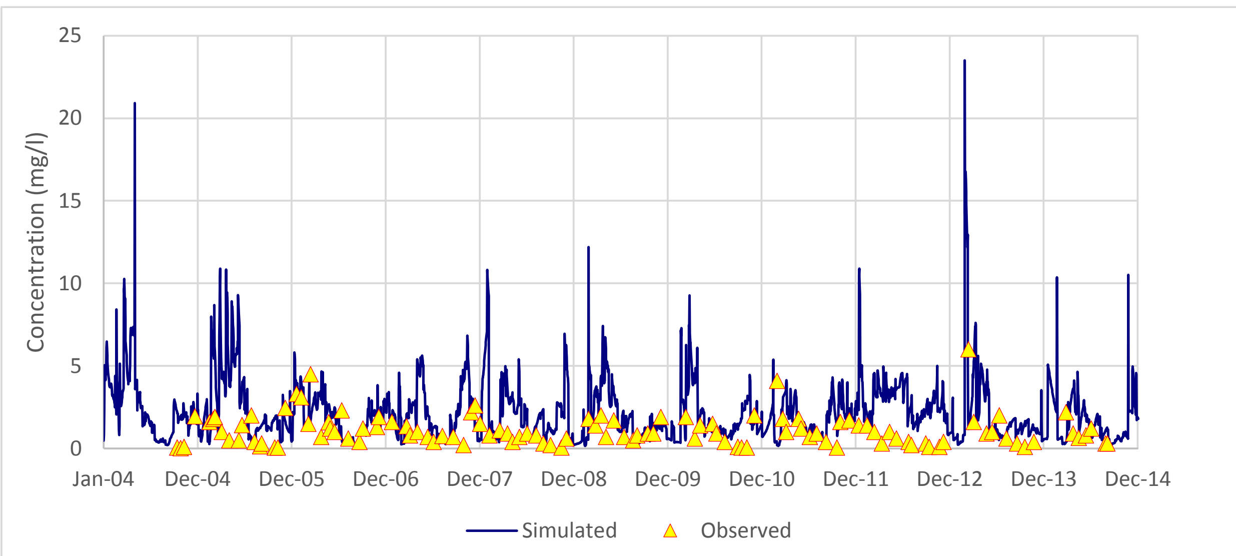


Figure D-143. Time series of observed and simulated NOx concentrations at LEJ050-0007.

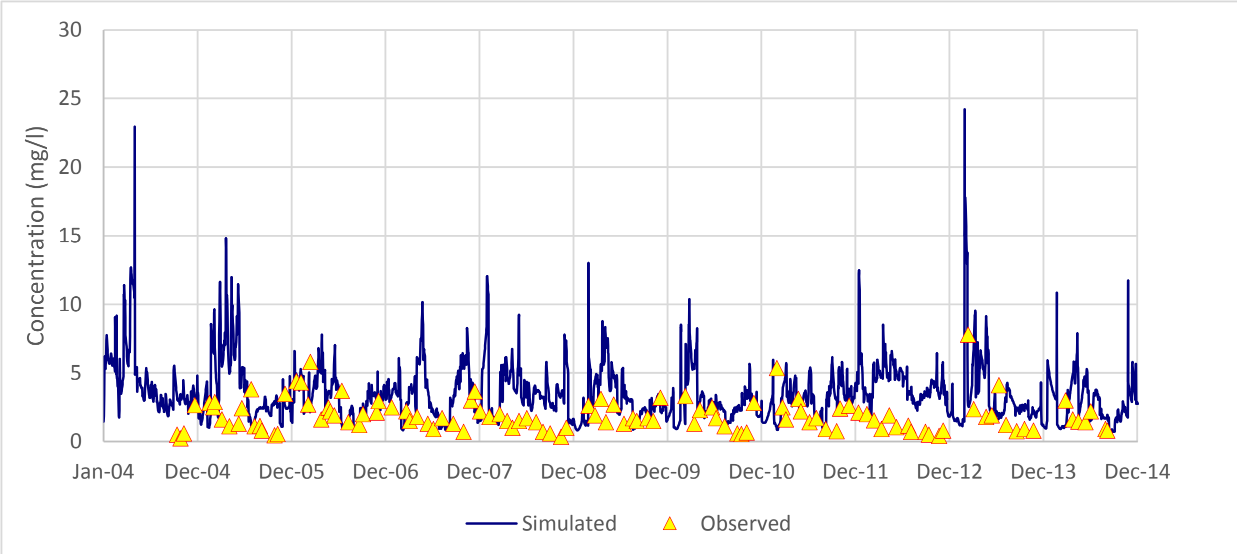


Figure D-144. Time series of observed and simulated TN concentrations at LEJ050-0007.

D-2.2.2.1.7 P08S20 - Fish Creek (Ohio EPA) (SWAT Subbasin # 47)

Table D-54. Evaluation of SWAT model performance on paired observed and simulated concentrations at P08S20

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	28.42	2.50	14.50	134.00	84.72	23.84	91.56	167.62	-198.1%	12
TP	0.11	0.02	0.08	0.30	0.12	0.03	0.11	0.24	-5.2%	12
TKN	0.71	0.10	0.62	1.33	1.44	0.67	1.25	3.58	-104.0%	12
NOx	1.86	0.14	0.90	6.27	1.84	0.53	1.65	3.83	1.1%	12
TN	2.57	0.54	1.54	7.60	3.28	1.62	2.88	7.41	-27.8%	12

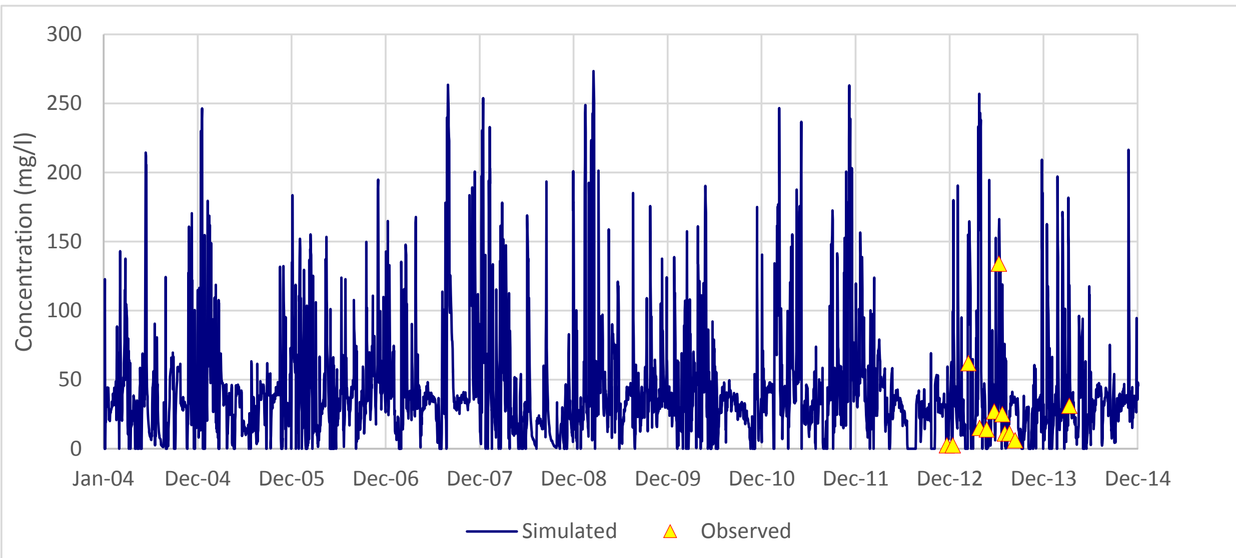


Figure D-145. Time series of observed and simulated TSS concentrations at P08S20.

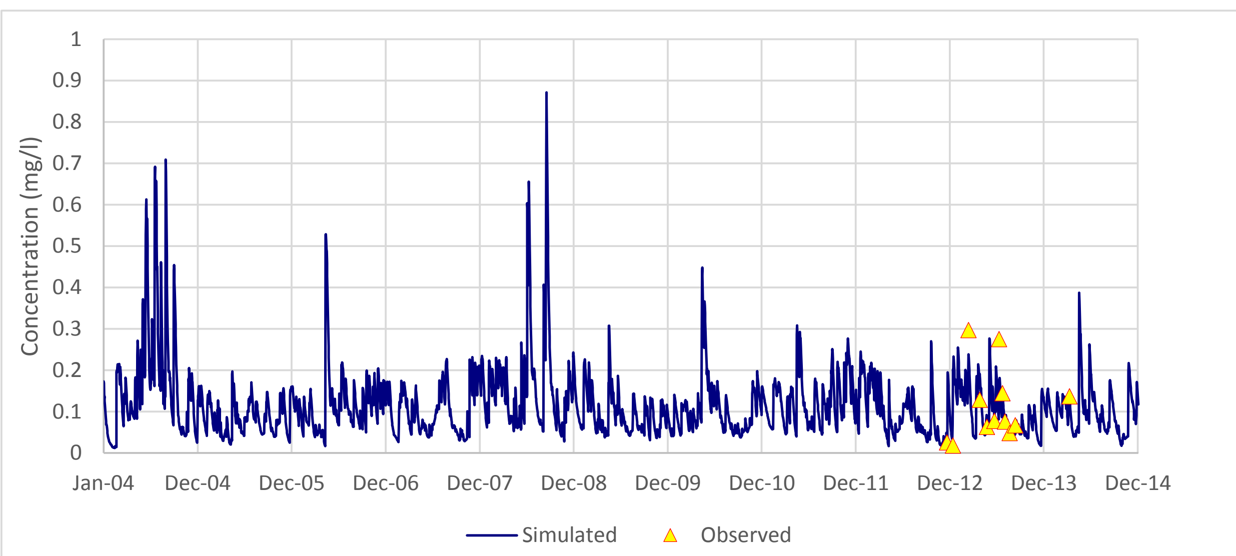


Figure D-146. Time series of observed and simulated TP concentrations at P08S20.

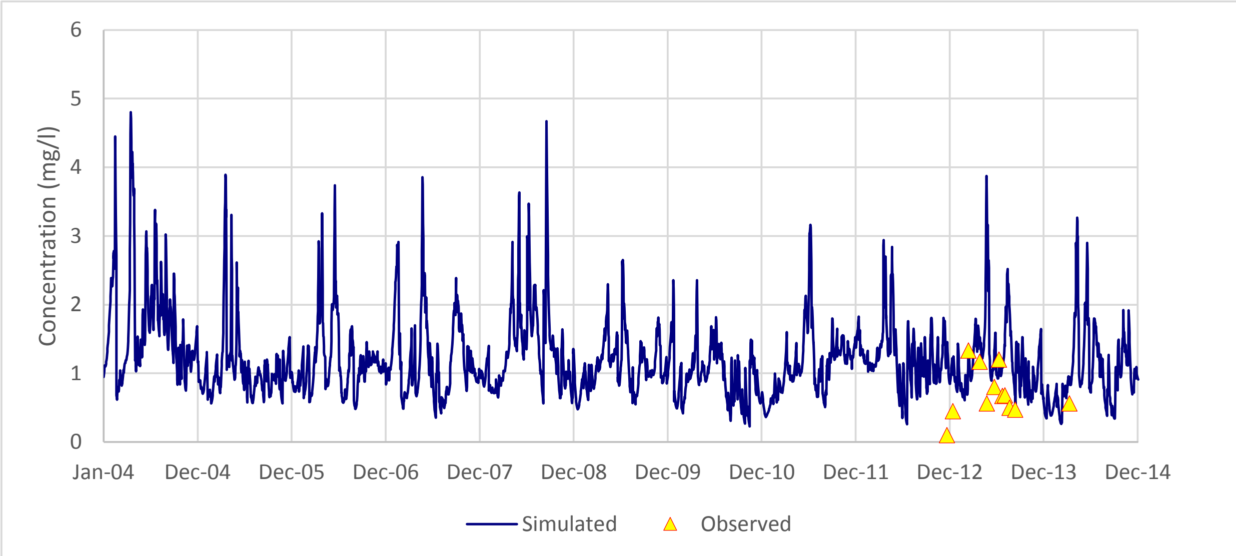


Figure D-147. Time series of observed and simulated TKN concentrations at P08S20.

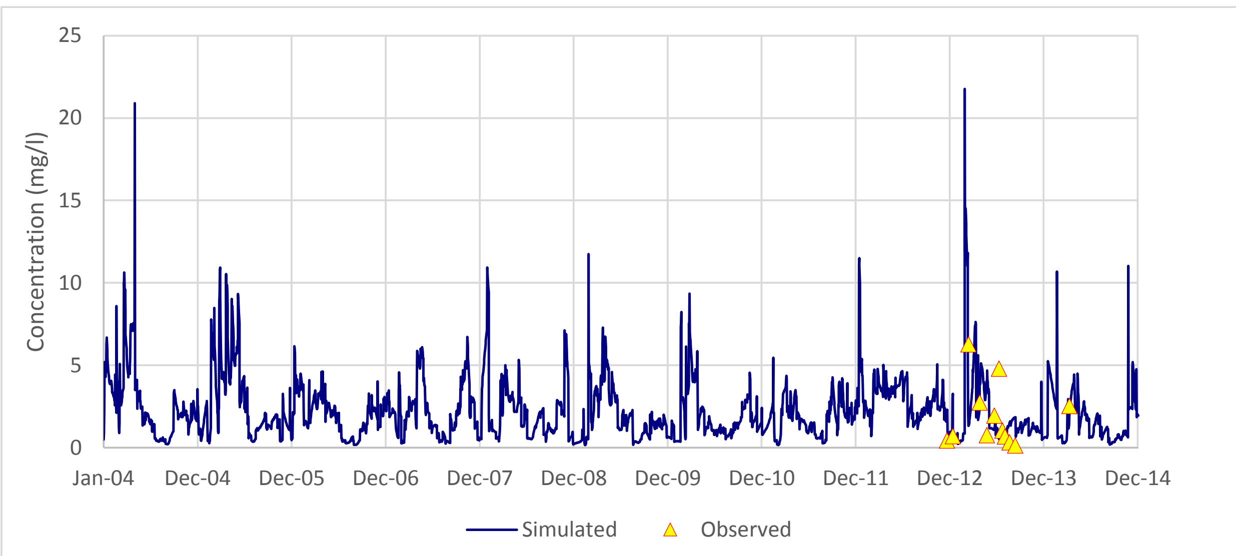


Figure D-148. Time series of observed and simulated NOx concentrations at P08S20.

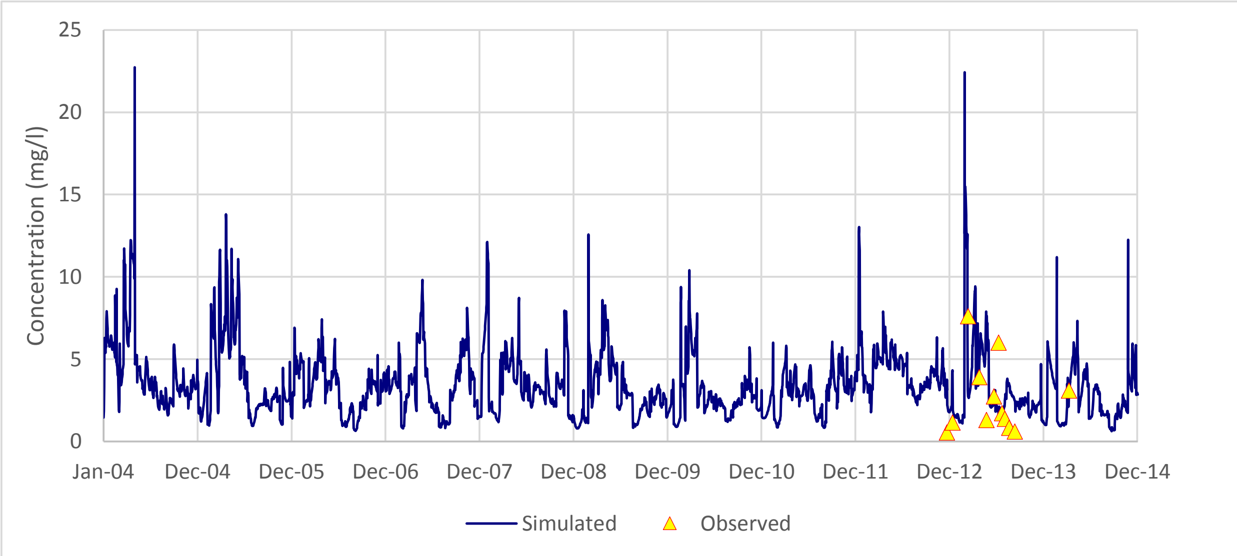


Figure D-149. Time series of observed and simulated TN concentrations at P08S20.

D-2.2.2.1.8 510220 - St. Joseph River upstream of Newville (Ohio EPA) (SWAT Subbasin # 43)

Table D-55. Evaluation of SWAT model performance on paired observed and simulated concentrations at 510220

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	34.21	5.00	25.00	191.00	23.87	0.87	14.89	99.69	30.2%	59
TP	0.12	0.03	0.09	0.45	0.16	0.08	0.15	0.36	-30.1%	59
TKN	0.72	0.26	0.66	1.47	0.60	0.08	0.63	1.10	16.1%	59
NOx	1.85	0.10	1.40	6.92	2.54	0.44	2.25	8.21	-37.4%	59
TN	2.57	0.52	2.08	8.39	3.14	0.68	2.86	8.87	-22.4%	59

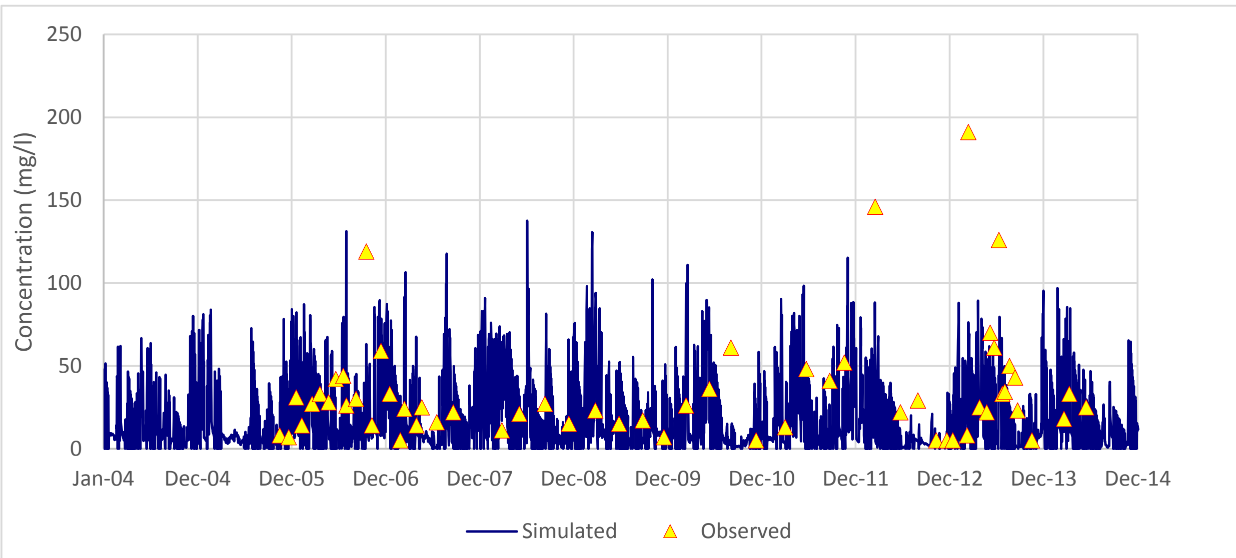


Figure D-150. Time series of observed and simulated TSS concentrations at 510220.

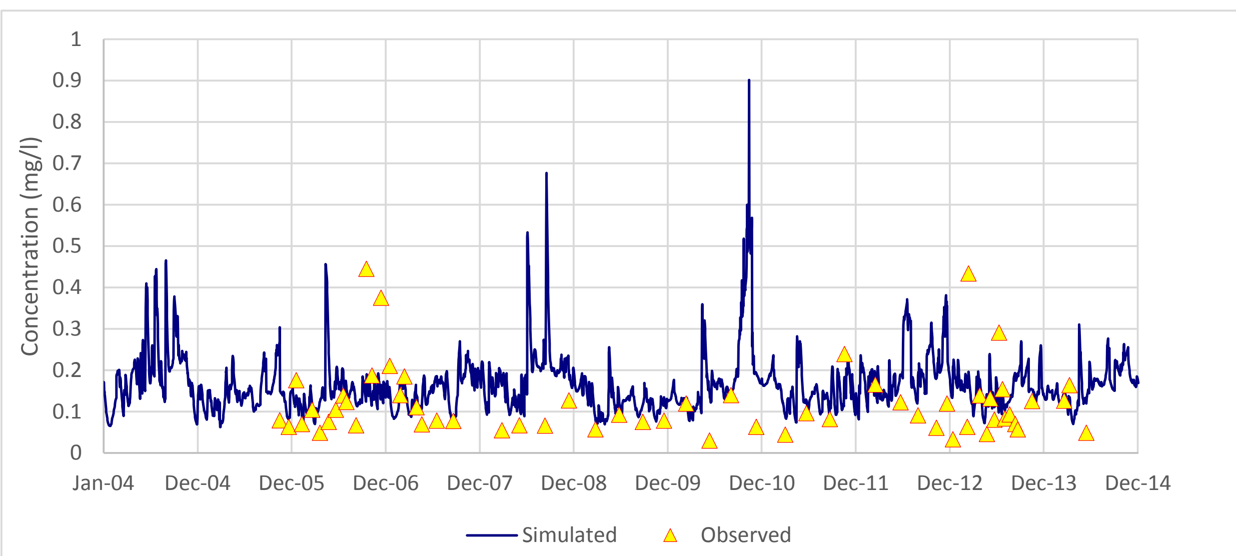


Figure D-151. Time series of observed and simulated TP concentrations at 510220.

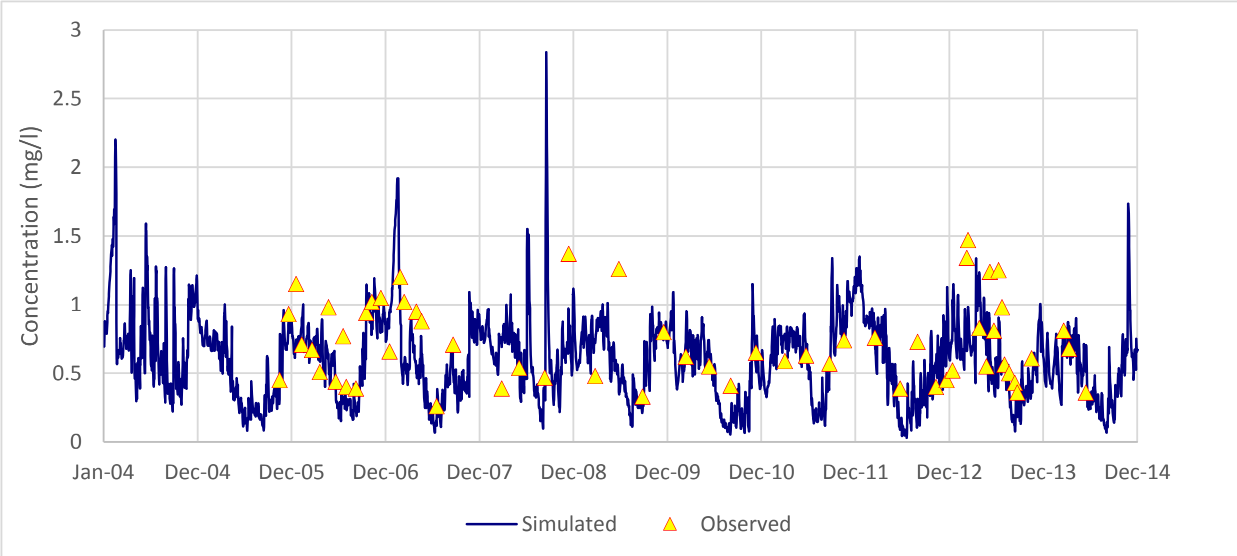


Figure D-152. Time series of observed and simulated TKN concentrations at 510220.

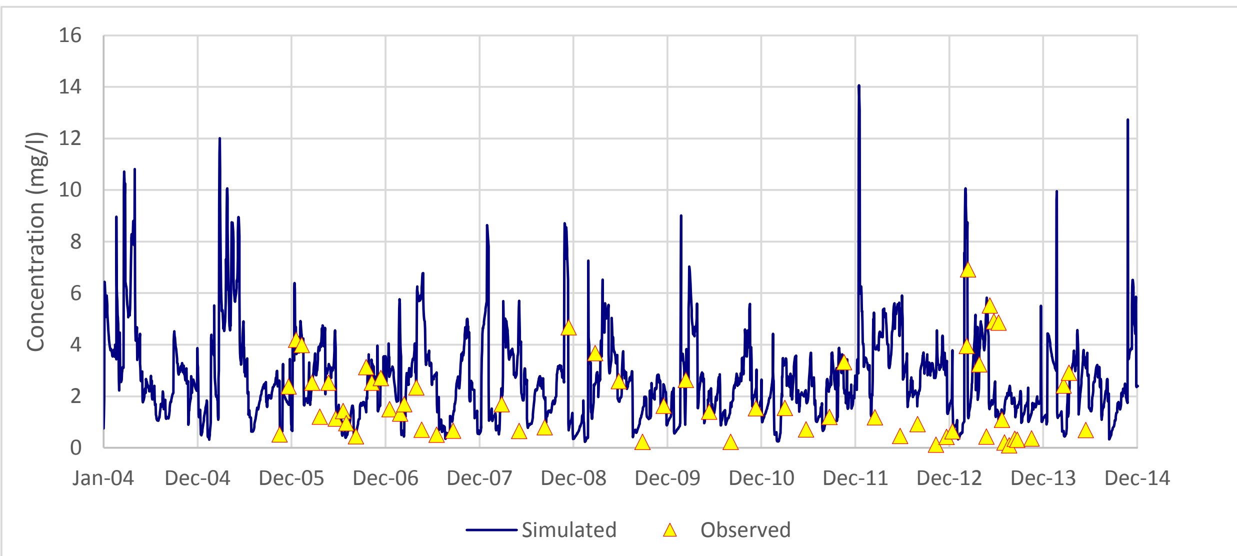


Figure D-153. Time series of observed and simulated NOx concentrations at 510220.

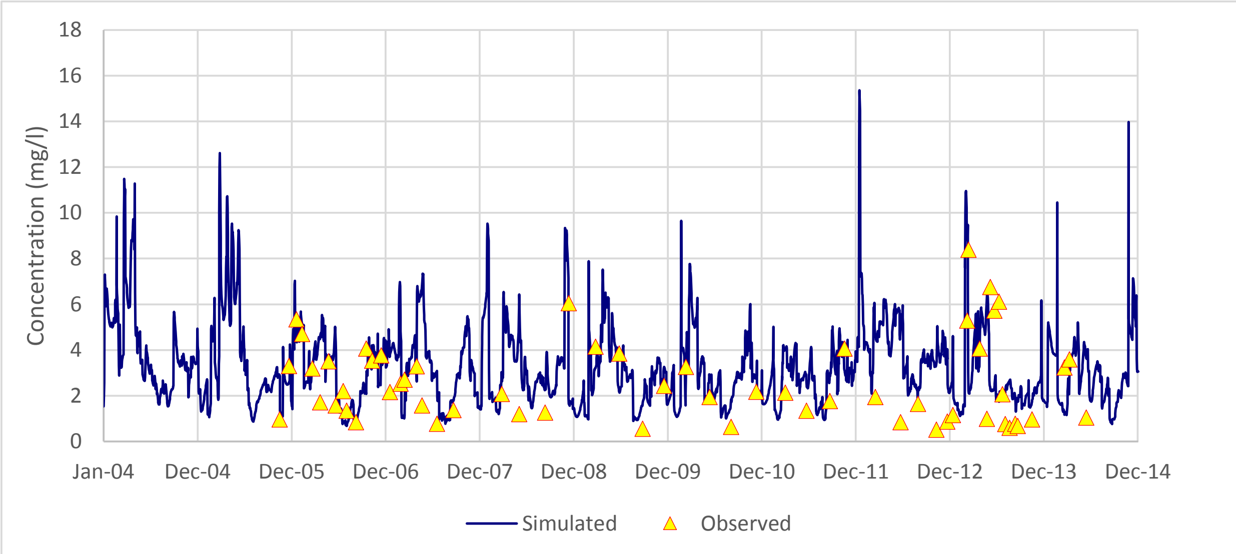


Figure D-154. Time series of observed and simulated TN concentrations at 510220.

D-2.2.2.1.9 LEJ060-0006 - St. Joseph River (IDEM) (SWAT Subbasin # 38)

Table D-56. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ060-0006

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	32.08	2.00	26.00	181.00	21.27	0.06	17.32	74.12	33.7%	111
TP	0.13	0.02	0.11	0.48	0.16	0.07	0.14	0.52	-23.7%	111
TKN	0.95	0.30	0.90	2.50	0.55	0.08	0.55	1.21	41.7%	111
NOx	1.37	0.05	1.10	6.65	2.69	0.30	2.50	8.90	-96.6%	111
TN	2.32	0.35	1.90	9.15	3.24	0.93	2.91	9.46	-39.9%	111

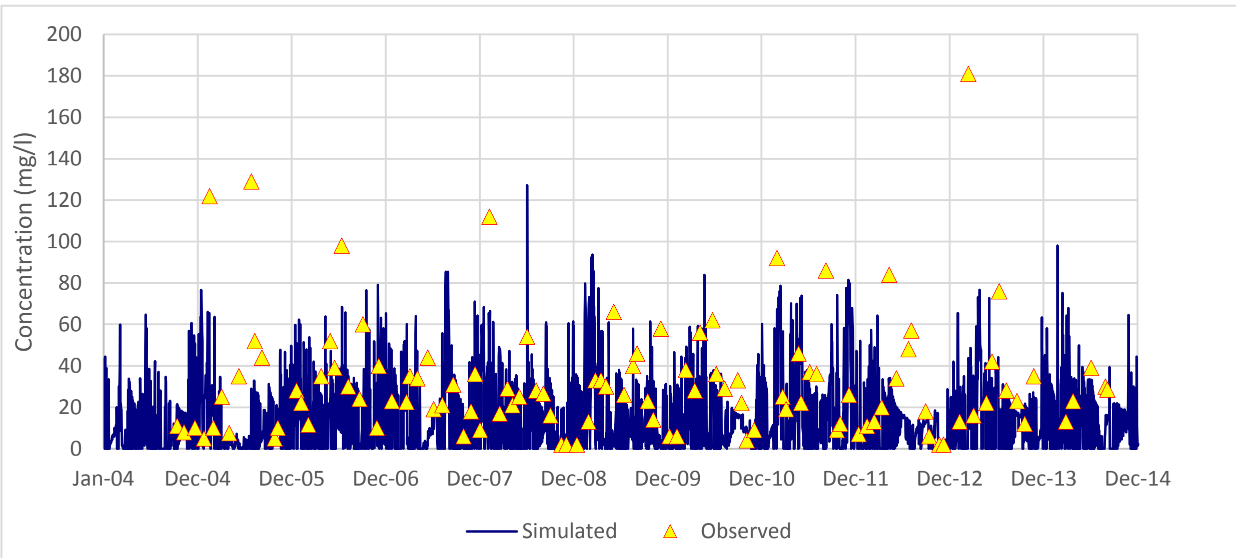


Figure D-155. Time series of observed and simulated TSS concentrations at LEJ060-0006.

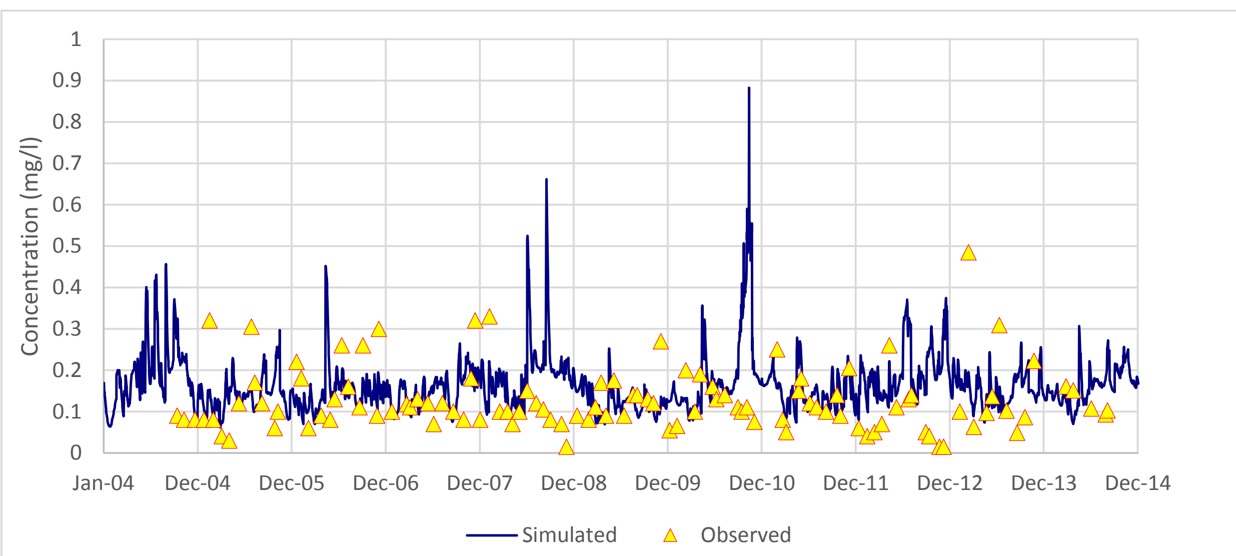


Figure D-156. Time series of observed and simulated TP concentrations at LEJ060-0006.

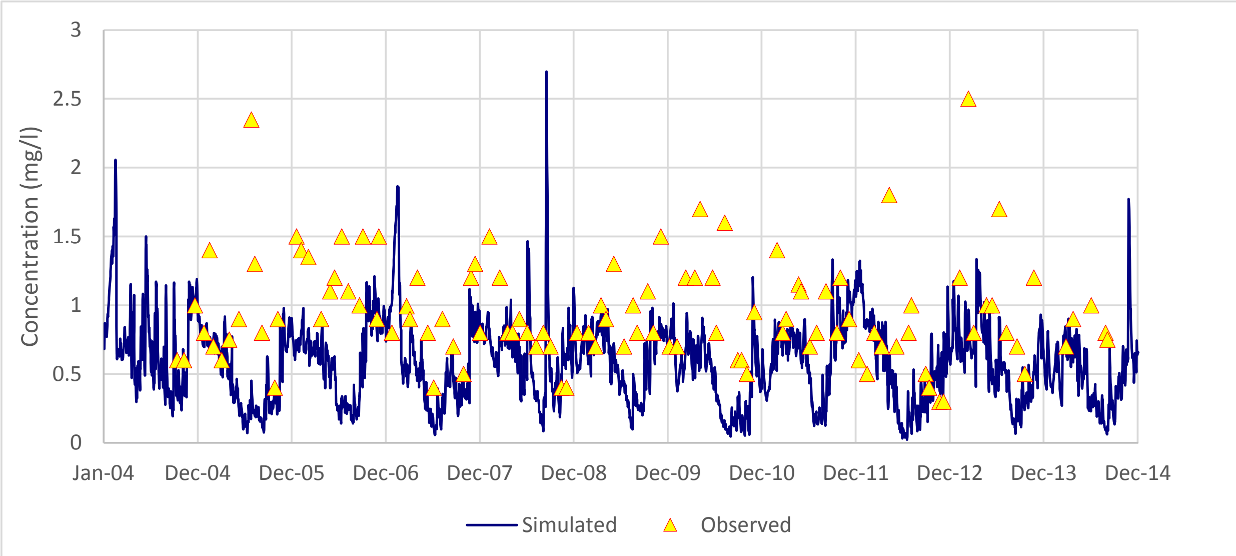


Figure D-157. Time series of observed and simulated TKN concentrations at LEJ060-0006.

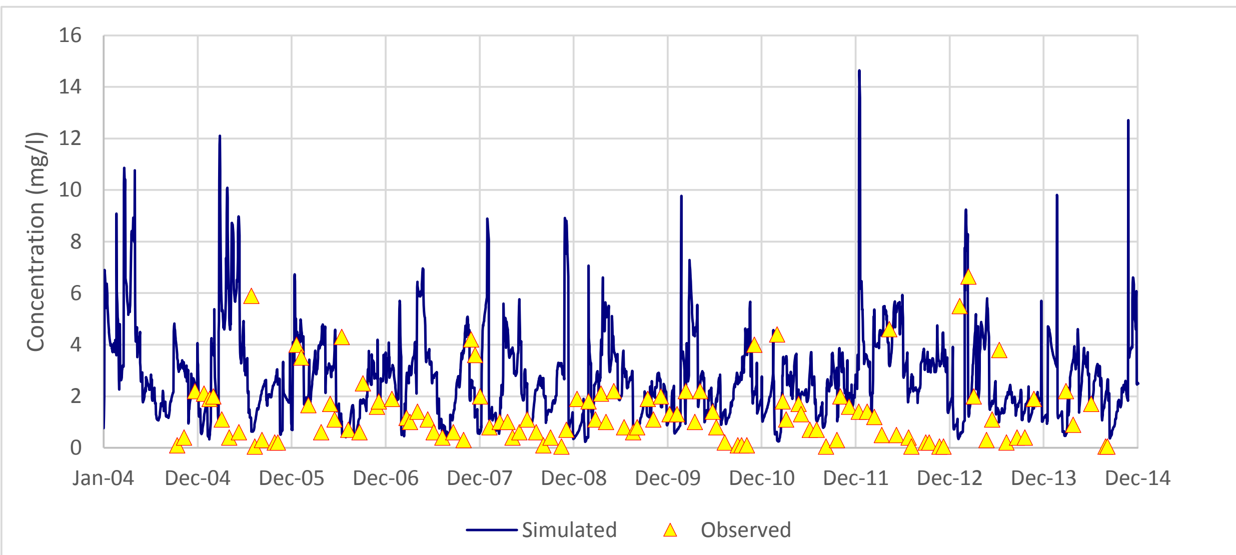


Figure D-158. Time series of observed and simulated NOx concentrations at LEJ060-0006.

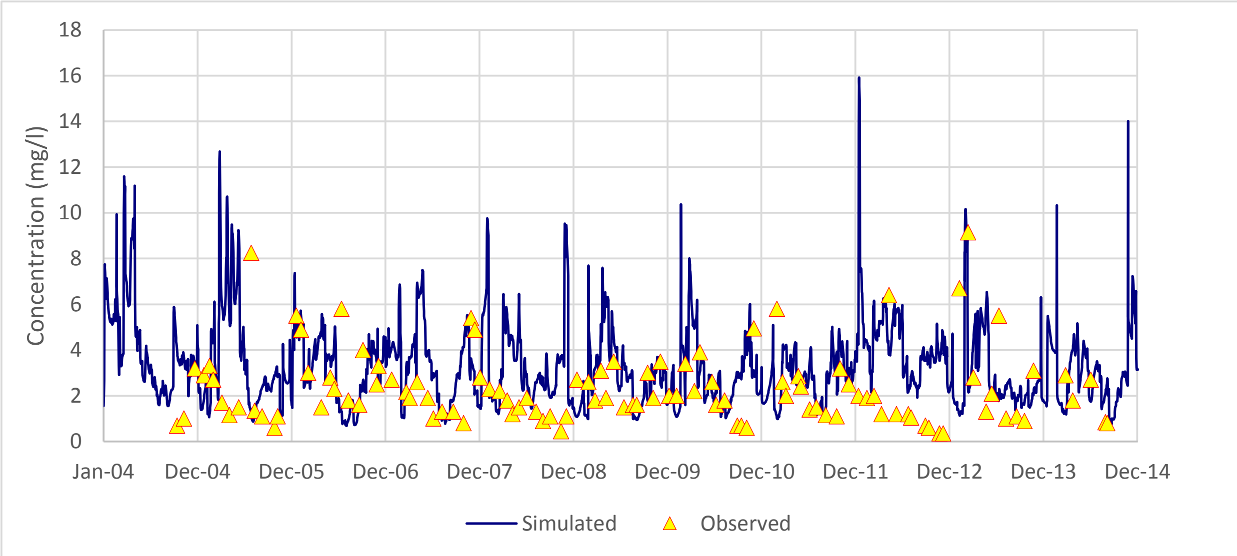


Figure D-159. Time series of observed and simulated TN concentrations at LEJ060-0006.

D-2.2.2.1.10 LEJ090-0026 - Cedar Creek (IDEM) (SWAT Subbasin # 8)

Table D-57. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ090-0026

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	19.53	2.00	10.00	238.00	17.45	0.07	6.94	145.37	10.6%	112
TP	0.09	0.02	0.07	0.45	0.15	0.05	0.14	0.29	-57.9%	112
TKN	0.84	0.28	0.80	2.05	0.95	0.12	0.96	2.18	-13.8%	112
NOx	2.37	0.60	1.65	13.00	2.32	0.19	2.03	7.64	2.3%	112
TN	3.21	1.10	2.50	14.45	3.27	0.93	3.11	9.79	-1.9%	112

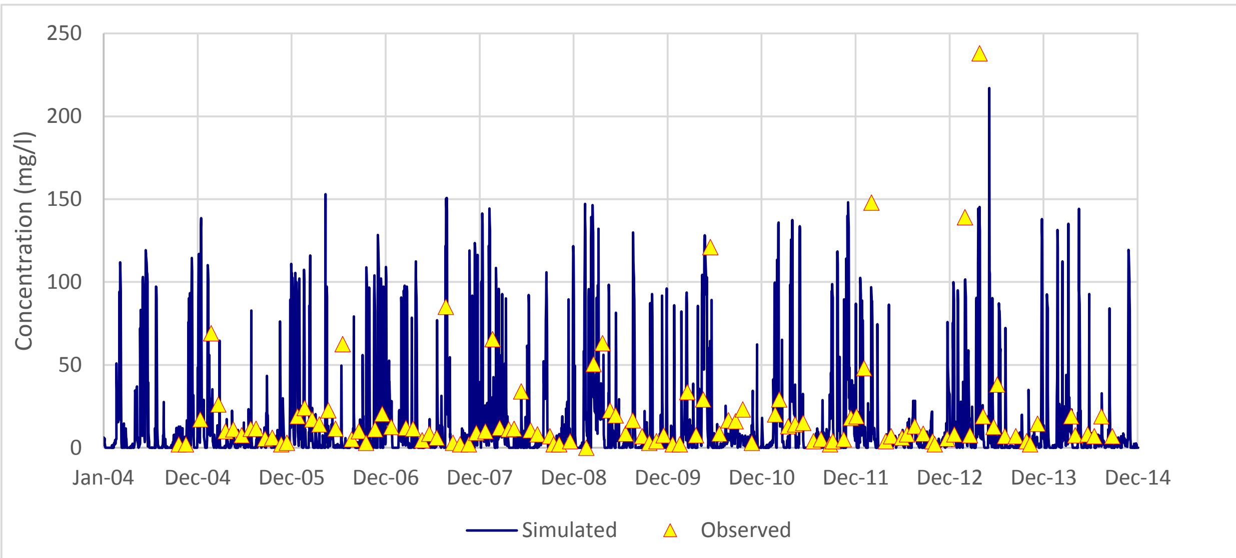


Figure D-160. Time series of observed and simulated TSS concentrations at LEJ090-0026.

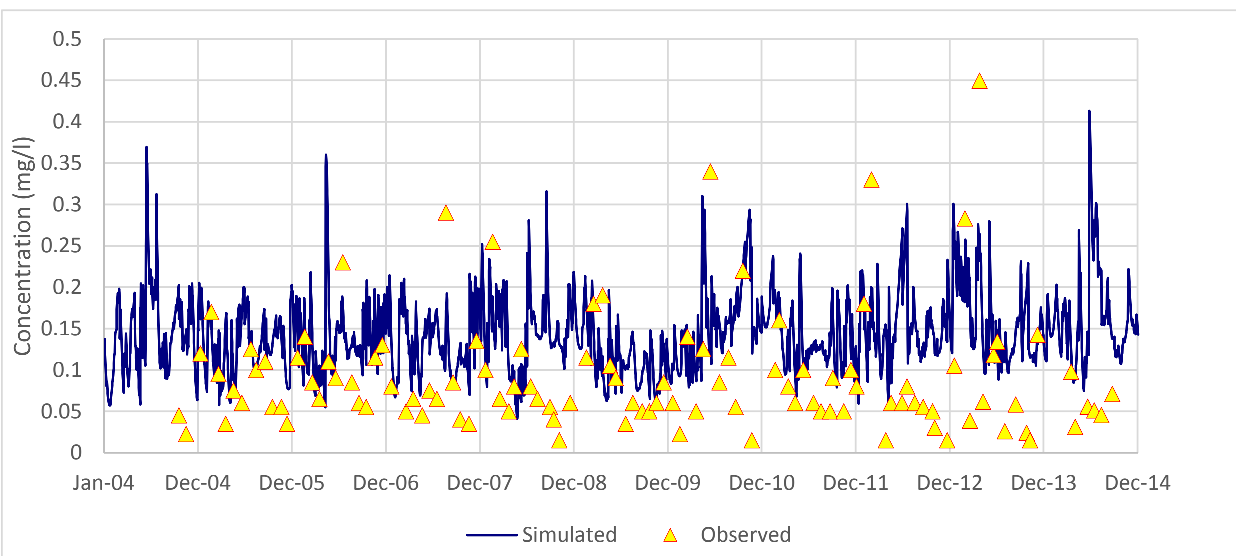


Figure D-161. Time series of observed and simulated TP concentrations at LEJ090-0026.

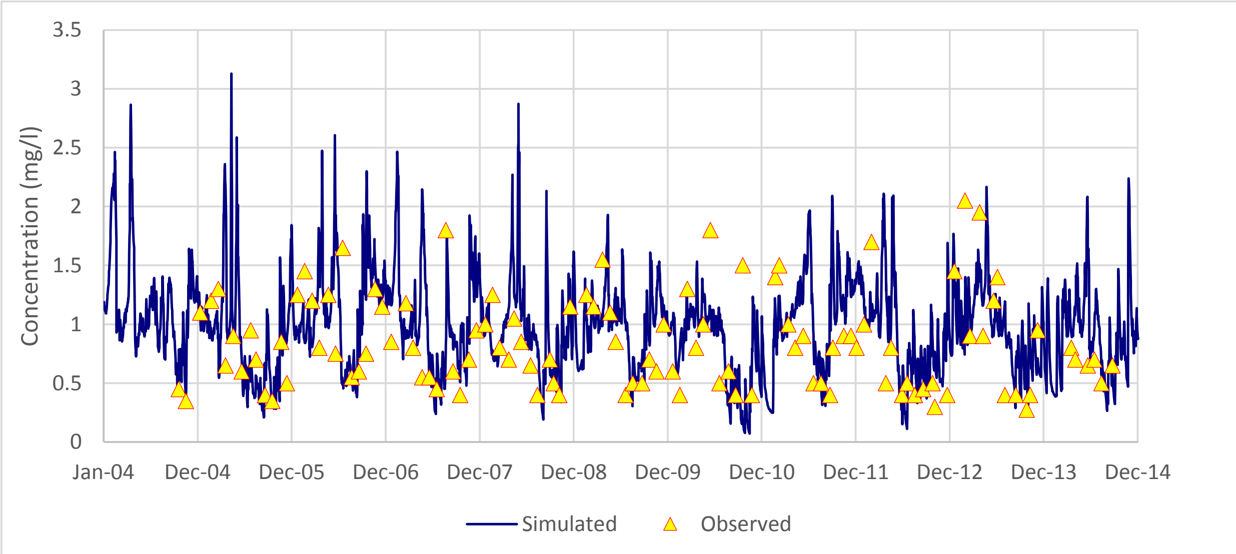


Figure D-162. Time series of observed and simulated TKN concentrations at LEJ090-0026.

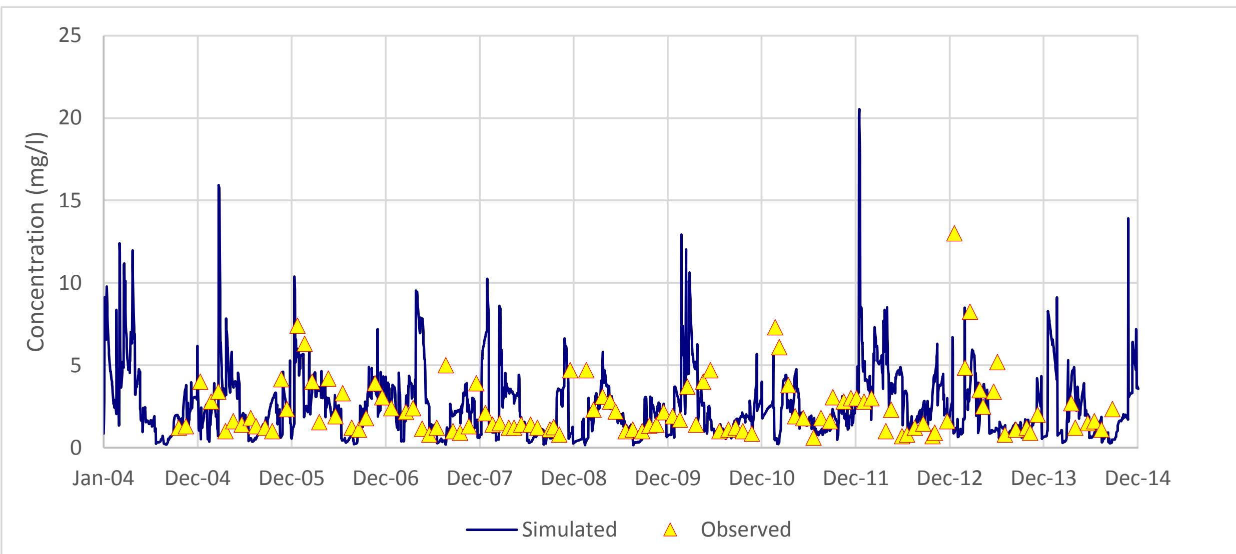


Figure D-163. Time series of observed and simulated NOx concentrations at LEJ090-0026.

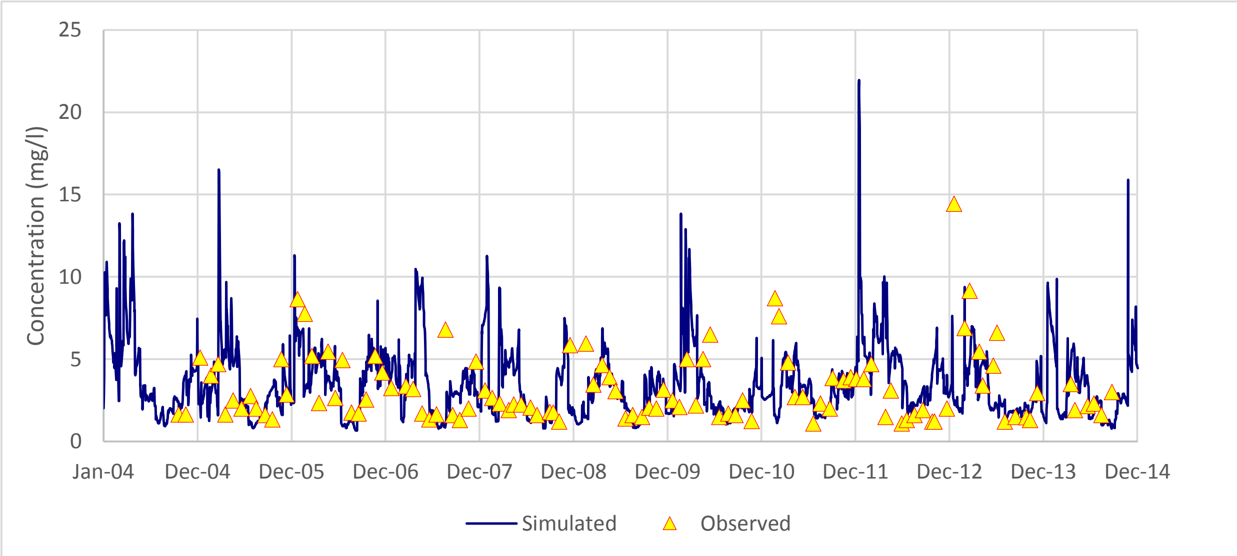


Figure D-164. Time series of observed and simulated TN concentrations at LEJ090-0026.

D-2.2.2.1.11 LEJ100-002 - St. Joseph River (IDEM) (SWAT Subbasin # 5)

Table D-58. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	38.82	2.00	28.55	856.00	16.10	0.00	6.33	116.16	58.5%	332
TP	0.14	0.01	0.12	1.01	0.13	0.02	0.13	0.52	9.0%	332
TKN	1.11	0.50	1.00	5.40	0.51	0.01	0.53	2.04	54.5%	71
NOx	1.57	0.20	1.00	6.60	2.26	0.31	2.02	7.63	-43.9%	71
TN	2.68	0.75	2.00	8.30	2.76	0.47	2.48	8.75	-3.0%	71

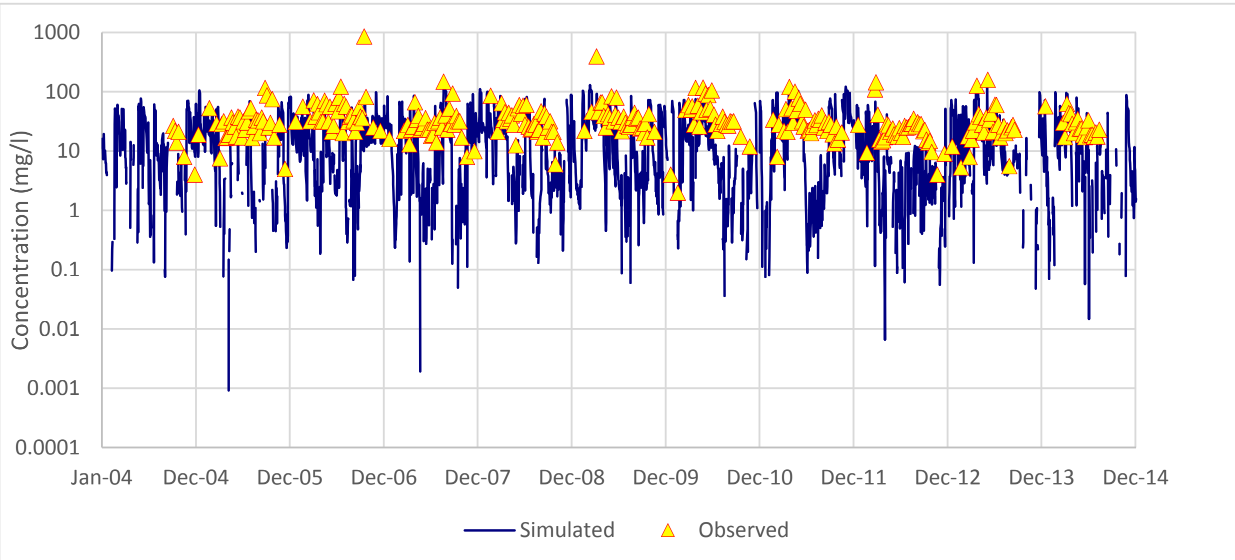


Figure D-165. Time series of observed and simulated TSS concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road.

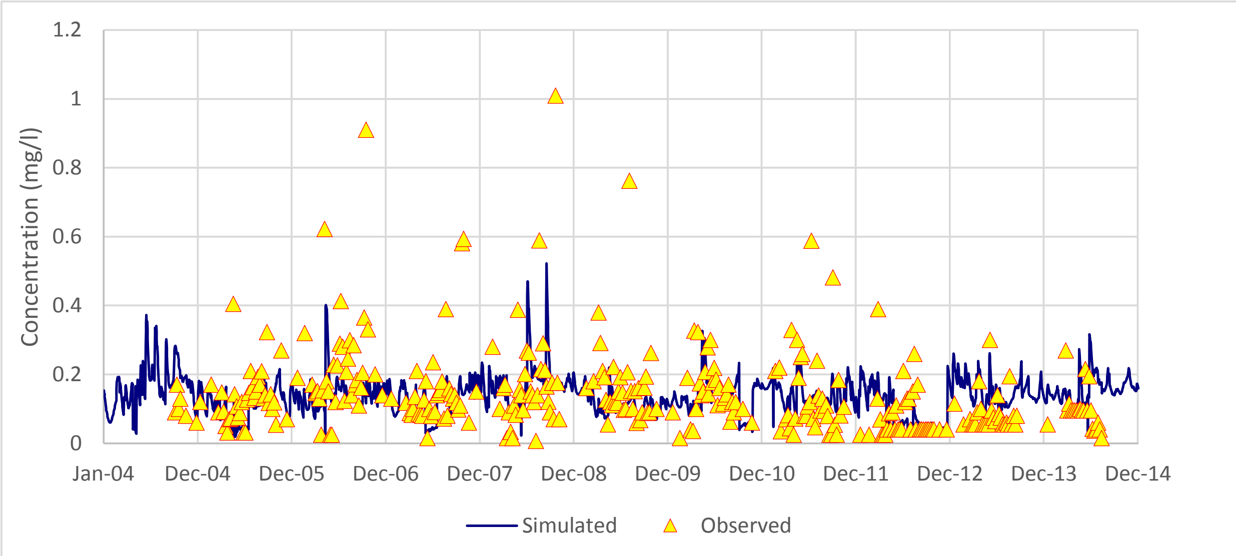


Figure D-166. Time series of observed and simulated TP concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road.

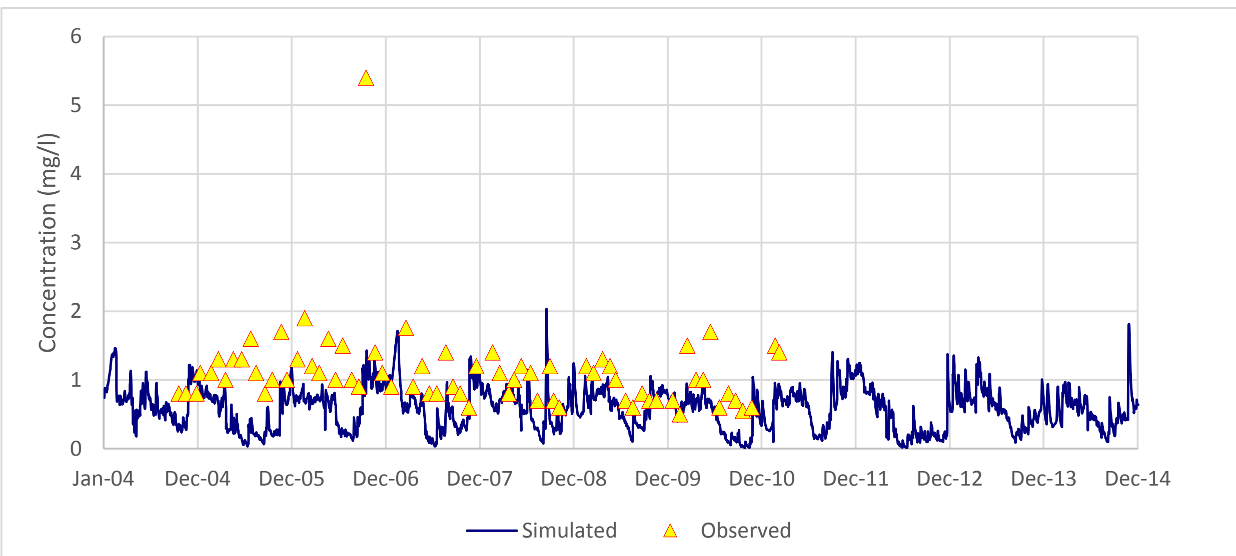


Figure D-167. Time series of observed and simulated TKN concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road.

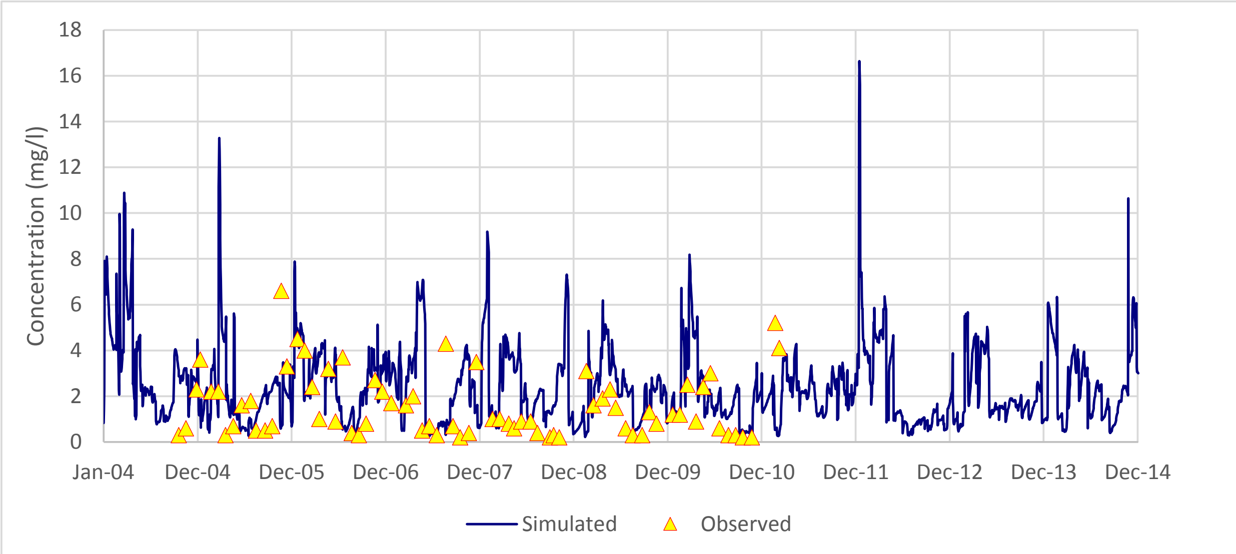


Figure D-168. Time series of observed and simulated NOx concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road.

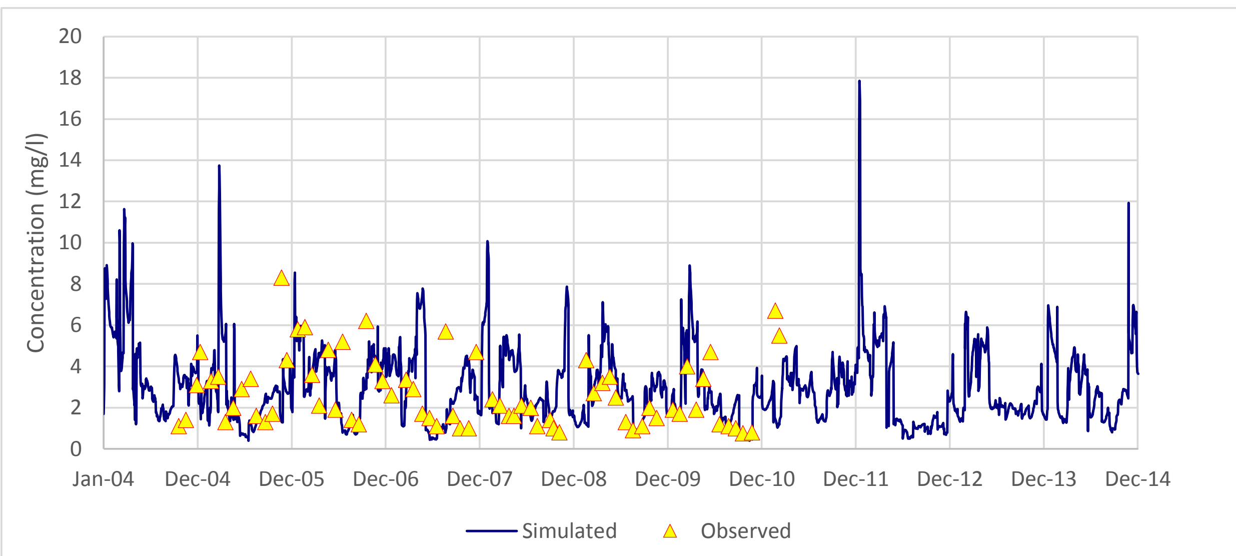


Figure D-169. Time series of observed and simulated TN concentrations at LEJ100-002 and the city of Fort Wayne's sample site at Mayhew Road.

D-2.2.2.1.12 LEJ100-003 - St. Joseph River (IDEM) (SWAT Subbasin # 2)

Table D-59. Evaluation of SWAT model performance on paired observed and simulated concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue

Constituent	Observed				Simulated				RE	n
	Mean	Min	Median	Max	Mean	Min	Median	Max		
TSS	30.48	5.00	22.10	260.00	27.57	10.00	11.01	155.22	9.5%	358
TP	0.15	0.01	0.10	7.14	0.13	0.02	0.13	0.51	15.2%	358
TKN	1.04	0.40	1.00	2.20	0.46	0.04	0.43	1.87	56.1%	105
NOx	1.50	0.05	1.00	10.00	2.28	0.34	2.03	8.34	-52.0%	105
TN	2.54	0.60	1.90	11.80	2.74	0.53	2.41	9.43	-7.7%	105

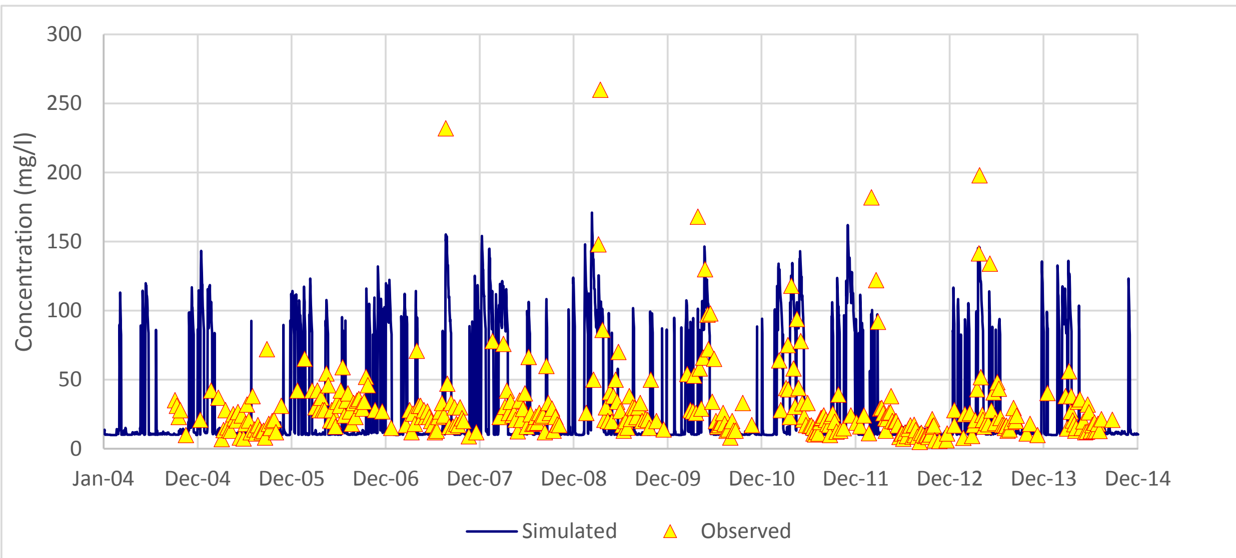


Figure D-170. Time series of observed and simulated TSS concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue.

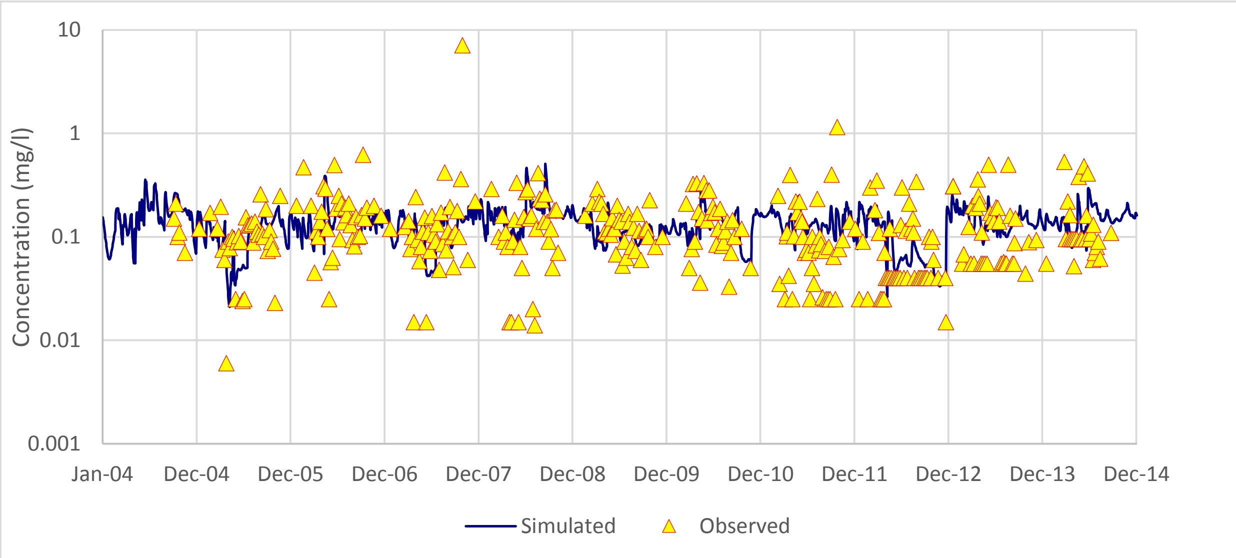


Figure D-171. Time series of observed and simulated TP concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue.

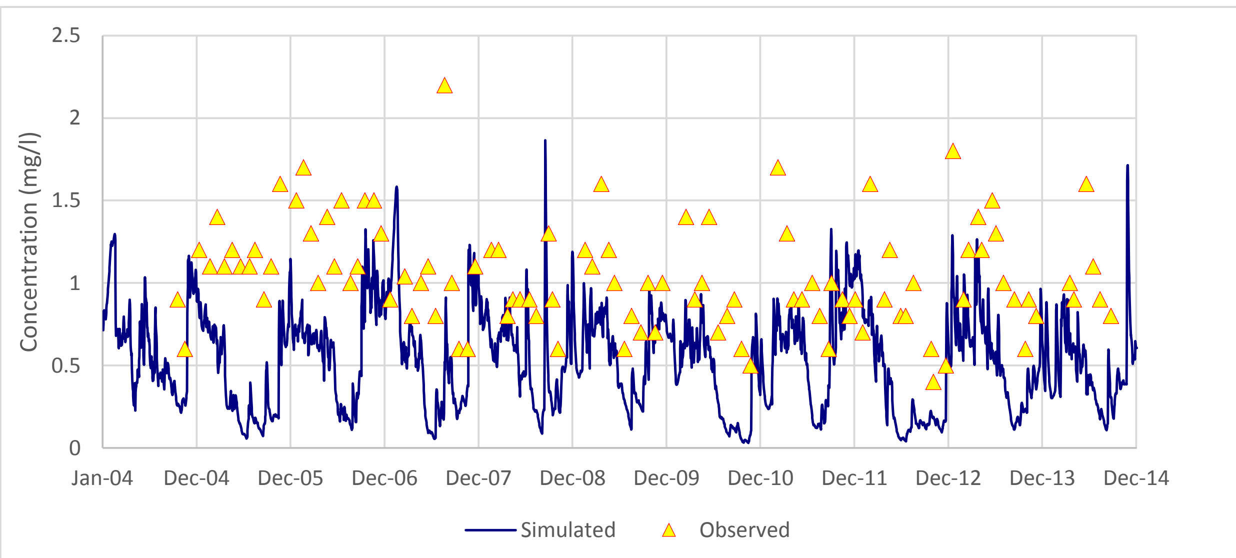


Figure D-172. Time series of observed and simulated TKN concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue.

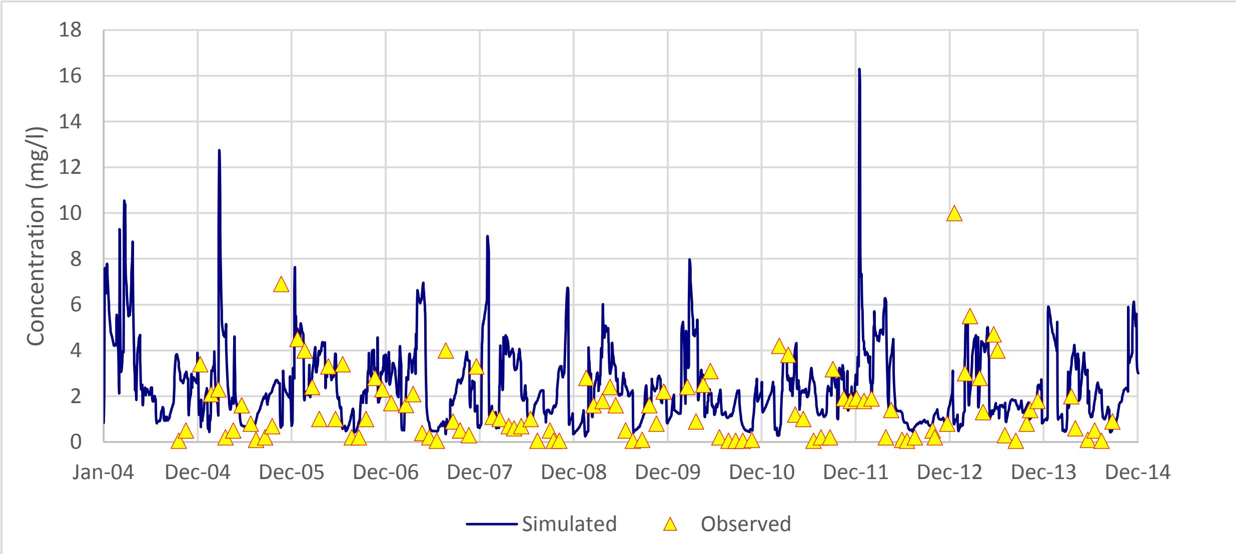


Figure D-173. Time series of observed and simulated NOx concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue.

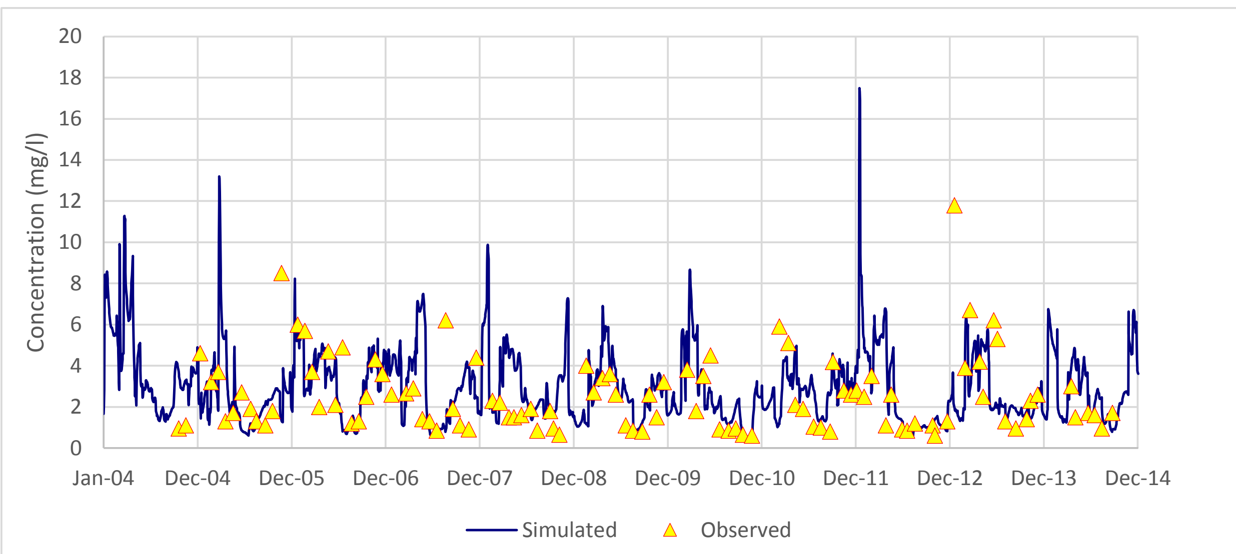


Figure D-174. Time series of observed and simulated TN concentrations at LEJ100-003 and the city of Fort Wayne's sample site at Tennessee Avenue.

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Appendix E.

Model Results Maps

Figures

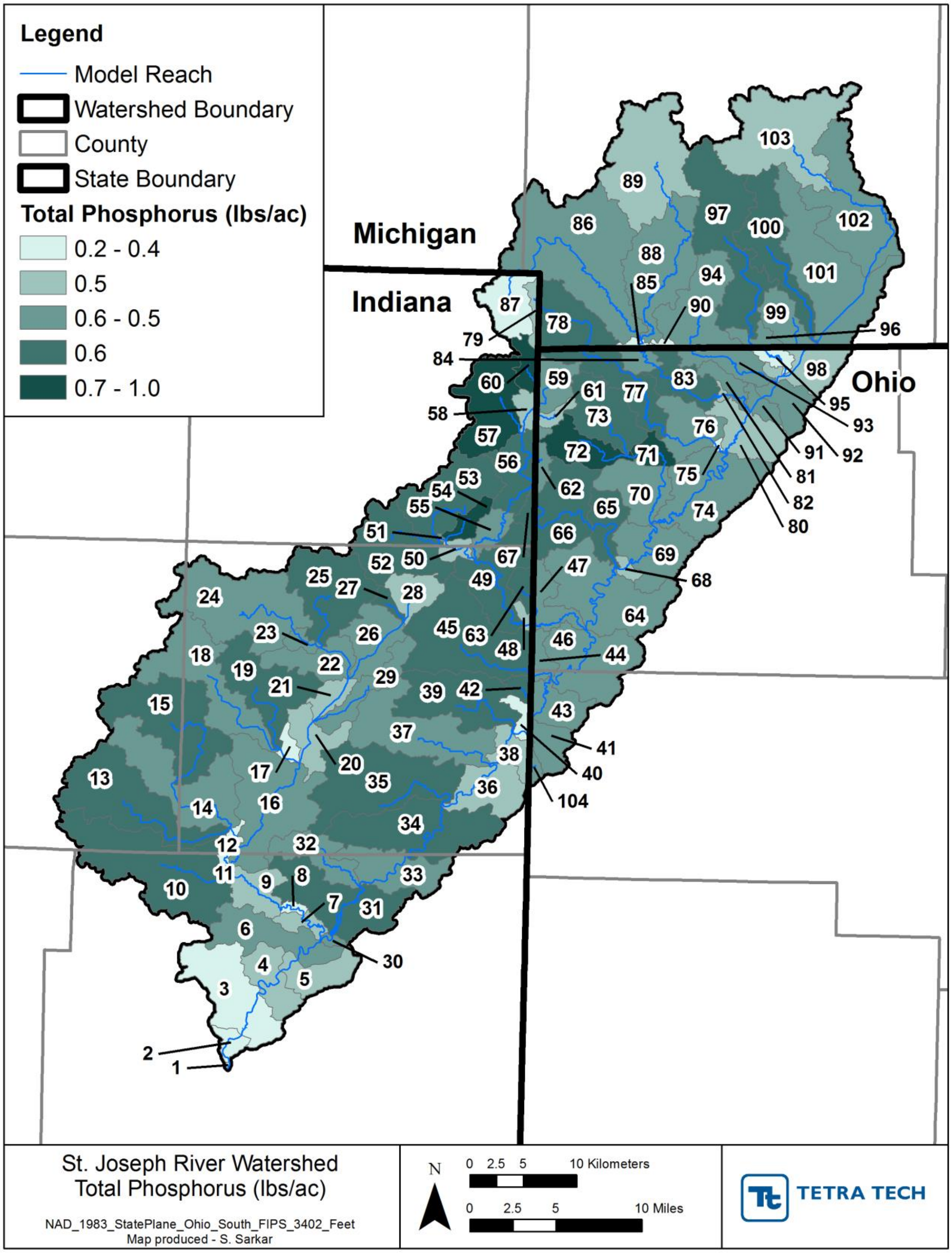


Figure E-1. Total phosphorus results by model subbasin.

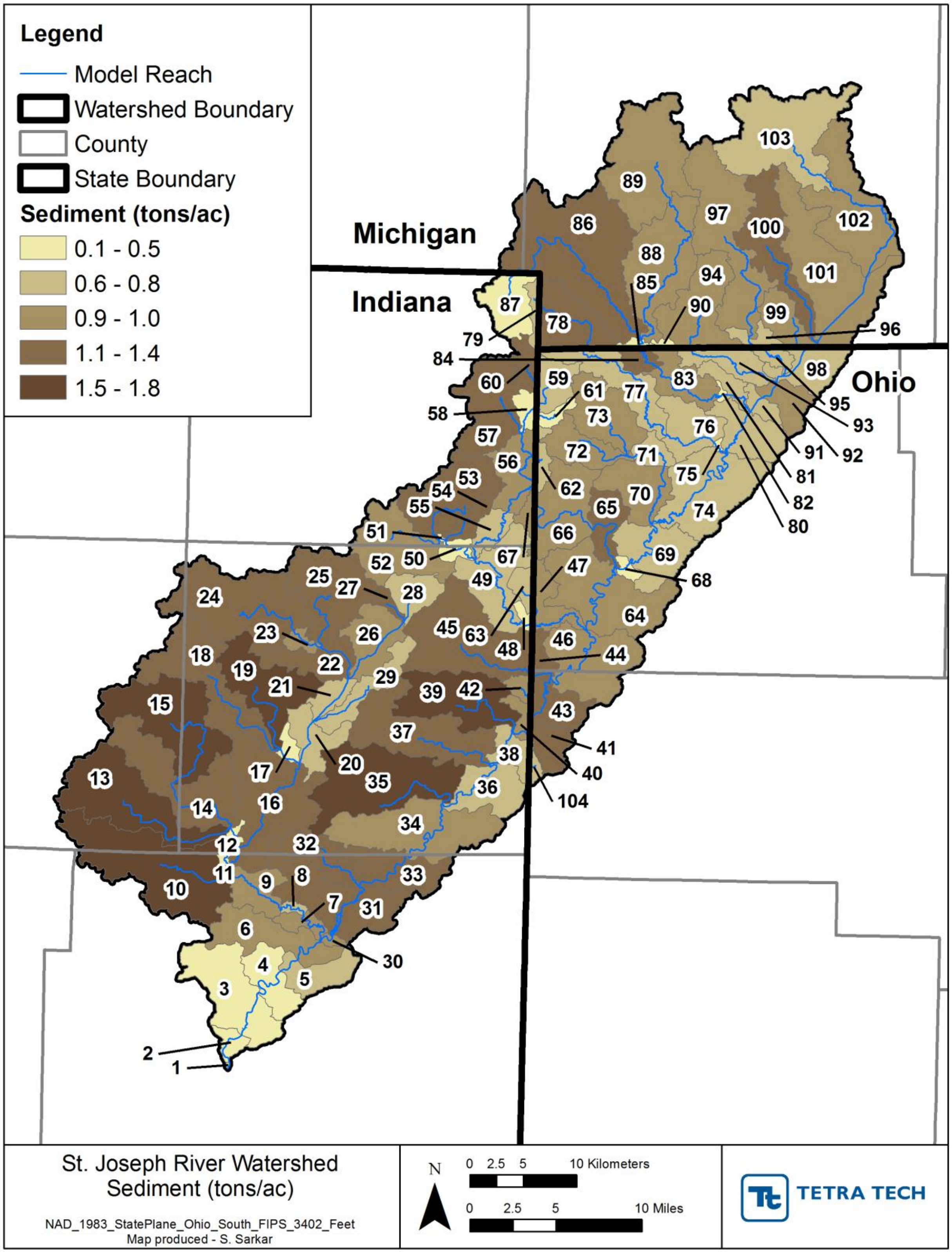


Figure E-2. Total suspended solids results by model subbasin.

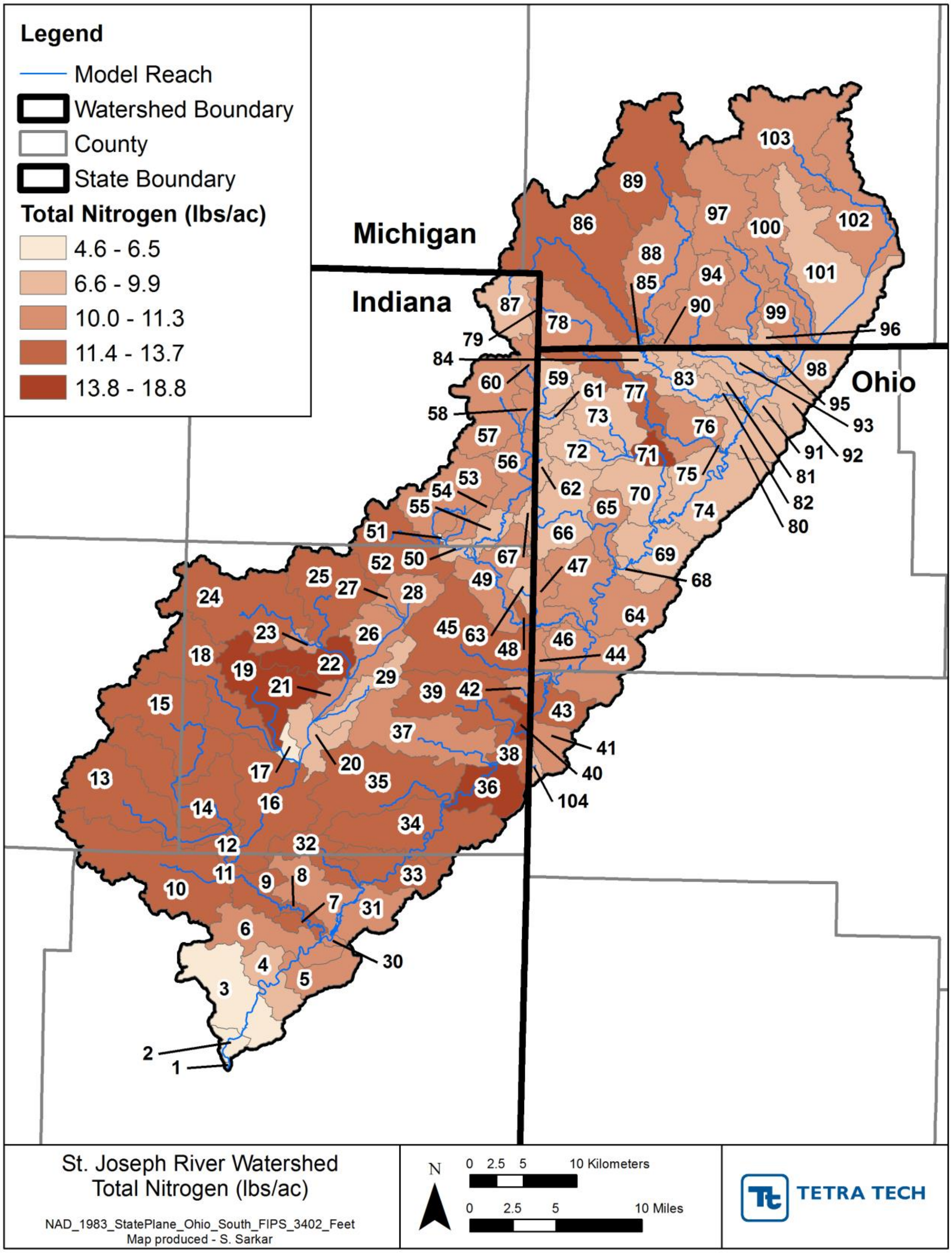


Figure E-3. Total nitrogen results by model subbasin.

Appendix F.

Linkage Analysis

Content

Tables

Figures

Abbreviations and Acronyms[1]

ALU	aquatic life use
DA	drainage area
DO	dissolved oxygen
DMR	discharge monitoring report
EWH	exceptional warmwater habitat
HSTS	household sewage treatment systems
HU	hydrologic unit
HUC	hydrologic unit code
IBC	impaired biotic communities
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
LDC	load duration curve
NPDES	National Pollutant Discharge Elimination System
Ohio EPA	Ohio Environmental Protection Agency
OWTS	on-site wastewater treatment systems
RM	river mile
RU	recreational use
SJR	St. Joseph River
SJRW	St. Joseph River watershed
SJRWI	St. Joseph River Watershed Initiative
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
UT	unnamed tributary
WAU	watershed assessment unit
WWH	warmwater habitat

Units of Measure[2]

cfs	cubic foot per second
gpd	gallon per day
lb/d	pound per day
mgd	million gallons per day
mg/L	milligram per liter
µg/L	microgram per liter

[1] All abbreviations and acronyms in this appendix are defined above. They are not defined in the footnotes below each table or figure.
[2] All units of measure in this appendix are defined above. They are not defined in the footnotes below each table or figure.

F-1. Source Assessment Information Applicable to All Subwatersheds

This section presents general source assessment information, assumptions, and data gaps applicable to all subwatersheds in the St. Joseph River watershed (SJRW).

F-1.1 Facilities Covered by General NPDES Permits

Industrial, construction, and municipal separate storm sewer system (MS4) stormwater can transport deposited bacteria, nutrients, or sediments from impervious surfaces, through pipes or open channels, to streams. However, flow, concentration, and load data are not available for regulated stormwater sources. Regulated stormwater is assumed to contribute to aquatic life use (ALU) and recreational use (RU) impairments but is not considered to be significant sources.

F-1.2 Regulated Livestock Operations

The Indiana Department of Environmental Management (IDEM) prohibits concentrated animal feeding operations (CAFOs) or confined feeding operations (CFOs) from discharging untreated wastewater to surface streams; the Ohio Environmental Protection Agency (Ohio EPA) does the same for Concentrated Animal Feeding Facilities (CAFFs). Such wastewater may be land-applied to agricultural fields. The only information available for CAFOs and CFOs is location information and counts of livestock. CAFOs, CAFFs, and CFOs are not considered to be significant sources of bacteria, nutrients, or sediment.

F-1.3 Unregulated Livestock Operations

Runoff from hobby farms and unregulated livestock operations may contain bacteria, nutrients, and sediment. SJRWI (2008a) identified livestock, livestock access to streams, and manure runoff directly to streams during its windshield survey. No additional information about hobby farms and small livestock operations are available but such operations are present throughout each subwatershed. Since livestock may contribute bacteria, nutrient, and sediment loads, they are considered a cause of impairment.

F-1.4 On-Site Wastewater Treatment Systems

On-site wastewater treatment systems (OWTS) treat commercial and domestic wastewater. In Ohio, OWTS that only treat domestic wastewater are called household sewage treatment systems (HSTS). Malfunctioning or poorly sited on-lot OWTS and all off-site discharging OWTS may contribute bacteria, nutrients, and sediment loads to nearby surface streams. No off-site discharging HSTS are in the Ohio-portion of the impaired subwatersheds discussion in this appendix.

Load data are not available to assess the potential impact OWTS. An estimated 40 percent of OWTS are failing across Indiana (Rice 2005, p. 29; SJRWI 2008b, p. 68-69) and an estimated 98 percent of HSTS are failing in Williams County, Ohio (Ohio Department of Health [ODH] 2012). Thus, OWTS and HSTS are assumed to have localized impacts especially when failing OWTS or HSTS are near streams.

In the areas served by OWTS throughout the SJRW, when OWTS are near crop fields, illicit cross-connections between OWTS and agricultural drain tiles are possible. Such illicit cross-connections likely contribute nutrient and sediment loads. Illicit cross-connections of OWTS to agricultural drain tiles is assumed to contribute to ALU and RU impairments but is not considered to be a significant source.

F-1.5 Crop Production

Most of the subwatersheds in the Indiana-portion of the SJRW are predominantly agricultural with fields of row crops adjacent to rural residences, woodlots, and small ponds. Analyses of aerial imagery generally shows that streams throughout the SJRW are straightened and channelized without forested riparian buffers.

Land application of septage, biosolids, and manure is a potential source of nutrients and sediment because precipitation events result in agricultural runoff may transport land-applied septage, biosolids, and manure to surface streams.

F-1.5.1 Land Application of Septage

No septage land application is permitted in the Indiana-portion of the SJRW. Thus, septage is not considered to be a source of nutrients or sediment that contribute to IBC or nutrient impairments.

F-1.5.2 Land Application of Biosolids

Land application of biosolids was common in the 1990s; a summary of biosolids land application is presented in the discussions for each impaired subwatershed. However, little to no application data (e.g., volume, rates) are available for biosolids applications. As such, biosolids application is generally considered an historic source of nutrients and sediment loads and are assumed not to contribute to recent impairments.

F-1.5.3 Land Application of Manure

Manure application likely occurs on farms throughout the SJRW; the sources of such manure are hobby farms, small livestock operations, CFOs, and CAFOs. No application date, volume, or rate data are available; thus, the significance of manure application cannot be determined.

F-2. Aquatic Life Use Linkage Analysis

This section presents the ALU linkage analyses for 24 impaired segments in Indiana's portion of the SJRW:

- Dissolved oxygen (2 segments)
- Impaired biotic communities (18 segments)
- Nutrients (7 segments)

Dissolved oxygen and nutrient impairments were addressed through the development of total phosphorus (TP) total maximum daily loads (TMDLs) and impaired biotic communities (IBC) were addressed through TP TMDLs or total suspended solids (TSS) TMDLs, depending on which pollutants exceeded targets.

F-2.1 Project Area Data

Ambient water quality data and discharge monitoring report (DMR) data are summarized in this section.

F-2.1.1 Summary of Water Quality Data

In-stream, ambient water quality data were collected by IDEM and St. Joseph River Watershed Initiative (SJRWI). IDEM TP and TSS data (Table F-1) and SJRWI TP data (Table F-2) are summarized in tables by sample station.

Table F-1. Summary of TP and TSS data collected by IDEM

Waterbody	IDEM site ID	ALU segment status	TP (mg/L)				TSS (mg/L)			
			No.	Min.	Max.	GM	No.	Min.	Max.	GM
West Branch St. Joseph River (HUC 04100003 02)										
Headwaters Fish Creek (HUC 04100003 02 03)										
Clear Lake	LEJ020-0002	n/a	10	0.010	0.094	0.040	-	-	-	-
Lake Anne	LEJ020-0004	n/a	2	0.022	0.197	0.110	-	-	-	-
Round Lake	LEJ020-0003	n/a	4	0.010	0.032	0.020	-	-	-	-
Nettle Creek-St. Joseph River (HUC 04100003 03)										
Nettle Creek (HUC 04100003 03 01)										
Handy Lake	LEJ030-0002	n/a	2	0.010	0.127	0.069	-	-	-	-
Long Lake	LEJ030-0001	n/a	8	0.010	**0.652**	0.173	-	-	-	-
Mirror Lake	LEJ030-0003	n/a	2	0.050	0.148	0.099	-	-	-	-
Fish Creek (HUC 04100003 04)										
West Branch Fish Creek (HUC 04100003 04 01)										
West Branch Fish Creek	LEJ050-0020	Impaired	1	0.058	--	--	1	7	--	--
	LEJ050-0064	Impaired	7	0.025	0.100	0.079	7	5	17	8
Headwaters Fish Creek (HUC 04100003 04 02)										
Fish Creek	LEJ050-0023	Full	1	0.170	--	--	1	**38**	--	--
Hamilton Lake (HUC 04100003 04 03)										
Hamilton Lake.	LEJ050-0061	n/a	4	0.050	**0.630**	0.281	-	-	-	-
UT of Black Creek	LEJ050-0002	Full	1	0.120	--	--	1	21	--	--
Hiram Sweet Ditch (HUC 04100003 04 04)										
Ball Lake	LEJ050-0060	n/a	6	0.061	**0.440**	0.182	-	-	-	-
Fish Creek	LEJ050-0050	Full	2	0.015	0.032	0.024	2	7	9	8
	LEJ050-0052	Insufficient data	1	0.041	--	--	1	14	--	--
	LEJ050-0054	Insufficient data	1	0.083	--	--	1	20	--	--
Town of Alvarado-Fish Creek (HUC 04100003 04 05)										
Fish Creek	LEJ050-0010	Impaired	1	0.096	--	--	1	18	--	--
Fish Creek	LEJ050-0027	Impaired	1	0.130	--	--	1	18	--	18
Fish Creek	LEJ050-0006	Impaired	174	0.015	**1.800**	0.093	174	2	**256**	--
Fish Creek	LEJ050-0029	Impaired	1	0.220	--	--	1	**34**	--	--
Fish Creek	LEJ050-0032	Impaired	1	0.180	--	--	1	**35**	--	--
Fish Creek	LEJ050-0066	Impaired	3	0.120	0.300	0.193	3	5	**40**	19
UT of Fish Creek	LEJ050-0026	Full	1	0.220	0.220	0.220	1	10	10	10

Waterbody	IDEM site ID	ALU segment status	TP (mg/L)				TSS (mg/L)			
Cornell Ditch-Fist Creek (HUC 04100003 04 06)										
Fish Creek	LEJ050-0040	Impaired	1	0.160	--	--	1	**32**	--	--
	LEJ050-0008	Insufficient data	1	0.110	--	--	1	19	--	--
	LEJ050-0035	Insufficient data	1	0.120	--	--	1	16	--	--
	LEJ050-0007	Insufficient data	213	0.015	**0.415**	0.077	213	2	**280**	17
	LEJ050-0068	Insufficient data	3	0.100	0.220	0.170	3	13	**32**	21
UT of Fish Creek	LEJ050-0001	Impaired	4	0.260	**0.520**	**0.335**	4	23	**75**	**54**
	LEJ050-0048	Impaired	1	0.097	--	--	1	8	--	--
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)										
Big Run (HUC 04100003 05 02)										
Big Run	LEJ050-0048	Impaired	4	0.160	0.250	0.215	4	5	18	10
Buck Creek (HUC 04100003 05 04)										
Metcalf Ditch	LEJ060-0002	Insufficient data	4	0.170	0.280	0.210	4	10	**41**	27
Hoodelmier Ditch-St. Joseph River (HUC 04100003 05 06)										
SJR	LEJ060-0006	Full	189	0.015	**0.650**	0.128	188	2	**348**	**36**
	LEJ060-0001	Full	3	0.160	**0.930**	**0.463**	3	**37**	**120**	**86**
Matson Ditch-Cedar Creek (HUC 04100003 06)										
Cedar Lake-Cedar Creek (HUC 04100003 06 01)										
Indian Lake	LEJ080-0012	n/a	4	0.010	0.162	0.075	0	--	--	--
UT of Leins Ditch	LEJ080-0014	Full	8	0.060	0.110	0.078	8	5	12	9
Leins Ditch	LEJ080-0016	Insufficient data	4	0.090	0.200	0.120	4	13	26	22
Cedar Creek	LEJ080-0005	Impaired	39	0.040	**0.340**	0.120	39	6	**164**	27
Matson Ditch (HUC 04100003 06 03)										
UT Mason Ditch	LEJ080-0013	Insufficient data	3	0.130	**0.360**	0.230	3	<10	18	11
Smith Ditch-Cedar Creek (HUC 04100003 06 04)										
West Smith Ditch	LEJ080-0017	Impaired	3	0.120	0.170	0.143	3	5	19	11
Cedar Creek (HUC 04100003 07)										
Headwaters John Diehl Ditch (HUC 04100003 07 01)										
Wiley Lake	LEJ090-0030	n/a	2	0.010	**0.828**	**0.419**	0	--	--	--
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)										
Peckhart Ditch	LEJ090-0040	Insufficient data	3	0.070	**0.320**	0.183	3	12	**51**	27
	LEJ090-0034	Insufficient data	4	0.100	0.130	0.113	4	12	19	15
Black Creek (HUC 04100003 07 04)										
Black Creek	LEJ090-0041	Impaired	4	0.120	0.140	0.130	4	5	**50**	18
King Lake-Little Cedar Creek (HUC 04100003 07 05)										
Little Cedar Creek	LEJ090-0033	Impaired	7	0.050	0.150	0.100	7	5	**40**	15
UT of Little Cedar Creek	LEJ090-0002	Impaired	3	0.075	0.180	0.115	3	6	**35**	17

Waterbody	IDEM site ID	ALU segment status	TP (mg/L)				TSS (mg/L)			
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)										
Cedar Creek	LEJ090-0031	Impaired	7	0.140	0.160	0.149	7	5	25	14
Cedar Creek	LEJ090-0008	Impaired	31	0.040	0.290	0.103	34	2	**86**	16
Cedar Creek	LEJ090-0001	Impaired	4	0.110	**0.340**	0.210	4	7	**78**	**36**
Cedar Creek	LEJ090-0026	Impaired	146	0.015	**0.580**	0.100	145	2	**346**	26
Cedar Creek	LEJ090-0003	Impaired	3	0.150	**0.330**	0.240	3	5	**76**	**46**
Dosch Ditch	LEJ090-0004	Impaired	3	0.072	0.150	0.117	3	6	15	11
St. Joseph River (HUC 04100003 08)										
Bear Creek (HUC 04100003 08 01)										
Bear Creek	LEJ070-0002	Full	1	0.180	--	--	1	26	--	--
Metcalf Ditch-St. Joseph River (HUC 04100003 08 02)										
SJR	LEJ070-0001	Full	4	0.110	**0.510**	0.228	4	**33**	**350**	**140**
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)										
Dunton Lake	LEJ070-0023	n/a	2	0.010	**0.968**	**0.489**	0	--	-	-
SJR	LEJ070-0027	Full	7	0.130	0.230	0.171	7	10	**39**	26
	LEJ070-0026	Full	7	0.100	0.150	0.126	7	18	**39**	28
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)										
Cedarville Reservoir	LEJ070-0022	n/a	2	0.162	0.167	0.165	0	--	--	--
SJR	LEJ070-0028	Insufficient data	4	**0.330**	**0.730**	**0.480**	4	**46**	**130**	**68**
Ely Run-St. Joseph River (HUC 04100003 08 05)										
SJR	LEJ100-0002	Full	103	0.015	**0.910**	0.150	104	2	**856**	**46**
Becketts Run-St. Joseph River (HUC 04100003 08 06)										
Becketts Run	LEJ100-0001	Insufficient data	3	0.034	**0.310**	0.151	3	8	**130**	**50**
SJR	LEJ100-0026	Impaired	3	0.260	**0.760**	**0.430**	3	23	**140**	**65**
	LEJ-08-0005	Impaired	44	0.040	**0.630**	0.129	44	6	**174**	29
	LEJ100-0023	Full	2	0.156	0.165	0.161	0	--	--	--
	LEJ100-0003	Full	257	0.015	**0.570**	0.145	259	2	**434**	**40**

Source: IDEM 2014, 2015b
Notes
n/a = not applicable because the listed waterbody is a lake
Bolded minima, maxima, and averages exceed the TP or TSS targets of 0.3 mg/L and 30 mg/L, respectively.

Table F-2. Summary of TP (mg/L) data collected by SJRWI

Stream name	Site ID	No.	Min.	Max.	Average
Fish Creek (HUC 04100003 04)					
Cornell Ditch-Fish Creek (HUC 04100003 04 06)					
Fish Creek	124	203	0.010	**1.256**	0.112
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)					
Bluff Run-St. Joseph River (HUC 04100003 05 01)					
Bluff Run	162	75	0.035	**0.599**	0.158
Big Run-St. Joseph River (HUC 04100003 05 02)					
Big Run-West	159	87	0.025	**0.401**	0.093
Big Run	127	203	0.010	**0.938**	0.140
Russell Run-St. Joseph River (HUC 04100003 05 03)					
Russel Run-N.	161	50	0.025	**0.544**	0.126
Russel Run-S.	160	50	0.035	**0.558**	0.204
Buck Creek (HUC 04100003 05 04)					
Buck Creek	158	84	0.025	**4.607**	0.128
Willow Run-St. Joseph River (HUC 04100003 05 05)					
Willow Run	156	18	0.025	**0.428**	0.169
SJR	163	29	0.022	**0.242**	0.089
Hoodelmier Ditch-St. Joseph River (HUC 04100003 05 06)					
Shank Ditch-W.	157	47	0.025	**1.253**	0.162
Shank Ditch	123	203	0.010	**1.480**	0.123
Matson Ditch-Cedar Creek (HUC 04100003 06)					
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)					
Dibbling Ditch	143	115	0.010	**1.041**	0.153
David Link Ditch	142	175	0.020	**0.750**	0.124
Matson Ditch (HUC 04100003 06 03)					
Matson Ditch	106	329	0.010	**1.645**	0.143
Smith Ditch-Cedar Creek (HUC 04100003 06 04)					
Walter Smith D.	141	317	0.010	**9.564**	0.219
Upper Cedar Cr.	105	29	0.022	**0.762**	0.101
Cedar Creek (HUC 04100003 07)					
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)					
Diehl/Peckhart D.	104	326	0.010	**1.215**	0.124
Black Creek (HUC 04100003 07 04)					
Black Creek	102	115	0.010	**0.956**	0.141
King Lake-Little Cedar Creek (HUC 04100003 07 05)					
Little Cedar Cr.	103	175	0.010	**1.123**	0.120
Willow Creek (HUC 04100003 07 06)					
Willow Creek	101	175	0.010	**0.474**	0.094
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)					
Garrett City Ditch	117	175	0.020	**1.096**	0.236
Cedar Creek	100	354	0.010	**0.848**	0.125
St. Joseph River (HUC 04100003 08)					
Bear Creek (HUC 04100003 08 01)					
Bear Creek-IN	128	191	0.010	**1.891**	0.132
Metcalf Ditch-St. Joseph River (HUC 04100003 08 02)					
Metcalf Ditch	149	9	0.010	**1.181**	0.238
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)					
SJR	121	29	0.022	**1.036**	0.125
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)					
SJR	122	29	0.022	**0.667**	0.140

Stream name	Site ID	No.	Min.	Max.	Average
Ely Run-St. Joseph River (HUC 04100003 08 05)					
Ely Run	150	124	0.010	**0.946**	0.174

Source: SJRWI 2014, 2015
Notes
Bolded minima, maxima, and averages exceed the TP target of 0.3 mg/L.

F-2.1.2 Summary of Discharge Monitoring Report Data

Discharge monitoring report (DMR) data for permitted facilities were provided by IDEM. The DMR TP (Table F-3) and TSS (Table F-4) concentration and load data are summarized by permitted facility.

Table F-3. Summary of DMR data for facilities permitted to discharge TP in Indiana

NPDES ID	Outfall	Flow (cfs)				TP concentration (mg/L)				TP load (lbs/d)			
		No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.
Fish Creek (HUC 04100003 04)													
Hiram Sweet Ditch (HUC 04100003 04 04)													
IN0050822	001	132	0.202	0.398	0.280	132	0.19	89.40	1.15	132	0.231	125.341	1.661
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)													
Big Run-St. Joseph River (HUC 04100003 05 02)													
IN0022462	001	20	0.885	2.299	1.383	20	0.20	0.50	0.30	20	1.297	3.643	2.159
	002	111	1.017	2.825	1.707	110	0.02	1.20	0.39	110	0.107	10.955	3.521
Sol Shank Ditch-St. Joseph River (HUC 04100003 05 06)													
IN0059021	005	0	--	--	--	4	<0.04	1.01	0.28	0	--	--	--
Matson Ditch-Cedar Creek (HUC 04100003 06)													
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)													
IN0020711	001	132	0.174	8.955	0.521	132	0.2	1.3	0.6	132	0.318	18.919	1.591
Smith Ditch-Cedar Creek (HUC 04100003 06 04)													
IN0000868	001	0	--	--	--	7	<0.04	0.12	0.09	0	--	--	--
IN0000566	001	57	0.034	0.259	0.168	3	<0.10	<0.10	<0.10	3	0.019	0.064	0.039
	002	74	0.104	0.706	0.242	3	<0.10	19.70	6.60	3	0.036	56.095	18.767
Cedar Creek (HUC 04100003 07)													
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)													
IN0061263	001	50	<0.001	0.366	0.052	8	0.025	>0.100	0.065	7	<0.001	0.152	0.030
Sycamore Creek-Little Cedar Creek (HUC 04100003 07 03)													
IN0020664	001	132	0.053	0.820	0.529	132	0.20	0.90	0.50	132	0.197	3.118	1.471
Dosch Ditch-Cedar Creek (HUC 041100003 07 07)													
IN0029969	001	89	0.722	1.938	1.137	89	0.20	1.50	0.52	89	1	13	3

Source: IDEM EPA 2015a
Notes
The following are excluded from this table: (1) facilities not permitted to discharge total phosphorus, and (2) facilities without total phosphorus DMR data.
a. Number of DMR records for the specified parameter.

Table F-4. Summary of DMR data for facilities permitted to discharge TSS in Indiana

NPDES ID	Outfall	Flow (cfs)				TSS concentration (mg/L)				TSS load (lb/day)			
		No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.
Fish Creek (HUC 04100003 04)													
Hiram Sweet Ditch (HUC 04100003 04 04)													
IN0060216	001	80	0.003	0.332	0.026	80	1	7	3	80	<1	6	<1
IN0050822	001	84	0.202	0.373	0.272	84	2	19	5	84	2	31	8
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)													
Big Run-St. Joseph River (HUC 04100003 05 02)													
IN0022462	002	84	1.017	2.825	1.725	84	2	12	6	84	15	140	53
Matson Ditch-Cedar Creek (HUC 04100003 06)													
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)													
IN0020711	001	84	0.174	1.067	0.455	84	<1	12	4	84	<1	55	10
Smith Ditch-Cedar Creek (HUC 04100003 06 04)													
IN0000868	001	84	0.400	0.937	0.656	84	<1	12	3	84	2	44	11
IN0000566	001	10	0.073	0.237	0.171	10	2	11	4	10	1	8	4
IN0000566	002	74	0.104	0.706	0.242	74	1	19	2	74	1	23	2
IN0020672	001	84	2.334	7.883	4.181	84	1	6	3	84	16	183	61
Cedar Creek (HUC 04100003 07)													
Headwaters John Diehl Ditch (HUC 04100003 07 01)													
IN0047473	001	83	0.006	0.126	0.020	39	2	56	12	39	<1	6	1
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)													
IN0061263	001	50	<0.001	0.366	0.052	43	<1	37	6	43	<1	14	2
Sycamore Creek-Little Cedar Creek (HUC 04100003 07 03)													
IN0052035	001	84	0.030	0.051	0.037	83	<1	19	6	83	<1	4	1
IN0020664	001	84	0.053	0.819	0.514	84	2	15	7	84	1	49	21
IN0029955	001	32	0.002	0.011	0.006	32	4	26	11	32	<1	<1	<1
Black Creek (HUC 04100003 07 04)													
IN0058611	001	80	0.002	0.066	0.035	23	2	80	24	23	<1	21	5
King Lake-Little Cedar Creek (HUC 04100003 07 05)													
IN0032107	001	47	0.001	0.032	0.008	47	1	25	8	47	<1	2	<1
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)													
IN0022969	001	84	0.722	1.938	1.134	84	3	14	6	84	13	115	34
St. Joseph River (HUC 04100003 08)													
Hursey Ditches-Bear Creek (HUC 04100003 08 01)													
IN00032981	001	19	0.009	0.141	0.038	19	8	275	76	19	<1	102	17

NPDES ID	Outfall	Flow (cfs)				TSS concentration (mg/L)				TSS load (lb/day)			
		No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)													
IN0059749	001	76	0.001	0.020	0.010	76	3	23	10	76	<1	2	<1
IN0063061	001	75	0.011	0.116	0.013	75	<1	30	4	75	<1	6	<1
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)													
IN0044369	001	84	0.063	0.995	0.114	84	1	14	4	84	<1	25	2
Becketts Run-St. Joseph River (HUC 04100003 08 06)													
IN0060127	001	3	0.041	0.063	0.056	3	8	21	13	3	3	5	3

Source: 2015a
Notes
The following are excluded from this table: (1) facilities not permitted to discharge TSS, and (2) facilities without TSS DMR data.
Treated effluent is discharged through outfall 001.
a. Number of DMR records for the specified parameter.

F-2.2 West Branch Fish Creek (HUC 04100003 04 01)

West Branch Fish Creek is in Indiana and the subwatershed is bisected by the Indiana East-West Toll Road (I-80) and U.S. route 20. The subwatershed is agricultural with many woodlots. Rural residential properties are adjacent to cultivated crop fields and pastures.

F-2.2.1 Monitoring Data

IDEM collected water chemistry samples at two sites on the West Branch Fish Creek (LEJ050-20 and LEJ050-064), just upstream of the confluence with Fish Creek; both sites are on segment INA0341_02. TP (0.058 mg/L) and TSS (7 mg/L) in the single sample collected at site LEJ050-020 were below the TP (0.30 mg/L) and TSS (30 mg/L) targets. Additionally, as shown in Table F-1, TP and TSS concentrations from all seven samples collected at site LEJ050-064 were below targets.

IDEM listed two segments of the West Branch Fish Creek (INA0341_01 and INA0341_02) for IBC. Such listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. Since neither TP results nor TSS results exceed targets, TMDLs were not developed to address IBC listings on West Branch Fish Creek.

F-2.2.2 Load Duration Curve

Since no TP or TSS sample results exceeded targets, no load duration curves (LDCs) nor TMDLs were developed.

F-2.2.3 Sources of Impairment

Nutrient and sediment sources were not assessed because these pollutants are not the cause of impairment. During the development of the point sources inventory, no permitted point sources were identified in this subwatershed[3]. However, the Angola Municipal Sewage Treatment Plant (STP) was permitted to land apply biosolids to 20 fields in this subwatershed (Figure C-3 in Appendix C).

While IDEM provided field locations of biosolids land applications, the following data are sparse: application dates, methods, and rates (Table C-11). Except for a single application in 2003, biosolids land applications in this watershed occurred from 1990 through 1995. Since biosolids application has not occurred in this HU during the last decade, biosolids did not likely contribute to the IBC.

[3] No public or private facilities with individual or general NPDES permits, communities with combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs), or regulated municipal separate storm sewer systems (MS4s) are in this subwatershed.

F-2.3 Town of Alvarado-Fish Creek (HUC 04100003 04 05)

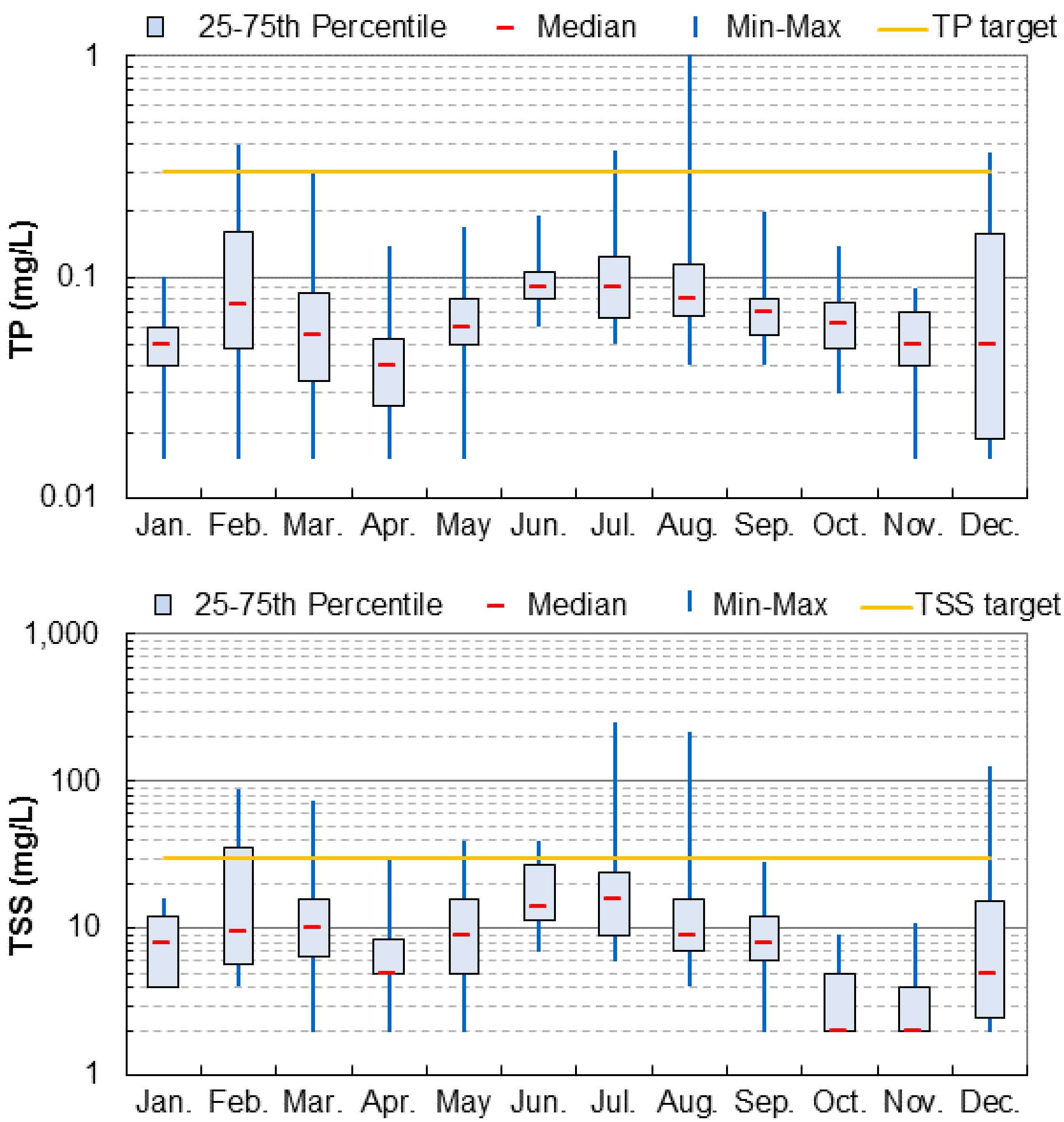
This subwatershed begins in Indiana at the confluence of West Branch Fish Creek with Fish Creek. After the confluence, Fish Creek flows southerly toward the Ohio-Indiana border before it then flows southwest away from the border. The landscape is dominate by crop agriculture with some woodlots, especially along Fish Creek. Rural residences are throughout the subwatershed.

F-2.3.1 Monitoring Data

IDEM collected water chemistry samples at six sites on Fish Creek (LEJ050-0006, LEJ050-0010, LEJ050-0027, LEJ050-0029, LEJ050-0032, and LEJ050-0066) and one site (LEJ050-0026) on an unnamed tributary to Fish Creek.

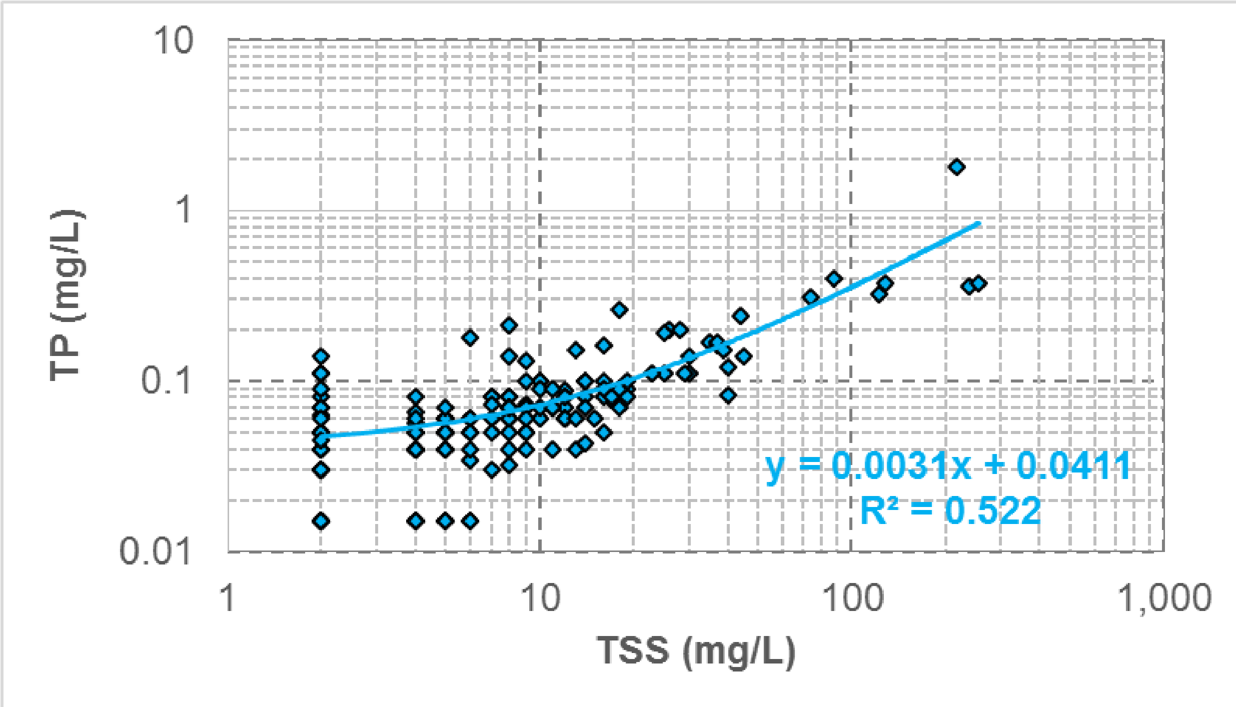
TP results from the single samples collected on Fish Creek at the four sites were below the target of 0.30 mg/L, while the TSS target (30 mg/L) was exceeded twice (Table F-1). Only one TSS result from the three samples collected at site LEJ050-0066 exceeded the target. The TP and TSS results from the single sample collected at site LEJ050-0026 on an unnamed tributary to Fish Creek were below the targets. Long-term data collected at site LEJ050-0006 indicates that the TP and TSS targets are occasionally exceeded.

Long-term data collected at site LEJ050-0006 are summarized in Figure F-1. TP and TSS increase in the spring and decrease in the late summer and fall. TSS was not detected in 17 percent of samples. A linear regression of TSS and TP (R^2=0.52) at site LEJ050-0006 may indicate a predictive relationship. Such results likely indicate that TP is bound to sediment. When TP is sediment-bound, sources of sediment erosion (both upland and in-channel) typically increase the in-stream concentrations of TP and TSS.



Notes
The August TP maximum is 1.80 mg/L.
161 samples collected 1999-2014.

Figure F-1. TP (top) and TSS (bottom) at site LEJ050-0006 on Fish Creek.



Note: Non-detects were included in this analysis as one-half of the detection limit.

Figure F-2. Paired TP and TSS samples at site LEJ050-0006.

Dissolved oxygen data can indicate nutrient impairment. At long-term site LEJ050-0006, DO was measured when water chemistry samples were collected. Continuous DO data are not available. Instantaneous DO ranged from 4.8 to 16.2 mg/L. Over 97 percent of sample results were 6 mg/L or greater.

IDEM listed segment INA0345_01 of Fish Creek for IBC and DO. As TP and TSS both occasionally exceed targets, the IBC listing was addressed through the development of TP and TSS TMDLs at the outlet of the subwatershed.

F-2.3.2 Load Duration Curve

A LDC was developed for Fish Creek (Figure F-3 and Figure F-4) and TP or TSS data collected by IDEM in 2004-2014 are displayed as loads[4]. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones for TP and in the high flow, moist conditions, and mid-range flow zones for TSS. To achieve the TMDL (i.e., reduce loads to the LDC), reductions on a per sample basis, for the samples that exceed the TMDL target, range from 2 to 83 percent for TP and range from 14 to 88 for TSS.

[4] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

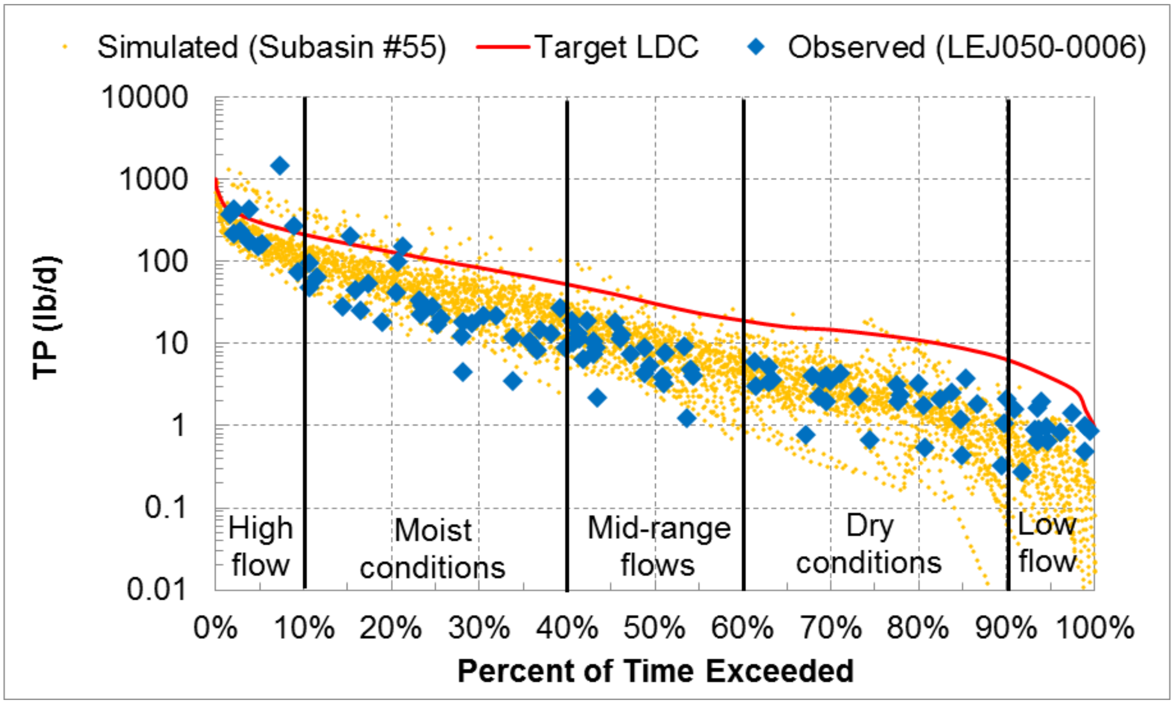


Figure F-3. TP loads and LDC for Fish Creek in *Town of Alvarado-Fish Creek* (*04 05) at the HU outlet.

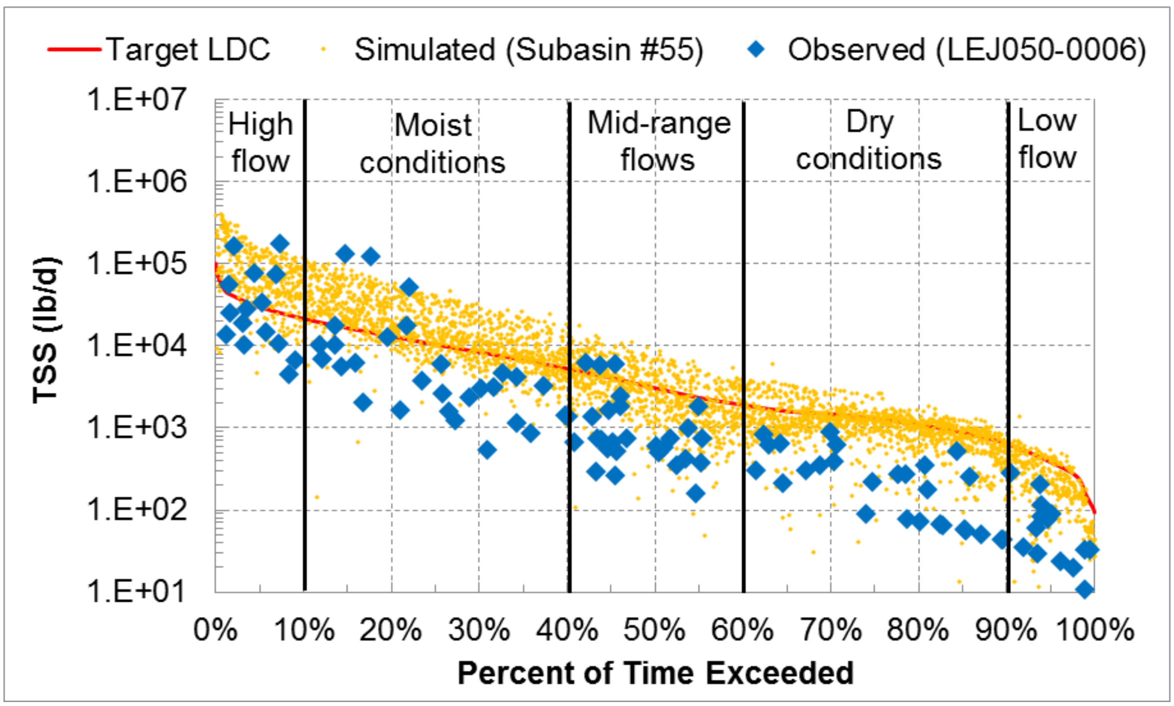
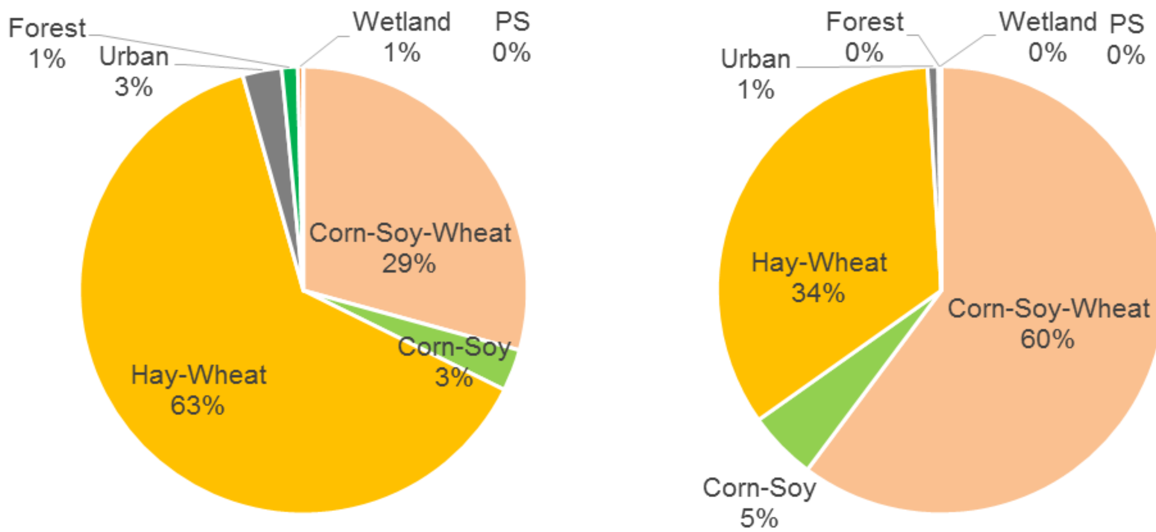


Figure F-4. TSS loads and LDC for Fish Creek in *Town of Alvarado-Fish Creek* (*04 05) at the HU outlet.

F-2.3.3 Sources of Impairment

SWAT-simulated source loads[5] indicate that crops are the dominant source of TP and TSS load to Fish Creek in this HU (Figure F-5). In this multi-state TMDL subwatershed, 82 percent of the TP source load is from Indiana and 18 percent from Ohio; these results do not account for in-stream processes. Similarly, for TSS, 85 percent is from Indiana and 15 percent from Ohio.



Notes

Relative loads are rounded to the nearest percentage point.

No point sources were simulated.

SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-5. Summary of SWAT-simulated annual TP (left) and TSS (right) loads that drain to Fish Creek at the outlet of Town *of Alvarado-Fish Creek* (*04 05).

The potential sources of nutrients in this HU are evaluated in the following sections.[6]

F-2.3.3.1 On-Site Wastewater Treatment Systems

Except for the Hamilton Lake area, OWTS treat commercial and domestic wastewater. No permitted off-site discharging HSTS are in the Ohio-portion of this subwatershed. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.3.3.2 Unregulated Livestock Operations

No CAFOs, CFOs, or concentrated animal feeding facilities (CAFFs; state permit issued by Ohio) are in this subwatershed. No information about hobby farms and small livestock operations are available but

[5] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.

[6] No industrial or public facilities with individual or general NPDES permits, biosolids application fields, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

such operations are likely present throughout the subwatershed. Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 25 locations in Indiana and 14 locations in Ohio; no manure storage or livestock direct access to streams were observed. At the 25 locations in Ohio, SJRWI (2008a) estimated 2 to 12 animals at 21 locations, 50 and 75 beef cattle at two locations, and 80 and 120 dairy cattle at two locations. No additional information about hobby farms and small livestock operations are available. Thus, livestock in Indiana and Ohio may contribute nutrients or sediment that impair biotic communities.

F-2.3.3.3 Crop Production

As shown in Figure F-5, cropland is the dominant source of TP loading in the TMDL subwatershed. Most of this subwatershed is agricultural land, with some woodlots along Fish Creek and its tributaries. An analysis of aerial imagery shows that, with the exception of Fish Creek, streams throughout this subwatershed are channelized and straightened, especially when flowing through crop fields. Fish Creek meanders through large woodlots near the outlet of this subwatershed.

F-2.4 Cornell Ditch-Fish Creek (HUC 04100003 04 06)

Fish Creek flows through predominantly agricultural land with few residences and few woodlots in Indiana and Ohio. Only Fish Creek has a forested riparian corridor. The confluence of Fish Creek with the St. Joseph River is in Ohio just upstream of the city of Edgerton.

F-2.4.1 Monitoring Data

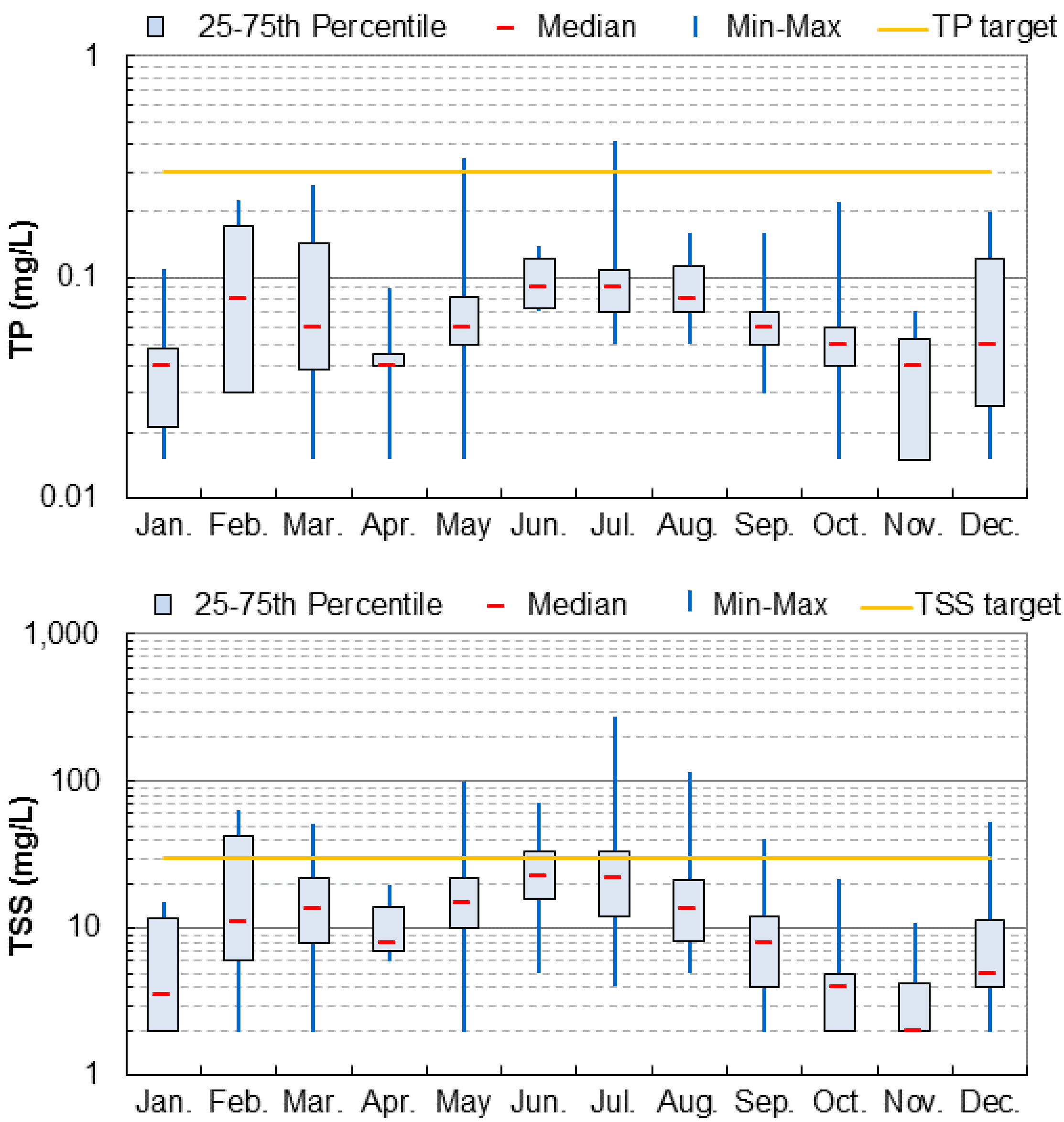
Samples were collected by IDEM (Section F-2.4.1.1), Ohio EPA (Section F-2.4.1.2), SJRWI (Section F-2.4.1.3), and USGS (Section F-2.4.1.4). IDEM listed segment INA0346_01 of Fish Creek and segment INA0346_T1003 of the unnamed tributary to Fish Creek for IBC. As TP and TSS both occasionally exceed targets, the IBC listings were addressed through the development of TP and TSS TMDLs at the Ohio-Indiana state line on Fish Creek.

F-2.4.1.1 IDEM

IDEM collected water chemistry samples at seven sites on Fish Creek (LEJ050-0007, LEJ050-0008, LEJ050-0011, LEJ050-0012, LEJ050-0035, LEJ050-0040, and LEJ050-0068) and at two sites on an unnamed tributary to Fish Creek (LEJ050-0001 and LEJ050-0048).

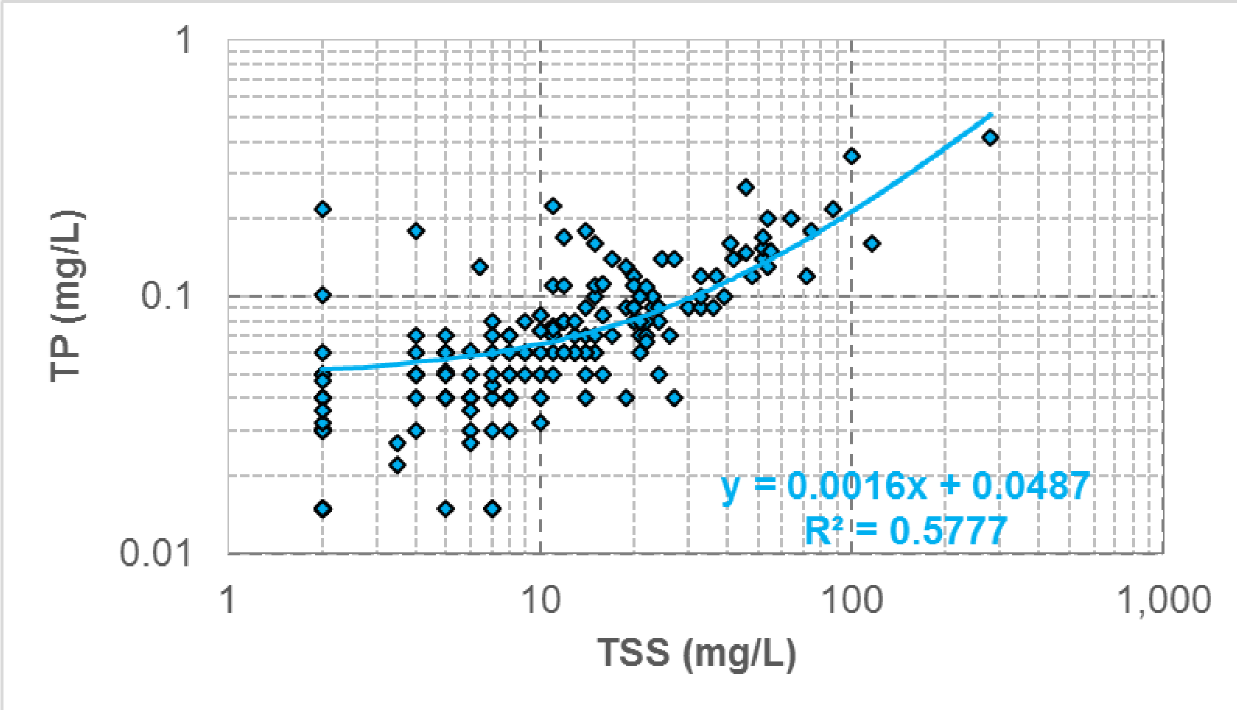
In Indiana, water chemistry samples from five sites on Fish Creek and two sites on its unnamed tributary were evaluated for nutrients. As show in Table F-1, TP results at sites LEJ050-001 and LEJ050-0007 indicated impairment while TSS results at those two sites and two additional sites indicate impairment.

Long-term data collected at site LEJ050-0007 are summarized in Figure F-6. TP and TSS increase in the spring and decrease in the late summer and fall. A linear regression of TSS and TP (R^2=0.58) at site LEJ050-0007 may indicate a predictive relationship. Such results likely indicate that TP is bound to sediment. When TP is sediment-bound, sources of sediment erosion (both upland and in-channel) typically increase the in-stream concentrations of TP and TSS.



Note: 179 samples collected 1999-2014.

Figure F-6. TP (top) and TSS (bottom) at site LEJ050-0007 on Fish Creek.



Note: Non-detects were included in this analysis as one-half of the detection limit.

Figure F-7. Paired TP and TSS samples at site LEJ050-0007.

Dissolved oxygen data can indicate nutrient impairment. At long-term site LEJ050-0007, DO was measured when water chemistry samples were collected. Continuous DO data are not available. Instantaneous DO ranged from 4.6 to 14.5 mg/L. Over 97 percent of sample results were 6 mg/L or greater.

F-2.4.1.2 Ohio EPA

Ohio EPA collected water chemistry samples from three sites on Fish Creek (P08K09, P08K10, and P08S20). TP concentrations varied considerably in 2013 (0.015 – 0.339 mg/L); 15 of 24 samples exceed their respective wading WWH (0.1 mg/L) or EWH (0.05 mg/L) targets, while only one sample exceeded the Indiana target (0.3 mg/L). TSS concentrations ranged from non-detect to 176 mg/L. Four of 24 samples were non-detect. Six samples exceeded Ohio (29 mg/L) and Indiana (30 mg/L) TSS targets.

All three sites were in full attainment of their WWH or EWH ALU and Ohio EPA did not list this WAU as impaired.

F-2.4.1.3 SJRWI

SJRWI collected 203 samples at site 124 (Table F-2) that is collocated with Ohio EPA site P08S20. Most samples were collected from 2008 through 2014.Ten of 153 samples evaluated for TP exceeded the Indiana target (0.3 mg/L).

F-2.4.1.4 USGS

USGS historically recorded daily flow on Fish Creek at Artic, IN (04177810; 1988-2007) and collected water chemistry samples on Fish Creek near Edgerton, OH (04177820). Suspended sediment concentration was recorded at gage 04177810 from April 1998 through water year 2007. Six samples collected at site 04177820 from 1972 through 1977 yield TP concentrations from 0.03 to 0.09 mg/L.

F-2.4.2 Load Duration Curve

LDCs were developed for Fish Creek (Figure F-8 and Figure F-9) and TP or TSS data collected by IDEM in 2004-2014 are displayed as loads[7]. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones for TP and in the high flow and moist conditions zones for TSS. To achieve the TMDLs (i.e., reduce loads to the LDCs), reductions on a per sample basis, for the samples that exceed the TMDL target, range from 14 to 28 percent for TP and range from 9 to 89 for TSS.

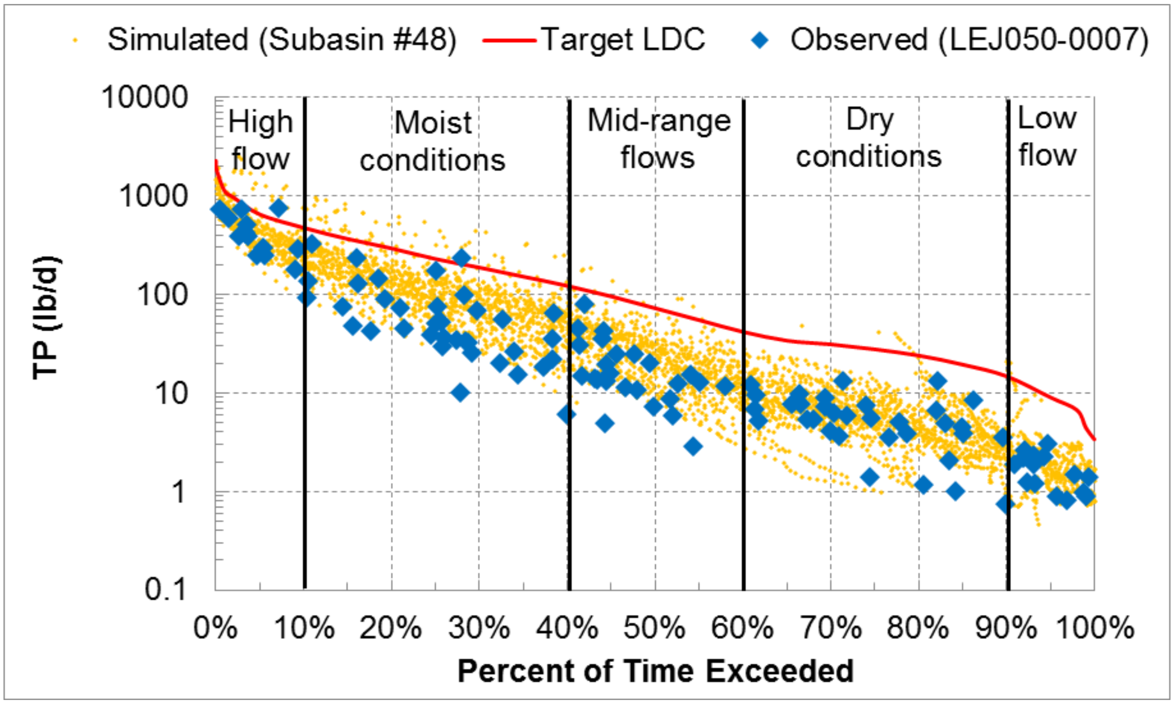


Figure F-8. TP loads and LDC for Fish Creek in *Cornell Ditch-Fish Creek* (*04 06) at the HU outlet.

[7] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

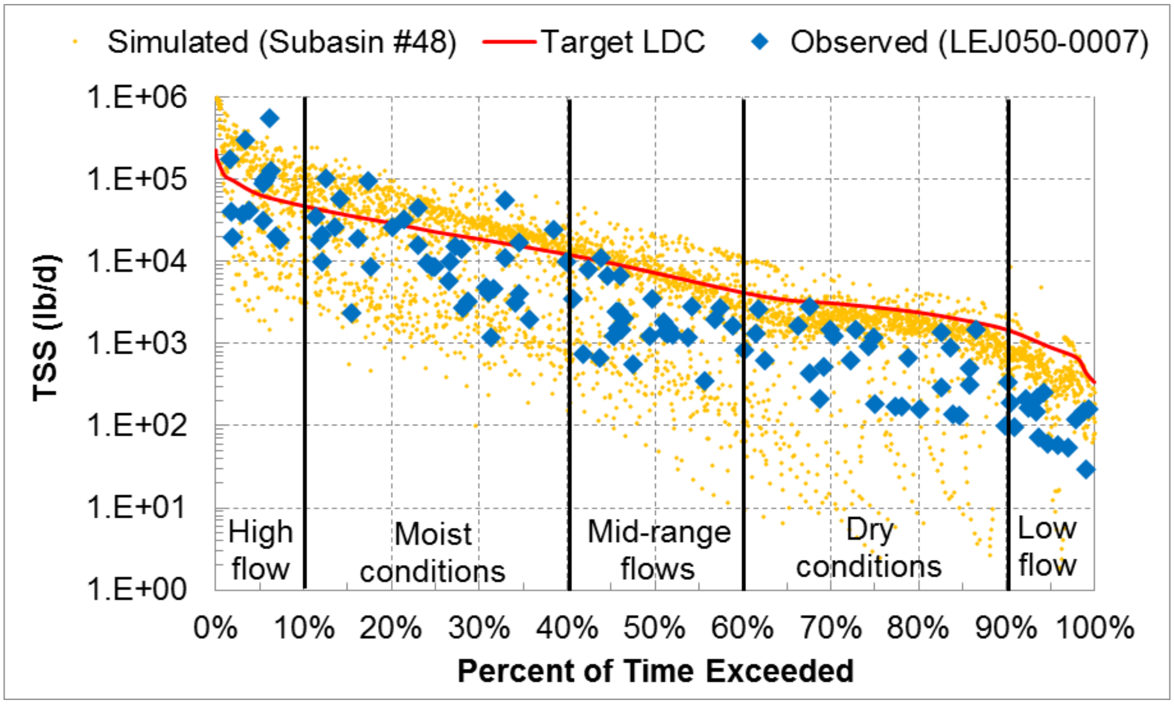
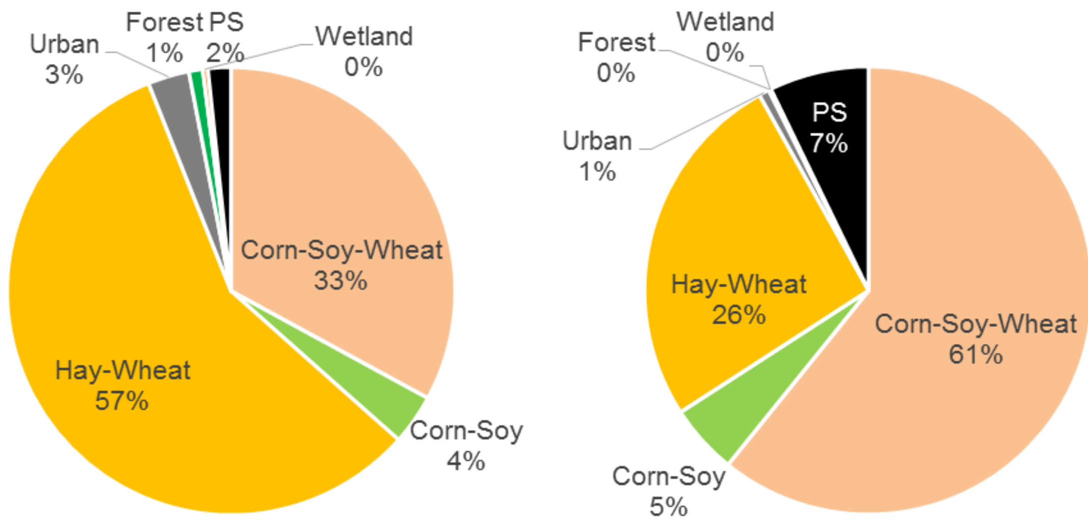


Figure F-9. TSS loads and LDC for Fish Creek in *Cornell Ditch-Fish Creek* (*04 06) at the HU outlet.

F-2.4.3 Sources of Impairment

SWAT-simulated source loads[8] indicate that crops are the dominant source of TP and TSS load to Fish Creek in this HU (Figure F-10). In this multi-state TMDL subwatershed, 92 percent of the TP source load is from Indiana and 8 percent from Ohio; these results do not account for in-stream processes. Similarly, for TSS, 94 percent is from Indiana and 6 percent from Ohio.

[8] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-10. Summary of SWAT-simulated annual TP (left) and TSS (right) loads that drain to Fish Creek at the outlet of *Cornell Ditch-Fish Creek* (*04 06).

The potential sources of nutrients in this HU are evaluated in the following sections.[9]

F-2.4.3.1 On-Site Wastewater Treatment Systems

As no publicly owned treatment works (POTWs) are in this subwatershed, OWTS and HSTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.4.3.2 Livestock Operations

No CAFOs or CAFFS are in this subwatershed. The single CFO in the subwatershed is Long Lane Farms Incorporated, which raises hogs (see Figure C-8 and Table C-14 in Appendix C).The CFO drains to the unnamed tributary to Fish Creek, specifically to segment INA0346_T1003 that is listed for IBC. Aerial imagery shows structures for housing the hogs, containment ponds, and a pivot irrigation system. Indiana Department of Natural Resources (IDNR 2015) records indicate that an 8-inch diameter, 85-foot deep well is used to withdraw water for irrigation purposes on this property. Manure from this facility may be land-applied to cropland owned by the CFO or nearby farms. Given the small size of this facility, its central location in this subwatershed, and the proximity of the Ohio-Indiana state border, it less likely that manure from the CFO is transported out of this subwatershed for land application.

Within *Fish Creek* (HUC 0410003 04), SJRWI (2008a) observed livestock during windshield surveys at 14 locations in Ohio, at 76 locations in Steuben County, Indiana, and 50 locations in DeKalb County,

[9] No industrial or public facilities with individual or general NPDES permits, biosolids application fields, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

Indiana; no livestock direct access to streams was observed and manure storage was observed at two locations in DeKalb County. Thus, livestock in Indiana and Ohio may contribute nutrients or sediment that impair biotic communities.

F-2.4.3.3 Crop Production

As shown in Figure F-10, cropland is the dominant source of TP and TSS loading in the TMDL subwatershed. Most of this subwatershed is agricultural land, with woodlots along Fish Creek and some of its tributaries. An analysis of aerial imagery shows that, with the exception of Fish Creek, streams throughout this subwatershed are channelized and straightened, especially when flowing through crop fields. Many streams have very thin forested riparian buffers or are without buffers.

F-2.5 Big Run (HUC 04100003 05 02)

Big Run flows easterly and is mostly in Indiana. The subwatershed includes many named tributaries (e.g., Donnell, John Smith, King, and Mary Metcalf ditches). While most of the subwatershed is rural and agricultural, the city of Butler is mostly in the Big Run subwatershed. U.S. route 6 and railroad lines bisect the subwatershed. As with much of the SJRW, forested woodlots are throughout the subwatershed.

F-2.5.1 Monitoring Data

Samples collected by IDEM and SJRWI in Indiana are discussed in Section F-2.5.1.1 and Section F-2.5.1.2 (respectively), while samples collected by Ohio EPA in Ohio are discussed in Section F-2.5.1.3. IDEM listed two segments of the Big Run (INA0352_04 and INA0352_05) for IBC. Such listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. Since neither TP results nor TSS results exceed targets, TMDLs were not developed to address IBC listings on Big Run.

F-2.5.1.1 IDEM

IDEM collected water chemistry samples at two sites on the Big Run. Site LEJ060-015 is on segment INA0352_04, and site LEJ060-008 is on segment INA0352_05. As shown in Table F-1, TP and TSS concentrations from all three samples collected at site LEJ060-0015 were below targets. Samples at site LEJ060-0008 were not evaluated for TP or TSS.

F-2.5.1.2 SJRWI

SJRWI sampled site 127 that is just east of IDEM site LEJ060-0008; while TP concentrations varied over a considerable range (Table F-2) about 40 percent of samples were non-detects.

F-2.5.1.3 Ohio EPA

Ohio EPA sampled site P08K08 at the confluence of Big Creek with the SJR. One of six samples collected in 2013 yielded a TP concentration (0.46 mg/L on 7/8/2013) above the Indiana (0.30 mg/L) and Ohio (0.08 mg/L; wading WWH) TP targets. Four of six TSS samples were non-detect; one sample (236 mg/L on 7/8/2013) was above the Indiana (30 mg/L) and Ohio (29 mg/L) targets.

Site P08K08 was in full attainment of its WWH ALU and Ohio EPA did not list this WAU as impaired for its ALU.

F-2.5.2 Load Duration Curve

Since no TP or TSS sample results exceeded targets, no LDCs nor TMDLs were developed.

F-2.5.3 Sources of Impairment

Nutrient and sediment sources were not assessed because these pollutants are not the cause of impairment. During the development of the point sources inventory, a few permitted point sources were identified in this subwatershed[10].

F-2.5.3.1 Public Facility with an Individual NPDES Permit[11]

One public facility is covered by an individual NPDES permit: Butler WWTP (IN0022462; see Figures C-3 and C-4 in Appendix C for maps and Table F-3 and Table F-4for DMR data). The facility is a 2 mgd sanitary POTW that discharges to Big Run. The city has one CSO outfall on Big Run (003) that discharged in 2008 through 2014 (Table C-6 in Appendix C).

F-2.5.3.2 Facilities Covered by General NPDES Permits

Five entities are covered by general NPDES permits. Eastside High School (ING250077) discharges NCCW to Butler's storm sewers that drain to Big Run. Three industrial facilities hold general NPDES permit coverage for industrial stormwater (INRM00985, INRM01605, and INRM01734 in Table C-3), while one construction site held coverage for stormwater.

F-2.5.3.3 On-Site Wastewater Treatment Systems

Except for the city of Butler, this subwatershed is served by OWTS. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.5.3.4 Livestock Operations

No CAFFs are in the Ohio-portion of the subwatershed and one CAFO is in the Indiana-portion of the subwatershed (see Figure C-6 and Table C-11). The Irish Acres Dairy, LLC, is a CAFO with 1,196 dairy cattle. The CAFO drains to Haverstock Ditch, which is tributary to Big Run. Aerial imagery shows that the CAFO has containment ponds. Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

F-2.6 Cedar Lake-Cedar Creek (HUC04100003 06 01)

Cedar Creek begins at the outflow of Cedar Lake in DeKalb County. The main tributary to Cedar Lake is Leins Ditch. About half of the Leins Ditch subwatershed is drained by McCullough Ditch that beings at the outlet of Indian Lake. Besides numerous small lakes and woodlots (including a few large woodlots in the headwaters) the land cover is predominantly agricultural. A small portion of the lower subwatershed includes industrial and commercial development, which is the outskirts of the town of Waterloo (e.g., Techo Bloc quarry and manufacturing facility). The U.S. Route 6 interchange with Interstate 69 is just upstream of the outlet of the subwatershed.

F-2.6.1 Monitoring Data

IDEM sampled one location each on Indian Lake (LEJ080-0012), Leins Ditch (LEJ080-0016), Cedar Creek (LEJ080-0015), and an unnamed tributary to Leins Ditch (LEJ080-0014). Just downstream of this subwatershed, IDEM also sampled Cedar Creek (LEJ080-0011); however, TP and TSS data were not collected at this site. Neither TP nor TSS exceeded targets at sites LEJ080-0016 or LEJ080-0014. Of the 39 samples collected at site LEJ080-0005 (Table F-1), one TP sample (3 percent) and 10 TSS samples (26 percent) exceeded targets.

[10] No industrial facilities with individual NPDES permits, no biosolids application fields, or regulated MS4s are in this subwatershed.

[11] The following four permits were terminated: Citation Bohn Aluminum (IN0000515; NCCW and stormwater), DeKalb County East Community School District (IN0055808), DeKalb Molded Plastics Company (IN0051659), and Universal Tool and Stamping Company (IN0000639; rinse water).

IDEM listed two segments of Cedar Creek (INA0361_03 and INA0361_04) for nutrients. As TP occasionally exceed targets, the nutrient listing was addressed through the development of a TP TMDL at the outlet of the subwatershed.

F-2.6.2 Load Duration Curve

A LDC was developed for Cedar Creek (Figure F-11). No TP data were collected near the HU outlet by IDEM in 2004-2014. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones. However, the majority of SWAT-simulated TP loads in each of these flow zones was less than the LDC.

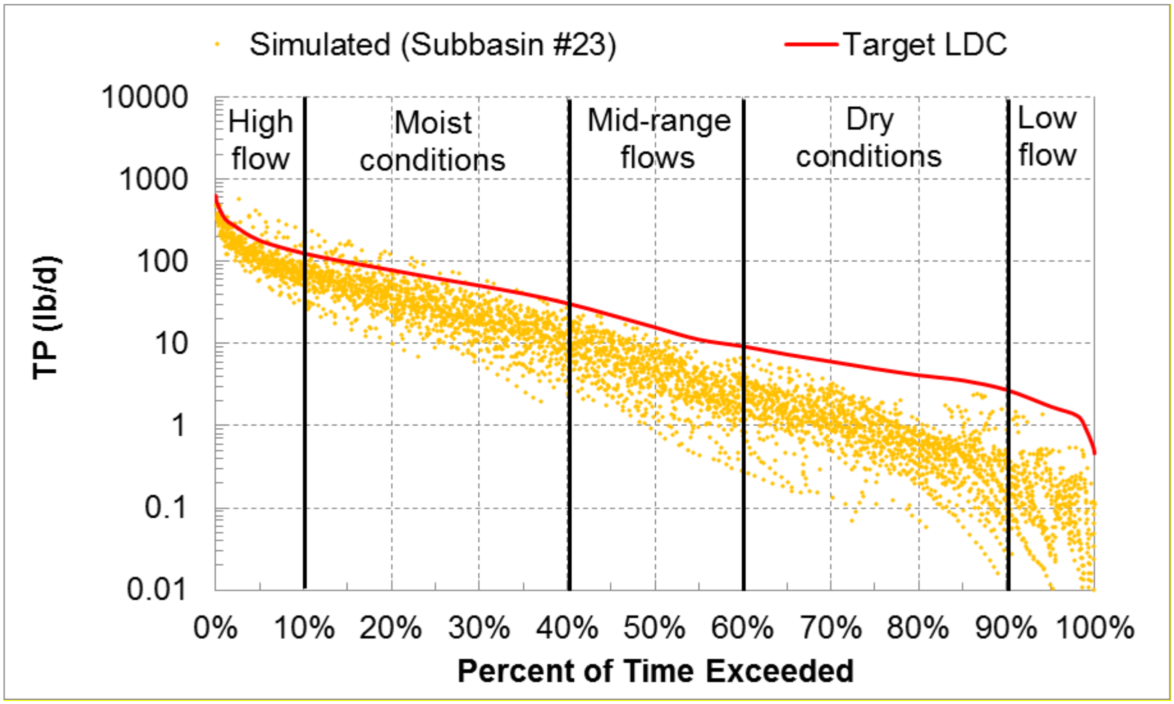
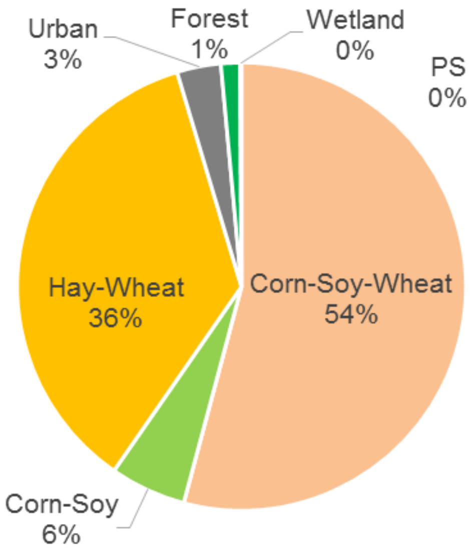


Figure F-11. TP LDC for Cedar Creek in *Cedar Lake-Cedar Creek* (*06 01) at the HU outlet.

F-2.6.3 Sources of Impairment

SWAT-simulated source loads[12] indicate that crops are the dominant source of TP load to Cedar Creek in this HU (Figure F-12).

[12] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
Relative loads are rounded to the nearest percentage point.
No point sources were simulated.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-12. Summary of SWAT-simulated annual TP loads that drain to Cedar Creek at the outlet of *Cedar Lake-Cedar Creek* (*06 01).

The potential sources of nutrients in this HU are evaluated in the following sections.[13]

F-2.6.3.1 Facilities Covered by a General NPDES Permit

Benchmark Distribution Terminals (ING340037) is covered by Indiana's general permit for petroleum distribution terminals; the facility is permitted to discharge industrial stormwater. Additionally, three industrial facilities hold general NPDES permit coverage for industrial stormwater (INRM00244, INRM00941, and INRM01759 in Table C-3), while two construction site held coverage for stormwater.

F-2.6.3.2 On-Site Wastewater Treatment Systems

As no publicly owned treatment works (POTWs) are in this subwatershed, OWTS and HSTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.6.3.3 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. No information about hobby farms and small livestock operations are available but such operations are likely present throughout the subwatershed. Within *Cedar Lake-Cedar Creek* (*06 01), SJRWI (2008a) observed livestock during windshield surveys at 62 locations; no manure storage or livestock with direct access to streams were observed. Between 1 and 12 animals were observed at 52 locations, 15 to 20 animals were observed at nine locations, and 200 sheep

[13] No industrial or public facilities with individual NPDES permits, CAFOs or CFOs, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed. Marathon Oil (ING340018; steam condensate hydrostatic test waters) was physically located in *Dibbling Ditch-Cedar Creek* (HUC 04100003 06 02) but formerly discharged through outfall 001 in this subwatershed; the permit was later terminated.

were observed at one location. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrient loads to the impairment.

F-2.6.3.4 Crop Production

As shown in Figure F-12, cropland is the dominant source of TP loading in the TMDL subwatershed. Most of this subwatershed is agricultural land. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized and straightened, especially when flowing through crop fields. Many streams have very thin forested riparian buffers or are without buffers.

No septage land application is permitted in this subwatershed. Application of biosolids from the Auburn WWTP was permitted on one field (CLU-SO6; 15 acres) in the lower subwatershed; no information on any actual applications is available. Manure application likely occurs on farms; the sources of such manure are small livestock operations. No application date, volume, or rate data are available; thus, the significance of manure application cannot be determined.

F-2.7 Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)

This subwatershed is composed of a short segment of Cedar Creek from the confluence of Dibbling Ditch to the confluence with Mason Ditch. Most the subwatershed drains to two tributaries of Cedar Creek: Dibbling Ditch and Schwartz Ditch. The Dibbling Ditch subwatershed is almost all rural, agricultural but does include the outskirts of the town of Ashley (to the north of this HU). The Schwartz Ditch subwatershed is also rural and agricultural. Cedar Creek flows along the perimeter of the town of Waterloo.

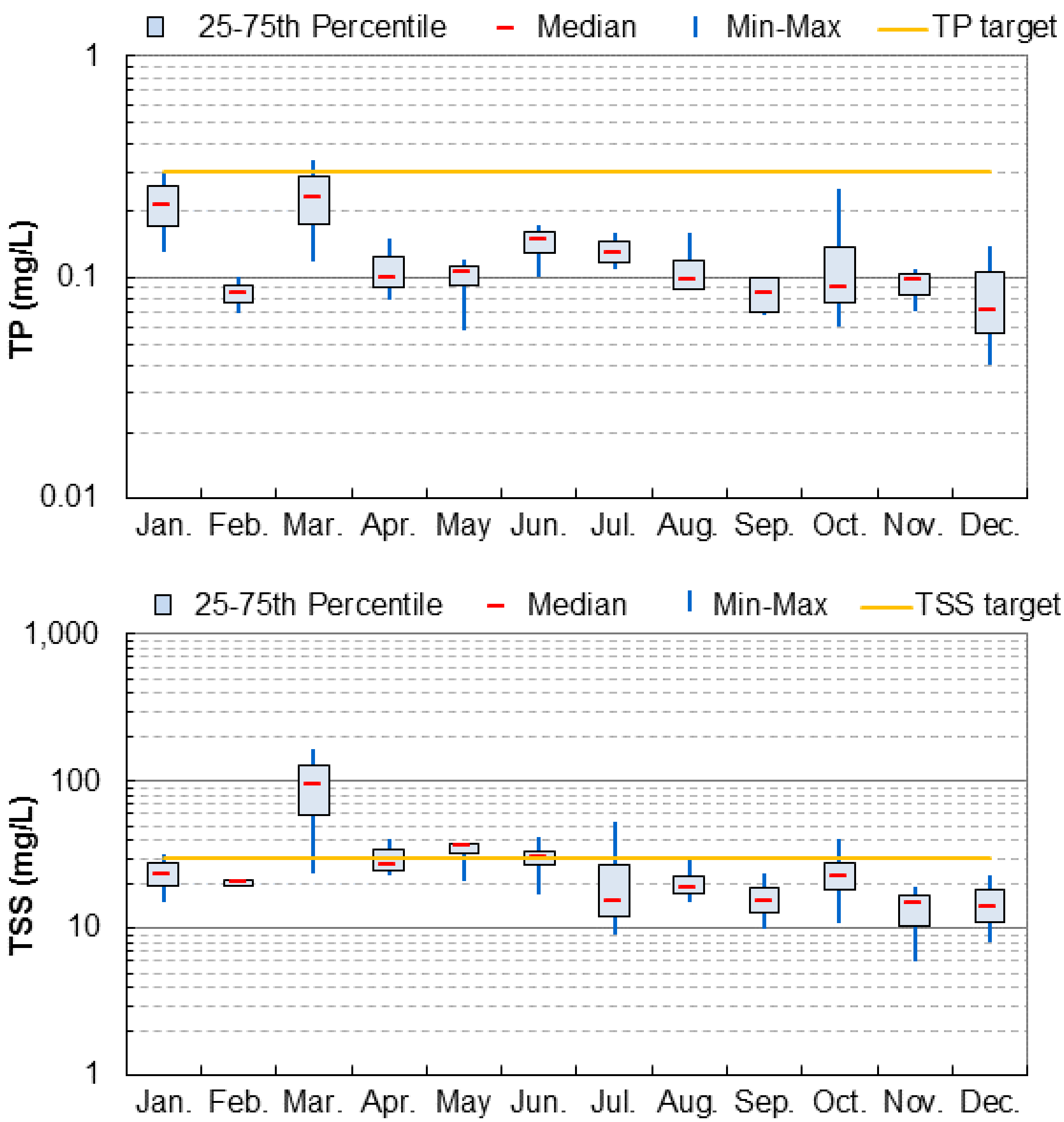
F-2.7.1 Monitoring Data

Samples were collected by IDEM (Section F-2.7.1.1) and SJRWI (Section F-2.7.1.2). IDEM listed four segments of Cedar Creek (INA0362_02, INA0362_03, INA0362_04, and INA0363_03) as impaired by nutrients. The nutrient listing was addressed through the development of a TP TMDL at the outlet of the HU.

F-2.7.1.1 IDEM

IDEM sampled three sites on Cedar Creek (LEJ080-0005, LEJ080-0006, and LEJ080-0011) and one site on Schwartz Ditch (LEJ080-0008). In 2000, five samples were collected from sites LEJ080-0006 and LEJ080-0008 and three samples were collected from site LEJ080-0011. No samples were evaluated for TP. Chlorophyll-*a* was evaluated at site LEJ080-0008 (3.4 to 40.2 µg/L) and site LEJ080-0008 (1.4 to 17.2 µg/L). DO was evaluated at sites LEJ080-0006 (7.69 to 13.56 mg/L) and LEJ080-0011 (6.89 to 9.64 mg/L) on Cedar Creek and site LEJ080-0008 (5.96 to 13.94 mg/L) on Schwartz Ditch.

Long-term data collected at site LEJ080-0005 are summarized in Figure F-13. TP and TSS increase in late spring and decrease in the summer and fall.



Note: 39 samples collected 2013-2014.

Figure F-13. TP (top) and TSS (bottom) at site LEJ080-0005 on Cedar Creek.

F-2.7.1.2 SJRWI

SJRWI sampled Cedar Creek (site 116), Dibbling Ditch (sites 115 and 143), and Schwartz Ditch (site 142). Samples collected in 2008 through 2010 and 2013 at sites 142 and 143 were evaluated for TP (Table F-2). TP results exceed at both sites 142 (14 of 175 results; 8 percent) and 143 (12 of 115 results; 10 percent).

F-2.7.2 Load Duration Curve

A LDC was developed for Cedar Creek (Figure F-14). No TP data were collected near the HU outlet by IDEM in 2004-2014. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones. However, the majority of SWAT-simulated TP loads in each of these flow zones was less than the LDC.

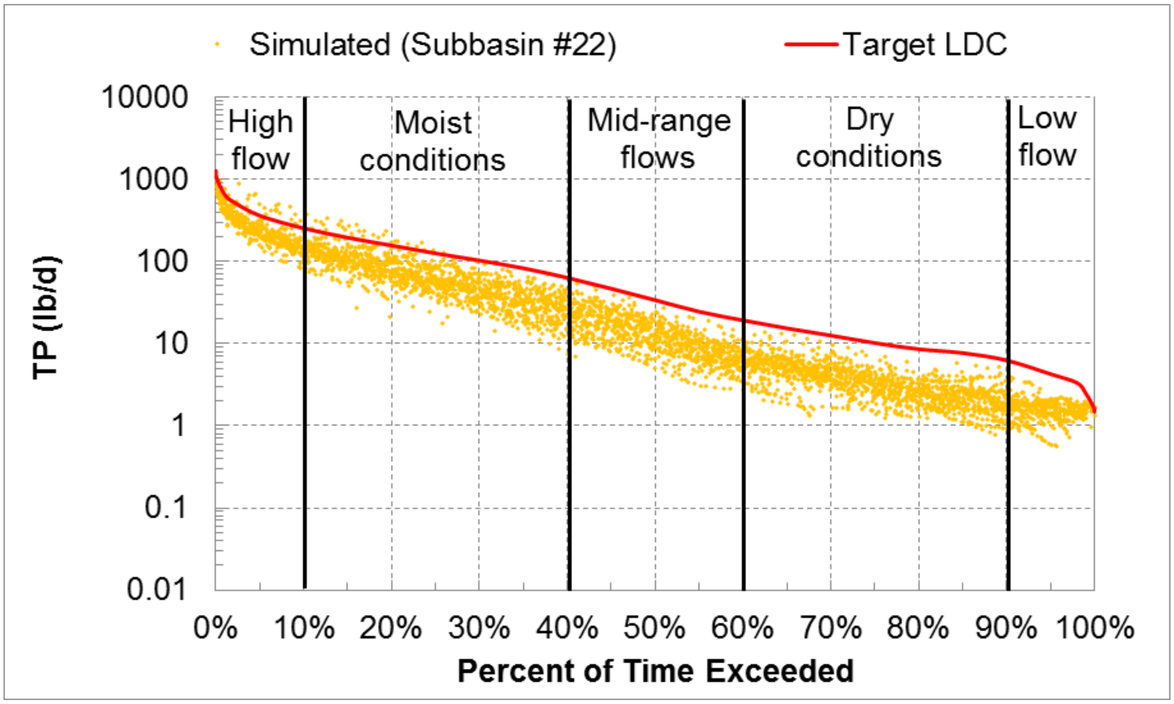
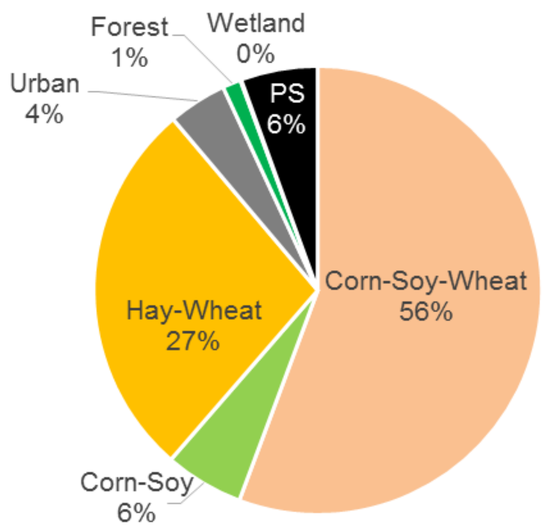


Figure F-14. TP LDC for Cedar Creek in *Dibbling Ditch-Cedar Creek* (*06 02) at the HU outlet.

F-2.7.3 Sources of Impairment

SWAT-simulated source loads[14] indicate that crops are the dominant source of TP load to Cedar Creek in this HU (Figure F-15). One-half of the TP source load at the mouth of this HU is derived from this HU while the other one-half of the load is derived from *Cedar Lake-Cedar Creek* (*06 01).

[14] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-15. Summary of SWAT-simulated annual TP loads that drain to Cedar Creek at the outlet of *Dibbling Ditch-Cedar Creek* (*06 02).

The potential sources of nutrients in this HU are evaluated in the following sections.[15]

F-2.7.3.1 Public Facilities with Individual NPDES Permits

Two public facilities are covered by individual NPDES permits[16] (see Figures C-3 and C-4 for maps and Table F-3 for DMR data).

- **Waterloo Municipal STP** (IN0020711; 240,000 gpd) is a sanitary POTW that discharges to the Cedar Creek. Effluent volumes were fairly consistent (0.2 to 1.1 cfs, average 0.5 cfs), while TP concentrations (0.2 to 1.3 mg/L, average 0.6 mg/L) and loads (0.3 to 18.9 lbd/s, average 1.6 lbs/d) were often high. Based upon SWAT-simulated TP loads, in-stream TP loads are typically considerably larger than effluent loads; only during in-stream low flow conditions could effluent loads become a dominant portion of the in-stream load.
- **Waterloo Public Water Supply** (IN0049433) was a WTP that formerly discharged to a county drain tributary to Cedar Creek. As the WTP should not discharge TP and its effluent volumes were very small, the WTP was not a source of nutrient impairment.

F-2.7.3.2 **Facilities Covered by General NPDES Permits**

Benchmark Distribution Terminals (ING340037) is covered by Indiana's general permit for petroleum distribution terminals; the facility is permitted to discharge industrial stormwater. Two industrial facilities hold general NPDES permit coverage for industrial stormwater (INRM00184 and INRM00487 in Table C-3). Four construction site in the headwaters of the Dibbling Ditch subwatershed (near the town of

[15] No industrial or public facilities with individual NPDES permits, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.
[16] Marathon Oil (ING340018; steam condensate hydrostatic test waters) was formerly permitted to discharge in this HU.

Ashley) and three construction sites between Cedar Creek and Schwartz Ditch held coverage for stormwater.

F-2.7.3.3 On-Site Wastewater Treatment Systems

Outside of the town of Waterloo, OWTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.7.3.4 Livestock Operations

Only one permitted livestock operation is in this HU; Phillips Farm is a CAFO with dairy calves and dairy heifers (see Figure C-8 and Table C-14 in Appendix C). The CAFO drains to Schwartz Ditch. Aerial imagery shows structures for housing the cattle and man-made containment ponds. Manure from this facility may be land-applied to cropland owned by the CAFO or nearby farms. As the town of Waterloo is to the east and two HUs are 0.5 mile north and south of the CAFO, it is feasible that manure is transported outside of the HU for land application.

Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 98 locations; no manure storage or livestock with direct access to streams were observed. Between 1 and 9 animals were observed at 70 locations; 10 to 25 animals, 18 locations; 30 to 40 animals, 4 locations; and 100-200 animals, five locations. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.7.3.5 Crop Production

As shown in Figure F-15, cropland is the dominant source of TP loading in the TMDL subwatershed. Except along Cedar Creek that flows around the town of Waterloo, most of this subwatershed is agricultural land. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized without forested riparian buffers.

No septage land application is permitted in this subwatershed. Application of biosolids from the following facilities was permitted (Table C-11):

- Auburn WWTP (8 fields; over 100 acres; incorporation, injections, and surficial; 1992-1993)
- Kendallville Municipal STP (1 field; 2 acres of corn; injection in 1999)
- Waterloo STP (7 fields; over 100 acres of corn and soybean; injections 1989-1999)

Manure application likely occurs on farms; the sources of such manure are small livestock operations. No application date, volume, or rate data are available; thus, the significance of manure application cannot be determined.

F-2.8 Matson Ditch-Cedar Creek (HUC 04100003 06 03)

The Matson Ditch subwatershed is predominantly rural and agricultural. Residential properties are at a higher density in the lower reaches of the subwatershed in areas closer to the town of Waterloo. The unnamed tributary to Matson Ditch meanders through crop fields and woodlots, with no forested riparian buffers along the segments flowing through crop fields. The unnamed tributary pass through culverts under state route 427 and county roads 16 and 51; it then flows in a straightened channel parallel to country road 51 until its confluence with Matson Ditch.

F-2.8.1 Monitoring Data

Samples were collected by IDEM (Section F-2.8.1.1) and SJRWI (Section F-2.8.1.2). IDEM listed the unnamed tributary to Matson Ditch (INA0363_T1001) as impaired by nutrients. The nutrient listing was addressed through the development of a TP TMDL at the confluence of the unnamed tributary to Matson Ditch with Matson Ditch.

F-2.8.1.1 IDEM

IDEM sampled one location on the unnamed tributary to Matson Ditch (LEJ080-0013; Table F-1) in 2005. One of the three samples evaluated for TP exceeded the TP target. These three samples were also evaluated for ash-free dry mass (171.7 to 241.6 grams per square meter), periphyton chlorophyll-*a* (35.5 to 357.8 milligrams per square meter), and seston chlorophyll-a (1.78 to 3.58 µg/L). Finally, DO was evaluated on 11 occasions (4.78 to 8.94 mg/L, median 6.05 mg/L)

F-2.8.1.2 SJRWI

SJRWI sampled one location at the mouth of Matson Ditch on Cedar Creek (106; Table F-2). Of the 329 samples collected from 2002 through 2013, 40 samples (12 percent) exceed the TP target.

F-2.8.2 Load Duration Curve

An LDC was developed for the unnamed tributary to Matson Ditch (Figure F-16) and TP data collected by IDEM in 2005 are displayed as loads[17]. An exceedance of the LDC occurred in the dry conditions zone. To achieve the TMDL (i.e., reduce load to the LDC), a 17 percent reduction is necessary.

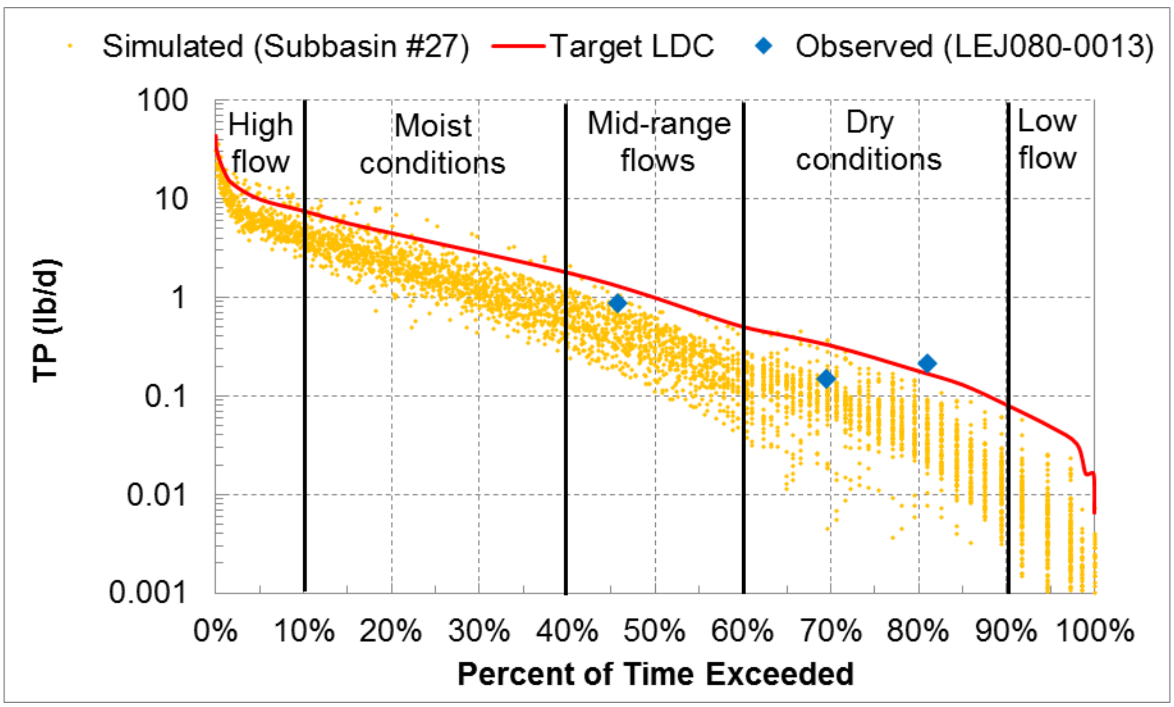
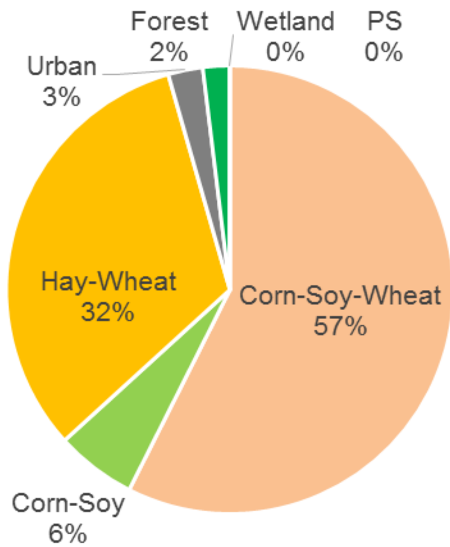


Figure F-16. TP loads and LDC for the unnamed tributary to Matson Ditch in *Matson Ditch-Cedar Creek* (*06 03) at the confluence of the unnamed tributary with Matson Ditch.

[17] TP concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

F-2.8.3 Sources of Impairment

SWAT-simulated source loads[18] indicate that crops are the dominant source of TP load to the unnamed tributary of Matson Ditch in this HU (Figure F-10).



Notes
Relative loads are rounded to the nearest percentage point.
No point sources or wetlands were simulated.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-17. Summary of SWAT-simulated annual TP loads that drain to the unnamed tributary to Matson Ditch at the confluence with Matson Ditch of *Matson Ditch-Cedar Creek* (*06 03).

The potential sources of nutrients and sediment in this HU are evaluated in the following sections.[19]

F-2.8.3.1 On-Site Wastewater Treatment Systems

The unnamed tributary to Matson Ditch subwatershed includes about a dozen residences that are assumed to use OWTS. As this subwatershed is mostly composed of crop fields, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.8.3.2 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. An analysis of aerial imagery is inconclusive but hobby farms appear to be present. Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at two locations; no manure storage or livestock with direct access to streams were

[18] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.

[19] No industrial or public facilities with individual or general NPDES permits, CAFOs or CFOs, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

observed. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.8.3.3 Crop Production

As shown in Figure F-17, cropland is the dominant source of TP loading in the TMDL subwatershed. This subwatershed is composed of about a dozen residences, each adjacent to row crop operations, and a few woodlots. Agricultural runoff is likely the source of any pollutants because the vast majority of land in this subwatershed is under cultivation.

F-2.9 Smith Ditch-Cedar Creek (HUC 04100003 06 04)

This subwatershed is composed of a Cedar Creek from the confluence of Matson Ditch to the confluence with John Diehl Ditch. Three tributaries in this HU drain to Cedar Creek: Smith Ditch, Metcalf Ditch, and an unnamed tributary. The Smith Ditch subwatershed, upstream of the unnamed tributary to Smith Ditch (INA0364_T1003), is rural and agricultural. Smith Ditch and its unnamed tributary are channelized and straightened without forested riparian buffers. The lower reaches of Smith Ditch (INA0364_T1002) flow through the city of Auburn.

F-2.9.1 Monitoring Data

Samples were collected by IDEM (Section F-2.9.1.1) and SJRWI (Section F-2.9.1.2). IDEM listed one segment of Smith Ditch (INA0364_T1001) for IBC. Such listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. Since neither TP results nor TSS results exceed targets, TMDLs were not developed to address IBC listings on Smith Ditch.

F-2.9.1.1 IDEM

IDEM collected water chemistry samples from Cedar Creek (LEJ080-0004, LEJ080-0007, LEJ080-0009, and LEJ080-0010), and Smith Ditch (LEJ080-0017). None of the Cedar Creek samples were evaluated for TP or TSS. Three samples were collected in 2010 from Smith Creek; none exceeded the TP or TSS targets (Table F-1).

F-2.9.1.2 SJRWI

SJRWI collected water chemistry samples from Cedar Creek (105) and Smith Ditch (141). Cedar Creek was sampled downstream of the confluence with Smith Ditch in 2014, and two of 29 samples (7 percent) exceeded the TP target. Smith Ditch was sampled in 2002 through 2014, and 50 of 317 samples (16 percent) exceeded the TP target.

F-2.9.2 Load Duration Curve

Since no TP or TSS sample results exceeded targets, no LDCs nor TMDLs were developed.

F-2.9.3 Sources of Impairment

Nutrient and sediment sources were not assessed because these pollutants are not the cause of impairment. During the development of the point sources inventory, only three permitted point sources were identified in the Smith Ditch subwatershed[20]: three construction sites were permitted for stormwater discharge. None of the permitted construction sites drained to the impaired segment of Smith Ditch.

[20] No public or private facilities with individual NPDES permits, CAFOs or CFOs , communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

F-2.10 Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)

This HU is composed of the John Diehl Ditch from the confluence of Peckart Ditch to the confluence with Cedar Creek. Much of the HU is composed of the Peckart Ditch subwatershed, while most of the John Diehl Ditch subwatershed is contained in the *Headwaters John Diel Hitch* HU (HUC 041000003 07 01). The largest tributary to Peckhart Ditch is Ober Ditch.

The Peckhart Ditch subwatershed is predominantly rural and agricultural. The headwaters of the Ober Ditch subwatershed include much of the town of Corunna, while the lower reaches of Peckhart Ditch are in commercial development (e.g., movie theater, hardware store) within the outskirts of the city of Auburn. Peckhart Ditch flows beneath Interstate 69 just before its confluence with John Diehl Ditch.

F-2.10.1 Monitoring Data

Samples were collected by IDEM (Section F-2.10.1.1) and SJRWI (Section F-2.10.1.2). IDEM listed one segment of Peckhart Ditch (INA0364_T1001) for IBC and DO. This segment begins at the confluence of Ober Ditch and ends at the confluence with John Diehl Ditch. IBC listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. As TP and TSS both occasionally exceed targets, the IBC listings were addressed through the development of TP and TSS TMDLs at the mouth of Peckhart Ditch.

F-2.10.1.1 IDEM

IDEM collected water chemistry samples from John Diehl Ditch (LEJ090-0018) and from Peckhart Ditch above (LEJ090-0040) and below (LEJ090-0034) Ober Ditch (Table F-1). TP and TSS were not evaluated in samples collected from John Diehl Ditch (site LEJ090-0018).

Three samples were collected at site LEJ090-0040 in 2010; one sample each exceeded the TP and TSS targets. DO was monitored nine times (2.40 to 8.97 mg/L, median 6.92 mg/L). Three samples were collected from site LEJ090-0034 in 2005, no sample exceeded targets. DO was monitored eight times (4.80 to 11.80 mg/L, median 6.43 mg/L).

F-2.10.1.2 SJRWI

SJRWI collected water chemistry samples from John Diehl Ditch (104) and from Peckhart Ditch (114 and 137). Site 104 is collocated with IDEM site LEJ090-0018 and site 114 is co-located with IDEM site LEJ090-0034. John Diehl Ditch was sampled from 2002 through 2013; 25 of 326 results (8 percent) exceeded the TP target. Samples were not evaluated for TP at either site on Peckhart Ditch.

F-2.10.2 Load Duration Curve

LDCs were developed for Peckhart Ditch (Figure F-18 and

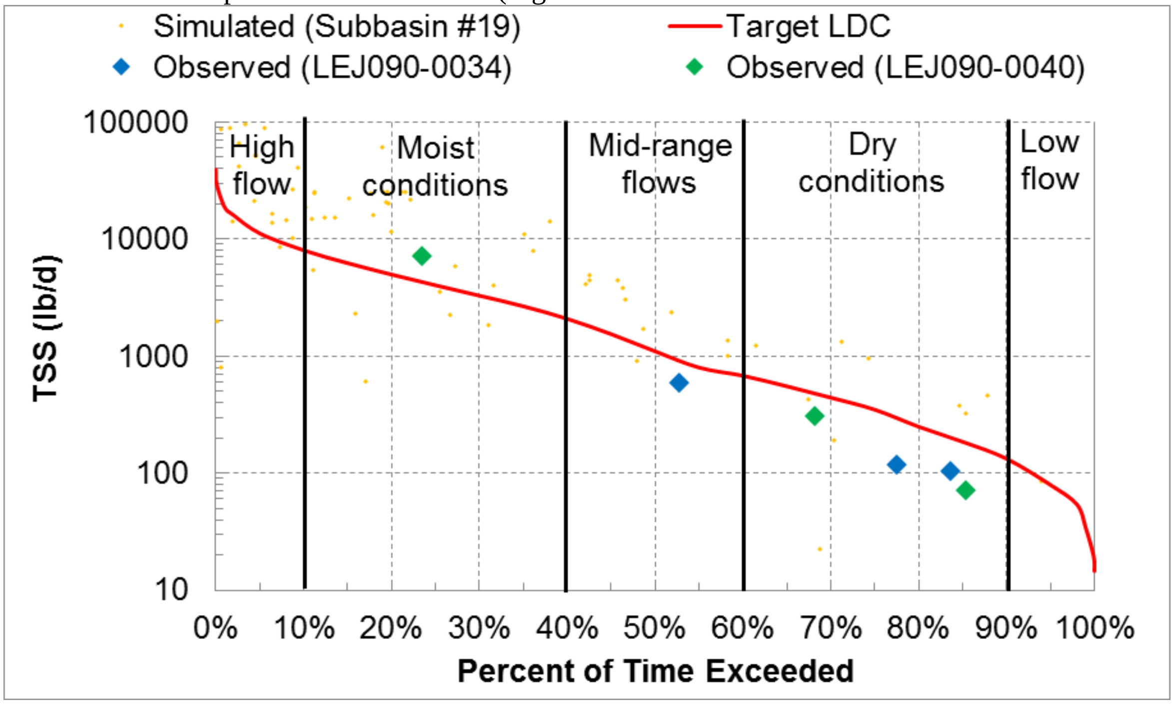
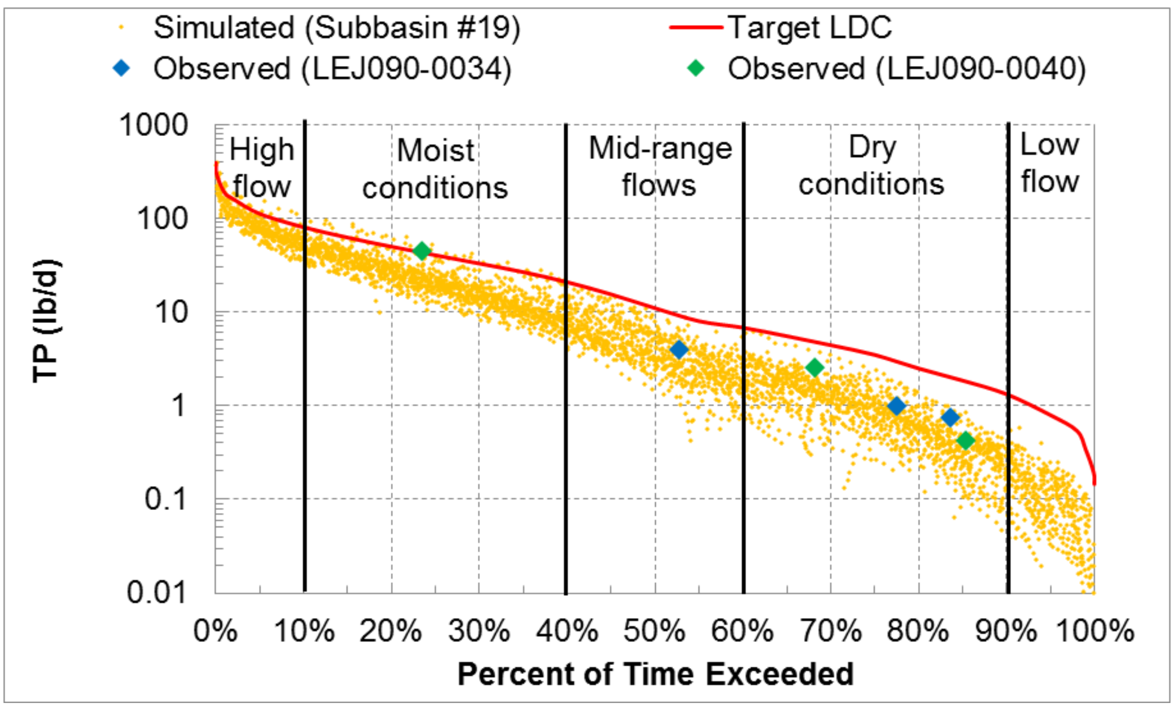


Figure F-19) and TP or TSS data collected by IDEM in 2005 and 2010 are displayed as loads[21]. Exceedances of the LDC only occurred in the moist conditions flow zones for TP and TSS. To achieve the TMDLs (i.e., reduce loads to the LDCs), reductions of 6 percent for TP and 41 percent for TSS are necessary.



[21] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

Figure F-18. TP loads and LDC for Peckhart Ditch in *Peckhart Ditch-John Diehl Ditch* (*07 02) at the confluence with John Diehl Ditch.

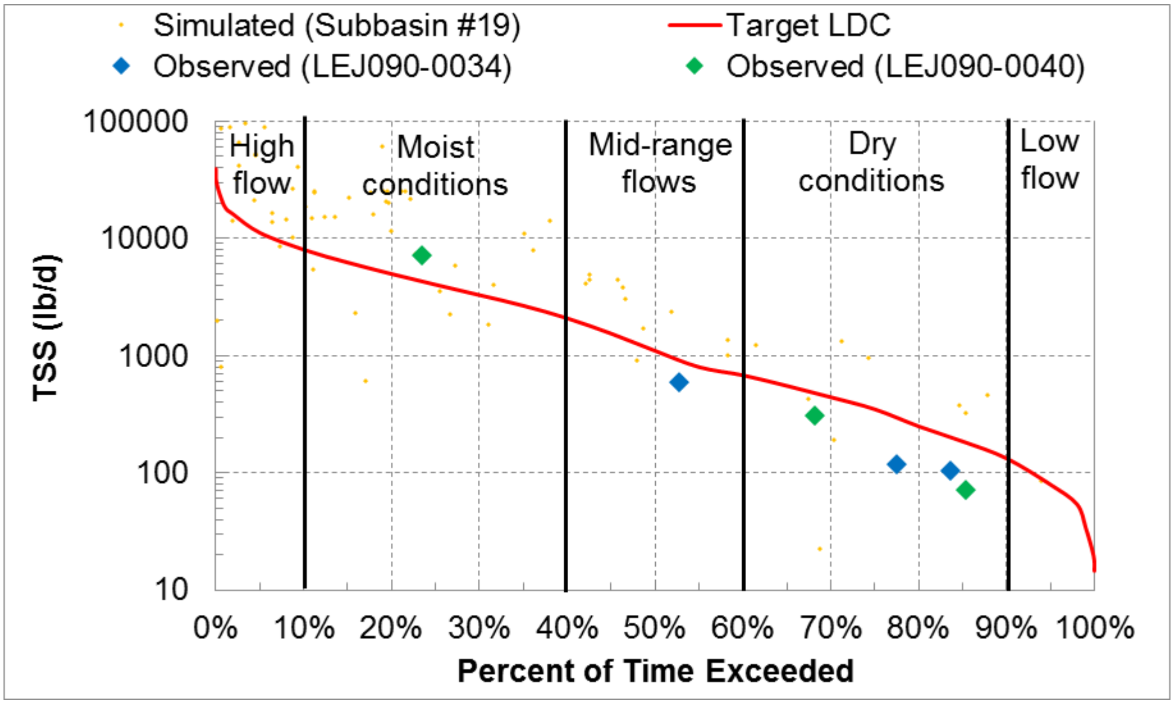
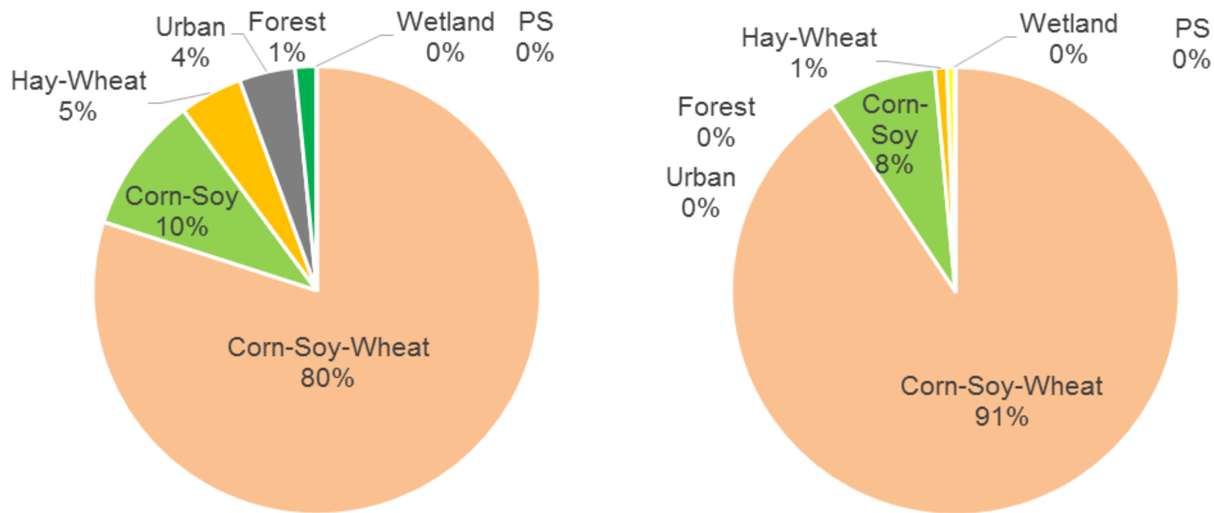


Figure F-19. TSS loads and LDC for Peckhart Ditch in Peckhart Ditch-John Diehl Ditch (*07 02) at the confluence with John Diehl Ditch.

F-2.10.3 Sources of Impairment

SWAT-simulated source loads[22] indicate that crops are the dominant source of TP and TSS load to Peckhart Ditch in this HU (Figure F-20).

[22] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
Relative loads are rounded to the nearest percentage point.
No point sources were simulated.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-20. Summary of SWAT-simulated annual TP (left) and TSS (right) loads that drain to Peckhart Ditch at the confluence with John Diehl Ditch of *Peckhart Ditch-John Diehl Ditch* (*07 02).

The potential sources of nutrients and sediment in this HU are evaluated in the following sections.[23]

F-2.10.3.1 Industrial Facilities with Individual NPDES Permits

A single industrial facility is covered by an individual NPDES permit (see Figures C-3 and C-4 for maps and Table F-3 for DMR data).

- **Metal Technologies** (IN0061263; 200,000 gpd)[24] is an industrial facility that discharges NCCW and industrial stormwater to Diehl Ditch. Effluent volumes varied considerably (<0.01 to 0.37 cfs, average 0.05 cfs), while maximum daily TP concentrations and loads (0.025 to >0.1 mg/L, average 0.065 mg/L; <0.16 lb/d) and TSS concentrations and loads (<1 to 37 mg/L, average 6 mg/L; <1 to 14 .b/d, average 2 lb/d) were low. This facility's NCCW is not a source of TP and TSS, and its industrial stormwater is a negligible source of these pollutants.

F-2.10.3.2 Facilities Covered by General NPDES Permits

Two industrial facilities hold general NPDES permit coverage for industrial stormwater (INRM01370 and INRM01768 in Table C-3), while five construction sites held coverage for stormwater.

F-2.10.3.3 On-Site Wastewater Treatment Systems

Residences in the northwest portion of the subwatershed are served by the Corunna WWTP (IN0047473) and residences in the southeast portion are served by the Auburn WWTP (IN0020672). The rural

[23] No public facilities with individual NPDES permits, CFOs, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

[24] Metal Technologies (IN0061263) is located at the same address as the former Auburn Foundry Landfill (IN0061590). Adjacent grassed areas, ponds, and wetlands that are associated with Metal Technologies appear to discharge to *Dosch Ditch-Cedar Creek* (*07 07).

residences within agricultural areas along Ober and Peckhart ditches are assumed to use OWTS. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.10.3.4 Unregulated Livestock Operations

Two permitted livestock operations are in this HU; Sunrise Heifer Farms LLC is a CAFO with dairy heifers and Haynes Dairy Farm is a CFO with finishers, nursery pigs, and sows (see Table 11 in the main report and Figure C-8 and Table C-14 in Appendix C). The CAFO drains to Peckhart Ditch with the CFO drains to Ober Ditch. Aerial imagery shows structures for housing the livestock at both facilities. Manure from this facility may be land-applied to cropland owned by the CAFO or nearby farms. As both operations are within 1.3 miles of an adjacent HU, it is feasible that manure is transported outside of the HU for land application.

Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 31 locations; no manure storage or livestock with direct access to streams were observed. Between 1 and 10 animals were observed at 23 locations; 15 to 60 animals, 6 locations; and 400-600 animals, two locations. None of these locations is within 2 RM of the TMDL site. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.10.3.5 Crop Production

As shown in Figure F-20, cropland is the dominant source of TP loading in the TMDL subwatershed. Except for Corunna and Auburn, this subwatershed is composed of rural agriculture with many row crop operations. Agricultural runoff is likely the source of any pollutants because the vast majority of land in this subwatershed is under cultivation.

F-2.11 Black Creek (HUC 04100003 07 04)

The Black Creek subwatershed is predominantly rural and agricultural. Segments of streams and ditches throughout the subwatershed are straightened and channelized. The western half of the subwatershed drains to Bilger Ditch; most residences are adjacent to row crop fields and there are many undeveloped woodlots. Wahn Ditch is the only major tributary to Bilger Ditch. Below the confluence of Bilger Ditch with Black Creek, Black Creek flows around the town of La Otto. The lower reaches of Black Creek, as it flows due east, are bounded by wider, forested riparian buffers.

F-2.11.1 Monitoring Data

Samples were collected by IDEM (Section F-2.11.1.1) and SJRWI (Section F-2.11.1.2). IDEM listed one segment of Black Creek (INA0374_05) for IBC. This segment begins at the La Otto Regional Sewer District (RSD) WWTP and ends at the confluence of the Black Creek with Little Cedar Creek. IBC listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. As TSS occasionally exceed the target, the IBC listing was addressed through the development of a TSS TMDL at the mouth of Black Creek on Little Cedar Creek (i.e., the outlet of the subwatershed).

F-2.11.1.1 IDEM

IDEM collected water chemistry samples from Black Creek (LEJ090-0041). Four samples were evaluated for TP and TSS. TP concentrations did not exceed the target (0.12 to 0.14 mg/L), while one TSS concentration did exceed the target (range from non-detect to 50 mg/L; Table F-1).

F-2.11.1.2 SJRWI

SJRWI collected water chemistry samples from Black Creek (sites 102, 110, and 138). TP was evaluated in 115 samples at site 102 and exceed the TP target in 8 samples (7 percent).

F-2.11.2 Load Duration Curve

A LDC was developed for Black Creek (Figure F-21) and TSS data collected by IDEM in 2010 are displayed as loads[25]. An exceedance of the LDC occurred in the low flow zones. To achieve the TMDLs (i.e., reduce loads to the LDCs), a reduction of 40 percent is necessary.

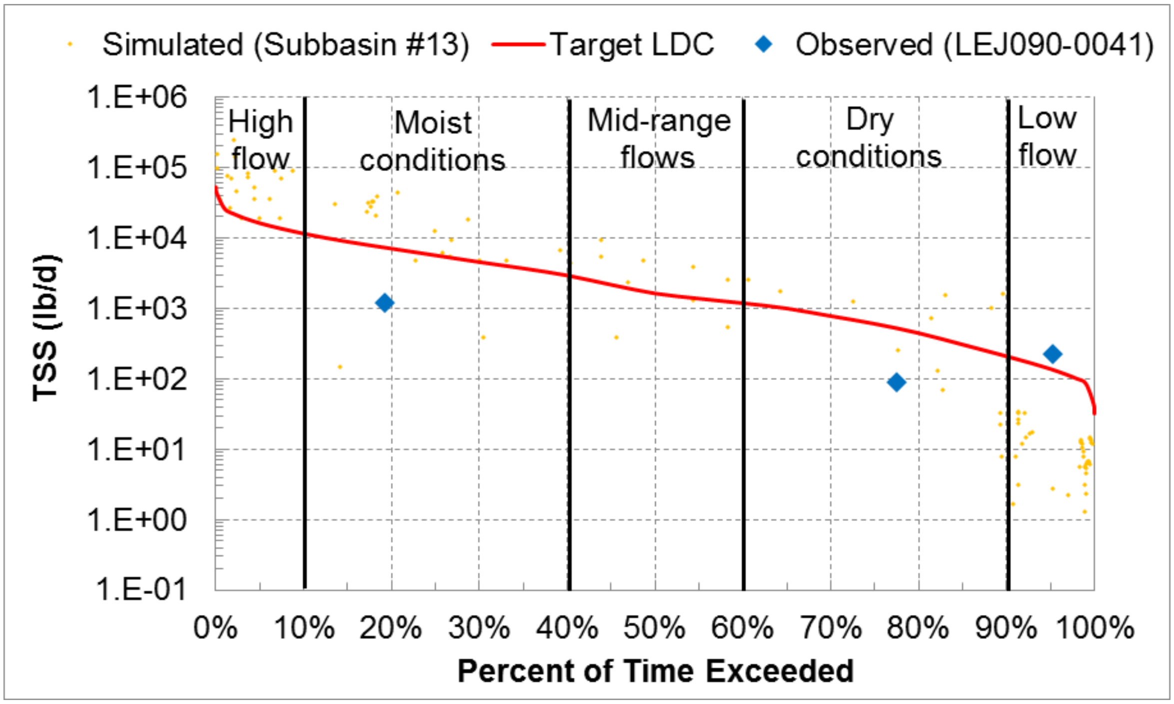
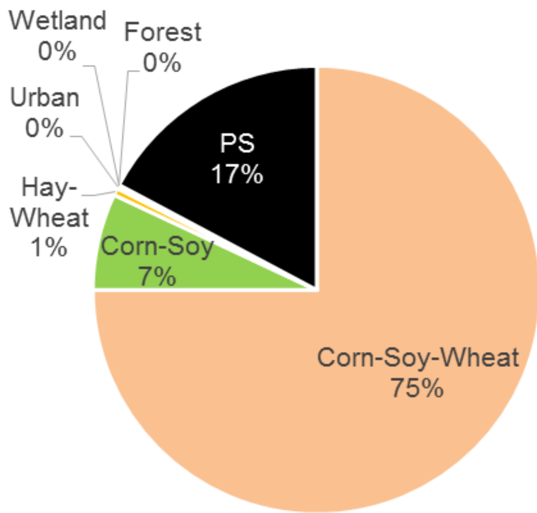


Figure F-21. TSS loads and LDC for Black Creek in *Black Creek* (*07 04) at the HU outlet.

F-2.11.3 Sources of Impairment

SWAT-simulated source loads[26] indicate that corn and soybean crops are the dominant source of TSS load to Black Creek in this HU (Figure F-10).

[25] TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.
[26] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-22. Summary of SWAT-simulated annual TSS loads that drain to Black Creek at the outlet of *Black Creek* (*07 04).

The potential sources of nutrients in this HU are evaluated in the following sections.[27]

F-2.11.3.1 Public Facilities with Individual NPDES Permits

One public facility is covered by an individual NPDES permit[28] (see Figures C-3 and C-4 for maps and Table F-3 for DMR data).

- **La Otto RSD WWTP** (IN0058611; 50,000 gpd) is a sanitary POTW that discharges to Black Creek. Aerial imagery indicates that the lagoon facility has three cells. Effluent volumes were very low (0.002 to 0.066 cfs, average 0.035 cfs). TSS concentrations (2 to 80 mg/L, average 24 mg/L) were typically low with the occasional spike. TSS loads (<0.1 to 21 lbd/s, average 5lbs/d) were typically low. An evaluation of SWAT-simulated in-stream loads indicates that effluent loads are orders of magnitude less than in-stream loads.

F-2.11.3.2 Facilities Covered by General NPDES Permits

One construction site in the Wahn Ditch subwatershed and one construction site along the lower segment of Black Creek held stormwater permit coverage.

F-2.11.3.3 On-Site Wastewater Treatment Systems

Outside of the town of La Otto, OWTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

[27] No industrial or with individual NPDES permits, communities with CSOs or SSOs, CAFOs or CFOs, biosolids application fields, or regulated MS4s are in this subwatershed.
[28] Marathon Oil (ING340018; steam condensate hydrostatic test waters) was formerly permitted to discharge in this HU.

F-2.11.3.4 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 5 locations in DeKalb County and 56 locations in Noble County; no livestock with direct access to streams was observed and manure storage was observed at one location in DeKalb County. Between 1 and 12 animals were observed at 50 locations; 15 to 30 animals, 10 locations; and 150 animals, one location. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.11.3.5 Crop Production

As shown in Figure F-22, corn and soybean cropland is the dominant source of TSS loading in the TMDL subwatershed. Except in the town of La Otto, most of this subwatershed is agricultural land with occasional woodlots. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized without forested riparian buffers. Most rural residences are adjacent to row crop fields.

F-2.12 King Lake-Little Cedar Creek (HUC 04100003 07 05)

With the exception of the town of Avilla and city of Garrett in the headwaters of unnamed tributaries to Little Cedar Creek, this HU is predominantly agricultural, with most rural residences adjacent to row crop fields. Several subdivision have developed near Avilla, Garrett, and in the lower segments of Little Cedar Creek below the confluence of Black Creek (e.g., around the Holiday Lakes). Numerous small ponds and woodlots are scattered across the landscape. King Lake is south of Avilla and is an in-channel lake along an unnamed tributary of Little Cedar Creek.

F-2.12.1 Monitoring Data

Samples were collected by IDEM (Section F-2.12.1.1) and SJRWI (SectionF-2.12.1.2). IDEM listed two segments of Little Cedar Creek (INA0375_05 and INA0375_06) and a segment of an unnamed tributary to Little Cedar Creek (INA0375_T1007) for IBC. IBC listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. As TSS occasionally exceed the target, the IBC listing was addressed through the development of a TSS TMDL at the mouth of Little Cedar Creek (i.e., the outlet of the subwatershed).

F-2.12.1.1 IDEM

Three samples collected from Little Cedar Creek (LEJ090-0033) in 2005 were evaluated for TP (0.05 to 0.15 mg/L). TSS was detected in only one sample (40 mg/L); which exceeded the TSS target. DO was monitored at eight sites and ranged from 6.18 to 8.04 mg/L. Three samples collected from an unnamed tributary to Cedar Creek (LEJ090-0002) in 2000 were evaluated for TP (0.075 to 0.180 mg/L), TSS (6 to 35 mg/L), and DO (2.35 to 7.85 mg/L).

F-2.12.1.2 SJRWI

SJRWI sampled Little Cedar Creek (site 103 and 111). Samples collected in 2008 through 2013 at site 103 were evaluated for TP (Table F-2). TP results exceeded the target (15 of 175 results; 8.6 percent).

F-2.12.2 Load Duration Curve

A LDC was developed for Little Cedar Creek (Figure F-23) and TSS data collected by IDEM in 2005 are displayed as loads[29]. An exceedance of the LDC occurred in the low flow zone. To achieve the TMDLs (i.e., reduce loads to the LDCs), a reduction of 25 percent is necessary.

[29] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

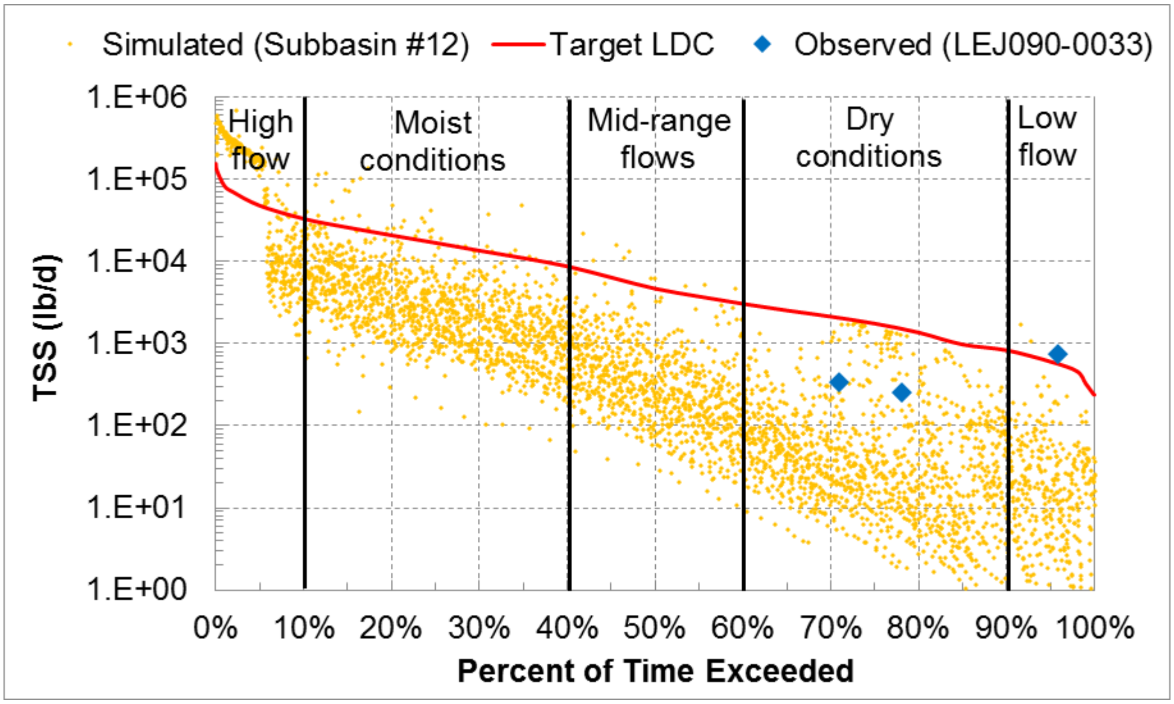
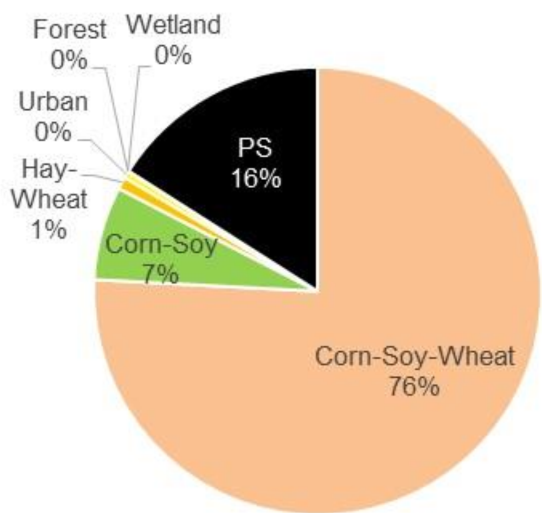


Figure F-23. TSS loads and LDC for Little Cedar Creek in *King Lake-Little Cedar Creek* (*07 05) at the HU outlet.

F-2.12.3 Sources of Impairment

SWAT-simulated source loads[30] indicate that corn and soybean crops are the dominant source of TSS load to Little Cedar Creek in this HU (Figure F-24).

[30] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.



Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-24. Summary of SWAT-simulated annual TSS loads that drain to Little Cedar Creek at the outlet of *King Lake-Little Cedar Creek* (*07 05).

The potential sources of nutrients in this HU are evaluated in the following sections.[31]

F-2.12.3.1 Public Facilities with Individual NPDES Permits

Three public facilities are covered by individual NPDES permits (see Figures C-3 and C-4 for maps and Table F-3 for DMR data).

- **Avilla WTP** (IN0052035; 34,000 gpd) is a WTP that discharges filter backwash to an unnamed tributary of Kings Lake. Effluent volumes were fairly consistent (0.030 to 0.051 cfs, average 0.037 cfs), while TSS concentrations (1 to 19 mg/L, average 6 mg/L) and loads (0.1 to 3.8 lbd/s, average 1.1 lbs/d) were very low. While the WTP is a source of TSS, its loads are very small and are an insignificant contributor to TSS loads in Little Cedar Creek.
- **Avilla WWTP** (IN0020664; 200,000 gpd) is a sanitary POTW that discharges to an unnamed tributary of Kings Lake. Effluent volumes varied considerably (0.053 to 0.819 cfs, average 0.514 cfs), while TSS concentrations (2 to 15 mg/L, average 7 mg/L) were very low. TSS loads varied with occasional larger loads (1.4 to 49.0 lb/d, average 20.7 lbs/d). An evaluation of SWAT-simulated in-stream loads indicates that effluent loads are orders of magnitude less than in-stream loads.
- **Indian Springs Recreational Campground** (IN0032107; 40,000 gpd) is a sanitary POTW that discharges seasonally to Little Cedar Creek. Effluent flows ranged from 0.001 to 0.032 cfs (average 0.008 cfs) during April through October. TSS concentrations (1 to 25 mg/L, average 8 mg/L) and loads (0.01 to 1.67 lb/d, average 0.36 lb/d) were very low. An evaluation of SWAT-simulated in-stream loads indicates that effluent loads are orders of magnitude less than in-stream loads.

[31] No industrial facilities with individual NPDES permits, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

F-2.12.3.2 Facilities Covered by General NPDES Permits

Two industrial facilities in the town of Avilla hold general NPDES permit coverage for industrial stormwater (INRM01208 and INRM01494 in Table C-3). Ten construction site held coverage for stormwater.

F-2.12.3.3 On-Site Wastewater Treatment Systems

Outside of the town of Avilla, city of Garrett, and Indian Springs Recreational Campground, which are all served by POTWs, OWTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.12.3.4 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 51 locations in DeKalb County and 119 locations in Noble County; no manure storage or livestock with direct access to streams were observed. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.12.3.5 Crop Production

As shown in Figure F-24, cropland is the dominant source of TP loading in the TMDL subwatershed. Except in the town of Avilla and city of Garrett, most of this subwatershed is agricultural land with occasional woodlots and ponds. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized without forested riparian buffers. Most rural residences are adjacent to row crop fields. The lower reaches of Little Cedar Creek (below Black Creek) are bounded by large, forested riparian buffers.

No septage land application is permitted in this subwatershed. Application of biosolids from the Garrett WWTP was permitted on five fields (164 acres; 1990-1995 and unknown years) in the eastern portion of the HU drained by an unnamed tributary to Little Cedar Creek; no information on any actual applications is available. Manure application likely occurs on farms; the sources of such manure are small livestock operations. No application date, volume, or rate data are available; thus, the significance of manure application cannot be determined.

F-2.13 Dosch Ditch-Cedar Creek (HUC 04100003 07 07)

This HU begins on Cedar Creek at the confluence of John Diehl Ditch and ends at the confluence of Cedar Creek with the SJR just below the Cedarville Reservoir. The Garret City Ditch and Schmadel Ditch discharge to Cedar Creek in the northern portion of this HU. Little Cedar and Willow creeks discharge to Cedar Creek in the southwest corner of this HU where Cedar Creek switches from flowing southwest to flowing southeast. The lower reaches of Cedar Creek flow through large, forested parcels.

Much of the city of Garrett and the outskirts of the city of Auburn are in the northern portion of this HU. The southeast, lower portion of the HU is composed of subdivisions and the suburban-rural transition along the city of Fort Wayne. Much of the land from Garrett and Auburn to Fort Wayne is row crops with adjacent rural residences.

F-2.13.1 Monitoring Data

Samples were collected by IDEM (Section F-2.13.1.1) and SJRWI (Section F-2.13.1.2). IDEM listed two segments of Cedar Creek (INA0377_03 and INA0377_04) and one segment of Dosch Ditch (INA0377_T1002) for IBC. IDEM also listed one segment of Dosch Ditch as impaired by nutrients. IBC listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. As TP and TSS both occasionally exceed targets, the IBC listings were addressed through the development of TP and TSS TMDLs at the mouth of Cedar Creek. The TP TMDL at the mouth of Cedar Creek will also address the nutrient impairment on Dosch Ditch.

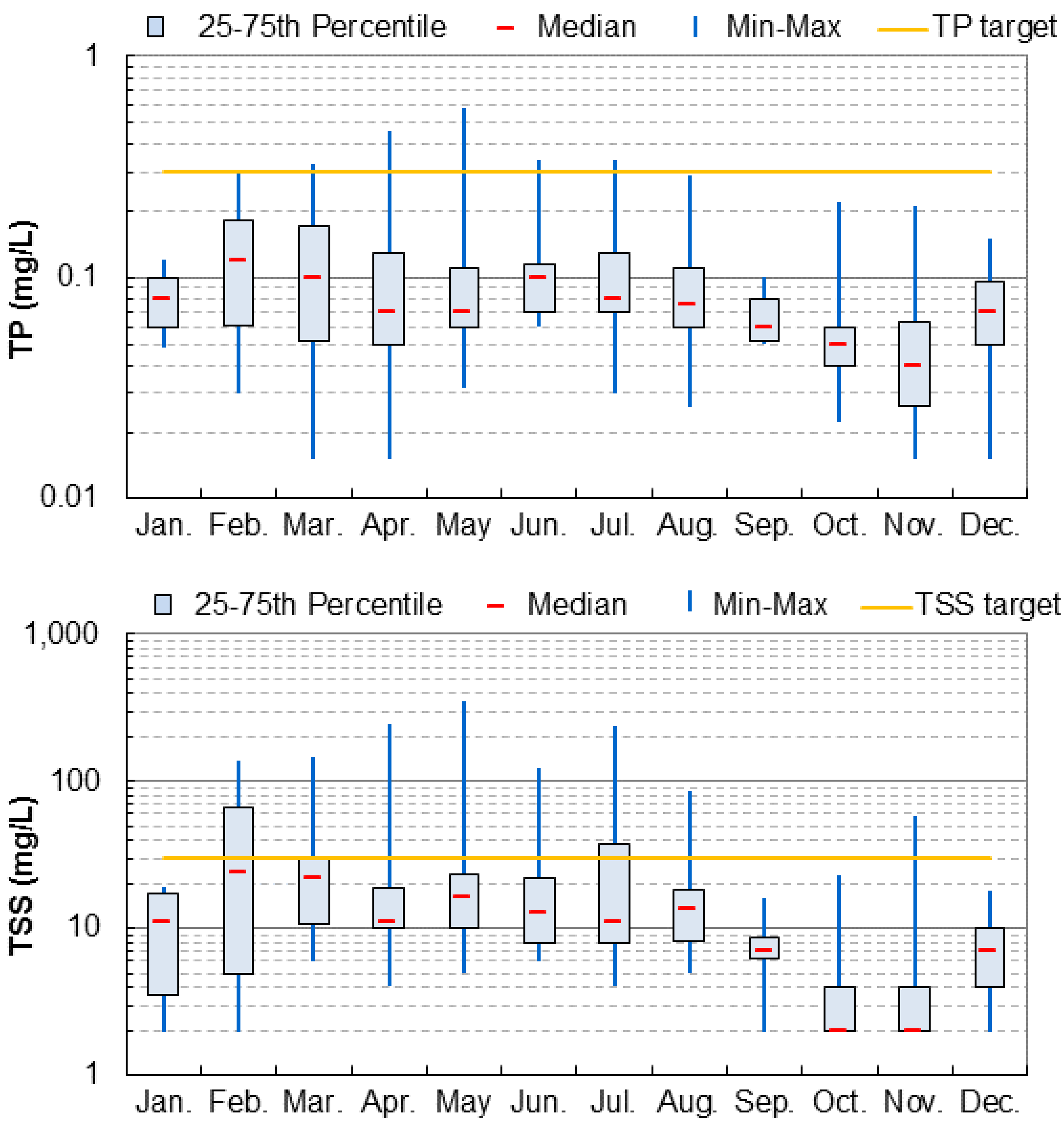
F-2.13.1.1 IDEM

IDEM sampled nine sites on Cedar Creek[32], one site on Dosch Ditch (LEJ090-0004), and five sites on Garrett City Ditch[33] (Table F-1). TP and TSS were evaluated for samples collected at five sites on Cedar Creek[34] and the single site on Dosch Ditch.

TP and TSS concentrations exceeded targets at three sites on Cedar Creek (Table F-1). No TP samples exceeded the target at site LEJ090-0008 (0.04 to 0.29 mg/L, n=31), while five samples exceeded the target at long-term site LEJ090-0026 (4 percent; 0.02 to 0.61 mg/L, n=146). Three TSS samples exceed the target at site LEJ090-0008 (10 percent; 2 to 86 mg/L, n=31) and 21 TSS samples exceeded the target at site LEJ090-0026 (14 percent, 2 to 346 mg/L, n=145). None of the three samples collected from Dosch Ditch exceeded applicable targets.

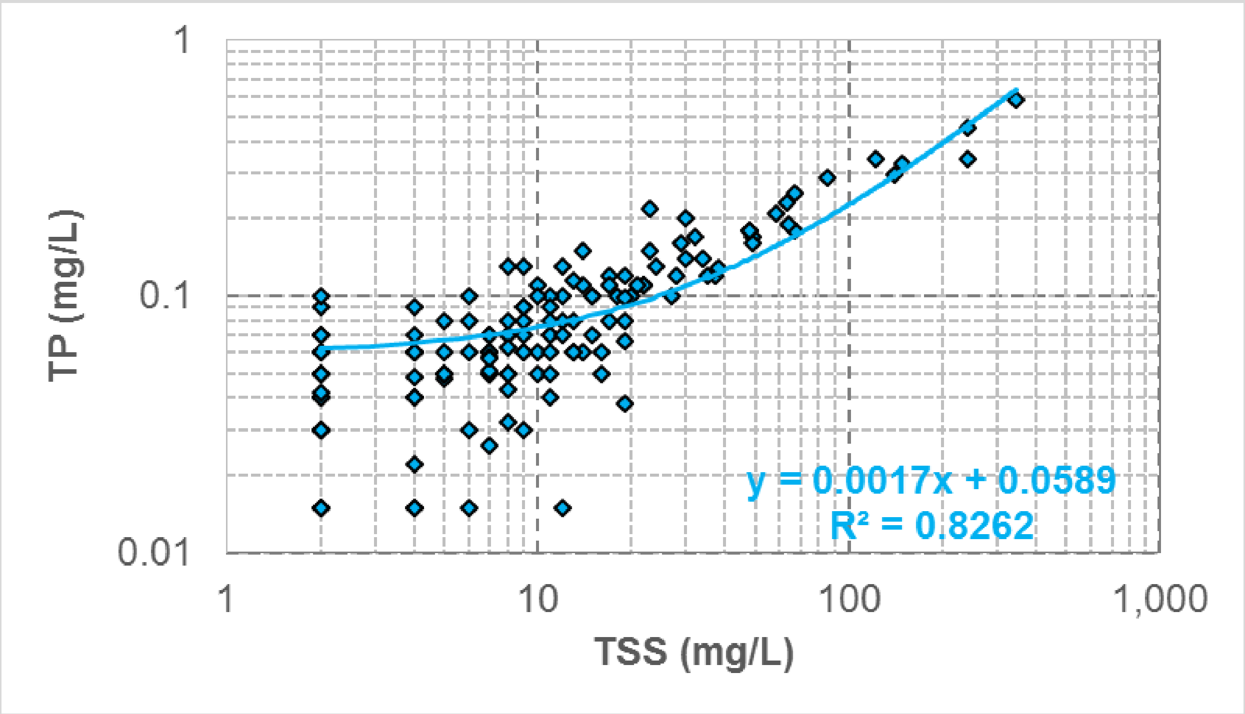
Long-term data collected at site LEJ090-0026 are summarized in Figure F-25. TP and TSS increase in the spring and decrease in the late summer and fall. TP was not detected in 6 samples (4 percent) and TSS was not detected in 21 samples (14 percent). A linear regression of TSS and TP (R^2=0.83) at site LEJ090-0026 may indicate a predictive relationship (Figure F-2). Such results likely indicate that TP is bound to sediment. When TP is sediment-bound, sources of sediment erosion (both upland and in-channel) typically increase the in-stream concentrations of TP and TSS.

[32] Sites LEJ090-0001, LEJ090-0003, LEJ090-0008, LEJ090-0009, LEJ090-0011, LEJ090-0021, LEJ090-0022, LEJ090-0026, and LEJ090-0031.
[33] Sites LEJ090-0012, LEJ090-0013, LEJ090-0014, LEJ090-0015, and LEJ090-0016.
[34] Sites LEJ090-0001, LEJ090-0003, LEJ090-0008, LEJ090-0026, and LEJ090-0031.



Note: 146 TP samples and 145 TSS samples collected 2001-2014.

Figure F-25. TP (top) and TSS (bottom) at site LEJ090-0026 on Cedar Creek.



Note: Non-detects were included in this analysis as one-half of the detection limit.

Figure F-26. Paired TP and TSS samples at site LEJ090-0026.

F-2.13.1.2 SJRWI

SJRWI sampled Cedar Creek (site 100, 107, and 109) and Garrett City Ditch (site 117). Samples collected in 2002 through 2014 at site 100 and in 2008 through 2013 at site 117 were evaluated for TP (Table F-2). TP results exceed at both sites 100 (27 of 354 results; 8 percent) and 117 (43 of 175 results; 25 percent).

F-2.13.2 Load Duration Curve

LDCs were developed for Cedar Creek (Figure F-27 and Figure F-28) and TP or TSS data collected by IDEM in 2004-2014 are displayed as loads[35]. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones for TP and in the high flow, moist conditions, and mid-range flow zones for TSS. To achieve the TMDLs (i.e., reduce loads to the LDCs), reductions on a per sample basis, for the samples that exceed the TMDL target, range from 9 to 48 percent for TP and range from 6 to 91 for TSS.

[35] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

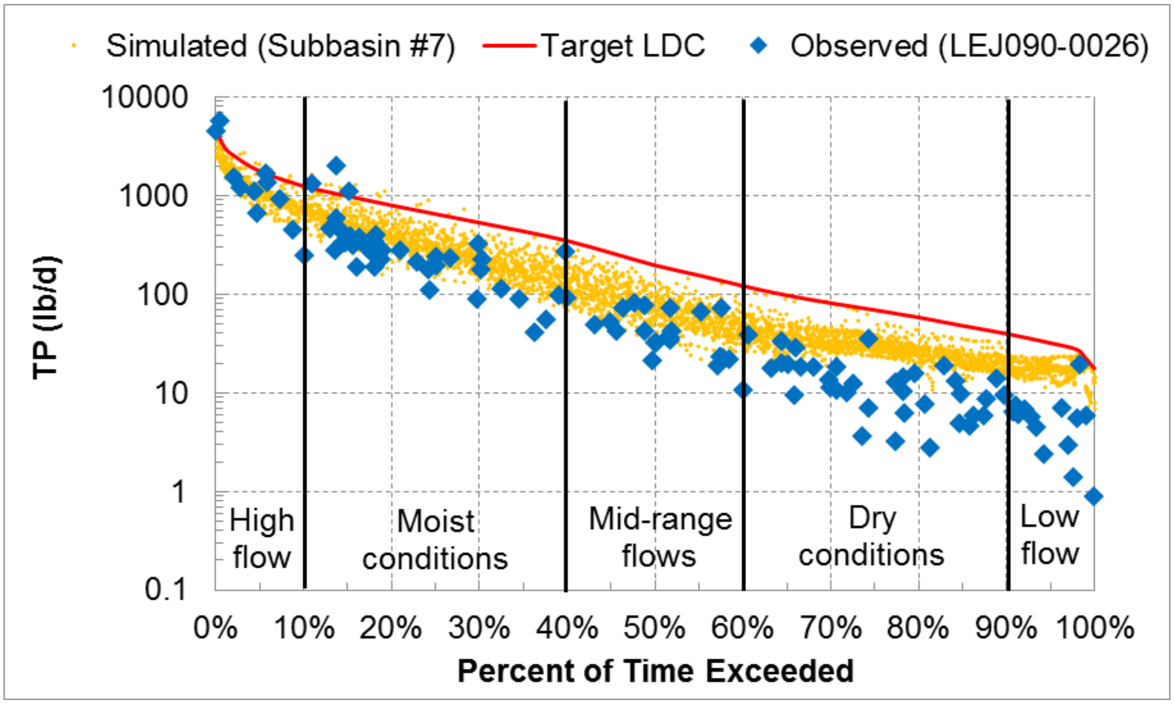


Figure F-27. TP loads and LDC for Cedar Creek in *Dosch Ditch-Cedar Creek* (*07 07) at the HU outlet.

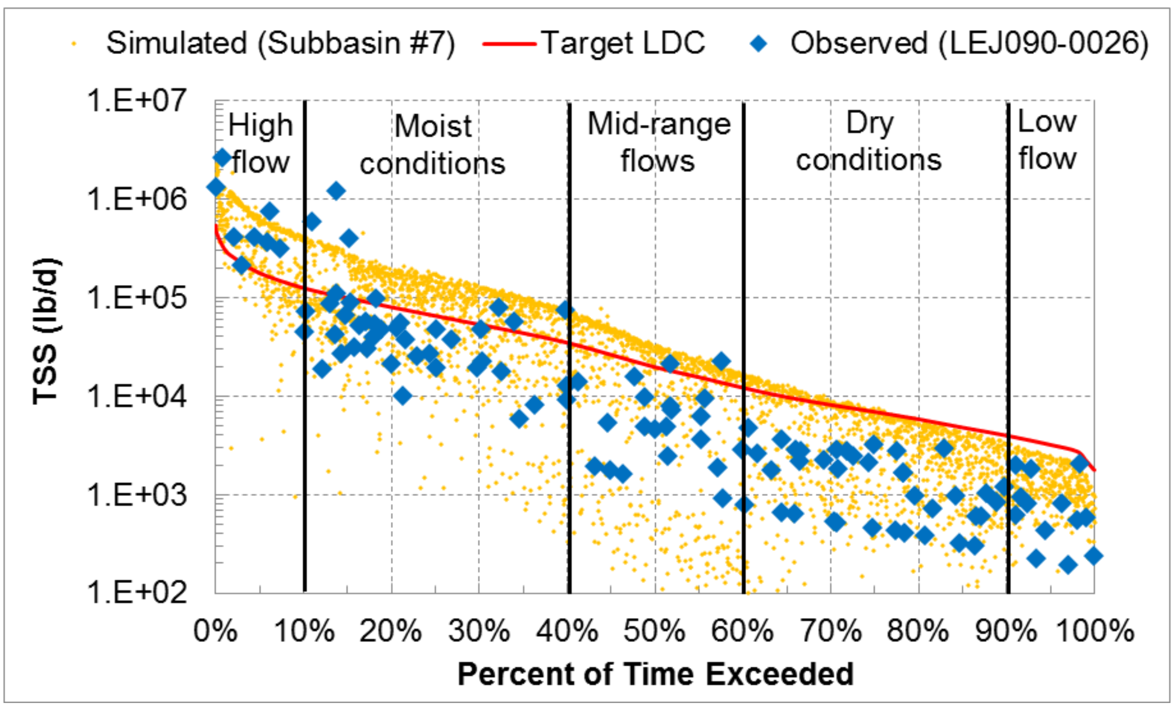
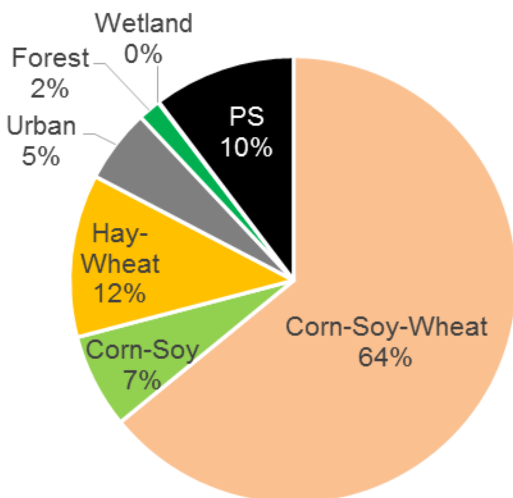
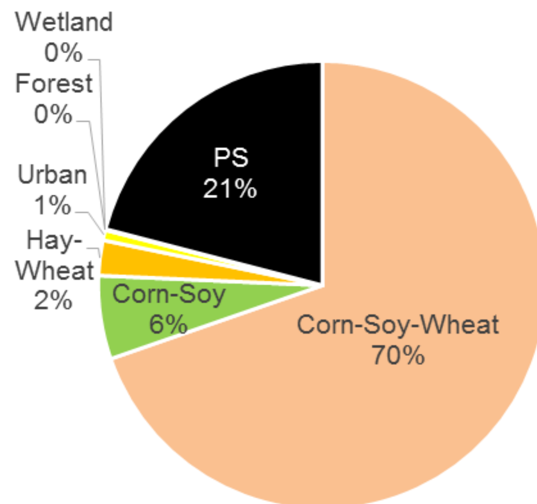


Figure F-28. TSS loads and LDC for Cedar Creek in *Dosch Ditch-Cedar Creek* (*07 07) at the HU outlet.

F-2.13.3 Sources of Impairment

SWAT-simulated source loads[36] indicate that corn and soybean crops are the dominant source of TP and TSS load to Cedar Creek (Figure F-29). Of the 11 HUs draining to the mouth of Cedar Creek, TP source load contributions per HU ranged from 6 to 13 percent of the total source load and for TSS, it ranged from 4 to 14 percent. Typically, the larger the HU, the larger the pollutant source loading.





Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-29. Summary of SWAT-simulated annual TP (left) and TSS (right) loads that drain to Cedar Creek at the outlet of *Dosch Ditch-Cedar Creek* (*07 07).

The potential sources of nutrients in this HU are evaluated in the following sections.[37]

F-2.13.3.1 Public Facilities with Individual NPDES Permits[38]

One public facilities is covered by an individual NPDES permits (see Figures C-3 and C-4 for maps and Table F-3 for DMR data). The Garrett WWTP (IN0029969; 1.2 mgd) is a sanitary POTW that discharges to Garrett City Ditch. Effluent volumes were fairly consistent (0.7 to 1.9 cfs, average 1.1 cfs). TP concentrations (0.2 to 1.5 mg/L, average 0.5 mg/L) were high; TP loads varied with occasional larger loads (1 to 13 lbd/s, average 3 lbs/d). TSS concentrations (3 to 14 mg/L, average 6 mg/L) were low; TSS loads varied with occasional larger loads (13 to 115 lbd/s, average 34 lbs/d). Both TP and TSS effluent loads were orders of magnitude less than SWAT-simulated in-stream loads across most flow conditions.

[36] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.

[37] No industrial or public facilities with individual or general NPDES permits, biosolids application fields, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

[38] The following four permits were terminated: Auburn Foundry Landfill (IN0061590; stormwater), Auburn Rest Area I-69 North (IN0038504; sanitary), and Auburn Rest Area I-69 South (IN0038941; sanitary).

F-2.13.3.2 Facilities Covered by General NPDES Permits

Four industrial facilities in the town of Avilla hold general NPDES permit coverage for industrial stormwater (INRM00487, INRM00501, INRM00519, and INRM01740 in Table C-3). Seventeen construction site held coverage for stormwater. Allen County (INR040131, including the towns of Hunterstown and Leo-Cedarville), Auburn (INR040119), and Fort Wayne[39] (INR040029) are regulated MS4s.

F-2.13.3.3 On-Site Wastewater Treatment Systems

Outside of the cities of Auburn, Fort Wayne, and Garrett, which are all served by POTWs, OWTS are the main methods of sanitary treatment. As this subwatershed is mostly composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.13.3.4 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. Within the TMDL subwatershed, SJRWI (2008a) observed livestock during windshield surveys at 149 locations in Noble County and 267 locations in DeKalb County. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.13.3.5 Crop Production

As shown in Figure F-29, corn and soybean cropland is the dominant source of TP and TSS loading in the TMDL subwatershed. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized and straightened, especially when flowing through crop fields. Many streams have very thin forested riparian buffers or are without buffers.

F-2.14 Becketts Run-St Joseph River (HUC 04100003 08 06)

This HU begins on the SJR at the confluence of Becketts Run and ends at the confluence of the SJR with the St. Mary's River where the Maumee River is formed. The HU is dominated by the city of Fort Wayne, with subdivisions along Becket's Run and downtown Fort Wayne and dense residential areas in the lower half of the HU.

F-2.14.1 Monitoring Data

Samples were collected by IDEM (Section F-2.14.1.1) and SJRWI (Section F-2.14.1.2). IDEM listed one segment of the SJR (INA0386_01) for IBC. IBC listings are addressed via TP and TSS TMDLs when one or both parameters exceeds its target. As TP and TSS both occasionally exceed targets, the IBC listings were addressed through the development of TP and TSS TMDLs at the mouth of the SJR. TMDLs were developed at the mouth, in lieu of the downstream terminus for segment INA0386_01, to support SJRW-scale implementation and to quantify loads from the SJRW to the Maumee River.

F-2.14.1.1 IDEM

IDEM sampled seven sites on the SJR[40] and one site on Becketts Run[41] (Table F-1) in Becketts Run-St. Joseph River (*08 06). TP and TSS were evaluated for samples collected at four sites on Cedar Creek[42] and the single site on Becketts Run.

[39] Regulated MS4 permit INR040029 covers the city of Fort Wayne, Indiana University-Purdue University - Fort Wayne, Ivy Tech State College - Northwest, the Indiana Institute of Technology, and the University of St. Francis. Refer to Section 4.2.5.4 of the main report for additional information on these MS4s.

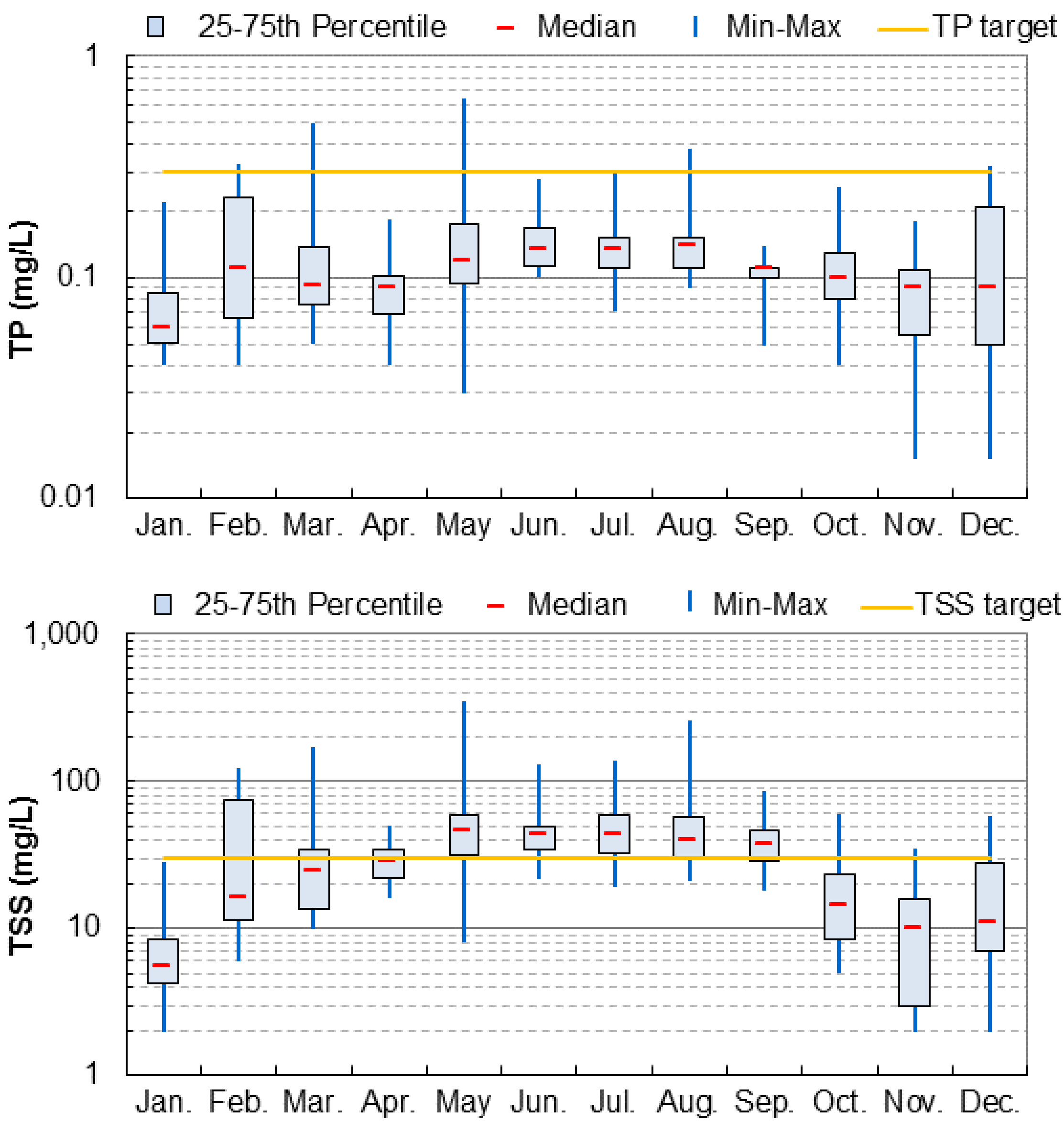
[40] Sites LEJ08-0005, LEJ100-0003, LEJ100-0004, LEJ100-0013, LEJ100-0018, LEJ100-0016, LEJ100-0023, and LEJ100-0026.

[41] Site LEJ100-0001.

[42] Sites LEJ08-0005, LEJ100-0003, LEJ100-0023, and LEJ100-0026.

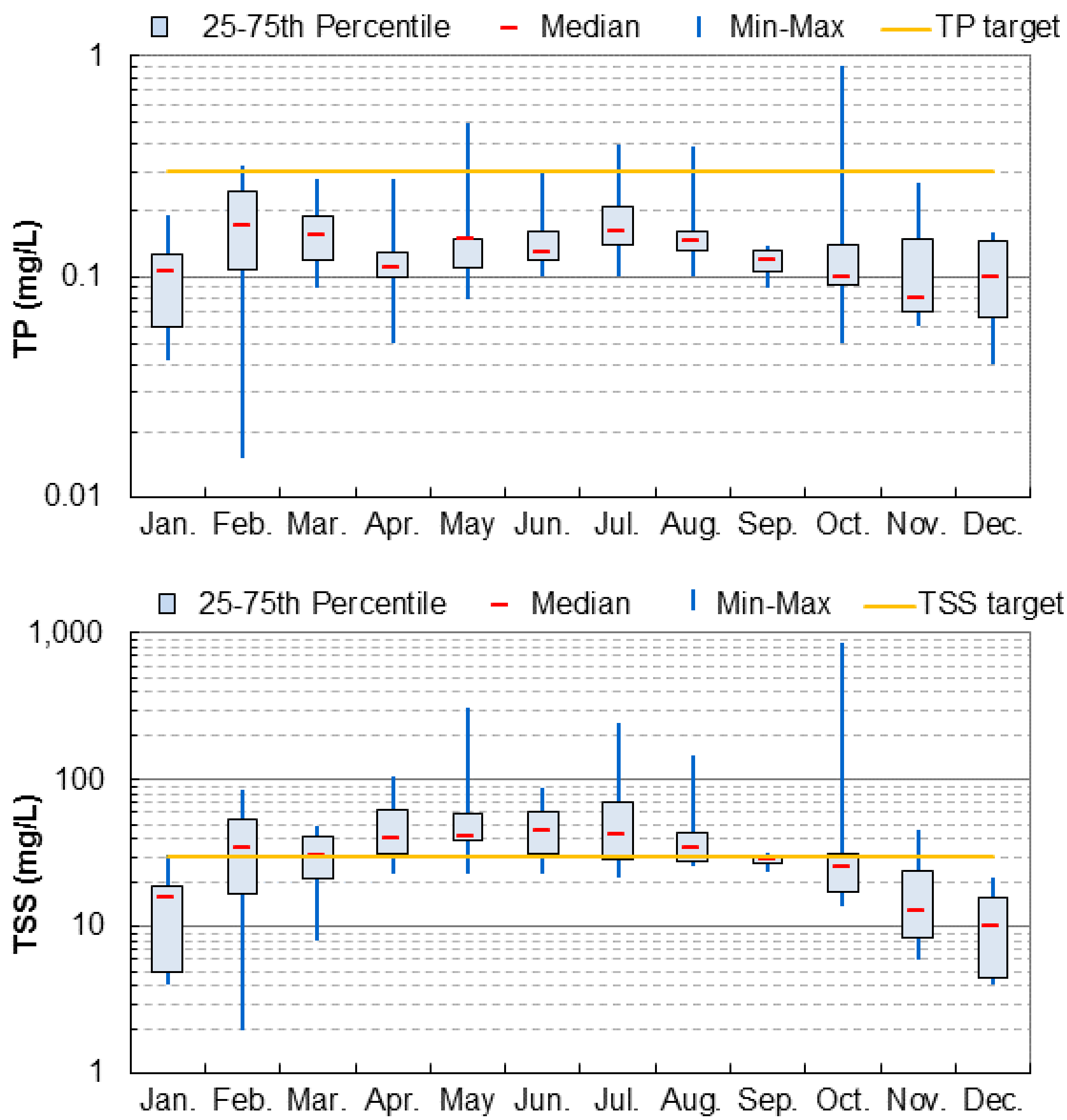
TP and TSS concentrations exceeded targets at three sites on the SJR and one site on Becketts Run (Table F-1). Samples collected at site LEJ08-0005 (n=44), LEJ100-0003 (n=247), and LEJ100-0026 (n=3) on the SJR and site LEJ100-0001 on Beckets Run (n=2) exceeded both the TP and TSS targets. Two samples collected at site LEJ100-0023 were evaluated for TP (and not TSS) and neither sample exceeded the target.

In addition to site LEJ100-0003 on the SJR in *08 02, long-term TP and TSS data were also collected by IDEM at sites LEJ060-0060 (*05 06) and LEJ100-0002 (*08 05). Data from these upstream sites, along segments of the SJR that are not impaired for their ALU, are presented for reference. Long-term data collected at site LEJ060-0006, LEJ100-0002, and LEJ100-0003 are summarized in Figure F-30, Figure F-31, and Figure F-32, respectively. Seasonal trends with TP are not as apparent on the SJR as elsewhere in the SJRW. Generally, most monthly interquartile ranges span the same range. TSS, however, shows an increasing trend during the spring and decreasing trend during the late summer and fall.



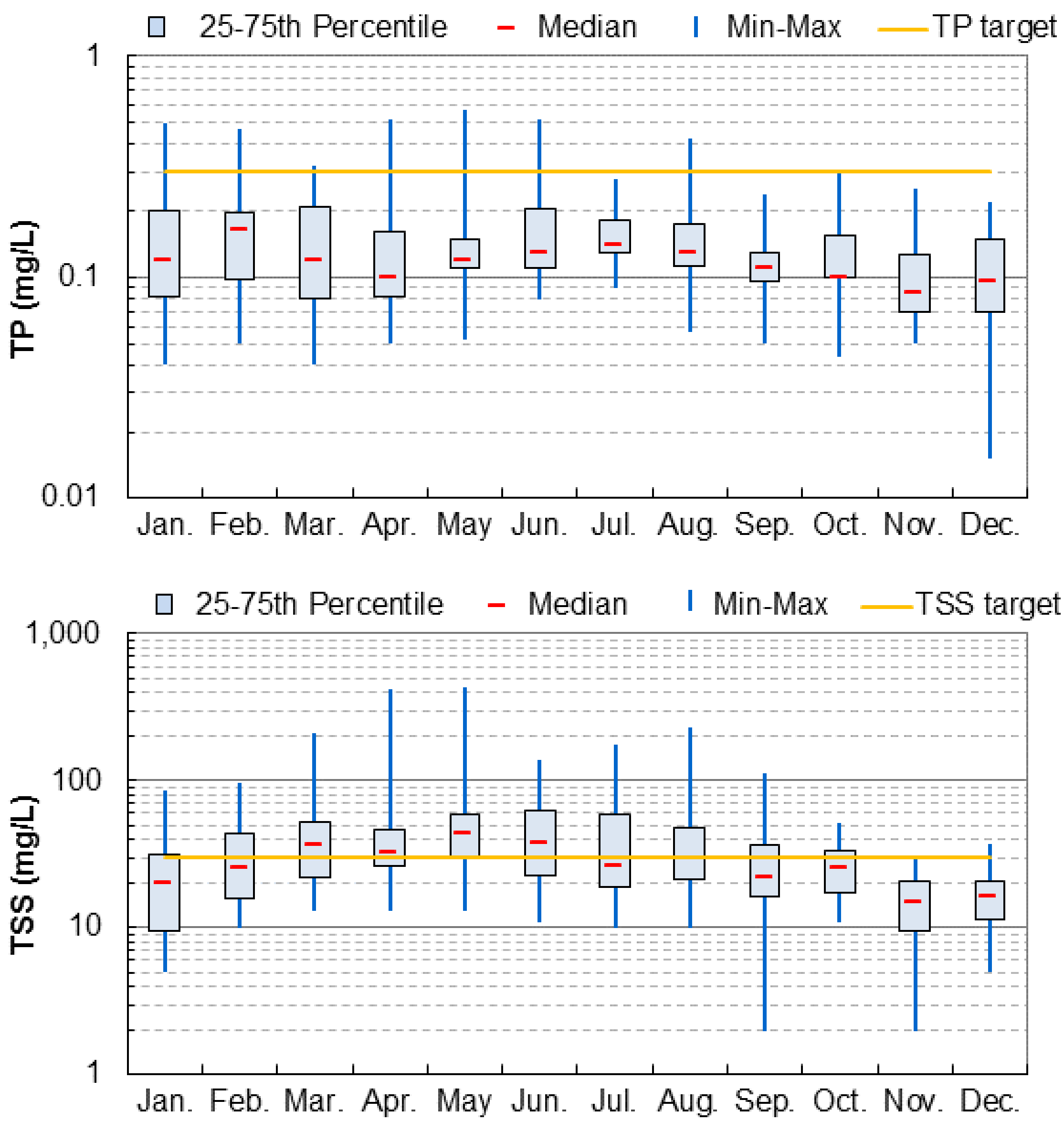
Note: 172 TP samples and 171 TSS samples collected 1999-2014.

Figure F-30. TP (top) and TSS (bottom) at site LEJ060-0006 on the St. Joseph River.



Note: 101 TP samples and 103 TSS samples collected 2001-2011.

Figure F-31. TP (top) and TSS (bottom) at site LEJ100-0002 on the St. Joseph River.



Note: 251 TP samples and 253 TSS samples collected 1991-2014.

Figure F-32. TP (top) and TSS (bottom) at site LEJ100-0003 on the St. Joseph River.

F-2.14.1.2 SJRWI

SJRWI sampled the SJR at two sites: St. Joe Dam (site 700) and Tennessee Bridge (site 601).Much of SJRWI's TP data were collected at upstream sites.

F-2.14.2 Load Duration Curve

LDCs were developed for the SJR (Figure F-33 and Figure F-34) and TP or TSS data collected by IDEM in 2004-2014 are displayed as loads[43]. Exceedances of the LDC only occurred in the high flow and moist conditions flow zones for TP and in all flow zones except the low flow zone for TSS. To achieve the

[43] TP and TSS concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

TMDLs (i.e., reduce loads to the LDCs), reductions on a per sample basis, for the samples that exceed the TMDL target, range from 3 to 47 percent for TP and range from 3 to 93 for TSS.

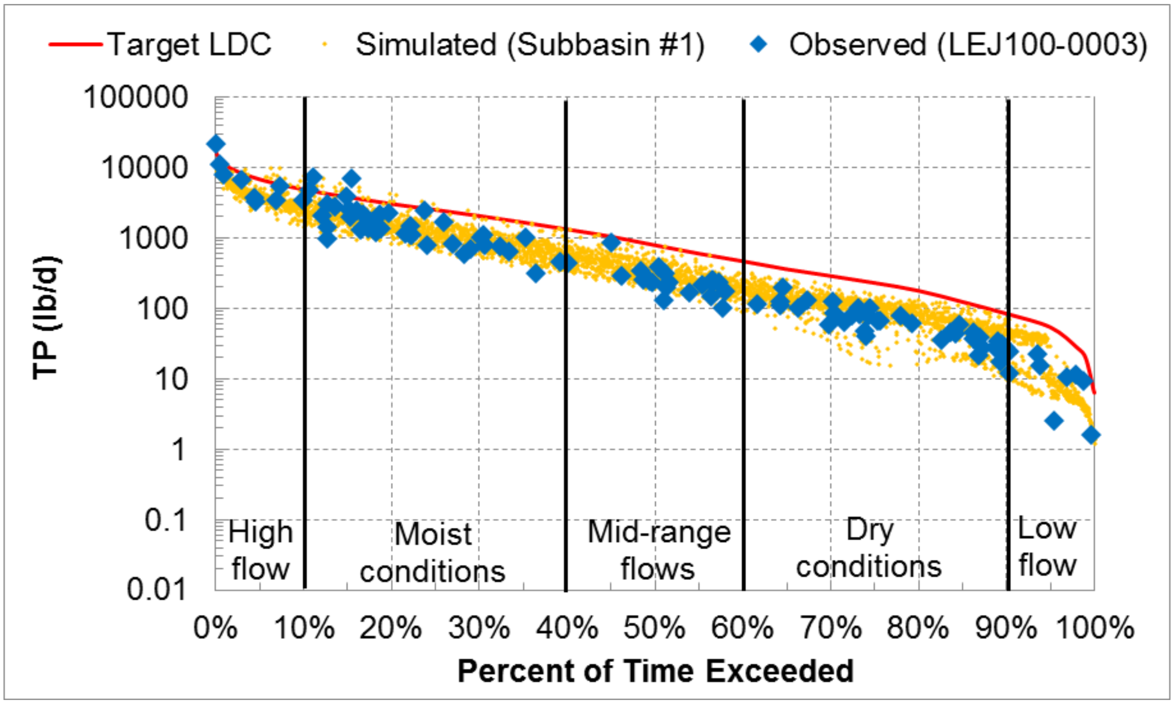


Figure F-33. TP loads and LDC for the SJR in *St. Joseph River* (*08 06) at the HU outlet.

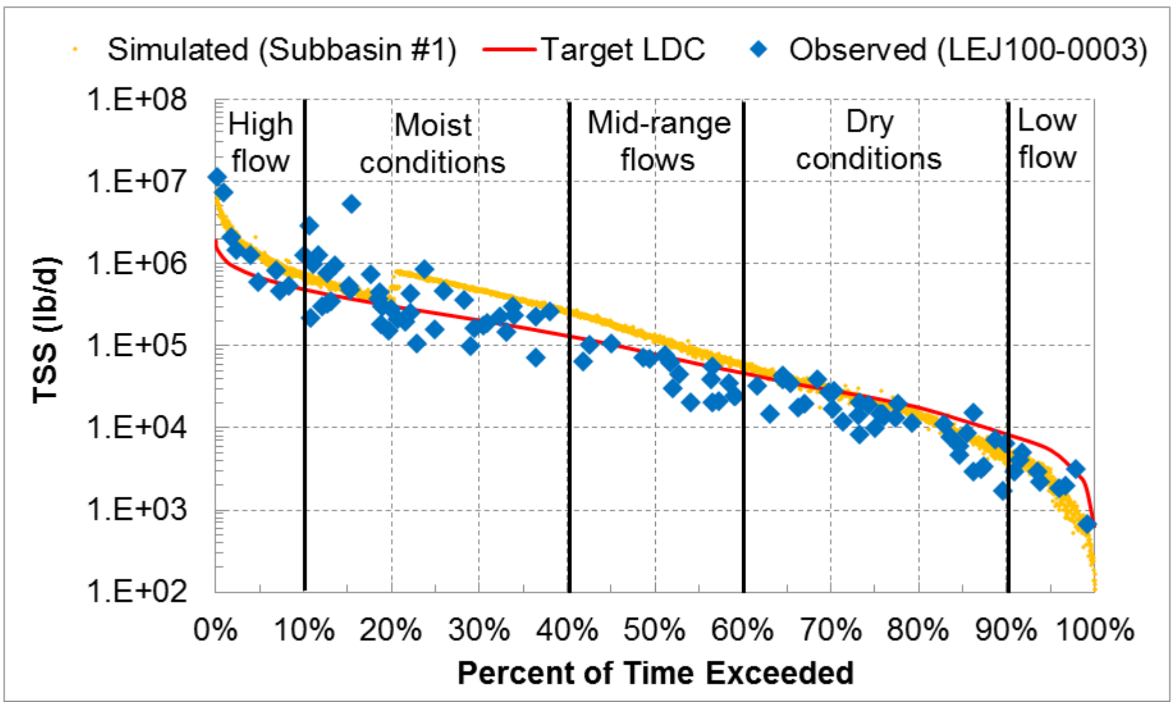
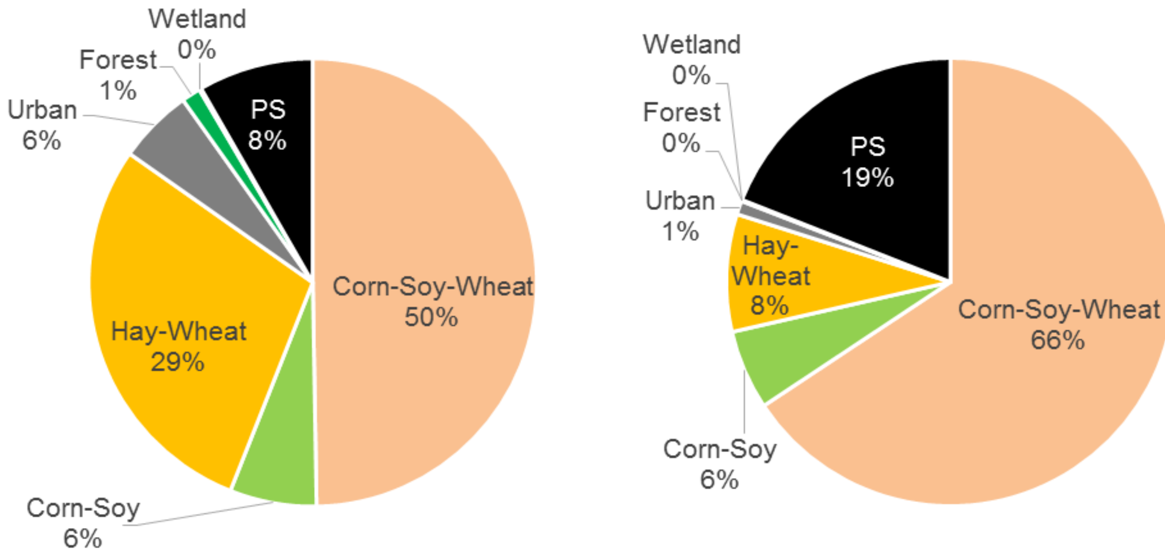


Figure F-34. TSS loads and LDC for the SJR in *St. Joseph River* (*08 06) at the HU outlet.

F-2.14.3 Sources of Impairment

SWAT-simulated source loads[44] indicate that corn and soybean crops are the dominant source of TP and TSS load to the SJR (Figure F-35). An analysis of Beckett's Run-St. Joseph River (*06 06) indicates that 51 percent of TP source load is derived from urban development; however, on the scale of the SJRW, agriculture upstream of the greater Fort Wayne area dominates all other sources.

Across the SJRW, 56 percent of the TP source load is from Indiana, 23 percent is from Ohio, and 21 percent is from Michigan; these results do not account for in-stream processes. Similarly, 63 percent of the TSS source load is from Indiana, 18 percent is from Michigan, and 19 percent is from Ohio TP source loads from the eight HUC10s vary from 9 to 17 percent of the total load across the SJRW and roughly coincide with land area per HUC10.



Notes
"PS" = permitted point sources.
Relative loads are rounded to the nearest percentage point.
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure F-35. Summary of SWAT-simulated annual TP (left) and TSS (right) loads that drain to the SJR at the mouth.

The potential sources of nutrients and TSS are evaluated in the following sections.[45]

F-2.14.3.1 Industrial and Public Facilities with Individual NPDES Permits

Two facilities are covered by individual NPDES permits[46] (see Figures C-3 and C-4 for maps).

[44] SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads across the 11-year SWAT model simulation period. As the TMDL subwatersheds are composed of multiple model subbasins, the results per subbasin are summed.

[45] No facilities with general NPDES permits, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.

- **<u>DuPont Water Treatment Plant - North End</u>** (IN0060127; 0.1 mgd) is a WTP that discharges to a wetland that is tributary to Keefer Creek. WTPs are not permitted to discharge TP or TSS. This facility has been terminated, however discussion is still relevant since it has active during the SWAT modeled flows.
- **<u>Fort Wayne Municipal WWTP</u>** (IN0032191; 60 mgd) is a major sanitary WWTP that discharges treated effluent to the Maumee River, which the SJRW is tributary to.

  Fort Wayne is a CSO and SSO community. In the SJRW, six CSO outfalls discharge to the SJR, three SSO outfalls discharge to Salgy Drain, and one SSO outfall discharges to Krunckenberg Ditch. In 2010 through 2014, the six CSO outfalls discharged between 12 and 171 times. CSO volumes ranged from <0.01 to 9.98 million gallons per month. The end point of the long-term control plan and federal consent decree is for one CSO event per year. While these outfalls are downstream of the ALU impaired segments on the SJR, they do contribute to TP and TSS load discharged to the Maumee River.

F-2.14.3.2 Facilities Covered by General NPDES Permits

In *Becketts Run-St. Joseph River* (*08 02), two industrial facilities, 63 construction sites and two MS4s are covered by general NPDES permits. Portions of the city of Fort Wayne (INR040029) are a regulated as an MS4; such areas exclude the sewersheds draining the CSS. The other regaled MS4 is Allen County (INR040131), which excludes Fort Wayne and Fort Wayne's co-permittees.

F-2.14.3.3 On-Site Wastewater Treatment Systems

Outside of the cities of Fort Wayne, OWTS are the main methods of sanitary treatment. As a portion of this subwatershed is composed of crop fields and woodlots, illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute TP and TSS loads.

F-2.14.3.4 Unregulated Livestock Operations

No CAFOs or CFOs are in this subwatershed. SJRWI inventoried livestock across the SJRW through windshield surveys in 2009 and identified "1,218 locations where livestock were present" (Quandt 2015, p. 58). No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute nutrients loads that impair this HU.

F-2.14.3.5 Crop Production

As shown in Figure F-35, corn and soybean cropland is the dominant source of TP and TSS loading in the TMDL subwatershed. An analysis of aerial imagery shows that streams throughout this subwatershed are channelized and straightened, especially when flowing through crop fields. Many streams have very thin forested riparian buffers or are without buffers.

[46] The following facility no longer has a permit: Beatrice Cheese Company (IN0000261. The following two permits were terminated or otherwise no longer have permit coverage: Leo Elementary and High Schools (IN0025267; sanitary) and St. Joseph – Spencerville Regional Sewer District (IN0058411; sanitary).

F-3. Recreational Use Linkage Analysis

This section presents the recreation use (RU) linkage analyses for the 67 impaired segments in Indiana's portion of the SJRW (refer to Section 2 of the main report for a summary, map, and table of Indiana's RU impairments). The RU impairments s were evaluated on the scale of a hydrologic unit defined by a 10-digit hydrologic unit code (HUC). All of the impairments were addressed through the development of *Escherichia coli* (*E. coli)* TMDLs at WAU outlets or state borders.

F-3.1 Project Area Data

Ambient water quality data and discharge monitoring report (DMR) data are summarized in this section.

F-3.1.1 Summary of Water Quality Data

This section presents summary tables for *E. coli* data. Table F-5 and Table F-6 summarize *E. coli* concentrations in water quality samples collected by Ohio EPA and IDEM, respectively.

Table F-5. *E. coli* data summary for the SJRW in Ohio

Stream name	RM	Site ID	DA	RU	RU status	No. of samples	Min.	Max.	GM
Fish Creek (HUC 04100003 04)									
Headwaters Fish Creek (HUC 04100003 04 02)									
Fish Creek	30.54	P08K12	8.8	B	Non	5	250	**1,400**	**581**
Cornell Ditch-Fish Creek (HUC 04100003 04 06)									
Fish Creek	5.40	P08K10	106.0	B	Non	5	400	**780**	**575**
	0.38	P08S20	109.0	B	Non	5	530	**920**	**667**
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)									
Bluff Run-St. Joseph River (HUC 04100003 05 01)									
SJR	56.77	P08S16	435.0	A	Non	5	230	**380**	**286**
Big Run-St. Joseph River (HUC 04100003 05 02)									
Big Run	0.30	P08K08	30.0	B	Non	5	230	**700**	**410**
Russell Run-St. Joseph River (HUC 04100003 05 03)									
SJR	49.75	510180	554.0	A	Non	5	280	**1,200**	**426**
Willow Run-St. Joseph River (HUC 04100003 05 06)									
SJR	42.34	510220	609.0	A	Non	10 [a]	20	**720**	**173**

Source: Ohio EPA 2014
Notes
Samples were collected in the year 2013, except as noted.
Bolded minima and maxima exceed the single sample maximum criteria and **bolded** geometric means exceed the seasonal geometric mean criteria.
a. In addition to the 5 samples collected in 2013, 3 samples each were collected in 2006 and 2007, and 2 samples were collected in 2008.

Table F-6. *E. coli* data summary for the SJRW in Indiana

Waterbody	IDEM site ID	RU segment status	No. of samples	Min.	Max.	GM
West Branch St. Joseph River (HUC 04100003 02)						
Headwaters Fish Creek (HUC 04100003 02 03)						
Clear Lake	LEJ020-0001	--	8	1	6	1
Fish Creek (HUC 04100003 04)						
West Branch Fish Creek (HUC 04100003 04 01)						
West Branch Fish Creek	LEJ050-0020	Not	2	1,553	2,105	1,808
	LEJ050-0064	Not	6	261	1,046	445
Headwaters Fish Creek (HUC 04100003 04 02)						
Fish Creek	LEJ050-0023	Not	2	1,553	9,208	3,782
Hamilton Lake (HUC 04100003 04 03)						
Hamilton Lake	LEJ050-0009	Insufficient data	6	11	37	20
Hiram Sweet Ditch (HUC 04100003 04 04)						
Fish Creek	LEJ050-0050	Insufficient data	3	291	1,210	495
	LEJ050-0052	Not	2	345	517	422
	LEJ050-0054	Not	2	365	727	515
Town of Alvarado-Fish Creek (HUC 04100003 04 05)						
Fish Creek	LEJ050-0010	Not	7	816	12,100	2,038
Fish Creek	LEJ050-0027	Not	2	2,419	3,448	2,888
Fish Creek	LEJ050-0029	Not	2	548	2,420	1,151
Fish Creek	LEJ050-0032	Not	2	687	1,046	848
Fish Creek	LEJ050-0066	Not	5	249	1,733	652
UT of Fish Creek	LEJ050-0026	Insufficient data	2	461	17,329	2,827
Cornell Ditch-Fish Creek (HUC 04100003 04 06)						
Fish Creek	LEJ050-0040	Not	3	770	866	801
	LEJ050-0008	Not	7	192	12,996	1,075
	LEJ050-0035	Not	2	488	548	517
	LEJ050-0007	Not	8	300	4,611	869
	LEJ050-0068	Not	5	308	1,733	548
UT of Fish Creek	LEJ050-0048	Insufficient data	2	461	2,419	1,056
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)						
Big Run (HUC 04100003 05 02)						
Big Run	LEJ060-0015	Not	5	78	1,210	290
Hoodelmier Ditch-St. Joseph River (HUC 04100003 05 06)						
SJR	LEJ060-0006	not available	2	230	260	245
Matson Ditch-Cedar Creek (HUC 04100003 06)						
Cedar Lake-Cedar Creek (HUC 04100003 06 01)						
Cedar Creek	LEJ080-0005	Not	5	10	23,000	519
Leins Ditch	LEJ080-0016	Not	5	727	1,120	937
UT of Leins Ditch	LEJ080-0014	Not	5	99	276	155
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)						
Cedar Creek	LEJ080-0006	Not	6	110	2,000	247
Swartz Ditch	LEJ080-0008	Not	5	390	1,200	552
Matson Ditch (HUC 04100003 06 03)						
UT Mason Ditch	LEJ080-0013	Insufficient data	5	411	1,300	744
Smith Ditch-Cedar Creek (HUC 04100003 06 04)						
Cedar Creek	LEJ080-0007	Not	5	140	25,000	768
	LEJ080-0004	Not	6	649	7,701	1,499

	LEJ080-0009	Not	5	90	**1,500**	**270**
West Smith Ditch	LEJ080-0017	Not	6	20	**1,120**	**250**
Cedar Creek (HUC 04100003 07)						
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)						
John Diehl Ditch	LEJ090-0018	Not	5	220	**11,000**	**609**
Peckhart Ditch	LEJ090-0040	Insufficient data	5	29	105	64
	LEJ090-0034	Not	6	**1,210**	**19,863**	**7,196**
Black Creek (HUC 04100003 07 04)						
Black Creek	LEJ090-0041	Not	5	435	**1,046**	**701**
King Lake-Little Cedar Creek (HUC 04100003 07 05)						
Little Cedar Creek	LEJ090-0010	Not	5	272	**1,210**	**639**
	LEJ090-0033	Not	6	104	**2,419**	**476**
	LEJ090-0017	Not	4	220	**690**	**378**
Willow Creek (HUC 04100003 07 06)						
Willow Creek	LEJ090-0020	Insufficient data	5	260	**17,000**	**799**
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)						
Cedar Creek	LEJ090-0021	Insufficient data	6	100	410	**236**
Cedar Creek	LEJ090-0031	Not	5	517	**1,986**	**692**
Cedar Creek	LEJ090-0008	Not	9	5	**6,867**	**243**
Cedar Creek	LEJ090-0011	Not	5	186	**3,130**	**873**
Garrett City Ditch	LEJ090-0015	Not	5	300	**8,200**	**864**
St. Joseph River (HUC 04100003 08)						
Metcalf Ditch-St. Joseph River (HUC 04100003 08 02)						
SJR	LEJ070-0008	Non	5	147	**1,733**	**610**
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)						
SJR	LEJ070-0027	Not	6	37	**649**	**148**
	LEJ070-0026	Not	5	35	**1,733**	**129**
Cedarville Reservoir-St. Joseph River (HUC 04100003 08 04)						
SJR	LEJ070-0006	Not	6	140	**3,448**	**424**
Ely Run-St. Joseph River (HUC 04100003 08 05)						
Tiernan Ditch	LEJ100-0005	Insufficient data	2	150	170	**160**
Becketts Run-St. Joseph River (HUC 04100003 08 06)						
SJR	LEJ100-0026	Insufficient data	5	45	261	87
	LEJ100-0004	Insufficient data	5	238	**14,136**	**1,336**
	LEJ100-0003	Insufficient data	82	5	**28,000**	**199**

Source: IDEM 2014, 2015
Notes
Samples were collected in the year 2013, except as noted. **Bolded** minima and maxima exceed the single sample maximum criteria and **bolded** geometric means exceed the monthly geometric mean criteri

a.

F-3.1.2 Summary of Discharge Monitoring Report Data

DMR data for permitted facilities were provided by Ohio EPA and IDEM. Data for Ohio are limited to a single 12-digit HU (Table F-7Table F-7 DMR data for facilities that are not in 12-digit HUs that drain directly to Indiana are excluded. Indiana DMR data presented in Table F-8.

Table F-7. Summary of DMR data for facilities permitted to discharge bacteria in Ohio

OEPA ID	Outfall	Flow (cubic feet per second)				Fecal coliform concentration (counts per 100 milliliters)				Fecal coliform load (counts per day)			
		No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.	No. [a]	Min.	Max.	Avg.
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)													
Bluff Run-St. Joseph River (HUC 04100003 05 01)													
2PB00047	001	483	0.033	6.34	2.644	22	1	1,600	247	22	4.3E+07	5.6E+10	1.2E+10
	801	--	--	--	--	3	182	3,300	1,261	--	--	--	--
	901	--	--	--	--	3	91	1,800	742	--	--	--	--

Source: Ohio EPA 2015
Notes
The following are excluded from this table: (1) facilities not permitted to discharge bacteria, and (2) facilities without bacteria DMR data.
Treated effluent is discharged through outfall 001 while upstream and downstream monitoring are reported as outfalls 801 and 901, respectively.
a. Number of DMR records for the specified parameter.

Table F-8. Summary of DMR data for facilities permitted to discharge bacteria in Indiana

NPDES ID	Outfall	Flow (cubic feet per second)				*E. coli* concentration [a] (counts per 100 milliliters)				*E. coli* load [b] (counts per day)			
		No. [c]	Min.	Max.	Avg.	No. [c]	Min.	Max.	Avg.	No. [c]	Min.	Max.	Avg.
Fish Creek (HUC 04100003 04)													
Hiram Sweet Ditch (HUC 04100003 04 04)													
IN0050822	001	132	0.202	0.398	0.280	77	2	34	7	77	1.2E+07	3.0E+08	5.0E+07
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)													
Big Run-St. Joseph River (HUC 04100003 05 02)													
IN0022462	002	111	1.017	2.825	1.707	64	2	23	7	64	5.1E+07	1.5E+09	2.6E+08
Matson Ditch-Cedar Creek (HUC 04100003 06)													
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)													
IN0020711	001	132	0.174	1.067	0.460	76	1	868	20	76	4.4E+06	1.3E+10	2.9E+08
Smith Ditch-Cedar Creek (HUC 0100003 06 04)													
IN0020672	001	90	1.477	4.989	2.665	52	2.	233.	30	52	1.5E+08	2.1E+10	2.6E+09
Cedar Creek (HUC 04100003 07)													
Headwaters John Diehl Ditch (HUC 04100003 07 01)													
IN0047473	001	118	0.002	0.600	0.037	34	1	36,260	1,272	34	1.6E+06	9.8E+09	4.9E+08
Sycamore Creek-Little Cedar Creek (HUC 04100003 07 03)													
IN0020664	001	132	0.053	0.820	0.529	77	1	29	7	77	5.1E+06	3.5E+08	8.8E+07
Black Creek (HUC 04100003 07 04)													
IN0058611	001	99	0.002	0.788	0.122	6	6	1,720	318	6	1.2E+07	1.8E+10	3.4E+09
King Lake-Little Cedar Creek (HUC 04100003 07 05)													
IN0032107	001	70	0.001	0.046	0.008	44	1	2,000	162	44	1.2E+04	4.8E+08	3.3E+07
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)													
IN0029969	001	89	0.722	1.938	1.137	46	1	60	15	46	1.9E+07	2.0E+09	3.8E+08
St. Joseph River (HUC 04100003 08)													
Swartz Cannahan Ditch-St. Joseph River (HUC 04100003 08 03)													
IN0059749	001	123	0.001	0.020	0.008	36	1	195	34	36	2.5E+05	4.4E+07	6.2E+06

Source: IDEM 2015
Notes
The following are excluded from this table: (1) facilities not permitted to discharge bacteria, and (2) facilities without bacteria DMR data.
Treated effluent is discharged through outfall 001 while upstream and downstream monitoring are reported as outfalls 801 and 901, respectively.
a. Monthly geometric mean of *E. coli* concentrations.
b. *E. coli* load calculated using monthly geometric mean of *E. coli* concentrations and monthly average flow.
c. Number DMR records for the specified parameter.

F-3.2 Fish Creek (HUC 04100003 04)

F-3.2.1 Monitoring Data

Ohio EPA collected 5 samples at three sites (Table F-5) in the Fish Creek subwatershed, while IDEM collected between 2 and 7 samples at 18 sites in the subwatershed (Table F-6). *E. coli* in Ohio ranged from 250 to 1,400 counts/100 mL, with geometric means from 575 to 667 counts/100 mL. All three Ohio assessment sites were in nonattainment. Excluding samples collected from Hamilton Lake, *E. coli* in Indiana ranged from 192 to 17,329 counts/100 mL, with geometric means from 445 to 2,888 counts/100 mL. RU attainment was assessed at 14 locations and IDEM found all 14 sites to be in nonattainment.

F-3.2.2 Load Duration Curves

LDCs were developed for the five HUC12s with segments impaired for their RUs: Figure F-36, Figure F-37, Figure F-38, Figure F-39, and Figure F-40. *E. coli* data collected by IDEM in 2005 and 2010 are displayed as loads[47] in some LDC figures. Data collected in 2000 and 2001 are not displayed because loads could not be calculated due to a lack of flow data[48].

All loads exceeded the LDCs. To achieve the TMDL (i.e., reduce loads to the LDC), reductions on a per sample basis range from 54 to 93 percent.

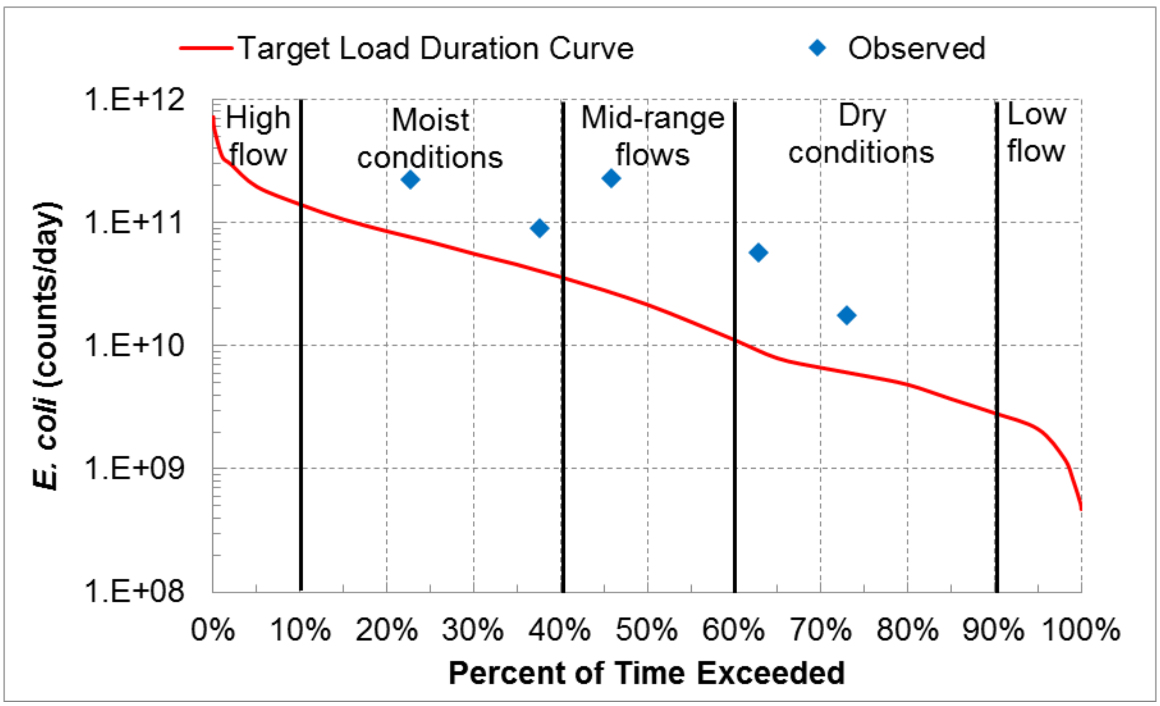


Figure F-36. *E. coli* loads and LDC for West Branch Fish Creek in *West Branch Fish Creek* (*04 01) at HU outlet.

[47] *E. coli* concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.
[48] The SWAT model was developed to simulate calendar years 2004 through 2014.

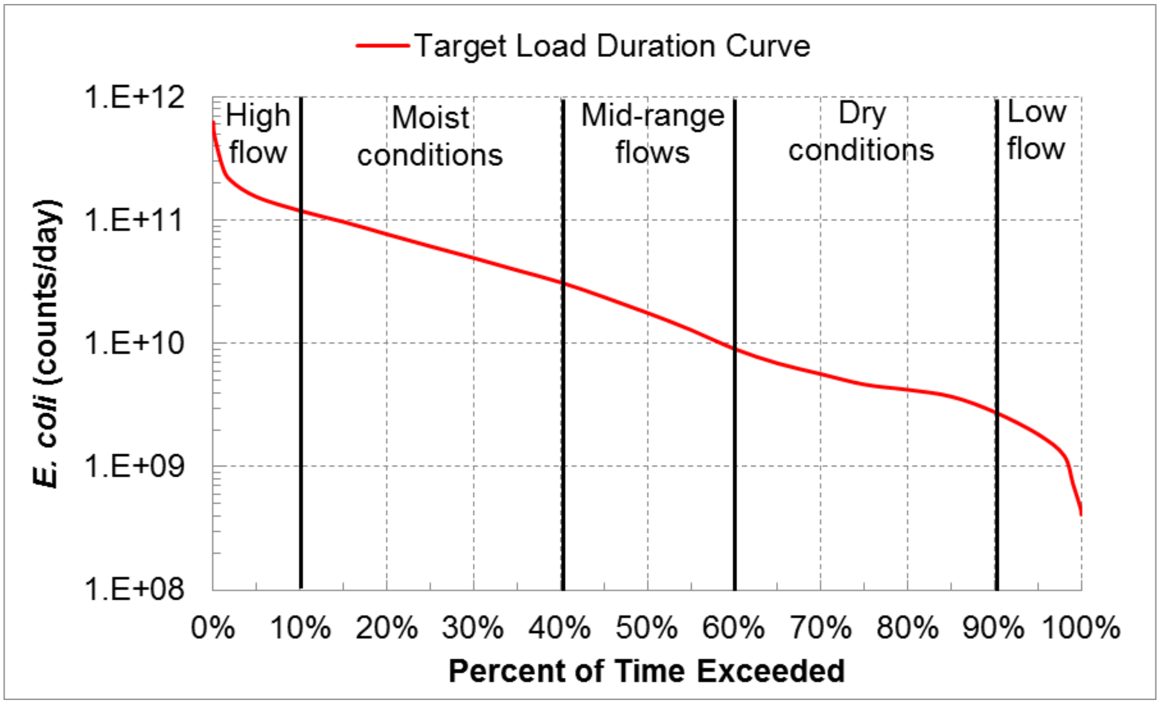


Figure F-37. *E. coli* LDC for Fish Creek in *Headwaters Fish Creek* (*04 02) at HU outlet.

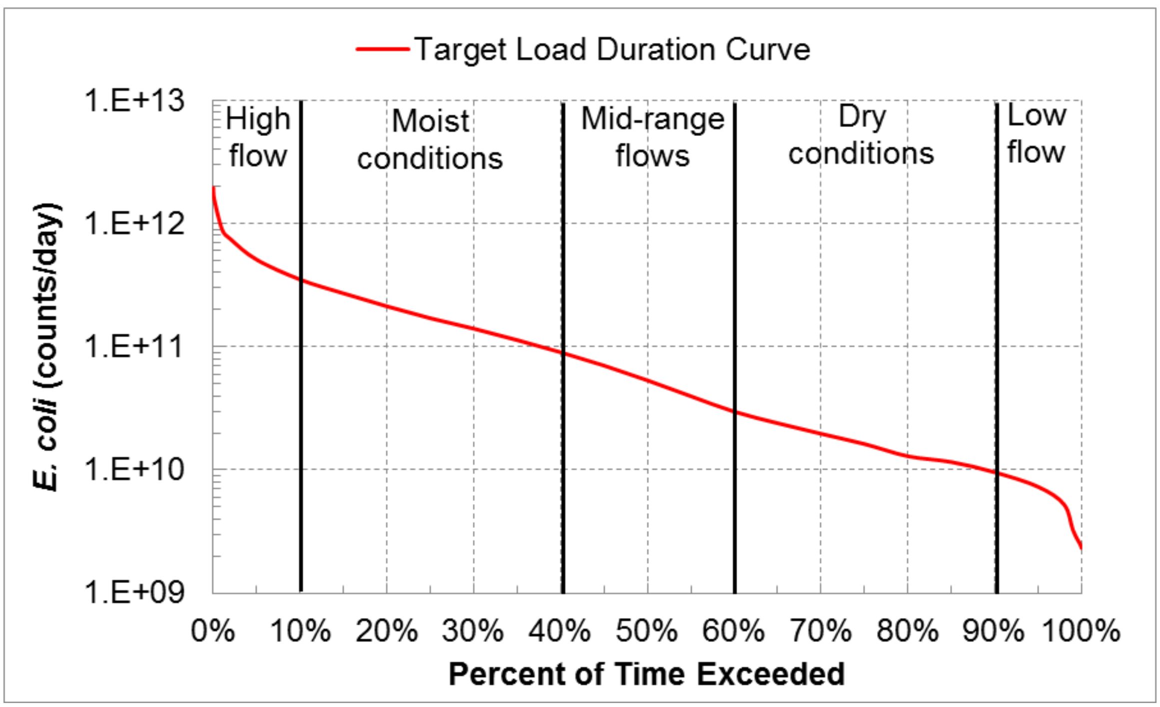


Figure F-38. *E. coli* LDC for Hiram Sweet Ditch in *Hiram Sweet Ditch* (*04 04) at HU outlet.

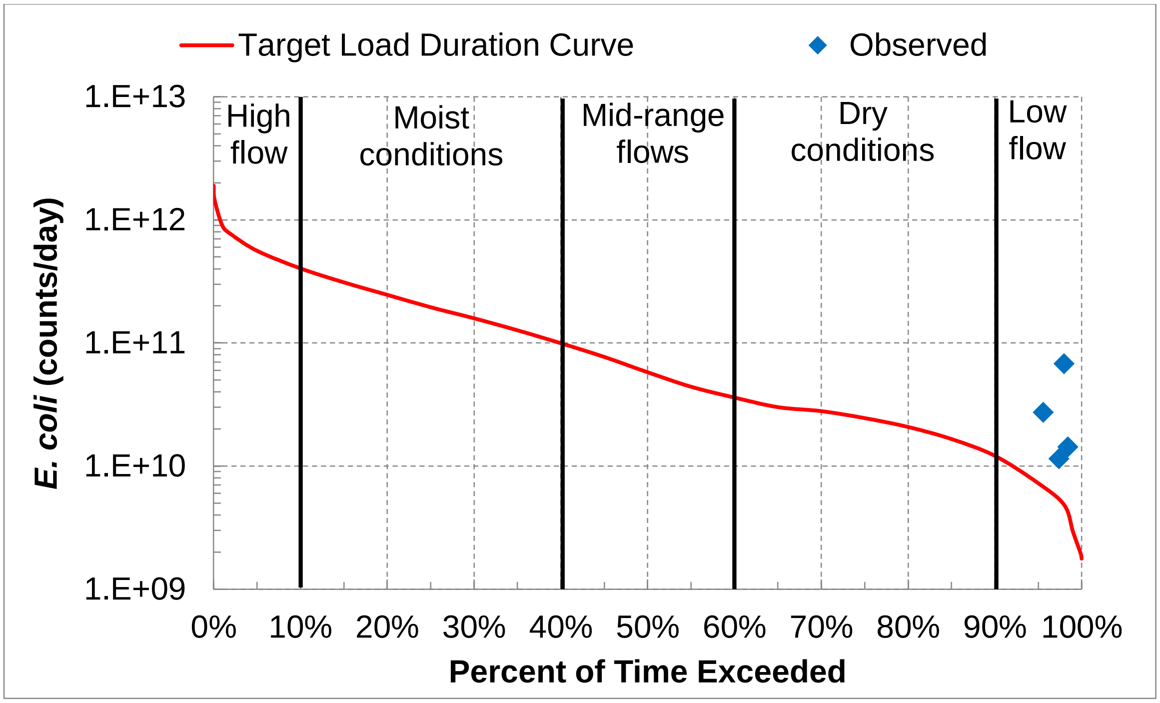


Figure F-39. *E. coli* loads and LDC for Fish Creek in *Town of Alvarado-Fish Creek* (*04 05) at HU outlet.

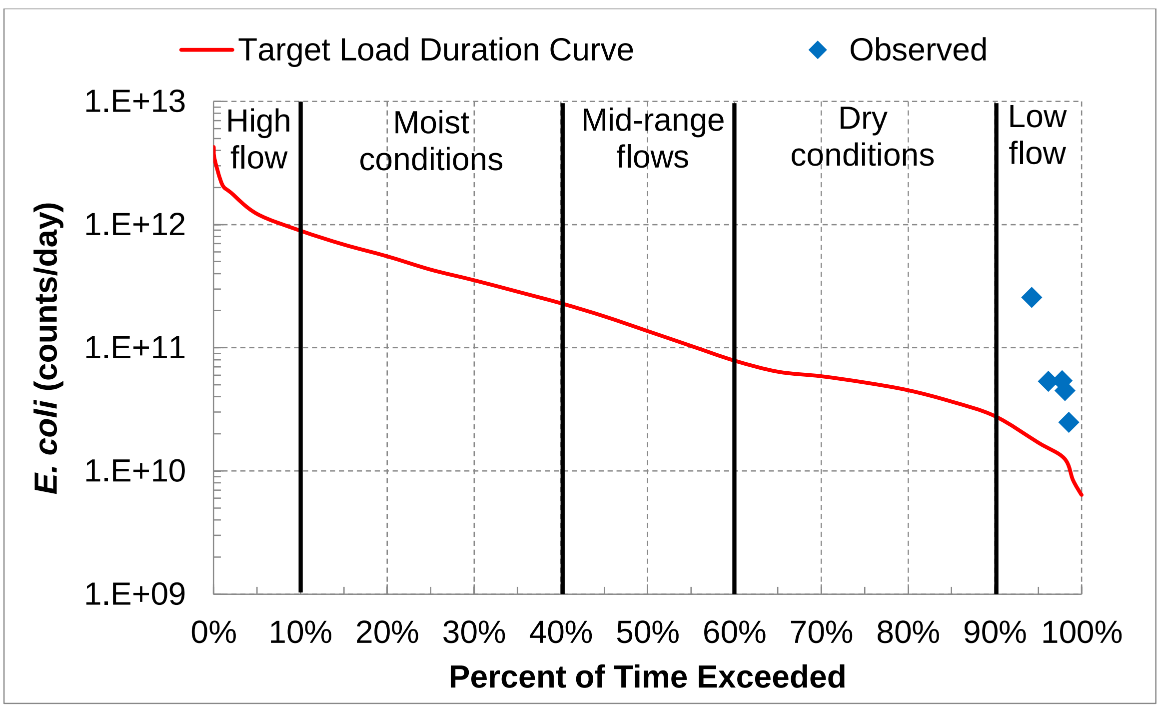


Figure F-40. *E. coli* loads and LDC for Fish Creek in *Cornell Ditch-Fish Creek* (*04 06) at the Indiana-Ohio state line.

F-3.2.3 Sources of Impairment

The potential sources of *E. coli* in this HU are evaluated in the following sections.[49]

F-3.2.3.1 Facilities with Individual NPDES Permits

Two facilities are covered by individual NPDES permits (see Figures C-3 in Appendix C for a map and Table F-8 for DMR data).

- **Hamilton Lake Conservancy District** (IN0050822; 300,000 gpd) is a sanitary POTW that serves the residential community around Hamilton Lake; it discharges to Hiram Sweet Ditch below Hamilton Lake and Baker Ditch. Monthly geometric means of *E. coli* concentrations were low (2 to 34 counts/100 mL, average 7 counts/100 mL) as were loads calculated from the geometric means (12 million to 300 million c/d, average 50 million c/d). Even under low flow conditions, 300 million c/d is an order of magnitude less than the LDC for *Hiram Sweet Ditch* (*04 03; Figure F-38). Thus, this facility is not a significant source of bacteria.

  The POTW land applied biosolids to two fields in the Fish Creek subwatershed in the 1980s and 1990s. One filed is 8 acres (directly adjacent to the POTW) and the other field is 41 acres. As the biosolids land application did not occur in the past decade, they are not considered a source of bacteria to the current impairments.

- **Hamilton Water Works** (IN0060216; 58,000 gpd) is a WTP that discharges to William Egbert Ditch, which is a tributary of Hiram Sweet Ditch upstream of Hamilton Lake. The WTP may not discharge bacteria and reports no bacteria DMR data. Daily maximum flow was low (0.005 to 0.062 cfs, average 0.029 cfs). Given its low effluent volumes and the fact that it's a WTP, the facility is not expected to be a significant source of bacteria.

F-3.2.3.2 Facilities Covered by General NPDES Permits

Two industrial facilities are permitted to discharge regulated stormwater in *Hiram Sweet Ditch* (*04 03).

F-3.2.3.3 On-Site Wastewater Treatment Systems

Except for the Hamilton Lake area, OWTS treat commercial and domestic wastewater. No permitted off-site discharging HSTS are in the Ohio-portion of this subwatershed. This subwatershed is mostly composed of crop fields and woodlots. Illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute bacteria loads.

F-3.2.3.4 Livestock Operations

No CAFFs are in the Ohio-portion of the subwatershed and two CFOs are in the Indiana-portion of the subwatershed. Brand Farms is a CFO in the *Hiram Sweet Ditch* HU (*04 04) and Long Lane Farms Inc. is a CFO in the *Cornell Ditch-Fish Creek* HU (*04 06; see Figure C-6 and Table C-11). Aerial imagery shows that each CFO has containment ponds. Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

Within *Fish Creek* (HUC 0410003 04), SJRWI (2008a) observed livestock during windshield surveys at 14 locations in Ohio, at 76 locations in Steuben County, Indiana, and 50 locations in DeKalb County, Indiana; no livestock direct access to streams was observed and manure storage was observed at two locations in DeKalb County. Most operations were small (<10 animals). No additional information about

[49] No communities with CSOs or SSOs or regulated MS4s are in this subwatershed.

hobby farms and small livestock operations are available. Thus, livestock in Ohio and Indiana may contribute to the nutrient impairment.

F-3.2.3.5 Crop Productions

Fish Creek and its tributaries flows through and along row crop fields and woodlots. Manure application to cropland, including tiled cropland, is a potential source of *E. coli* to the impaired segments in the Fish Creek subwatershed.

In the 1980s and 1990s, the Angola Municipal STP, Apollo Disposal Inc., and Hamilton Lake Conservancy District land applied WWTP sludge to crop fields in the *Fish Creek* HU (Table C-10); while IDEM provided field locations, application dates, methods, and rates data are sparse. As biosolids application has not occurred in this HU during the last decade, biosolids are not considered a source of RU impairment.

- Biosolids from the Angola Municipal STP were land applied to 20 fields (807 acres) in the *West Branch Fish Creek* HU (*04 01); except for 4 applications in August 2003, no applications occurred in this HU since 1995.
- In the *Hiram Sweet Ditch* HU (*04 03) during the 1990s, three entities land applied biosolids to one field each: the Angola Municipal WTP (37 acres), Apollo Disposal Inc. (3 acres), and the Hamilton Lake Conservancy District (8 acres).

F-3.3 Sol Shank Ditch-St. Joseph River (HUC 04100003 05)

F-3.3.1 Monitoring Data

Ohio EPA collected 5 samples from one site on Big Run and 5 or 10 samples from the SJR (Table F-5), while IDEM collected 5 samples from one site on Big Run and 2 samples from one site on the SJR (Table F-6). *E. coli* in Big Run ranged from 78 to 1,210 counts/100 mL with a geometric mean of 290 counts/100 mL; this site was on a segment in non-attainment of its RU. *E. coli* in the SJR was 230 and 260 counts/100 mL; there were insufficient data to assess RU attainment on the SJR.

F-3.3.2 Load Duration Curve

A LDC was developed for Big Run (Figure F-41) and *E. coli* data collected by IDEM in 2005 are displayed as loads[50]. To achieve the TMDL (i.e., reduce loads to the LDC), reductions on a per sample basis, for the three samples that exceed the TMDL target, range from 12 to 81 percent.

[50] *E. coli* concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.

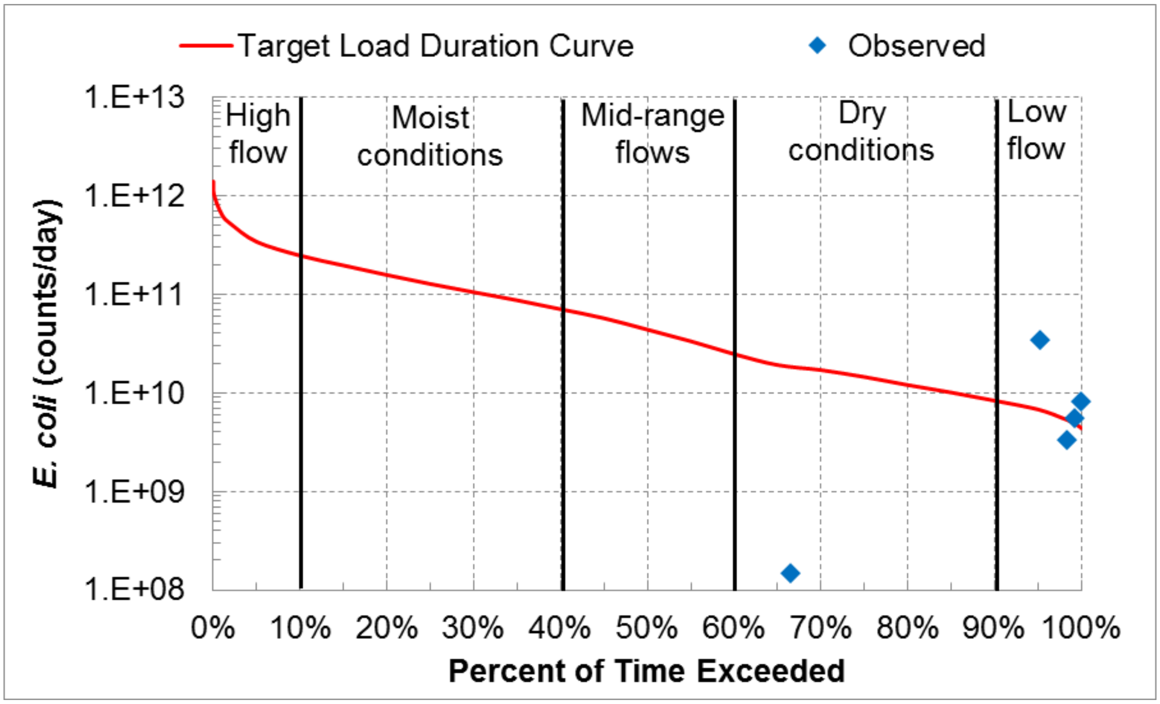


Figure F-41. *E. coli* loads and LDC for *Big Run* (*05 02) at the Indiana-Ohio state line.

F-3.3.3 Sources of Impairment

The potential sources of *E. coli* in this HU are evaluated in the following sections.

F-3.3.3.1 Industrial Facilities with Individual NPDES Permits

Two industrial facilities are covered by individual NPDES permits (see Figures C-2 and C-3 in Appendix C for maps). Neither facility is permitted to discharge bacteria nor considered to be sources of impairment.

- **Edgerton WTP** (2IZ00040; stormwater) is "is an ion exchange and iron-manganese removal water treatment facility" with "filter backwash and softener regeneration wastes" discharged to the St. Joseph River (Ohio EPA 1994, p. 19). The NPDES permit identifies storm sewers as the receiving waterbody. The WTP discharged 0.009 cfs 99 percent of the days from 2007 through 2013. As the facility is not permitted to discharge bacteria and almost always discharges very small effluent volumes, it is not a source of impairment.
- **Steel Dynamics, Inc.** (IN0059021; 144,000 gpd) discharges industrial and sanitary wastewater to the Butler WWTP (under Butler's pretreatment program); it also discharges non-contact cooling water, boiler blowdown water, boiler condensate, other industrial wastewater, and industrial stormwater to Sol Shank Ditch. Industrial stormwater may contain bacteria, whereas the other waste-streams should not contain bacteria. As Sol Shank Ditch attains its RU, the facility is not a source of impairment.

F-3.3.3.2 Public Facilities with Individual NPDES Permits

Two public facilities are covered by individual NPDES permits (see Figures C-2 and C-3 in Appendix C for maps and Table F-7 for DMR data). Both facilities are sanitary POTWs with SSOs; both WWTPs are sources of bacteria load.

- **Butler WWTP** (IN0022462, 2 mgd) is a sanitary POTW that discharges to Big Run. Effluent flows vary from 1.0 to 2.8 cfs (average 1.7 cfs) with low *E. coli* concentrations (2 to 23 counts/100 mL, average 7 counts/100 mL). *E. coli* loads ranged from 51 million to 1.5 billion c/d, average 258 million c/d. Only during low-flow conditions would the maximum effluent load be the dominant source of *E. coli* loading to Big Run. During most flow conditions, the WWTP contributes relatively small, insignificant, *E. coli* load to Big Run.

  Butler is a CSO community. The city has one CSO outfall on Big Run (003) that discharged in 2008 through 2014 (Table C-6 in Appendix C). Overflow volumes (<0.1 to 3.0 cfs, average 2.5 cfs), as compared to the Big Run were relatively small in the high flow through mid-range flow zones of Big Run, but CSO volumes would become the dominant flow by volume in the dry conditions and low flow zones. Despite relatively small flow volumes, bacteria concentrations of untreated combined waste were likely extremely elevated, which could yield large CSO bacteria loads. As discussed in Section 4.2.2.1 of the main report, Butler will reduce to six CSOs per year from its single outfall. The city has contributed to the localized impairment on Big Run and could continue to do so.

- **Edgerton WWTP** (2PB00047; 200,000 gpd) is a sanitary POTW that discharges to the SJR. The WWTP is composed of three facultative lagoons that were constructed in 1991; the WWTP serves a community with fully separated storm and sanitary sewers (Ohio EPA 1994, p. 10). Effluent volumes vary considerably (0.3 to 6.3 cfs, average 2.6 cfs), while fecal coliform concentrations (1 to 1,600 counts/100 mL, average 247 counts/100 mL) and loads (43 million to 56 billion c/d, average 12 billion c/d) are often high. Only a few upstream/downstream DMR data were collected and no pattern is apparent except that upstream concentrations are always considerably higher than effluent concentrations. Effluent flow volumes and *E. coli* load are typically several orders of magnitude less than the SJR. While the WWTP does contribute *E. coli* load to the SJR, the WWTP is not a significant source.

  Edgerton is a SSO community. The city reported zero SSOs per month from October 2006 through December 2007; no other data indicate any SSOs have occurred in recent years. Given the lack of recent SSOs, Edgerton SSOs did not cause the RU impairment. Future SSOs are a potential source, but they are illicit and would be addressed through Ohio EPA's NPDES program.

F-3.3.3.3 Facilities Covered by General NPDES Permits

Twelve facilities are covered by general NPDES permits[51]. According to the general permits (IDEM 2014b) for the two permittees below, such facilities are not allowed to discharge bacteria. Therefore, they are not considered a source of RU impairment.

- **Eastside High School** (ING250077) discharges NCCW to Butler's storm sewers that drain to Big Run.
- **Stafford Gravel Inc.** (ING490043) is a dimension stone and crushed stone that discharges to Christoffel Ditch.

Four facilities in Ohio and six facilities in Indiana are covered by the general permits for stormwater associated with industrial activities.

[51] The following four permits were terminated: Citation Bohn Aluminum (IN0000515; NCCW and stormwater), DeKalb County East Community School District (IN0055808), DeKalb Molded Plastics Company (IN0051659), and Universal Tool and Stamping Company (IN0000639; rinse water).

F-3.3.3.4 On-Site Wastewater Treatment Systems

Except for the city of Butler and village of Edgerton, OWTS treat commercial and domestic wastewater. No permitted off-site discharging HSTS are in the Ohio-portion of this subwatershed. This subwatershed is mostly composed of crop fields and woodlots. Illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute bacteria loads.

F-3.3.3.5 Livestock Operations

No CAFFs are in the Ohio-portion of the subwatershed and one CAFO and three CFOs are in the Indiana-portion of the subwatershed (see Figure C-6 and Table C-11). Except for R&D Malcolm Farms, aerial imagery shows that the CAFO and each CFO have containment ponds. Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

- **Don Hook Farms, Incorporated** is a CFO with 246 sows and 320 nursery pigs that is near Peter Grube Ditch, a direct tributary to the SJR (*05 05).
- **Irish Acres Dairy, LLC** is a CAFO with 1,196 dairy cattle in the Haverstock Ditch subwatershed, which is tributary to Big Run (*05 02).
- **KD Carnahan Farms, Inc.** is a CFO with 280 dairy heifers, 204 dairy cattle, and 70 dairy calves that is immediately adjacent to Hardwood Ditch, which is tributary to Buck Creek (*05 04).
- **R&D Malcolm Farms, Incorporated** is a CFO with 125 sheep in the Mason Ditch subwatershed, which is tributary to Buck Creek (*05 04).

A non-permitted livestock operation on County Road 6 northeast of the village of Edgerton, Ohio is visible in aerial imagery at GoogleEarth^{TM}. The livestock operation includes three large barns; an analysis of historic GoogleEarth^{TM} aerial imagery shows that two of long barns were built between December 2006 and August 2009 and the first long barn was built prior to April 1994.

Within *Sol Shank Ditch-St. Joseph River* (HUC 04100003 05), SJRWI (2008a) observed livestock during windshield surveys at 39 locations in Williams County, Ohio, at 35 locations in Defiance County, Ohio, and 145 locations in Indiana; manure storage was observed at one site in Defiance County and livestock in a stream were observed at another site in Defiance County. No additional information about hobby farms and small livestock operations are available. Thus, livestock in Ohio and Indiana may contribute to the nutrient impairment.

F-3.3.3.6 Crop Production

The SJR, Bear, Eagle, and Nettle creeks, and their tributaries flows through and along row crop fields and woodlots. Manure application to cropland, including tiled cropland, is a potential source of *E. coli* to the impaired segments.

Biosolids from Steel Dynamics, Inc. were land applied to 5 fields (87 acres) in the *Hoodelmier Ditch-St. Joseph River* HU (*05 06). All 5 fields are adjacent to or nearby the Steel Dynamics facility. No data regarding the dates, rates, or methods of application area available. Biosolids application are assumed not to have occurred during the last decade; therefore, biosolids are not considered a source of RU impairment.

F-3.4 Mason Ditch-Cedar Creek (HUC 04100003 06)

F-3.4.1 Monitoring Data

IDEM collected 5 or 6 samples from 5 sites on Cedar Creek and 5 sites on its tributaries (Table F-6). *E. coli* in Cedar Creek ranged from 10 to 25,000 counts/100 mL with geometric means at the 5 sites ranging from 247 to 1,499 counts/100 mL; all of the 5 sites were on segments that did not attain their RU. *E. coli* in the tributaries ranged from 20 to 1,300 counts/100 mL with geometric means at the 5 sites ranging from 155 to 937 counts/100 mL; four sites were on segments that did not attain their RU and one site was on a segment with insufficient data to assess RU attainment.

F-3.4.2 Load Duration Curves

LDCs were developed for the three HUC12s with segments impaired for their RUs: Figure F-42, Figure F-43, and Figure F-44. *E. coli* data collected by IDEM in 2000 are not displayed as loads due to a lack of flow data[52].

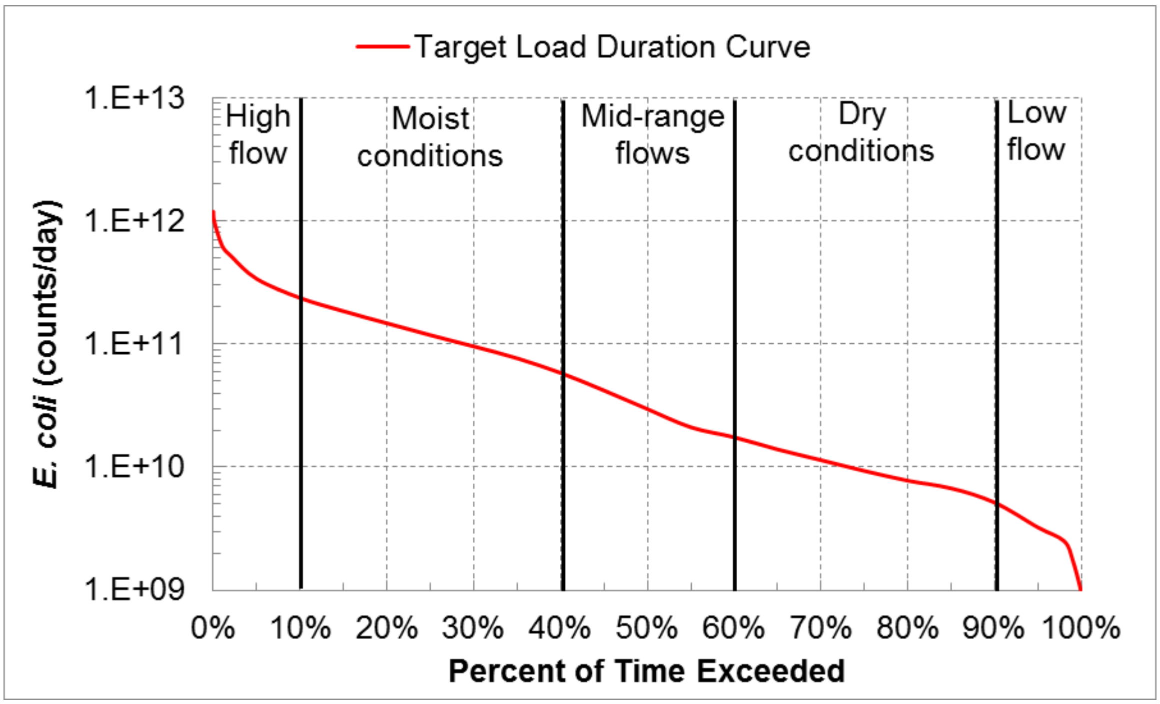


Figure F-42. *E. coli* LDC for Cedar Creek in *Cedar Lake-Cedar Creek* (*06 01) at the HU outlet.

[52] The SWAT model was developed to simulate calendar years 2004 through 2014.

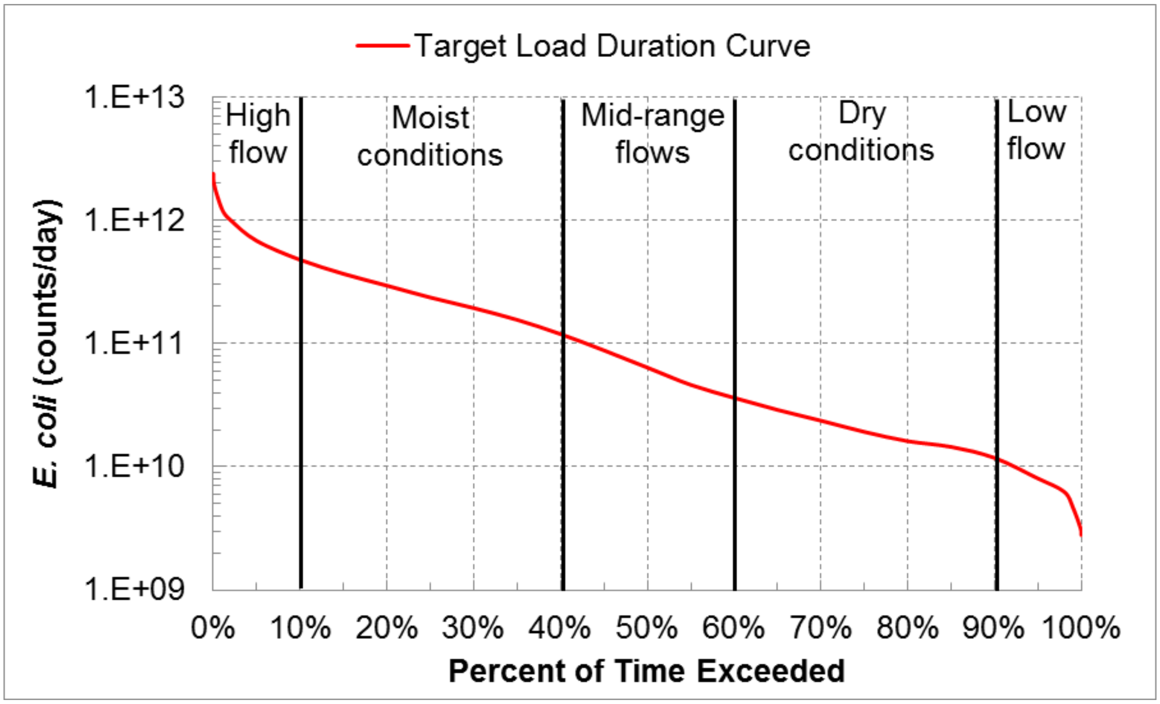


Figure F-43. *E. coli* LDC for Cedar Creek in *Dibbling Ditch-Cedar Creek* (*06 02) at the HUC12 outlet.

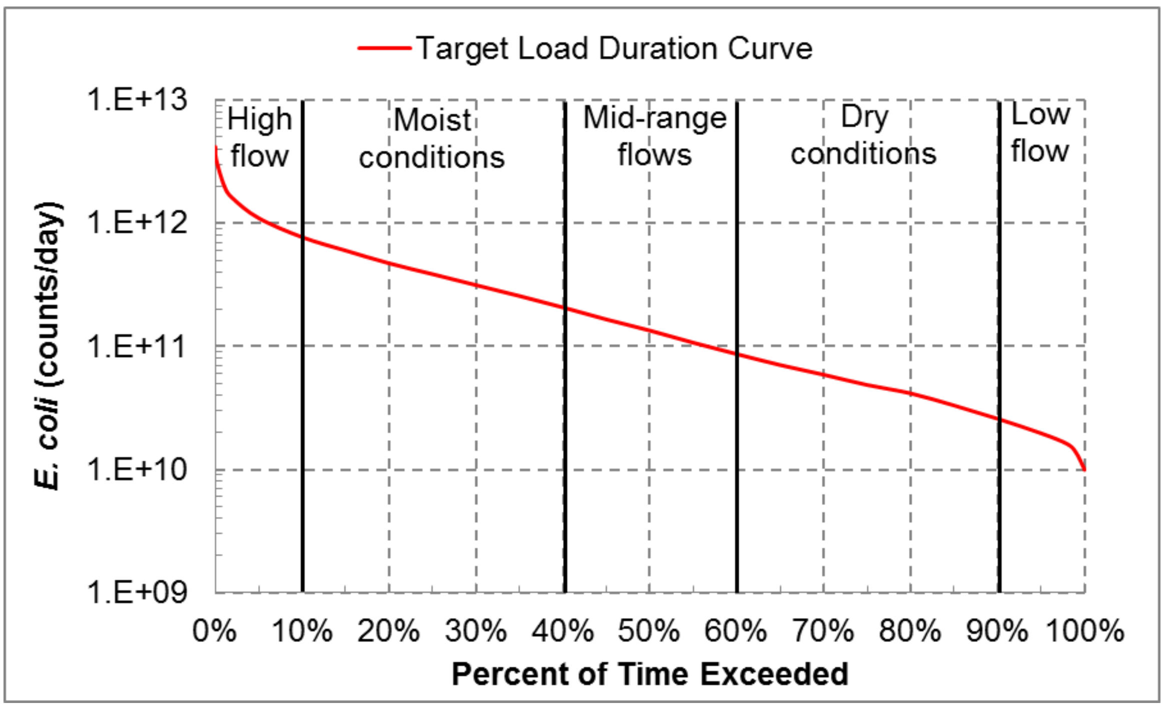


Figure F-44. *E. coli* LDC for Cedar Creek in *Smith Ditch-Cedar Creek* (*06 02) at the HUC12 outlet.

F-3.4.3 Sources of Impairment

The potential sources of *E. coli* in this HU are evaluated in the following sections.

F-3.4.3.1 Industrial Facilities with Individual NPDES Permits

Four industrial facilities are covered by individual NPDES permits[53] (see Figures C-3 and C-4 in Appendix C for maps). None of the facilities are permitted to discharge bacteria. While bacteria may be picked up by stormwater, none of these facilities are considered to be significant sources of bacteria.

- **Auburn Gear Inc.** (IN0000566; 100,000 gpd) discharges NCCW and stormwater through two outfalls to Cedar Creek.
- **Contech U.S., LLC** (IN0046043; 580,000) discharges NCCW and stormwater through 4 outfalls to Grandstaff Ditch.
- **Rieke Packaging Systems** (IN0000868; 760,000 gpd) discharges NCCW and stormwater to Cedar Creek.
- **Tower Automotive USA II** (IN0046761; 150,000 gpd) discharges industrial wastewater to Grandstaff Ditch.

F-3.4.3.2 Public Facilities with Individual NPDES Permits

Three public facilities are covered by individual NPDES permits (see Figures C-3 and C-4 for maps and Table F-8 for DMR data).

- **Auburn WWTP** (IN0020672, 4.5 mgd) is a sanitary POTW that discharges to Cedar Creek. Effluent flows vary from 1.5 to 5.0 cfs (average 2.7 cfs) with typically low *E. coli* monthly geometric means (2 to 233 counts/100 mL, average 30 counts/100 mL). *E. coli* loads ranged from 155 million to 21 billion c/d, average 2.6 billion c/d. Auburn WWTP's average *E. coli* load is one or more orders of magnitude less than the LDC for Cedar Creek; only during low flow conditions would the maximum effluent load become the dominant source of flow and bacteria.

  Auburn is a CSO community (refer to Section 4.2.2.1 of the main report). The city has 5 CSO outfalls that discharged in 2010 through 2014 (Table C-6 in Appendix C). Overflow volumes (CSOs: <0.1 to 4.7 cfs), as compared to the Cedar Creek were relatively small in the high flow through dry conditions flow zones of Cedar Creek, but CSO volumes would become the dominant flow by volume in the drier portion of the low flow zone. Despite relatively small flow volumes, bacteria concentrations of untreated combined waste were likely extremely elevated. Similarly, overflows (CSO outfall 010: <0.005 cfs) were orders of magnitude less than flows in John Diehl Ditch.

- **Waterloo Municipal STP** (IN0020711; 240,000 gpd) is a sanitary POTW that discharges to the Cedar Creek. Effluent volumes were fairly consistent (0.2 to 1.1 cfs, average 0.5 cfs), while *E. coli* concentrations (1 to 868 counts/100 mL, average 20 counts/100 mL) and loads (4.4 million to 12.6 billion c/d, average 285 million c/d) are occasionally high. Except for the spring of 2014, no monthly geometric mean exceeded 125 counts/100 mL. While average E. coli loads are typically one or more orders of magnitude less than the LDC for Cedar Creek (*06 02), the maximum *E. coli* load exceeds the LDC across the low flow zone and part of the dry conditions flow zone. Therefore, only if it discharges high effluent volumes during in-stream lower flow conditions would the Waterloo Municipal STP become a major source of impairment.

[53] The following four permits were terminated: Auburn Foundry, Inc. Plant #1 (IN0053651; NCCW), Auburn Foundry, Inc. Plant 1 (IN0061255), Cooper Tire and Rubber Company (IN0000361; NCCW), and Dana Corp. Spicer Clutch Div. (IN0000370; NCCW).

- **Waterloo Public Water Supply** (IN0049433) was a WTP that formerly discharged to a county drain tributary to Cedar Creek. As the WTP should not have discharged bacteria and its effluent volumes were very small, the WTP was not a source of bacteria impairment.

F-3.4.3.3 Facilities Covered by General NPDES Permits

Nine facilities and one MS4 are covered by general NPDES permits[54]. Portions of the city of Auburn (INR040119) are a regulated as an MS4; such areas exclude the sewersheds draining the CSS.

F-3.4.3.4 On-Site Wastewater Treatment Systems

Except for the city of Auburn and town of Waterloo, OWTS treat commercial and domestic wastewater. While this subwatershed does contain some urban development, much of the land area is composed of crop fields and woodlots. Illicit cross-connections between OWTS and agricultural drain tiles are likely. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute bacteria loads.

F-3.4.3.5 Livestock Operations

One CAFO and no CFOs are in this subwatershed (see Section 4.2.3 of the main report and Figure C-6 in Appendix C). Phillips Farm is a CAFO with 170 dairy calves and 1,950 dairy heifers that is in the Swartz Ditch subwatershed, which is a tributary of Cedar Creek (*06 01). Aerial imagery shows that the CAFO has containment ponds. Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

Within *Matson Ditch-Cedar Creek* (HUC 04100003 06), SJRWI (2008a) observed livestock during windshield surveys at 136 locations; no manure storage was observed and livestock in a stream were observed at one site. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute to the nutrient impairment.

F-3.4.3.6 Crop Production

Cedar Creek, Dibbling, Mason, Smith, and Swartz ditches, and their tributaries flows through and along row crop fields and woodlots. Manure application to cropland, including tiled cropland, is a potential source of *E. coli* to the impaired segments.

Biosolids were land applied to fields in each of the 12-digit HUs in this subwatershed:

- *Cedar Lake-Cedar Creek* (*06 01): Auburn WWTP (1 field, 15 acres)
- *Dibbling Ditch-Cedar Creek* (*06 02): Auburn WWTP (8 fields, 142 acres), Kendallville Municipal STP (1 field, 2 acres), Waterloo Municipal STP (7 fields, 108 acres)
- *Mason Ditch* (*06 03): Auburn WWTP (1 field, 2 acres)
- *Smith Ditch-Cedar Creek* (*06 04): Auburn WWTP (11 fields, 328 acres)

While IDEM provided field locations, biosolids application dates, methods, and rates data are sparse (Table C-10). Since biosolids application has not occurred in this HU during the last decade, biosolids are not considered a source of RU impairment. Historically, biosolids land application may have contributed to bacteria impairments to waterbodies in this HU. For example, Schwartz Ditch flows through crop fields with land application of biosolids, while Cedar Creek and an unnamed tributary to Dibbling Ditch flow directly adjacent to crop fields with land application.

[54] The following two permits were terminated: Auburn Foundry, Inc. Plant #1 (ING250020; NCCW), Eaton Corp. Clutch Division (ING250048; NCCW) and Marathon Oil. Co. (ING340018; petroleum products terminal). Neither facility was allowed to discharge bacteria; therefore, neither facility was an historic source of bacteria impairment.

F-3.5 Cedar Creek (HUC 04100003 07)

F-3.5.1 Monitoring Data

IDEM collected 5 to 9 samples from 4 sites on Cedar Creek, 4 to 6 samples from 3 sites on Little Cedar Creek, and 5 or 6 samples from 6 sites on their tributaries (Table F-6).

- **Cedar Creek:** concentrations ranged from 5 to 6,867 counts/100 mL with geometric means at the 4 sites ranging from 236 to 873 counts/100 mL; 3 sites were on segments that did not attain their RU and 1 site was on a segment that had insufficient data to assess RU attainment.
- **Little Cedar Creek:** concentrations ranged from 104 to 2,419 counts/100 mL with geometric means at the 3 sites ranging from 378 to 639 counts/100 mL; all of the 3 sites were on segments that did not attain their RU.
- **Tributaries:** concentrations ranged from 29 to 19,863 counts/100 mL with geometric means at the 6 sites ranging from 64 to 7,196 counts/100 mL; 4 sites were on segments that did not attain their RU and 2 sites were on segments that had insufficient data to assess RU attainment.

F-3.5.2 Load Duration Curves

LDCs were developed for the five HUC12s with segments impaired for their RUs: Figure F-45, Figure F-46, Figure F-47, Figure F-48, and Figure F-49. *E. coli* data collected by IDEM in 2005 and 2010 are displayed as loads[55] in some LDC figures. Data collected in 2000 and 2001 are not displayed because loads could not be calculated due to a lack of flow data[56].

Some loads exceeded the LDCs. To achieve the TMDLs (i.e., reduce loads to the LDCs), reductions on a per sample basis range from 94 to 99 percent for three samples collected from Peckhart Ditch; seven samples were below the LDC. For Black Creek, all five loads exceeded the LDC and required reductions of 71 to 88 percent.

[55] *E. coli* concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.
[56] The SWAT model was developed to simulate calendar years 2004 through 2014.

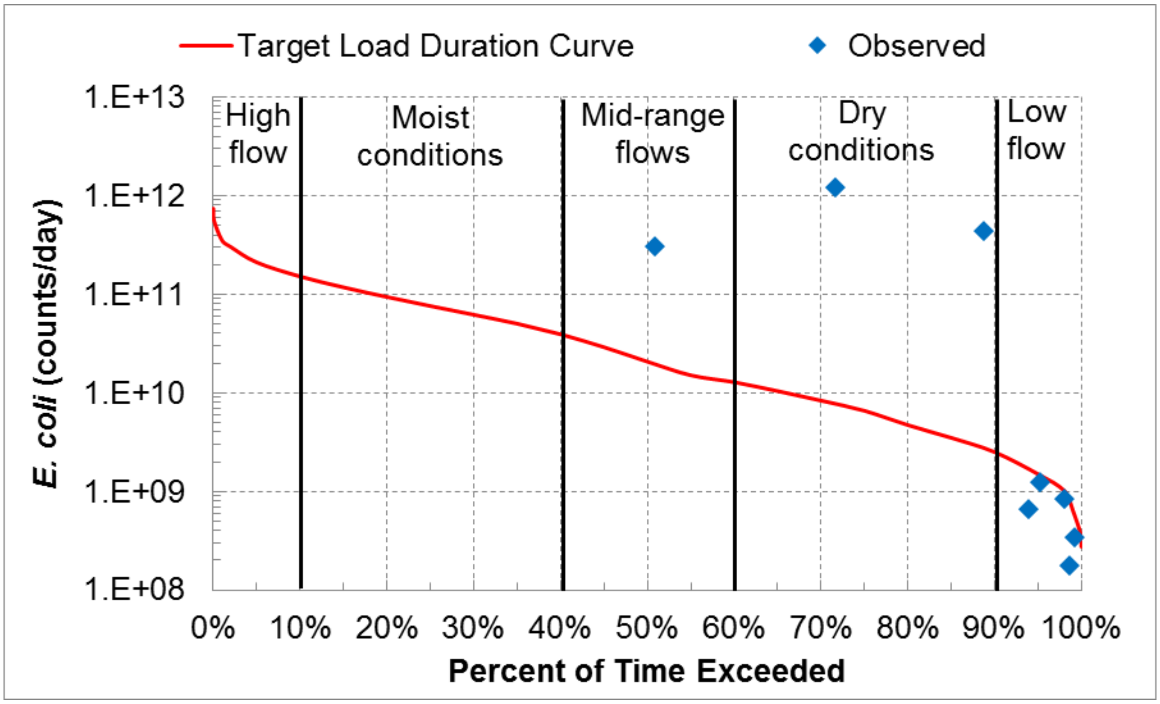


Figure F-45. *E. coli* loads and LDC for Peckhart Ditch in *Peckhart Ditch-John Diehl Ditch* (*07 02) at the confluence of Peckhart Ditch with John Diehl Ditch.

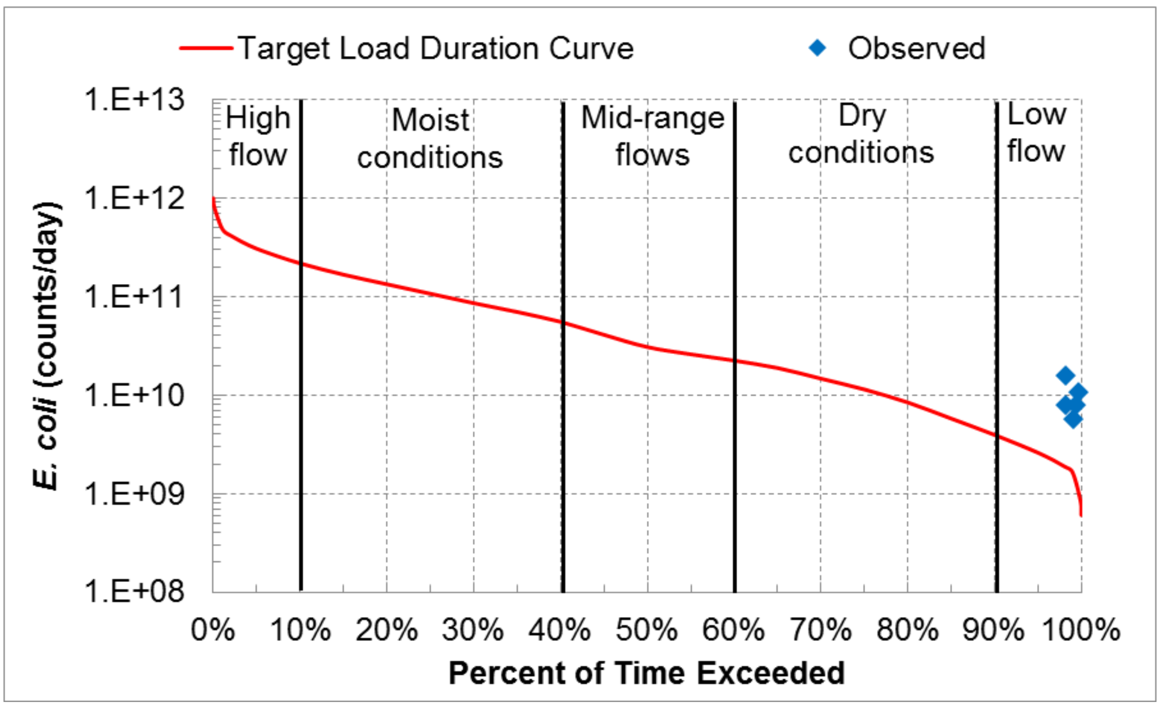


Figure F-46. *E. coli* loads and LDC for Black Creek in *Black Creek* (*07 04) at the HU outlet.

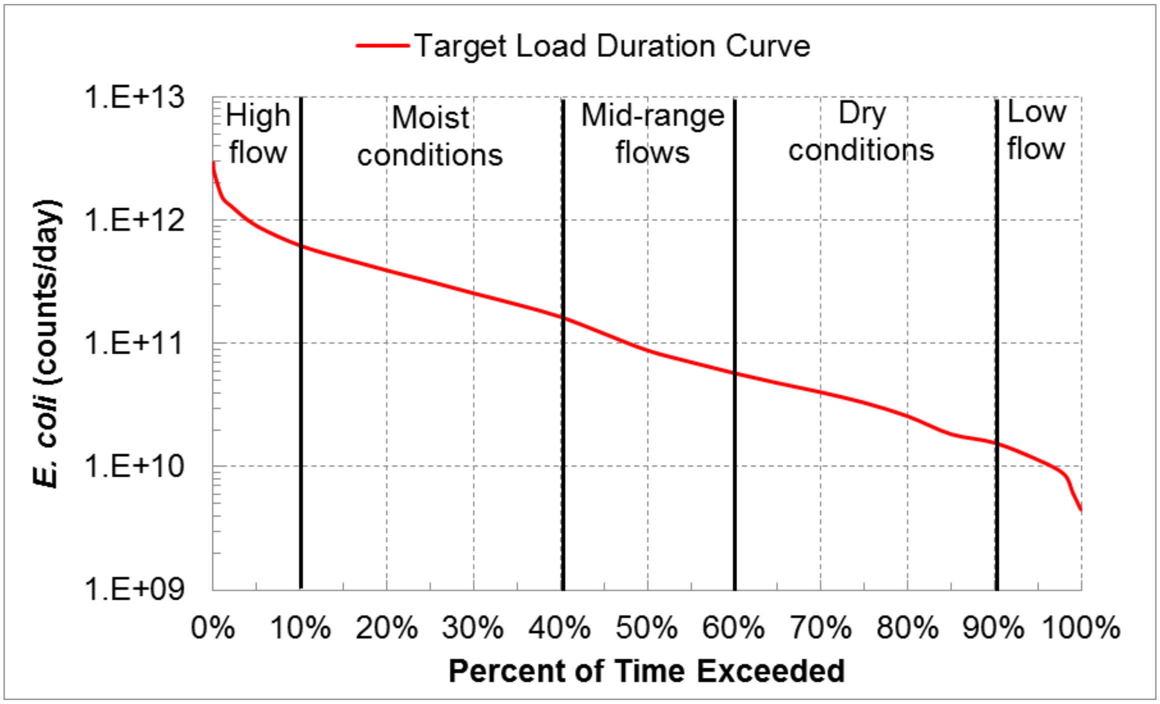


Figure F-47. *E. coli* LDC for Little Cedar Creek in *King Lake-Little Cedar Creek* (*07 05) at the HUC12 outlet.

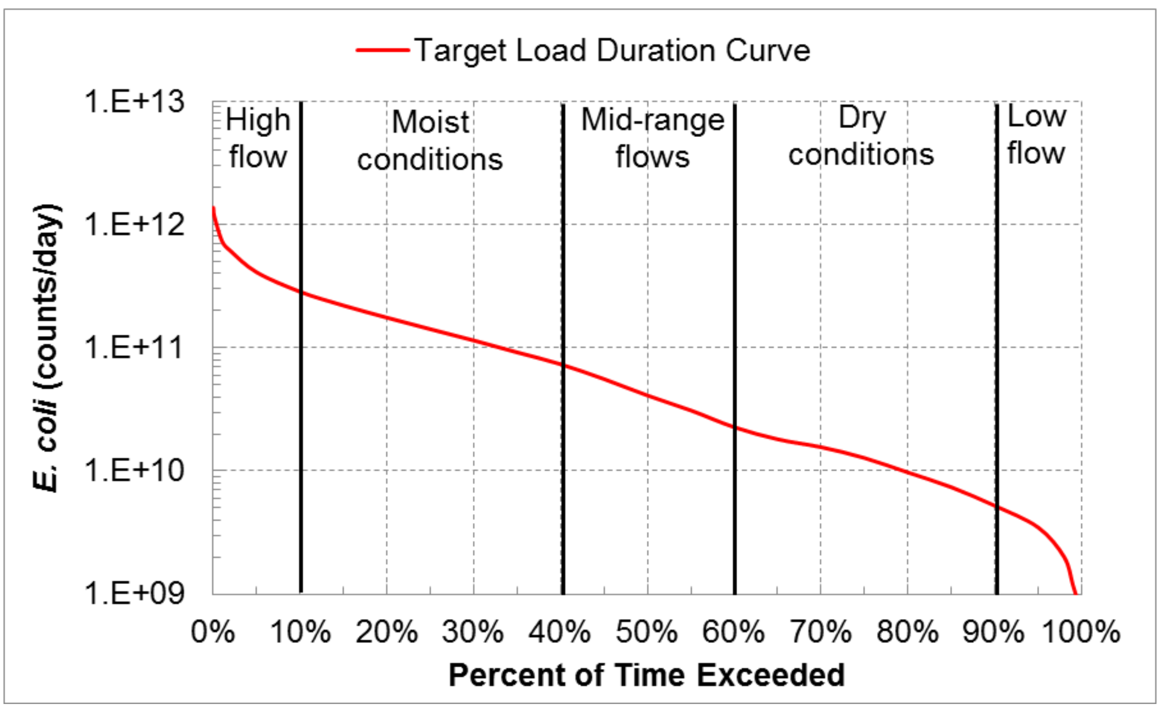


Figure F-48. *E. coli* LDC for Willow Creek in *Willow Creek* (*07 06) at the HUC12 outlet.

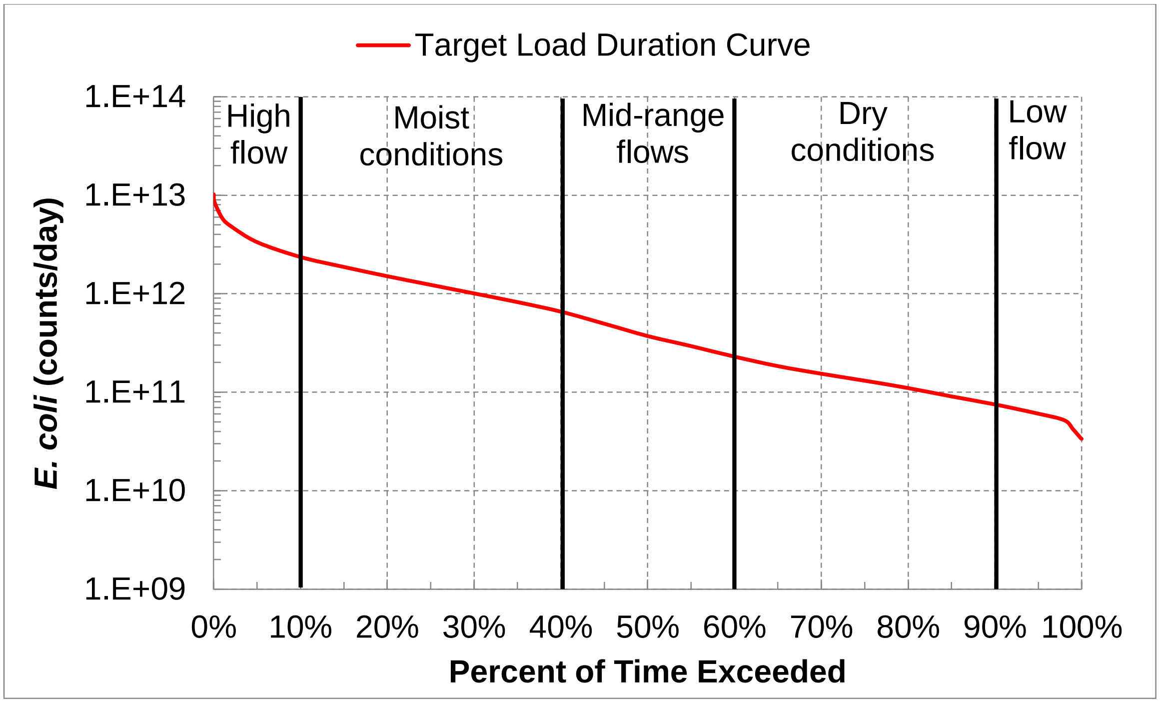


Figure F-49. *E. coli* LDC for Cedar Creek in *Dosch Ditch-Cedar Creek* (*07 07) at the HUC12 outlet.

F-3.5.3 Sources of Impairment

The potential sources of *E. coli* in this HU are evaluated in the following sections.

F-3.5.3.1 Facilities with Individual NPDES Permits

Six facilities are covered by individual NPDES permits[57] (see Figures C-3 and C-4 for maps and Table F-8 for DMR data). At the four WWTPs, geometric means of effluent loads were typically several orders of magnitude less than in-stream loads in the high flow through mid-range flow conditions. Effluent loads at elevated concentrations may be contributing significantly to in-stream loads in the low flow zone. Because the effluent DMR does not include raw data, it is not possible to determine if the extremely elevated in-stream concentrations during low flow conditions are due to effluent discharges.

- **Avila Water Department** (IN0052035, 0.034 mgd) is a WTP that discharges to an unnamed tributary of Kings Lake. This WTP is not permitted to discharge bacteria, and thus, is not a source of impairment.
- **Avila WWTP** (IN0020644, 0.2) is a sanitary POTW that discharges to an unnamed tributary of Kings Lake. Effluent flows varied (0.05 to 0.82 cfs, average 0.53 cfs), while monthly geometric mean *E. coli* concentrations were low (1 to 29 counts/100 mL, average 7 counts/ 100 mL) and loads varied (5.1 to 353 million c/d, average 88 million c/d).
- **Corunna WWTP** (IN0047473, 0.024 mgd) is a sanitary POTW that discharges to an unnamed tributary of John Diehl Ditch. Effluent volumes vary considerably (0.002 to 0.600 cfs, average 0.037 cfs), while monthly geometric mean *E. coli* concentrations are very high (1 to 36,260 counts/100 mL, average 1,272 counts/100 mL), and *E. coli* loads vary considerably (1.6 million to 9.8 billion c/d, average 492 million).

[57] The following five permits were terminated: Auburn Foundry Landfill (IN0061590), Auburn Rest Area I-69 North (IN0038504), Auburn Rest Area I-69 South (IN0038491), Huntertown WWTP (IN0023116), and Wawasee Sewer and Water (IN0042561).

- **Garrett WWTP** (IN0029969, 1.2 mgd) is a sanitary POTW that discharges to Garrett City Ditch. Effluent volumes were fairly consistent (0.7 to 1.9 cfs, average 1.1 cfs), while monthly geometric mean *E. coli* concentrations were generally low (1 to 60 counts/100 mL, average 15 counts/100 mL) and loads varied (19 million to 2.0 billion c/d, average 382 million c/d).
- **Indian Springs Rec Campground** (IN0032107, 0.04 mgd) is a sanitary POTW that discharges seasonally to Little Cedar Creek. Effluent volumes were low (0.001 to 0.046 cfs, average 0.008 cfs) while monthly geometric mean *E. coli* concentrations were often high (1 to 2,000 counts/100 mL, average 162 counts/100 mL) and loads varied considerably (12 thousand to 478 million c/d, average 33 million c/d). The campground always discharges several orders of magnitude less than the LDC. While this facility contributes *E. coli* load to Little Cedar Creek, its load is relatively insignificant.
- **La Otto Regional Sewer District** (IN0058611, 0.05 mgd) is a sanitary POTW that discharges to Black Creek. Effluent volumes varied considerably (0.002 to 0.788 cfs, average 0.122 cfs) while monthly geometric mean *E. coli* concentrations were often high (6 to 1,720 counts/100 mL, average 318 counts/100 mL) and loads varied considerably (12 million to 18 billion c/d, average 3.4 billion c/d).
- **Metal Technologies** (IN0061263; 200,000 gpd)[58] is an industrial facility that discharges NCCW and industrial stormwater to Diehl Ditch. Effluent volumes varied considerably (<0.01 to 0.37 cfs, average 0.05 cfs). Effluent is not evaluated for *E. coli*. This facility's NCCW is not a source of *E. coli*, and its industrial stormwater is likely a negligible source of bacteria.

F-3.5.3.2 Facilities Covered by General NPDES Permits

Benchmark Distribution Terminals (ING340037) is covered by Indiana's general permit for petroleum distribution terminals; the facility is permitted to discharge industrial stormwater. Nine industrial facilities and one MS4 are covered by general NPDES permits[59]. Portions of the city of Auburn (INR040119) are a regulated as an MS4; such areas exclude the sewersheds draining the CSS.

F-3.5.3.3 On-Site Wastewater Treatment Systems

Except for the cities of Auburn and Garrett, towns of Avila and Corunna, and unincorporated community of La Otto, OWTS treat commercial and domestic wastewater. Portions of this subwatershed are developed; other portions are composed of crop fields and woodlots. Illicit cross-connections between OWTS and agricultural drain tiles are possible. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute bacteria loads.

F-3.5.3.4 Livestock Operations

One CAFO and one CFO are in this subwatershed (see Section 4.2.3 of the main report and Figure C-6 in Appendix C). Sunrise Heifer Farm LLC is a CAFO with 2,650 dairy heifers that drains to an unnamed ditch in the Peckhart Ditch subwatershed (*07 02). Haynes Dairy Farm is a DVO with 264 sows and 400 nursery pigs that drains to Ober Ditch (the western and southern boundary of the property), which is tributary to Peckhart Ditch (*07 02). Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

[58] Metal Technologies (IN0061263) is located at the same address as the former Auburn Foundry Landfill (IN0061590). Adjacent grassed areas, ponds, and wetlands that are associated with Metal Technologies appear to discharge to *Dosch Ditch-Cedar Creek* (*07 07).

[59] The permit for Auburn Foundry, Inc. Plant #2 (ING250019; NCCW) was terminated. The facility was not allowed to discharge bacteria; therefore, it was not an historic source of bacteria impairment.

Within *Dibbling Ditch-Cedar Creek* (HUC 04100003 07), SJRWI (2008a) observed livestock during windshield surveys at 133 locations in DeKalb County and at 149 locations in Noble County; manure storage was observed at 4 locations in DeKalb County. No additional information about hobby farms and small livestock operations are available. Thus, livestock may contribute to the nutrient impairment.

F-3.5.3.5 Crop Production

Cedar, Little Cedar, Black, and Sycamore creeks; Dosch, Garrett City, and John Diehl ditches; and their tributaries flow through and along row crop fields and woodlots. Lower Cedar Creek flows through wooded areas and its tributaries mostly drain rural and suburban residential properties (with a few agricultural areas) on the fringes of the Fort Wayne metropolitan area.

While IDEM provided field locations, biosolids application dates, methods, and rates data are sparse (Table C-10). Since biosolids application has not occurred in this HU during the last decade, biosolids are not considered a source of RU impairment. Historically, biosolids land application may have contributed to bacteria impairments to waterbodies in this HUC.

F-3.6 St. Joseph River (HUC 04100003 08)

F-3.6.1 Monitoring Data

IDEM collected 5, 6, or 82 samples from 7 sites on the SJR and 2 samples from 1 site on Tiernan Ditch (Table F-6). *E. coli* in the SJR ranged from 5 to 28,000 counts/100 mL with geometric means at the 7 sites ranging from 87 to 1,336 counts/100 mL; 4 sites were on segments that did not attain their RU and 3 sites were on segments that had insufficient data to assess RU attainment.. *E. coli* in Tiernan Ditch was 150 and 170 counts/100 mL; this site was on a segment that had insufficient data to assess RU attainment.

F-3.6.2 Load Duration Curve

LDCs were developed for the two HUC12s with segments impaired for their RUs: Figure F-50 and Figure F-51. *E. coli* data collected by IDEM in 2005 are displayed as loads[60] in Figure F-51. Data collected in 2000 are not displayed in Figure F-50 because loads could not be calculated due to a lack of flow data[61].

One load exceeded the LDC in Figure F-51. To achieve the TMDL (i.e., reduce load to the LDC), the single sample in the moist conditions flow zone would need a reduction of 93 percent.

[60] *E. coli* concentrations from IDEM samples were multiplied by SWAT-simulated flows and converted to appropriate units.
[61] The SWAT model was developed to simulate calendar years 2004 through 2014.

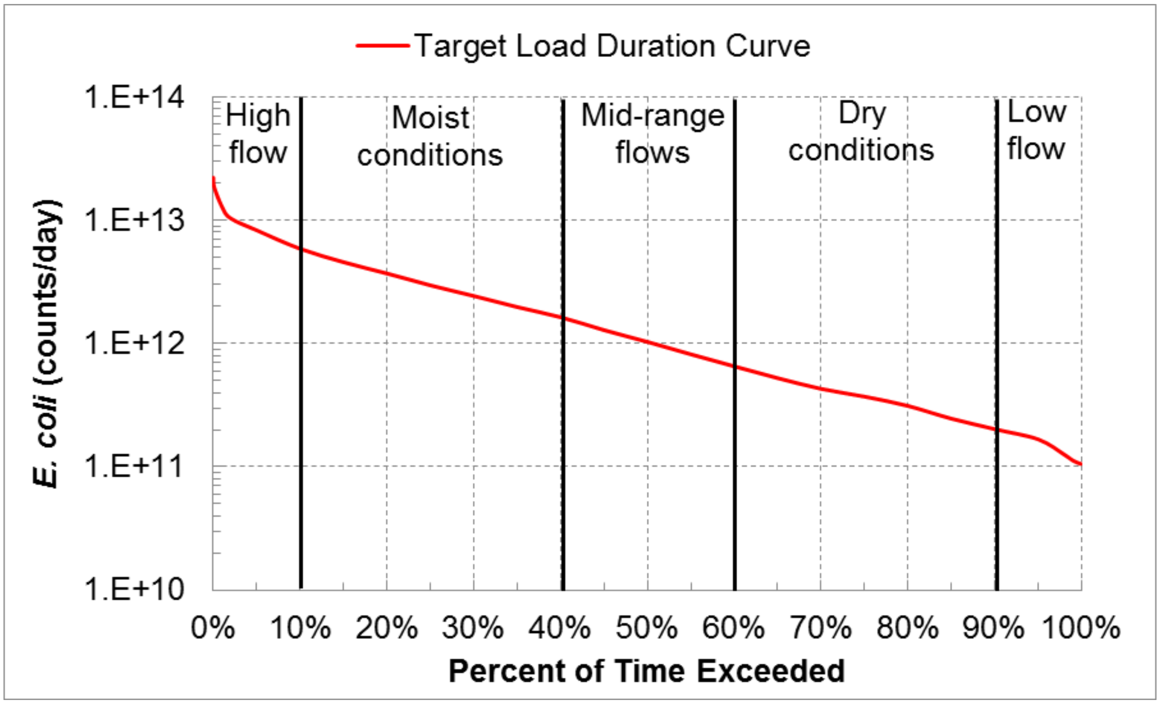


Figure F-50. *E. coli* LDC for the SJR in *Metcalf Ditch-St. Joseph River* (*08 02) just upstream of the confluence of Bear Creek.

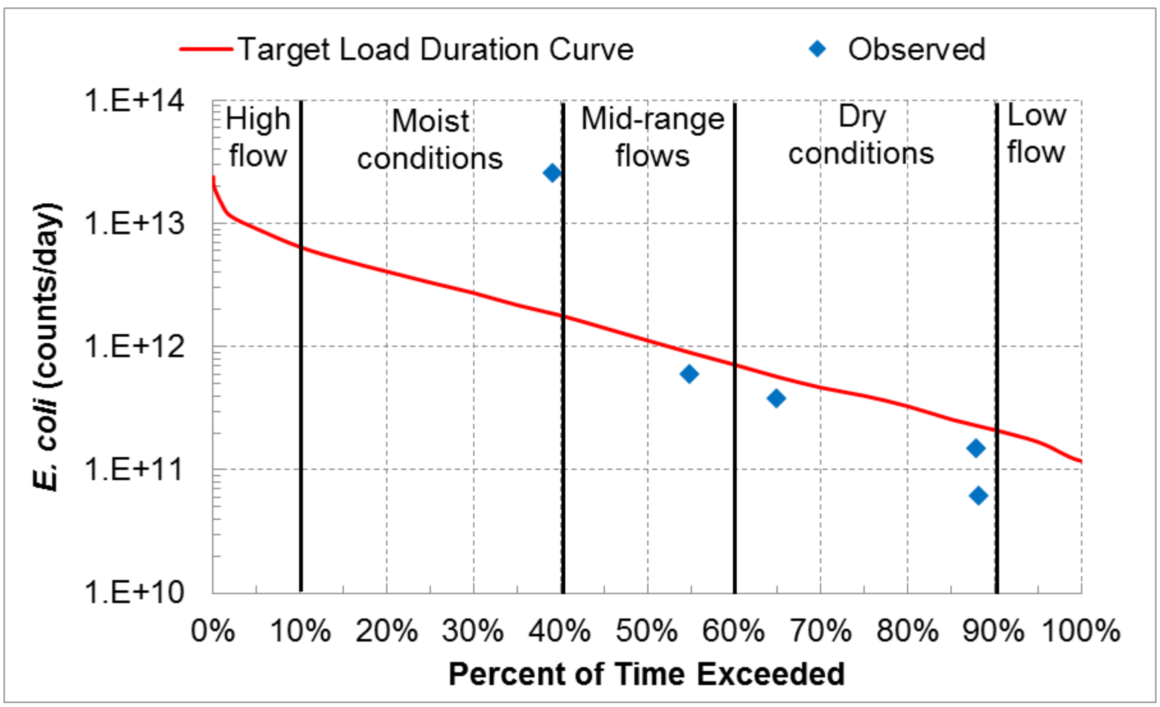


Figure F-51. *E. coli* loads and LDC for the SJR in *Becketts Run-St. Joseph River* (*08 03) at the HU outlet.

F-3.6.3 Sources of Impairment

The potential sources of *E. coli* in this HU are evaluated in the following sections.[62]

F-3.6.3.1 Industrial Facilities with Individual NPDES Permits

Three facilities are covered by individual NPDES permits[63] (see Figures C-3 and C-4 for maps). These facilities are not causing or contributing to the RU impairments on the SJR.

- **Eagle Pilcher Plastic Division** (IN0000574) discharges NCCW to Haifley Ditch. The facility is not permitted to discharge bacteria and NCCW is not expected to be a source of bacteria.
- **DuPont Water Treatment Plant - North End** (IN0060127; 0.1 mgd) is a WTP that discharged to a wetland that is tributary to Keefer Creek. WTPs are not permitted to discharge bacteria, and WTPs are not expected to be sources of bacteria. This facility is no longer operational.
- **Pickle Properties LLC** (IN0032891; 0.036 mgd) discharges is an agricultural property that discharges to Hindman Ditch. The facility is not permitted to discharge bacteria, and thus, is not expected to be a source of bacteria.

F-3.6.3.2 Public Facilities with Individual NPDES Permits

Four facilities are covered by individual NPDES permits[64] (see Figures C-3 and C-4 for maps and Table F-8for DMR data).

- **Deer Track Estates WWTP** (IN0059749; 0.007 mgd) is a sanitary POTW that discharges to an unnamed tributary to J.E. Piquognt Ditch. Effluent volumes were very low (0.001 to 0.020 cfs, average 0.008 cfs) while geometric means of *E. coli* concentrations (1 to 195 counts/100 mL, average 34 counts/100 mL) and loads (253 thousand to 44 million c/d, average 6.2 million c/d) were typically low. Such effluent loads are several orders of magnitude less than the LDC.
- **Fort Wayne Municipal WWTP** (IN0032191; 60 mgd) is a major sanitary WWTP that discharges treated effluent to the Maumee River, which the SJRW is tributary to.

  Fort Wayne is a CSO and SSO community. In the SJRW, six CSO outfalls discharge to the SJR, three SSO outfalls discharge to Salgy Drain, and one SSO outfall discharges to Krunckenberg Ditch. In 2010 through 2014, the six CSO outfalls discharged between 12 and 171 times. CSO volumes ranged from <0.01 to 9.98 million gallons per month. The WWTP's goal is for one CSO per year. Since these outfalls are downstream of the RU impairments on the St. Joseph River, they did not cause or contribute to the RU impairment.
- **Fort Wayne Utilities – Honeysuckle Site** (IN0063061, 0.02 mgd) is a WTP that discharges to the Schwartz-Carnahan Ditch. WTPs are not permitted to discharge bacteria, and WTPs are not expected to be sources of bacteria.
- **Grabill Water Works** (IN0044369; 0.035 mgd) is a WTP that discharges to Witmer Ditch This WTP is not permitted to discharge bacteria, and WTPs are not expected to be sources of bacteria.

F-3.6.3.3 Facilities Covered by General NPDES Permits

Thirteen industrial facilities and one MS4 are covered by general NPDES permits. Portions of the city of Fort Wayne (INR040029) are a regulated as an MS4; such areas exclude the sewersheds draining the

[62] No facilities with general NPDES permits, communities with CSOs or SSOs, or regulated MS4s are in this subwatershed.
[63] The following facility no longer has a permit: Beatrice Cheese Company (IN0000261.
[64] The following two permits were terminated or otherwise no longer have permit coverage: Leo Elementary and High Schools (IN0025267; sanitary) and St. Joseph – Spencerville Regional Sewer District (IN0058411; sanitary).

CSS. The other regaled MS4 is Allen County (INR040131), which excludes Fort Wayne and Fort Wayne's co-permittees.

F-3.6.3.4 On-Site Wastewater Treatment Systems

Much of the lower portion of this HUC10 uses public sewers in Fort Wayne. Rural areas use OWTS to treat commercial and domestic wastewater. Outside of the greater Fort Wayne area, rural areas are composed of crop fields and woodlots. Illicit cross-connections between OWTS and agricultural drain tiles are possible. Grandfathered or illicit off-site discharging OWTS, failing on-lot OWTS, and illicit OWTS connections to drain tiles likely contribute bacteria loads.

F-3.6.3.5 Livestock Operations

Two CFOs are in this subwatershed (see Section 4.2.3 of the main report and Figure C-6 in Appendix C). Concord Veal, with 536 veal calves, drains to Hindman Ditch in the Bear Creek subwatershed (*08 01). Strong Farms LLC, with 2990 beef calves, drains to an unnamed ditch to the SJR (*08 02). Untreated livestock wastewater may not be discharged to surface streams but is a potential source of impairment during larger precipitation events that cause overland flow and runoff.

Within *St. Joseph River* (HUC 04100003 08), SJRWI (2008a) observed livestock during windshield surveys at 164 locations in DeKalb County and 214 locations in Allen County; no livestock with direct access to streams were observed and manure storage was observed at one site in DeKalb County. No additional information about hobby farms and small livestock operations are available. Thus, livestock in Ohio and Indiana may contribute to the nutrient impairment.

F-3.6.3.6 Crop Production

The SJR; Bear Creek; Davis, Nettlehorst, Swartz-Cannahan, Tiernan, and Wilmer ditches; and their tributaries flow through and along row crop fields and woodlots. Manure application to cropland, including tiled cropland, is a potential source of *E. coli* to the impaired segments.

While IDEM provided field locations, biosolids application dates, methods, and rates data are sparse (Table C-10). Since biosolids application has not occurred in this HU during the last decade, biosolids are not considered a source of RU impairment. Historically, biosolids land application may have contributed to bacteria impairments to waterbodies in this HUC.

F-4. References

IDEM (Indiana Department of Environmental Management). 2014. Fish community, fish tissue, Index of Biotic Integrity, macroinvertebrate community, and water chemistry monitoring data files. IDEM. Provided by Staci Goodwin (IDEM) via file transfer protocol site on December 9, 2014.

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———. 2008b. *Lower St. Joseph – Bear Creek Watershed Management Plan.* SJRWI, Fort Wayne, IN. March 20, 2008.

———. 2014. In-stream water quality data [2 Excel files]. Provided by Dr. Robert Gillespie (Indiana University-Purdue University Fort Wayne) via electronic mail on July 6, 2015.

———. 2015. Latitudes and longitudes of SJRWI sample locations [Excel file]. Provided by Sharon Partridge-Dormer (SJRWI) via electronic mail on August 10, 2015.

Appendix G.

Stormwater WLA Development

Tables

Abbreviations and Acronyms[1]

HU	hydrologic unit
HUC	hydrologic unit code
NPDES	National Pollutant Discharge Elimination System
TMDL	total maximum daily load
WLA	wasteload allocation

[1] All abbreviations and acronyms in this appendix are defined above. They are not defined in the footnotes below each table.

Table G-1. Industrial stormwater WLAs for *E. coli* TMDLs

HUC (04100003)	TMDL		General NPDES permit coverages for industrial stormwater	No.	WLA calculation		
	Location	Area (acres)			Area (acres)	Area (%)	WLA percent
Fish Creek (HUC 04100003 04)							
04 04	HU outlet	24,841.75	INRM01097, INRM01504	2	46.85	0.18%	0.2%
Sol Shank Ditch-St. Joseph River (HUC 04100003 05)							
05 02	Indiana-Ohio state line	17,385.67	INRM00985, INRM01605, INRM01734	3	85.37	0.49%	0.5%
Matson Ditch-Cedar Creek (HUC 04100003 06)							
06 01	HU outlet	18,496.10	INRM00244, INRM01759	2	21.38	0.12%	0.2%
			ING340037	1	8.40	0.05%	0.1%
06 02	HU outlet	17,328.78	INRM00941, INRM00184, INRM00487	3	89.90	0.52%	0.6%
			ING340037	1	6.50	0.04%	0.1%
06 04	HU outlet	23,333.72	INRM00784, INRM01167, INRM01782	3	9.15	0.04%	0.1%
			IN0000566	1	34.56	0.15%	0.2%
			IN0000868	1	5.26	0.02%	0.1%
			IN0046043	1	12.91	0.06%	0.1%
Cedar Creek (HUC 04100003 07)							
07 02	at confluence with John Diehl Ditch	10,828.10	INRM01118, INRM01370, INRM01768	3	91.03	0.84%	0.9%
			IN0061263	1	25.20	0.23%	0.3%
07 05	HU outlet	15,048.20	INRM00918, INRM01208, INRM01494	3	29.44	0.19%	0.2%
07 07	HU outlet	53,474.18	INRM00501, INRM00519, INRM00652, INRM01740	4	286.65	0.54%	0.6%
St. Joseph River (HUC 04100003 08)							
08 02	just upstream of confluence of Bear Creek	36,182.06	INRM00939, INRM00973, INRM00978, INRM01233	4	230.84	0.64%	0.7%
			IN0059021	1	30.00	0.08%	0.1%
08 03	HU outlet	45,224.88	INRM00421, INRM00263	2	204.70	0.45%	0.5%

Note: Only HUs with industrial facilities covered by the individual or general NPDES permits are displayed.

Table G-1. Industrial stormwater WLAs for total phosphorus TMDLs

HUC (04100003)	TMDL Location	TMDL Area (acres)	General NPDES permit coverages for industrial stormwater	No.	WLA calculation Area (acres)	WLA calculation Area (%)	WLA calculation WLA percent
Fish Creek (HUC 04100003 04)							
04 06	Indiana-Ohio state line	34,915.96	INRM01097, INRM01504	2	46.85	0.13%	0.2%
Matson Ditch-Cedar Creek (HUC 04100003 06)							
06 01	HU outlet	18,496.10	INRM00244	1	10.80	0.06%	0.1%
			ING340037	1	8.40	0.05%	0.1%
06 02	HU outlet	17,328.78	INRM00184, INRM00487, INRM00941, INRM01759	4	25.39	0.15%	0.2%
			ING340037	1	6.50	0.04%	0.1%
Cedar Creek (HUC 04100003 07)							
07 02	at confluence with John Diehl Ditch	10,828.10	INRM01370, INRM01768	2	35.34	0.32%	0.4%
			IN0061263	1	25.20	0.02%	0.1%
07 07	HU outlet	127,211.86	INRM00501, INRM00519, INRM00652, INRM00784, INRM00918, INRM01118, INRM01167, INRM01208, INRM01494, INRM01740, INRM01782	11	390.16	0.31%	0.4%
			IN0000566	1	34.56	0.03%	0.1%
			IN0000868	1	5.26	<0.01%	0.1%
			IN0046043	1	12.91	0.01%	0.1%
St. Joseph River (HUC 04100003 08)							
08 06	HU outlet	148,662.15	INR210049, INRM00121, INRM00144, INRM00263, INRM00406, INRM00421, INRM00939, INRM00973, INRM00978, INRM00985, INRM01108, INRM01228, INRM01233, INRM01605, INRM01671, INRM01734, INRM01781	17	630.14	0.42%	0.5%
			IN0059021	1	30.00	0.02%	0.1%

Note: Only HUs with industrial facilities covered by the individual or general NPDES permits are displayed.

Table G-2. Industrial stormwater WLAs for total suspended solids TMDLs

HUC (04100003)	TMDL Location	TMDL Area (acres)	General NPDES permit coverages for industrial stormwater	No.	WLA calculation Area (acres)	WLA calculation Area (%)	WLA calculation WLA percent
Fish Creek (HUC 04100003 04)							
04 06	Indiana-Ohio state line	34,915.96	INRM01097, INRM01504	2	46.85	0.13%	0.2%
Cedar Creek (HUC 04100003 07)							
07 05	HU outlet	15,048.20	INRM00918, INRM01208, INRM01494	3	38.68	0.26%	0.3%
07 07	HU outlet	133,243.95	INRM00184, INRM00244, INRM00487, INRM00501, INRM00519, INRM00652, INRM00784, INRM00941, INRM01118, INRM01167, INRM01370, INRM01740, INRM01759, INRM01768, INRM01782	15	498.11	0.37%	0.4%
			IN0000566	1	34.56	0.03%	0.1%
			IN0000868	1	5.26	<0.01%	0.1%
			IN0046043	1	12.91	0.01%	0.1%
			IN0061263	1	25.20	0.02%	0.1%
			ING340037	1	14.90	0.01%	0.1%
St. Joseph River (HUC 04100003 08)							
08 06	HU outlet	148,662.15	INR210049, INRM00121, INRM00144, INRM00406, INRM00421, INRM00263, INRM00939, INRM00973, INRM00978, INRM00985, INRM01108, INRM01228, INRM01233, INRM01605, INRM01671, INRM01734, INRM01781	17	630.14	0.42%	0.5%
			IN0059021	1	30.00	0.02%	0.1%

Note: Only HUs with industrial facilities covered by the individual or general NPDES permits are displayed.

Table G-3. Construction site stormwater WLAs for total phosphorus TMDLs

HUC (04100003)	TMDL		No. of regulated construction sites	WLA calculation		
	Location	Area (acres)		Disturbed area (acres)	Area (%)	WLA percent
Fish Creek (HUC 04100003 04)						
04 06	Indiana-Ohio state line	34,916	4	38.29	0.11%	0.2%
Matson Ditch-Cedar Creek (HUC 04100003 06)						
06 01	HU outlet	18,496	2	22.00	0.12%	0.2%
06 02	HU outlet	17,329	7	116.79	0.67%	0.7%
Cedar Creek (HUC 04100003 07)						
07 02	at confluence with John Diehl Ditch	10,828	3	47.34	0.44%	0.5%
07 07	HU outlet	127,212	67	725.47	0.57%	0.6%
St. Joseph River (HUC 04100003 08)						
08 06	HU outlet	148,662	174	1,679.86	1.13%	1.2%

Note: Only HUs with construction sites covered by the general NPDES permit are displayed.

Table G-4. Construction site stormwater WLAs for total suspended solids TMDLs

HUC (04100003)	TMDL		No. of regulated construction sites	WLA calculation		
	Location	Area (acres)		Disturbed area (acres)	Area (%)	WLA percent
Fish Creek (HUC 04100003 04)						
04 06	Indiana-Ohio state line	34,916	4	38.29	0.11%	0.2%
Cedar Creek (HUC 04100003 07)						
07 02	at confluence with John Diehl Ditch	10,828	3	47.34	0.44%	0.5%
07 04	HU outlet	15,712	2	18.60	0.12%	0.2%
07 05	HU outlet	15,048	10	174.01	1.16%	1.2%
07 07	HU outlet	133,244	63	665.95	0.50%	0.5%
St. Joseph River (HUC 04100003 08)						
08 06	HU outlet	148,662	174	1,679.86	1.13%	1.2%

Note: Only HUs with construction sites covered by the general NPDES permit are displayed.

Appendix H.

TMDLs to Address Impairments

Contents

Tables

Acronyms and Abbreviations

*	hydrologic unit code 04100003
AFG	allocation for future growth
CAFO	concentrated animal feeding operation
CSO	combined sewer overflow
CSS	combined sewer system
HU	hydrologic unit
HUC	hydrologic unit code
LA	load allocation
LTCP	long term control plan
MOS	margin of safety
NCCW	non-contact cooling water
NPDES	National Pollutant Discharge Elimination System
RSD	regional sewer district
SJR	St. Joseph River
SSO	sanitary sewer overflow
TMDL	total maximum daily load
TP	total phosphorus
WLA	wasteload allocation
WTP	water treatment plant
WWTP	wastewater treatment plant

Important Information for the Allocation Tables

Allocation section

- The TMDL row (bolded) is the exact summation of the load allocation (LA), wasteload allocation (WLA) summation, margin of safety (MOS), allocation for future growth (AFG), any nested TMDLs, and any upstream state contributions.
- The WLA (sum) row is the summation of individual and gross WLAs presented in the *Wasteload allocation* section of each table (see discussion below).
- In some cases, a TMDL subwatershed is within two or more states.
    - If the impairments are in both Ohio and Indiana, only a TMDL for the Indiana-portion was developed for this report.
        - If the impaired Indiana segment flows into an impaired Ohio watershed assessment unit, then an Indiana TMDL was developed at the Indian-Ohio state line.
        - If an impaired Ohio watershed assessment unit discharges to an impaired Indiana segment, then a TMDL was developed at the mouth of the subwatershed in Indiana. The Ohio TMDL was then referenced within the Indiana TMDL.
    - If the impairment is in only in Indiana (and not Ohio), then an *Ohio upstream contribution* was set for the Ohio portion in the Indiana TMDL.
    - *Upstream state contributions* were not further delineated into LAs, WLA, MOS, or AFG in the Indiana TMDLs.
- The LA, WLAs, MOS and AFG were based upon the area within Indiana.
- The LA, WLA (sum), MOS, AFG, and any nested TMDLs were rounded to the same digit as the TMDL, which often varied between flow zones of the same TMDL. *E. coli* allocations are rounded to the third significant digit in scientific notation.

Wasteload allocation section

- The individual and gross WLAs were rounded to the last digit of the TMDL.
- For a TMDL containing *upstream state contributions* or nested TMDLs, the WLAs reported in this section are for point sources in the TMDL subwatershed that are downstream of the state border (for u*pstream state contributions*) or downstream of the nested TMDL.
- In some cases, a point source with multiple waste-streams received a WLA for each waste-stream because the WLAs for the waste-streams were calculated differently (e.g., *treated effluent* WLAs are concentration-based while *stormwater* WLAs are area-based) or because the NPDES permit prohibitions vary by waste-stream (e.g., *non-contact cooling water* may not contain bacteria while *treated effluent* may contain bacteria).
- Sanitary treatment facilities with combined sewer overflows (CSOs) received separate WLAs for *treated effluent* and *CSOs*. WLAs for CSOs were allocated for discharges following storm events in the high flow zone. CSOs must also comply with their long term control plan (LTCP).
- Sanitary treatment facilities with known sanitary sewer overflows (SSOs) received separate WLAs for *treated effluent* and *SSOs*. As SSOs are prohibited discharges; their WLAs are zero.

- Concentrated animal feeding operations (CAFOs) in Indiana are prohibited from discharging to surface waterbodies; their WLAs are zero. Ohio has no CAFOs in the St. Joseph River watershed. Michigan has a single CAFO; it does not receive an explicit WLA because no TMDLs were developed in Michigan.
- WLAs were not developed for facilities with terminated or inactive permits.

H-1 *E. coli* TMDLs to Address Recreation Use Impairments

Table H-1. *E. coli* TMDL for West Branch Fish Creek at HU outlet (HUC 04100003 04 01)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**1.96E+11**	**6.96E+10**	**2.16E+10**	**5.72E+09**	**2.11E+09**
LA	1.67E+11	5.92E+10	1.84E+10	4.86E+09	1.79E+09
WLA [a]	0	0	0	0	0
MOS (10%)	1.96E+10	6.96E+09	2.16E+09	5.72E+08	2.11E+08
AFG (5%)	9.82E+09	3.48E+09	1.08E+09	2.86E+08	1.05E+08

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. No NPDES permittees are in the TMDL subwatershed.

Table H-2. *E. coli* TMDL for Fish Creek at HU outlet (HUC 04100003 04 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**1.55E+11**	**6.15E+10**	**1.78E+10**	**4.66E+09**	**1.83E+09**
Ohio's *Fish Creek at Ohio-Indiana state line TMDL* (*04 02) [a]	1.42E+11	4.85E+10	1.40E+10	4.04E+09	1.23E+09
LA [b]	1.09E+10	1.11E+10	3.22E+09	5.25E+08	5.12E+08
WLA [c]	0	0	0	0	0
MOS (10%) [b]	1.28E+09	1.30E+09	3.79E+08	6.18E+07	6.02E+07
AFG (5%) [b]	6.42E+08	6.48E+08	1.89E+08	3.09E+07	3.01E+07

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. A small portion of the HUC12 in Indiana drains to Ohio and this load is included in Ohio's TMDL.

b. The LA, MOS, and AFG are allocated for the Indiana-portion of this TMDL subwatershed that is downstream Ohio's .*Fish Creek at Ohio-Indiana state line* (HUC 04100003 04 02) TMDL

c. No NPDES permittees are in the TMDL subwatershed downstream of Ohio's *Fish Creek at Ohio-Indiana state line* (HUC 04100003 04 02) TMDL.

Table H-3. *E. coli* TMDL for Hiram Sweet Ditch at HU outlet (HUC 04100003 04 04)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**5.11E+11**	**1.72E+11**	**5.49E+10**	**1.78E+10**	**9.02E+09**
LA	4.31E+11	1.44E+11	4.44E+10	1.30E+10	5.53E+09
WLA	3.00E+09	2.42E+09	2.22E+09	2.16E+09	2.14E+09
MOS (10%)	5.11E+10	1.72E+10	5.49E+09	1.78E+09	9.02E+08
AFG (5%)	2.56E+10	8.61E+09	2.75E+09	8.92E+08	4.51E+08
Wasteload allocations					
Hamilton Lake Conservancy District (IN0050322)	2.13E+09	2.13E+09	2.13E+09	2.13E+09	2.13E+09
Hamilton Lake Water Works (IN0060216) [a]	--	--	--	--	--
Industrial stormwater [b]	8.65E+08	2.89E+08	8.91E+07	2.61E+07	1.11E+07

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.
a. Hamilton Lake Water Works (IN0060216) is not expected to be a source of *E. coli*.
b. The gross WLA represents the following facilities: AZZ Galvanizing (INRM01504) and Rieke Packaging System (INRM01907).

Table H-4. *E. coli* TMDL for Fish Creek at HU outlet (HUC 04100003 04 05)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**5.62E+11**	**1.96E+11**	**5.93E+10**	**2.61E+10**	**8.97E+09**
Ohio upstream contribution [a]	3.34E+10	1.12E+10	3.73E+09	6.42E+08	2.45E+08
*Fish Creek at HU outlet (HUC *04 01) TMDL* (see Table H-1)	1.96E+11	6.96E+10	2.16E+10	5.72E+09	2.11E+09
*Fish Creek at HU outlet (HUC *04 02) TMDL* (see Table H-2)	1.55E+11	6.15E+10	1.78E+10	4.66E+09	1.83E+09
LA [b]	1.46E+11	4.43E+10	1.32E+10	1.27E+10	4.03E+09
WLA [c]	0	0	0	0	0
MOS (10%) [b]	2.11E+10	6.53E+09	1.99E+09	1.57E+09	5.03E+08
AFG (5%) [b]	1.05E+10	3.26E+09	1.00E+09	7.85E+08	2.51E+08

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.
a. The Ohio portion of this TMDL subwatershed is 16 percent of the TMDL subwatershed downstream of the nested TMDLs.
b. The LA, MOS, and AFG are allocated for the Indiana-portion of this TMDL subwatershed downstream of the nested TMDLs.
c. No NPDES permittees are in the TMDL subwatershed.

Table H-5. *E. coli* TMDL for Fish Creek at Indiana-Ohio state line (HUC 04100003 04 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**1.22E+12**	**4.32E+11**	**1.38E+11**	**5.38E+10**	**1.87E+10**
*Hiram Sweet Ditch at HU outlet (*04 04) TMDL* (see Table H-3)	5.11E+11	1.72E+11	5.49E+10	1.78E+10	9.02E+09
*Fish Creek at HU outlet (*04 05) TMDL* (see Table H-4)	5.62E+11	1.96E+11	5.93E+10	2.61E+10	8.97E+09
LA [a]	1.27E+11	5.40E+10	2.03E+10	8.41E+09	5.98E+08
WLA [b]	0	0	0	0	0
MOS (10%) [a]	1.49E+10	6.35E+09	2.39E+09	9.89E+08	7.03E+07
AFG (5%) [a]	7.45E+09	3.18E+09	1.19E+09	4.95E+08	3.51E+07

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.
a. The LA, MOS, and AFG are allocated for the Indiana-portion of this TMDL subwatershed downstream of the *Fish Creek at HU outlet (HUC 04100003 04 05)* TMDL.
b. No NPDES permittees are in the TMDL subwatershed downstream of the *Fish Creek at HU outlet (HUC 04100003 04 05)* TMDL.

Table H-6. *E. coli* TMDL for Big Run at Indiana-Ohio state line (HUC 04100003 05 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**3.47E+11**	**1.36E+11**	**5.34E+10**	**2.46E+10**	**1.78E+10**
LA	2.79E+11	1.01E+11	3.10E+10	6.75E+09	9.22E+08
WLA (sum)	1.57E+10	1.47E+10	1.44E+10	1.42E+10	1.42E+10
MOS (10%)	3.47E+10	1.36E+10	5.34E+09	2.46E+09	1.78E+09
AFG (5%)	1.74E+10	6.80E+09	2.67E+09	1.23E+09	8.90E+08
Wasteload allocations					
Butler WWTP (IN0022462) *treated effluent*	1.42E+10	1.42E+10	1.42E+10	1.42E+10	1.42E+10
Butler WWTP (IN0022462) *CSOs* [a]	0	0	0	0	0
East Side High School (ING250077) [b]	0	--	--	--	--
Industrial stormwater [c]	1.40E+09	5.07E+08	1.56E+08	3.34E+07	4.63E+06
Irish Acres Dairy, LLC *CAFO* [d]	0	0	0	0	0

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.
a. The WLAs for Butler WWTP (IN0022462) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.
b. East Side High School (ING250077; NCCW) is not expected to be a source of *E. coli*.
d. The gross WLA represents the following facilities: DeKalb Molded Plastics Company (INRM01605), International Paper Company (INRM001734), and New Millennium Building Systems, LLC (INRM00985).
d. Irish Acres Dairy, LLC is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-7. *E. coli* TMDL for Cedar Creek at HU outlet (HUC 04100003 06 01)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**3.39E+11**	**1.18E+11**	**2.97E+10**	**9.30E+09**	**3.24E+09**
LA	2.87E+11	1.00E+11	2.52E+10	7.90E+09	2.75E+09
WLA (sum)	8.64E+08	3.01E+08	7.56E+07	2.38E+07	8.25E+06
MOS (10%)	3.39E+10	1.18E+10	2.97E+09	9.30E+08	3.24E+08
AFG (5%)	1.69E+10	5.91E+09	1.48E+09	4.66E+08	1.62E+08
Wasteload allocations					
Benchmark Distribution Terminals (ING340037) [a]	2.88E+08	1.00E+08	2.52E+07	7.93E+06	2.75E+06
Industrial stormwater [b]	5.76E+08	2.01E+08	5.04E+07	1.59E+07	5.50E+06
Phillips Farm *CAFO* [c]	0	0	0	0	0

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The Benchmark Distribution Terminals (ING340037) is covered by Indiana's general NPDES permit for petroleum products terminals and the WLAs in this allocation table were calculated using Indiana's in-stream, geometric mean *E. coli* water quality standard. The specific WLAs in this allocation table will not be incorporated into the general permit.

b. The gross WLA represents the following facilities: Nucor Building Systems (INRM00941), OmniSource Corporation (INRM01759), and United Parcel Service Waterloo (INRM00244).

c. Phillips Farm is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-8. *E. coli* TMDL for Cedar Creek at HU outlet (HUC 04100003 06 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**6.81E+11**	**2.37E+11**	**6.44E+10**	**2.01E+10**	**9.15E+09**
*Cedar Creek at HU outlet (*06 01) TMDL* (see Table H-7)	3.39E+11	1.18E+11	2.97E+10	9.30E+09	3.24E+09
LA [a]	2.87E+11	9.92E+10	2.75E+10	7.35E+09	3.25E+09
WLA (sum) [a]	3.78E+09	2.44E+09	1.94E+09	1.80E+09	1.77E+09
MOS (10%) [a]	3.42E+10	1.18E+10	3.47E+09	1.08E+09	5.91E+08
AFG (5%) [a]	1.71E+10	5.92E+09	1.74E+09	5.38E+08	2.96E+08
Wasteload allocations					
Benchmark Distribution Terminals (ING340037)	2.89E+08	9.89E+07	2.78E+07	7.40E+06	3.28E+06
Industrial stormwater [c]	1.74E+09	5.94E+08	1.67E+08	4.44E+07	1.97E+07
Waterloo Public Water Supply (IN0049433) [d]	--	--	--	--	--
Waterloo WWTP (IN0020711)	1.75E+09	1.75E+09	1.75E+09	1.75E+09	1.75E+09

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the *Cedar Creek at HU outlet (HUC 04100003 06 01)* TMDL.

b. The Benchmark Distribution Terminals (ING340037) is covered by Indiana's general NPDES permit for petroleum products terminals and the WLAs in this allocation table were calculated using Indiana's in-stream, geometric mean *E. coli* water quality standard. The specific WLAs in this allocation table will not be incorporated into the general permit.

c. The gross WLA represents the following facilities: Aggregate Industries Klink Concrete (INRM00184) and IPI Waterloo Recylcing Center, LLC (INRM00487).

d. Waterloo Public Water Supply (IN0049433) is not expected to be a source of *E. coli*.

Table H-9. *E. coli* TMDL for Cedar Creek at HU outlet (HUC 04100003 06 04)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**1.13E+12**	**4.28E+11**	**1.39E+11**	**5.70E+10**	**3.78E+10**
*Cedar Creek at HU outlet (*06 02) TMDL* (see Table H-8)	6.81E+11	2.37E+11	6.44E+10	2.01E+10	9.15E+09
LA [a]	3.21E+11	1.25E+11	3.72E+10	8.59E+09	2.24E+09
WLA (sum) [a]	6.13E+10	3.72E+10	2.64E+10	2.28E+10	2.21E+10
MOS (10%) [a]	4.50E+10	1.91E+10	7.47E+09	3.70E+09	2.87E+09
AFG (5%) [a]	2.25E+10	9.56E+09	3.74E+09	1.85E+09	1.43E+09
Wasteload allocations					
Auburn (INR040119) *MS4*	3.81E+10	1.49E+10	4.41E+09	1.02E+09	2.77E+08
Auburn Gear (IN0000566)	4.73E+08	4.73E+08	4.73E+08	4.73E+08	4.73E+08
Auburn Gear (IN0000566) *NCCW* [b]	0	--	--	--	--
Auburn Gear (IN0000566) *stormwater*	7.22E+08	2.82E+08	8.35E+07	1.93E+07	5.26E+06
Auburn WWTP (IN0020672) *treated effluent*	2.13E+10	2.13E+10	2.13E+10	2.13E+10	2.13E+10
Auburn WWTP (IN0020672, outfalls 002, 007, and 009) *CSOs* [c]	0	0	0	0	0
Industrial stormwater [d]	3.61E+08	1.41E+08	4.18E+07	9.64E+06	2.63E+06
Rieke Packaging Systems (IN0000868) *NCCW* [b]	0	--	--	--	--
Rieke Packaging Systems (IN0000868) *stormwater*	3.61E+08	1.41E+08	4.18E+07	9.64E+06	2.63E+06

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the *Cedar Creek at HU outlet (HUC 04100003 06 02)* TMDL.

b. Auburn Gear (IN0000566; NCCW) and Rieke Packaging Systems (IN0000868; NCCW) are not expected to be a source of *E. coli*.

c. The WLAs for Auburn WWTP (IN0020672) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.

d. The gross WLA represents the following facilities: Auburn Gear Inc. (INRM01782), Cooper Standard Automotive (INRM01167), FXI Incorporated (INRM01118), and OmniSource Corporation Auburn (INRM00784).

Table H-10. *E. coli* TMDL for Peckhart Ditch at confluence with John Diehl Ditch (HUC 04100003 07 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**2.11E+11**	**7.61E+10**	**2.07E+10**	**6.62E+09**	**1.60E+09**
LA	1.77E+11	6.36E+10	1.73E+10	5.54E+09	1.34E+09
WLA (sum)	2.86E+09	1.03E+09	2.82E+08	8.98E+07	2.18E+07
MOS (10%)	2.11E+10	7.61E+09	2.07E+09	6.62E+08	1.60E+08
AFG (5%)	1.05E+10	3.81E+09	1.04E+09	3.31E+08	8.00E+07
Wasteload allocations					
Auburn (INR040119) *MS4*	5.30E+08	1.92E+08	5.22E+07	1.67E+07	4.03E+06
Contech U.S. LLC (IN0046043) *NCCW* [a]	--	--	--	--	--
Contech U.S. LLC (IN0046043) *stormwater*	1.79E+08	6.47E+07	1.76E+07	5.63E+06	1.36E+06
Haynes Dairy Farm CFO	0	0	0	0	0
Industrial stormwater [b]	1.61E+09	5.82E+08	1.59E+08	5.06E+07	1.23E+07
Metal Technologies (IN0061263) *NCCW* a	--	--	--	--	--
Metal Technologies (IN0061263) *stormwater*	5.37E+08	1.94E+08	5.29E+07	1.69E+07	4.09E+06
Sunrise Heifer Farms, LLC *CAFO* [c]	0	0	0	0	0
Tower Automotive USA II (IN0046761) [a]	--	--	--	--	--

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.
a. Contech U.S. LLC (IN0046043; NCCW), Metal Technologies (IN0061263), and Tower Automotive USA II (IN0046761; NCCW) are not expected to be a source of *E. coli*.
b. The gross WLA represents the following facilities: Ball Brass and Aluminum Foundry Inc. (INRM01370) and Metal X Auburn (INRM01768).
c. Sunrise Heifer Farms, LLC is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-11. *E. coli* TMDL for Black Creek at HU outlet (HUC 04100003 07 04)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**3.06E+11**	**1.07E+11**	**3.08E+10**	**1.14E+10**	**2.84E+09**
LA	2.60E+11	9.06E+10	2.59E+10	9.46E+09	2.18E+09
WLA (sum)	2.37E+08	2.37E+08	2.37E+08	2.37E+08	2.37E+08
MOS (10%)	3.06E+10	1.07E+10	3.08E+09	1.14E+09	2.84E+08
AFG (5%)	1.53E+10	5.34E+09	1.54E+09	5.70E+08	1.42E+08
Wasteload allocations					
LaOtto Regional Sewer District (IN0058611)	2.37E+08	2.37E+08	2.37E+08	2.37E+08	2.37E+08

Note: The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

Table H-12. *E. coli* TMDL for Little Cedar Creek at HU outlet (HUC 04100003 07 05)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**9.02E+11**	**3.19E+11**	**8.95E+10**	**3.47E+10**	**1.32E+10**
*Black Creek at HU outlet (*07 04) TMDL* (see Table H-11)	3.06E+11	1.07E+11	3.08E+10	1.14E+10	2.84E+09
LA [a]	5.02E+11	1.76E+11	4.67E+10	1.67E+10	5.79E+09
WLA (sum) [a]	5.04E+09	3.74E+09	3.22E+09	3.10E+09	3.05E+09
MOS (10%) [a]	5.95E+10	2.12E+10	5.87E+09	2.33E+09	1.04E+09
AFG (5%) [a]	2.98E+10	1.06E+10	2.94E+09	1.17E+09	5.20E+08
Wasteload allocations					
Allen County & others (INR040131) *MS4*	1.00E+09	3.54E+08	9.36E+07	3.35E+07	1.16E+07
Avila Water Department (IN0052035) [b]	--	--	--	--	--
Avila WWTP (IN0020664)	2.84E+09	2.84E+09	2.84E+09	2.84E+09	2.84E+09
Indian Springs Recreation Campground (IN0032107)	1.89E+08	1.89E+08	1.89E+08	1.89E+08	1.89E+08
Industrial stormwater [c]	1.01E+09	3.55E+08	9.38E+07	3.36E+07	1.16E+07

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the *Black Creek at HU outlet (HUC 04100003 07 04)* TMDL.

b. The Avila Water Department (IN0052035) is not expected to be a source of *E. coli*.

c. The gross WLA represents the following facilities: Electric Motors & Specialties Incorporated (INRM00918), Kautex Incorporated (INRM01494), and Victor Reinz Valve Seals, LLC (INRM01208).

Table H-13. *E. coli* TMDL for Willow Creek at HU outlet (HUC 04100003 07 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**4.10E+11**	**1.42E+11**	**4.10E+10**	**1.28E+10**	**3.49E+09**
LA	3.15E+11	1.09E+11	3.15E+10	9.82E+09	2.68E+09
WLA (sum)	3.31E+10	1.14E+10	3.31E+09	1.03E+09	2.82E+08
MOS (10%)	4.10E+10	1.42E+10	4.10E+09	1.28E+09	3.49E+08
AFG (5%)	2.05E+10	7.09E+09	2.05E+09	6.38E+08	1.74E+08
Wasteload allocations					
Allen County & others (INR040131) *MS4*	3.31E+10	1.14E+10	3.31E+09	1.03E+09	2.82E+08

Note: The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

Table H-14. *E. coli* TMDL for Cedar Creek at HU outlet (HUC 04100003 07 07)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**3.34E+12**	**1.24E+12**	**3.86E+11**	**1.48E+11**	**8.02E+10**
*Cedar Creek at HU outlet (*06 04) TMDL* (see Table H-9)	1.13E+12	4.28E+11	1.39E+11	5.70E+10	3.78E+10
*Peckhart Ditch at confluence with John Diehl Ditch (*07 02) TMDL* (see Table H-10)	2.11E+11	7.61E+10	2.07E+10	6.62E+09	1.60E+09
*Little Cedar Creek at HU outlet (*07 05) TMDL* (see Table H-12)	9.02E+11	3.19E+11	8.95E+10	3.47E+10	1.32E+10
*Willow Creek at HU outlet (*07 06) TMDL* (see Table H-13)	4.10E+11	1.42E+11	4.10E+10	1.28E+10	3.49E+09
LA [a]	5.54E+11	2.18E+11	7.27E+10	2.46E+10	1.40E+10
WLA (sum) [a]	3.25E+10	1.62E+10	9.24E+09	6.97E+09	6.47E+09
MOS (10%) [a]	6.90E+10	2.75E+10	9.53E+09	3.72E+09	2.41E+09
AFG (5%) [a]	3.45E+10	1.38E+10	4.76E+09	1.86E+09	1.20E+09
Wasteload allocations					
Allen County & others (INR040131) *MS4*	1.27E+10	4.99E+09	1.64E+09	5.64E+08	3.21E+08
Auburn (INR040119) *MS4*	1.04E+10	4.09E+09	1.35E+09	4.61E+08	2.62E+08
Auburn WWTP (IN0020672; outfall 010) *CSO* [b]	0	0	0	0	0
Corunna WWTP (IN0047473)	1.14E+08	1.14E+08	1.14E+08	1.14E+08	1.14E+08
Garrett Municipal WWTP (IN0022969)	5.68E+09	5.68E+09	5.68E+09	5.68E+09	5.68E+09
Industrial stormwater [c]	3.48E+09	1.37E+09	4.51E+08	1.55E+08	8.80E+07

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the nested TMDLs.

b. The WLAs for Auburn WWTP (IN0020672) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.

c. The gross WLA represents the following facilities: DeKalb County Airport (INRM00501), Griffith Rubber Mills- Taylor Road (INRM00652), Harsco Industrial IKG (INRM01740), and Momentive Performance Materials (INRM00519).

Table H-15. *E. coli* TMDL for St. Joseph River just upstream of confluence of Bear Creek (HUC 04100003 08 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**8.32E+12**	**2.99E+12**	**1.06E+12**	**4.00E+11**	**1.99E+11**
Ohio's *SJR at Ohio-Indiana state line (*05 05)* TMDL [a]	7.71E+12	2.73E+12	9.77E+11	3.76E+11	1.89E+11
LA [b]	5.09E+11	2.10E+11	6.23E+10	1.45E+10	3.07E+09
WLA (sum) [b]	9.78E+09	7.45E+09	6.18E+09	5.80E+09	5.70E+09
MOS (10%) [b]	6.10E+10	2.67E+10	8.06E+09	2.39E+09	1.03E+09
AFG (5%) [b]	3.05E+10	1.34E+10	4.03E+09	1.20E+09	5.16E+08
Wasteload allocations					
Industrial stormwater [c]	3.59E+09	1.55E+09	4.40E+08	1.03E+08	2.17E+07
Laub Farm LLC *CAFO* [d]	0	0	0	0	0
Mark S. Rekewege *CAFO* [d]	0	0	0	0	0
Stafford Gravel Inc. (ING490043) [e]	--	--	--	--	--
Steel Dynamics Inc. (IN0059201)	5.68E+09	5.68E+09	5.68E+09	5.68E+09	5.68E+09
Steel Dynamics Inc. (IN0059201) *stormwater*	5.13E+08	2.22E+08	6.28E+07	1.46E+07	3.09E+06

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. Small portions Indiana in the SJRW drain to Ohio and their loads are included in Ohio's *SJR at Ohio-Indiana state line (HUC *05 05)* TMDL.

b. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of Ohio's *SJR at Ohio-Indiana state line (HUC *05 05)* TMDL.

c. The gross WLA represents the following facilities: Auburn Transfer Station (INRM01233), Nucor Fastener (INRM00939), Nucor Vulcraft – St. Joe Division (INRM00978), and Therma Tru Corporation (INRM00973).

d. Laub Farm LLC and Mark S. Rekewege are CAFOs in Indiana; as such, they are prohibited from discharging to surface waterways.

e. Stafford Gravel Inc. (ING490043; dimeson stone and crushed stone operations) is not expected to be a source of *E. coli*.

Table H-16. *E. coli* TMDL for St. Joseph River at HU outlet (HUC 04100003 08 03)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**9.10E+12**	**3.35E+12**	**1.15E+12**	**4.29E+11**	**2.01E+11**
*SJR just upstream of the confluence of Bear Creek (*08 02) TMDL* (see Table H-15)	8.32E+12	2.99E+12	1.06E+12	4.00E+11	1.99E+11
LA [a]	6.42E+11	3.03E+11	6.81E+10	2.30E+10	1.39E+09
WLA (sum) [a]	1.68E+10	7.98E+09	2.71E+09	1.37E+09	8.14E+08
MOS (10%) [a]	7.86E+10	3.54E+10	9.51E+09	2.87E+09	1.42E+08
AFG (5%) [a]	3.93E+10	1.77E+10	4.76E+09	1.43E+09	7.08E+07
Wasteload allocations					
Allen County & others (INR040131) *MS4*	1.20E+10	5.38E+09	1.43E+09	4.22E+08	7.16E+06
Deer Track Estates WWTP (IN0059749)	6.64E+08	2.99E+08	7.97E+07	2.35E+07	3.98E+05
Fort Wayne Utilities - Honeysuckle Site (IN0063061) [b]	--	--	--	--	--
Industrial stormwater [c]	3.34E+09	1.50E+09	4.00E+08	1.18E+08	2.00E+06
Pickle Properties (IN0032981) [b]	--	--	--	--	--
St. Joe - Spencerville RSD (IN0058441)	8.04E+08	8.04E+08	8.04E+08	8.04E+08	8.04E+08

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in counts of *E. coli* per day.

a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of *SJR just upstream of the confluence with Bear Creek (HUC *08 02)* TMDL.

b. Fort Wayne Utilities - Honeysuckle Site (IN0063061; WTP) and Pickle Properties (IN0032981) are not expected to be a source of *E. coli*.

c. The gross WLA represents the following facilities: Rhinehart Finishing LLC (INRM00263) and Sechlers Pickles Incorporated (INRM00421).

H-2 Total Phosphorus TMDLs to Address Aquatic Life Use Impairments

Table H-17. TP TMDL for Fish Creek at HU outlet (HUC 04100003 04 05)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**297**	**103.9**	**31.4**	**13.8**	**4.74**
Ohio upstream contribution [a]	18	5.9	2.0	0.3	0.13
LA [b]	251	88.2	26.4	12.1	4.15
WLA [c]	0	0	0	0	0
MOS (5%) [b]	14	4.9	1.5	0.7	0.23
AFG (5%) [b]	14	4.9	1.5	0.7	0.23

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.
a. A small portion of the HUC12 in Indiana drains to Ohio. The Ohio portion of this TMDL subwatershed is not impaired for its aquatic life use.
b. The LA, MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the *Ohio upstream contribution*.
c. No NPDES permittees are in the TMDL subwatershed.

Table H-18. TP TMDL for Fish Creek at Indiana-Ohio state line (HUC 04100003 04 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**646**	**229**	**73.1**	**28.5**	**9.89**
*Fish Creek at HU outlet (*04 05) TMDL* (see Table H-17)	297	104	31.4	13.8	4.74
LA [a]	309	107	33.5	9.3	0.85
WLA (sum) [a]	6	6	4.0	4.0	3.78
MOS (5%) [a]	17	6	2.1	0.7	0.26
AFG (5%) [a]	17	6	2.1	0.7	0.26
Wasteload allocations					
Construction stormwater	1	1	0.1	0.1	0.01
Hamilton Lake Conservancy District (IN0050322)	4	4	3.8	3.8	3.76
Hamilton Lake Water Works (IN0060216) [b]	--	--	--	--	--
Industrial stormwater [c]	1	1	0.1	0.1	0.01

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.
a. The LA, WLA(sum), MOS, and AFG are allocated for the portion of this TMDL subwatershed downstream of the *Fish Creek at HU outlet (HUC *04 05)* TMDL.
b. Hamilton Lake Water Works (IN0060216) is not expected to be a source of TP.
c. The gross WLA represents the following facilities: AZZ Galvanizing (INRM01504) and Rieke Packaging System (INRM01907).

Table H-19. TP TMDL for Cedar Creek at HU outlet (HUC 04100003 06 01)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**179.2**	**62.6**	**15.7**	**4.94**	**1.71**
LA	160.5	56.0	13.8	4.41	1.50
WLA (sum)	0.7	0.4	0.3	0.03	0.03
MOS (5%)	9.0	3.1	0.8	0.25	0.09
AFG (5%)	9.0	3.1	0.8	0.25	0.09
Wasteload allocations					
Benchmark Distribution Terminals (ING340037) [a]	0.2	0.1	0.1	0.01	0.01
Construction stormwater	0.3	0.1	0.1	0.01	0.01
Industrial stormwater [b]	0.2	0.2	0.1	0.01	0.01
Phillips Farm *CAFO* [c]	0	0	0	0	0

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.

a. The Benchmark Distribution Terminals (ING340037) is covered by Indiana's general NPDES permit for petroleum products terminals and the WLAs in this allocation table were calculated using Indiana's in-stream 0.30 milligram per liter target. The specific WLAs in this allocation table will not be incorporated into the general permit.

b. The gross WLA represents the following facilities: Nucor Building Systems (INRM00941), OmniSource Corporation (INRM01759), and United Parcel Service Waterloo (INRM00244).

c. Phillips Farm is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-20. TP TMDL for Cedar Creek at HU outlet (HUC 04100003 06 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**360.3**	**125.2**	**34.1**	**10.63**	**4.842**
*Cedar Creek at HU outlet (*06 01) TMDL* (see Table H-19)	179.2	62.6	15.7	4.94	1.713
LA	158.2	52.7	13.2	2.02	1.242
WLA (sum)	4.7	3.7	3.4	3.11	1.575
MOS (5%)	9.1	3.1	0.9	0.28	0.156
AFG (5%)	9.1	3.1	0.9	0.28	0.156
Wasteload allocations					
Benchmark Distribution Terminals (ING340037) [a]	0.2	0.1	0.1	0.01	0.001
Construction stormwater	1.1	0.4	0.1	0.01	0.009
Industrial stormwater [b]	0.3	0.1	0.1	0.01	0.003
Waterloo WWTP (IN0020711)	3.1	3.1	3.1	3.08	1.562

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.

a. The Benchmark Distribution Terminals (ING340037) is covered by Indiana's general NPDES permit for petroleum products terminals and the WLAs in this allocation table were calculated using Indiana's in-stream 0.30 milligram per liter target. The specific WLAs in this allocation table will not be incorporated into the general permit.

b. The gross WLA represents the following facilities: Aggregate Industries Klink Concrete (INRM00184) and IPI Waterloo Recycling Center, LLC (INRM00487).

Table H-21. TP TMDL for Unnamed tributary to Mason Ditch at the confluence with Mason Ditch (HUC 04100003 06 03)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**9.8**	**3.56**	**0.99**	**0.24**	**0.049**
LA	8.8	3.20	0.89	0.22	0.045
WLA [a]	0	0	0	0	0
MOS (5%)	0.5	0.18	0.05	0.01	0.002
AFG (5%)	0.5	0.18	0.05	0.01	0.002

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.
a. No NPDES permittees are in the TMDL subwatershed.

Table H-22. TP TMDL for Peckhart Ditch at confluence with John Diehl Ditch (HUC 04100003 07 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**111.5**	**40.3**	**11.0**	**3.50**	**0.85**
LA	99.0	35.8	9.7	3.09	0.73
WLA (sum)	1.3	0.5	0.3	0.05	0.04
MOS (5%)	5.6	2.0	0.5	0.18	0.04
AFG (5%)	5.6	2.0	0.5	0.18	0.04
Wasteload allocations					
Auburn (INR040119) *MS4*	0.3	0.1	0.1	0.01	0.01
Construction stormwater	0.5	0.2	0.0	0.02	0.01
Contech U.S. LLC (IN0046043) *NCCW* [a]	--	--	--	--	--
Contech U.S. LLC (IN0046043) *storm water*	0.1	0.1	0.1	0.01	0.01
Haynes Dairy Farm *CFO*	0	0	0	0	0
Industrial stormwater [b]	0.4	0.1	0.1	0.01	0.01
Sunrise Heifer Farms, LLC *CAFO* [c]	0	0	0	0	0
Tower Automotive USA II (IN0046761) [a]	--	--	--	--	--

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.
a. Contech U.S. LLC (IN0046043; NCCW) and Tower Automotive USA II (IN0046761; NCCW) are not expected to be a source of TP.
b. The gross WLA represents the following facilities: Ball Brass and Aluminum Foundry Inc. (INRM01370) and Metal X Auburn (INRM01768).
c. Sunrise Heifer Farms, LLC is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-23. TP TMDL for Cedar Creek at HU outlet (HUC 04100003 07 07)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**1,769**	**656.1**	**203.8**	**78.2**	**42.33**
*Cedar Creek at HU outlet (*06 02) TMDL* (see Table H-20)	360	125.2	34.1	10.6	4.84
*Unnamed tributary to Matson Ditch at confluence with Matson Ditch (*06 03) TMDL* (see Table H-21)	10	3.6	1.0	0.2	0.05
*Peckhart Ditch at confluence with John Diehl Ditch (*07 02) TMDL* (see Table H-22)	111	40.3	11.0	3.5	0.85
LA	1,033	359.2	81.9	2.5	14.43
WLA (sum)	127	79.0	60.0	55.0	18.50
MOS (5%)	64	24.4	7.9	3.2	1.83
AFG (5%)	64	24.4	7.9	3.2	1.83
Wasteload allocations					
Allen County & others (INR040131) *MS4*	27	9.5	2.2	0.1	0.08
Auburn (INR040119) *MS4*	29	10.2	2.3	0.1	0.08
Auburn Gear (IN0000566)	1	0.8	0.8	0.8	0.83
Auburn Gear (IN0000566) *NCCW* [a]	0	--	--	--	--
Auburn Gear (IN0000566) *stormwater*	1	0.4	0.1	0.1	0.01
Auburn WWTP (IN0020672) treated *effluent*	38	37.6	37.6	37.6	16.56 [b]
Auburn CSS (IN0020672) *CSOs* [c]	0	0	0	0	0
Avila Water Department (IN0052035) [a]	--	--	--	--	--
Avila WWTP (IN0020664)	5	5.0	5.0	5.0	0.29 [b]
Construction stormwater	7	2.3	0.5	0.1	0.02
Corunna WWTP (IN0047473)	1	0.2	0.2	0.2	0.01 [b]
Garrett Municipal WWTP (IN0022969)	10	10.0	10.0	10.0	0.56 [b]
Indian Springs Recreation Campground (IN0032107)	1	0.3	0.3	0.3	0.01 [b]
LaOtto Regional Sewer District (IN0058611)	4	1.5	0.4	0.1	0.01
Industrial stormwater [d]	1	0.4	0.4	0.4	0.02 [b]
Metal Technologies (IN0061263) *NCCW* [a]	--	--	--	--	--
Metal Technologies (IN0061263) *stormwater*	1	0.4	0.1	0.1	0.01
Rieke Packaging Systems (IN0000868) *NCCW* [a]	--	--	--	--	--
Rieke Packaging Systems (IN0000868) *stormwater*	1	0.4	0.1	0.1	0.01

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.

a. Auburn Gear (IN0000556; NCCW), Avila Water Department (IN0052035; WTP), Metal Technologies (IN0061263; NCCW), and Rieke Packaging Systems (IN0000868; NCCW) are not expected to be a source of TP..

b. The WLAs for these sanitary wastewater treatment facilities were calculated using the average flow reported in discharge monitoring reports from July through September in lieu of using the average design flow. If the average design flows would be used, then during the low flow duration interval, the summation of these WLAs would exceed the TMDL. IDEM decided that use of the average of July through September effluent flows was appropriate for the low flow duration interval because these sanitary wastewater treatment facilities discharge at a small fraction of their average design flows during summer low-flow periods (i.e., July through September).
c. The WLAs for Auburn WWTP (IN0020672) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.
d. The gross WLA represents the following facilities: Auburn Gear Inc. (INRM01782), Cooper Standard Automotive (INRM01167), DeKalb County Airport (INRM00501), Electric Motors & Specialties Incorporated (INRM00918), FXI Incorporated (INRM01118), Griffith Rubber Mills- Taylor Road (INRM00652), Harsco Industrial IKG (INRM01740), Kautex Incorporated (INRM01494), Momentive Performance Materials (INRM00519), OmniSource Corporation Auburn (INRM00784), and Victor Reinz Valve Seals, LLC (INRM01208).

Table H-24. TP TMDL for St. Joseph River at HU outlet (HUC 04100003 08 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL at the mouth o the St. Joseph River (pounds per day)					
TMDL at mouth of St. Joseph River	**6,779**	**2,513**	**802.1**	**247.3**	**74.25**
TMDL at the Fort Wayne PWS intake	6,882	2,600	881.6	322.7	144.58
Withdrawal at the Fort Wayne PWS intake	-103	-87	-79.5	-75.3	-70.33
TMDL at the Fort Wayne PWS intake on the St. Joseph River (pounds per day)					
TMDL	**6,882**	**2,600**	**881.6**	**322.7**	**144.58**
Indiana upstream allocation	69	26	8.5	2.0	0.71
Michigan upstream allocation [a]	981	365	111.9	40.6	14.24
Ohio upstream allocation [a]	2,120	786	285.8	106.8	58.51
*Cedar Creek at HU outlet (*07 07) TMDL* (see Table H-23)	1,769	656	203.8	78.2	42.33
LA	1,394	531	168.5	39.3	6.35
WLA (sum)	356	160	75.9	46.2	19.56
MOS (5%)	97	38	13.6	4.8	1.44
AFG (5%)	97	38	13.6	4.8	1.44
Wasteload allocations at the Fort Wayne PWS intake on the St. Joseph River (pounds per day)					
Allen County & others (INR040131) *MS4*	104	40	12.7	3.0	0.47
Butler WWTP (IN0022462) *treated effluent*	25	25	25.0	25.0	7.57 [b]
Butler WWTP (IN0022462) *CSOs* [c]	0	0	0	0	0
Construction stormwater	21	8	2.5	0.6	0.09
East Side High School (ING250077) [d]	0	--	--	--	--
Fort Wayne & others (INR040029) *MS4*	185	71	22.5	5.3	0.84
Fort Wayne Municipal WWTP (IN0032191) *CSOs* [e]	0	0	0	0	0
Fort Wayne Municipal WWTP (IN0032191) *SSOs* [f]	0	0	0	0	0
Fort Wayne Utilities - Honeysuckle Site (IN0063061) [d]	--	--	--	--	--
Grabill Water Works (IN0044369) [d]	--	--	--	--	--
Industrial stormwater [g]	9	3	1.0	0.2	0.04
Irish Acres Dairy, LLC *CAFO* [h]	0	0	0	0	0
Laub Farm LLC *CAFO* [h]	0	0	0	0	0
Mark S. Rekewege *CAFO* [h]	0	0	0	0	0
Northcrest Shopping Center (ING080271) [d]	--	--	--	--	--
Pickle Properties (IN0032981) [d]	--	--	--	--	--
Stafford Gravel Inc. (ING490043) [d]	--	--	--	--	--
Steel Dynamics Inc. (IN0059201)	10	10	10.0	10.0	10.00
Steel Dynamics Inc. (IN0059201) *stormwater*	2	1	0.2	0.1	0.01
St Joe – Spencerville RSD (IN0058441)	2	2	2	2	0.54 [b]

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in pounds of TP per day.

The TMDL at the mouth of the St. Joseph River is equivalent to the TMDL at the Fort Wayne PWS intake less the load withdrawn at the PWS intake.

a. Michigan waters in the SJRW are not impaired for their aquatic life use. Two watershed assessment units in Ohio are impaired for their aquatic life use due to nutrients. Ohio EPA will develop TMDLs for these two watershed assessment units.

b. The WLAs for these sanitary wastewater treatment facilities were calculated using the average flow reported in discharge monitoring reports from July through September in lieu of using the average design flow. If the average design flows would be used, then during the low flow duration interval, the summation of these WLAs would exceed the TMDL. IDEM decided that use of the average of July through September effluent flows was appropriate for the low flow duration interval because these sanitary wastewater treatment facilities discharge at a small fraction of their average design flows during summer low-flow periods (i.e., July through September).

c. The WLAs for Butler WWTP (IN0022462) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.

d. Eagle-Picher Plastic Division (IN0000574; NCCW), East Side High School (ING250077; NCCW), Fort Wayne Utilities - Honeysuckle Site (IN0063061; WTP), Grabill Water Works (IN0044369), Northcrest Shopping Center (ING080271; groundwater petroleum remediation system), Pickle Properties (IN0032981), and Stafford Gravel, Inc. (ING490043; dimension stone and crushed stone operations) are not expected to be a source of TP..

e. The WLAs for Fort Wayne WWTP (IN032191) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP and Consent Decree.

f. This Fort Wayne Municipal WWTP (IN032191) WLA is for SSOs, which are prohibited discharges. The Fort Wayne CSS must comply with its LTCP and the Consent Decree.

g. The gross WLA represents the following facilities: Auburn Transfer Station (INRM01233), DeKalb Molded Plastics Company (INRM01605),Guardian Automotive Products Incorporated (INRM01012), International Paper Company (INRM001734), Irving Ready Mix Inc. (INR210049), M & W Countertops Inc. (INRM01108), Magna Exteriors & Interiors (INRM1781), New Millennium Building Systems, LLC (INRM00985), Nucor Fastener (INRM00939), Nucor Vulcraft – St. Joe Division (INRM00978), Rhinehart Finishing LLC (INRM00263), R3 Composites Corporation (INRM00406), Sauder Manufacturing Company (INRM00121 and INRM00144), Sechlers Pickles Incorporated (INRM00421), Smith Field Airport (INRM01228), Speedway Transit Mix and Concrete Plant Management (INRM01671), and Therma Tru Corporation (INRM00973).

h. Irish Acres Darily, LLC, Laub Farm LLC and Mark S. Rekewege are CAFOs in Indiana; as such, they are prohibited from discharging to surface waterways.

H-3 Total Suspended Solids TMDLs to Address Aquatic Life Use Impairments

Table H-25. TSS TMDL for Fish Creek at HU outlet (HUC 04100003 04 05)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**29,715**	**10,393**	**3,136**	**1,380**	**474**
Ohio allocation [a]	1,767	594	197	34	13
LA	25,154	8,819	2,645	1,212	415
WLA [b]	0	0	0	0	0
MOS (5%)	1,397	490	147	67	23
AFG (5%)	1,397	490	147	67	23

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.
a. Small portions of *Headwaters Fish Creek* (*04 02) and this HUC12 in Indiana drain to Ohio. The Ohio portions of this TMDL subwatershed are not impaired for their aquatic life use.
b. No NPDES permittees are in the TMDL subwatershed.

Table H-26. TSS TMDL for Fish Creek at Indiana-Ohio state line (HUC 04100003 04 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations [a]					
TMDL	**64,648**	**22,868**	**7,305**	**2,848**	**989**
*Fish Creek at HU outlet (*04 05) TMDL* (see Table H-17)	29,715	10,393	3,136	1,380	474
LA	31,185	11,055	3,611	1,190	333
WLA	254	172	142	132	130
MOS (5%)	1,747	624	208	73	26
AFG (5%)	1,747	624	208	73	26
Wasteload allocations					
Construction stormwater	63	22	7	2	1
Hamilton Lake Conservancy District (IN0050322)	113	113	113	113	113
Hamilton Lake Water Works (IN0060216)	15	15	15	15	15
Industrial stormwater [a]	63	22	7	2	1

Notes
The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.
a. The gross WLA represents the following facilities: AZZ Galvanizing (INRM01504) and Rieke Packaging System (INRM01907).

Table H-27. TSS TMDL for Peckhart Ditch at confluence with John Diehl Ditch (HUC 04100003 07 02)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**11,149**	**4,027**	**1,098**	**350**	**85**
LA	9,945	3,592	979	310	74
WLA (sum)	90	33	9	4	3
MOS (5%)	557	201	55	18	4
AFG (5%)	557	201	55	18	4
Wasteload allocations					
Auburn (INR040119) MS4	30	11	3	1	1
Construction stormwater	50	18	5	2	1
Contech U.S. LLC (IN0046043) *NCCW* [a]	--	--	--	--	--
Contech U.S. LLC (IN0046043) *storm water*	10	4	1	1	1
Haynes Dairy Farm CFO	0	0	0	0	0
Industrial stormwater					
Sunrise Heifer Farms, LLC *CAFO* [b]	0	0	0	0	0
Tower Automotive USA II (IN0046761) [a]	--	--	--	--	--

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.

a. Contech U.S. LLC (IN0046043; NCCW) and Tower Automotive USA II (IN0046741) are not expected to be a source of TSS.

b. Sunrise Heifer Farms, LLC is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-28. TSS TMDL for Black Creek at HU outlet (HUC 04100003 07 04)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**16,198**	**5,653**	**1,628**	**604**	**150**
LA	14,520	5,048	1,434	514	104
WLA (sum)	58	39	32	30	30
MOS (5%)	810	283	81	30	8
AFG (5%)	810	283	81	30	8
Wasteload allocations					
Construction stormwater	29	10	3	1	1
LaOtto Regional Sewer District (IN0058611)	29	29	29	29	29

Note: The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.

Table H-29. TSS TMDL for Little Cedar Creek at HU outlet (HUC 04100003 07 05)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**47,703**	**16,893**	**4,735**	**1,837**	**701**
Black Creek at HU outlet (*07 04) TMDL (see Table H-28)	16,198	5,653	1,628	604	150
LA	27,707	9,778	2,583	924	320
WLA (sum)	648	338	214	185	175
MOS (5%)	1,575	562	155	62	28
AFG (5%)	1,575	562	155	62	28
Wasteload allocations					
Allen County & others (INR040131) *MS4*	56	20	5	2	1
Avila Water Department (IN0052035)	9	9	9	9	9
Avila WWTP (IN0020664)	150	150	150	150	150
Construction stormwater	338	119	32	11	4
Indian Springs Recreation Campground (IN0032107)	10	10	10	10	10
Industrial stormwater [b]	85	30	8	3	1

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.

a. The gross WLA represents the following facilities: Electric Motors & Specialties Incorporated (INRM00918), Kautex Incorporated (INRM01494), and Victor Reinz Valve Seals, LLC (INRM01208).

Table H-30. TSS TMDL for Cedar Creek at HU outlet (HUC 04100003 07 07)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
Allocations					
TMDL	**176,886**	**65,608**	**20,351**	**7,776**	**4,162**
*Peckhart Ditch at confluence with John Diehl Ditch (*07 02) TMDL* (see Table H-27)	11,149	4,027	1,098	350	85
*Little Cedar Creek at HU outlet (*07 05) TMDL* (see Table H-29)	47,703	16,893	4,735	1,837	701
LA	98,031	36,132	10,674	3,141	1,272
WLA (sum)	8,199	4,088	2,392	1,890	1,766
MOS (5%)	5,902	2,234	726	279	169
AFG (5%)	5,902	2,234	726	279	169
Wasteload allocations					
Allen County & others (INR040131) *MS4*	2,477	913	270	79	32
Auburn (INR040119) *MS4*	2,683	989	292	86	35
Auburn Gear (IN0000566)	150	150	150	150	150
Auburn Gear (IN0000566) *NCCW* [a]	0	0	0	0	0
Auburn Gear (IN0000566) *stormwater*	105	39	11	3	1
Auburn WWTP (IN0020672) *treated effluent*	1,127	1,127	1,127	1,127	1,127
Auburn WWTP (IN0020672, outfalls 002, 007, and 009) *CSOs* [b]	0	0	0	0	0
Benchmark Distribution Terminals (ING340037) [c]	105	39	11	3	1
Construction stormwater	523	193	57	17	7
Corunna WWTP (IN0047473)	14	14	14	14	14
Garrett Municipal WWTP (IN0022969)	300	300	300	300	300
Industrial stormwater [d]	418	154	46	13	5
Metal Technologies (IN0061263) *NCCW* [a]	0	0	0	0	0
Metal Technologies (IN0061263) *stormwater*	105	39	11	3	1
Phillips Farm [e]	0	0	0	0	0
Rieke Packaging Systems (IN0000868) *NCCW* [a]	0	0	0	0	0
Rieke Packaging Systems (IN0000868) *stormwater*	105	39	11	3	1
Waterloo WWTP (IN0020711)	92	92	92	92	92

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.

a. Auburn Gear (IN0000566; NCCW), Metal Technologies (IN0061263; NCCW), Rieke Packaging Systems (IN0000868; NCCW), and Waterloo Public Water Supply (IN0049433; WTP) are not expected to be a source of TSS.

b. The WLAs for Auburn WWTP (IN0020672) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.

c. The Benchmark Distribution Terminals (ING340037) is covered by Indiana's general NPDES permit for petroleum products terminals and the WLAs in this allocation table were calculated using Indiana's in-stream 30 milligram per liter target. The specific WLAs in this allocation table will not be incorporated into the general permit.

d. The gross WLA represents the following facilities: Aggregate Industries Klink Concrete (INRM00184), Auburn Gear Inc. (INRM01782), Ball Brass and Aluminum Foundry Inc. (INRM01370), Cooper Standard Automotive (INRM01167), DeKalb County Airport (INRM00501), FXI Incorporated (INRM01118), Griffith Rubber Mills- Taylor Road (INRM00652), Harsco Industrial IKG (INRM01740), IPI Waterloo Recycling Center, LLC (INRM00487), Metal X Auburn (INRM01768), Momentive Performance Materials (INRM00519), Nucor Building Systems (INRM00941), OmniSource Corporation (INRM01759), OmniSource Corporation Auburn (INRM00784), and United Parcel Service Waterloo (INRM00244).
e. Phillips Farm is a CAFO in Indiana; as such, it is prohibited from discharging to surface waterways.

Table H-31. TSS TMDL for St. Joseph River at HU outlet (HUC 04100003 08 06)

Duration interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL at the mouth o the St. Joseph River (pounds per day)					
TMDL at mouth of St. Joseph River	**677,899**	**251,306**	**80,179**	**24,688**	**7,353**
TMDL at the Fort Wayne PWS intake	688,198	259,979	88,133	32,222	14,387
Withdrawal at the Fort Wayne PWS intake	-10,299	-8,672	-7,954	-7,535	-7,033
TMDL at the Fort Wayne PWS intake on the St. Joseph River (pounds per day)					
TMDL at the Fort Wayne PWS intake	**688,198**	**259,979**	**88,133**	**32,222**	**14,387**
Indiana upstream allocation	6,928	2,574	850	204	71
Michigan upstream allocation [a]	153,314	57,178	18,282	6,982	2,227
Ohio upstream allocation [a]	228,489	83,978	30,042	11,212	6,177
*Cedar Creek at HU outlet (*07 07) TMDL* (see Table H-30)	176,886	65,608	20,351	7,776	4,162
LA	88,787	36,143	12,701	3,509	365
WLA (sum)	21,536	9,434	4,047	1,935	1,211
MOS (5%)	6,129	2,532	930	302	87
AFG (5%)	6,129	2,532	930	302	87
Wasteload allocations at the Fort Wayne PWS intake on the St. Joseph River (pounds per day)					
Allen County & others (INR040131) *MS4*	6,648	2,706	951	263	27
Butler WWTP (IN0022462)	751	751	751	751	751
Butler WWTP (IN0022462) *CSOs* [b]	0	0	0	0	0
Construction stormwater	1,310	533	187	52	5
East Side High School (ING250077) [c]	--	--	--	--	--
Fort Wayne & others (INR040029) *MS4*	11,795	4,801	1,687	466	48
Fort Wayne Municipal WWTP (IN0032191) *CSOs* [d]	0	0	0	0	0
Fort Wayne Municipal WWTP (IN0032191) *SSOs* [e]	0	0	0	0	0
Fort Wayne Utilities - Honeysuckle Site (IN0063061)	5	5	5	5	5
Grabill Water Works (IN0044369)	13	13	13	13	13
Industrial stormwater [f]	546	222	78	22	2
Irish Acres Dairy, LLC *CAFO* [g]	0	0	0	0	0
Laub Farm LLC [g]	0	0	0	0	0
Mark S. Rekewege [g]	0	0	0	0	0
Northcrest Shopping Center (ING080271) [c]	--	--	--	--	--
Pickle Properties (IN0032981)	6	6	6	6	6
Stafford Gravel Inc. (ING490043)	10	10	10	10	10
Steel Dynamics Inc. (IN0059201)	300	300	300	300	300
Steel Dynamics Inc. (IN0059201) *stormwater*	109	44	16	4	1
St Joe – Spencerville RSD (IN0058441)	43	43	43	43	43

Notes

The allocation table components and structure are explained on page H-5, acronyms are defined on page H-4, and the loads are in tons of TSS per day.

The TMDL at the mouth of the St. Joseph River is equivalent to the TMDL at the Fort Wayne PWS intake less the load withdrawn at the PWS intake.

a. The Michigan and Ohio portions of this TMDL subwatershed are not impaired for their aquatic life use that would require a TSS TMDL.

b. The WLAs for Butler WWTP (IN0022462) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP.

c. Eagle-Picher Plastic Division (IN0000574; NCCW), East Side High School (ING250077; NCCW), and Northcrest Shopping Center (ING080271; groundwater petroleum remediation system) are not expected to be a source of TSS.

d. The WLAs for Fort Wayne WWTP (IN032191) are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP and Consent Decree.

e. This Fort Wayne Municipal WWTP (IN032191) WLA is for SSOs, which are prohibited discharges. The Fort Wayne CSS must comply with its LTCP and the Consent Decree.

f. The gross WLA represents the following facilities: Auburn Transfer Station (INRM01233), DeKalb Molded Plastics Company (INRM01605),Guardian Automotive Products Incorporated (INRM01012), International Paper Company (INRM001734), Irving Ready Mix Inc. (INR210049), M & W Countertops Inc. (INRM01108), Magna Exteriors & Interiors (INRM1781), New Millennium Building Systems, LLC (INRM00985), Nucor Fastener (INRM00939), Nucor Vulcraft – St. Joe Division (INRM00978), Rhinehart Finishing LLC (INRM00263), R3 Composites Corporation (INRM00406), Sauder Manufacturing Company (INRM00121 and INRM00144), Sechlers Pickles Incorporated (INRM00421), Smith Field Airport (INRM01228), Speedway Transit Mix and Concrete Plant Management (INRM01671), and Therma Tru Corporation (INRM00973).

g. Irish Acres Dairy, LLC, Laub Farm LLC, and Mark S. Rekewege are CAFOs in Indiana; as such, they are prohibited from discharging to surface waterways.

Appendix I.

Implementation through NPDES Program

Tables

Abbreviations and Acronyms[1]

HU	hydrologic unit
LTCP	long-term control plan
MS4	municipal separate storm sewer system
NCCW	non-contact cooling water
NPDES	National Pollutant Discharge Elimination System
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
UT	unnamed tributary
WTP	water treatment plant

Units of Measure[2]

c/d	*Escherichia coli* counts per day
c/hmL	*Escherichia coli* counts per 100 milliliters
lb/d	pounds per day
mgd	million gallons per day
mg/L	milligrams per liter

[1] All abbreviations and acronyms in this appendix are defined above. They are not defined in the footnotes below each table.
[2] All units of measure in this appendix are defined above. They are not defined in the footnotes below each table.

Table I-1. Recommended implementation actions through the NPDES program for total phosphorus

NPDES ID	Facility	Receiving waterbody	HU	Design flow (mgd)	WLA (lb/d	WLA (mg/L)	Comment
IN0000566	Auburn Gear Inc.	Cedar Creek	06 04	0.1	0.83 - 1.00	1.0	--
				storm water	0.01 - 1.00	0.3	--
IN0000868	Rieke Packaging Systems	Cedar Creek	06 04	storm water	0.01 - 1	0.3	--
IN0020664	Avila WWTP	UT to Kings Lake	07 05	0.2	0.29 - 5	1.0	0.29 lb/d for low flow duration only
IN0020672	Auburn WWTP	Cedar Creek	06 04	4.5	16.56 - 38	1.0	16.56 lb/d for low flow duration only
IN0020711	Waterloo Municipal STP	Cedar Creek	06 02	0.24	1.562 - 3.1	1.0	1.562 lb/d for low flow duration only
IN0022462	Butler WWTP	Big Run	05 02	2	7.57 - 25	1.0	7.57 lb/d for low flow duration only
IN0029969	Garrett WWTP	Garrett City Ditch	07 07	1.2	0.56 - 10	1.0	0.56 lb/d for low flow duration only
IN0032107	Indian Springs Rec Campground	Little Cedar Creek	07 05	0.04	0.01 - 1	1.0	0.01 lb/d for low flow duration only summer recreation season discharge only
IN0046043	Contech U.S., LLC	Grandstaff Ditch	06 04	storm water	0.01 - 0.1	0.30	--
IN0047473	Corunna WWTP	UT to John Diehl Ditch	07 01	0.024	0.01 - 1	1.0	0.01 lb/d for low flow duration only
IN0050822	Hamilton Lake Conservancy District	Hiram Sweet Ditch	04 04	0.3	3.76	1.0	--
IN0058441	St. Joe - Spencerville Regional Sewer District	St. Joseph River	08 02	0.17	0.54 - 2	1.0	0.54 lb/d for low flow duration only
IN0058611	La Otto Regional Sewer District	Black Creek	07 04	0.05	0.02 - 1	1.0	0.02 lb/d for low flow duration only
IN0059021	Steel Dynamics Inc.	Sol Shank Ditch	05 06	0.120	10	1.0	--
				storm water	0.01 - 2	0.3	--
IN0061263	Metal Technologies	Diehl Ditch	07 02	storm water	0.01 - 1	0.3	--
ING340037	Benchmark Distribution Terminals	Schwartz Ditch	06 01	storm water	0.01 - 0.2	0.3	petroleum product terminal
			06 02	storm water	0.001 - 0.2	0.3	

Note: Facilities are sorted alphanumerically by permit number.

The following facilities are not expected to discharge TSS and are excluded from this table: Avila Water Department (IN0052035; WTP); Eastside High School (IN0063061; NCCW); Fort Wayne Utilities – Honeysuckle Site (IN0063061; WTP); Grabill Water Works (IN0044369; WTP); Hamilton Water Works (IN0060216; WTP); Northcrest Shopping Center (ING080271; groundwater petroleum remediation systems); Pickle Properties. LLC (IN0032981); Stafford Gravel, Inc. (ING490043; dimension stone and crushed stone operations); and Tower Automotive USA II (IN0046761; NCCW).

Specified waste-streams at the following facilities are not expected to discharge TSS and are excluded from this table: Auburn Gear Inc. (IN0000566; NCCW); Contech U.S., LLC (IN0046043; NCCW); Metal Technologies (IN0061263:NCCW) and Rieke Packaging Systems (IN0000868; NCCW).

Table I-2. Recommended implementation actions through the NPDES program for TSS

NPDES ID	Facility	Receiving waterbody	HU	Design flow (mgd)	WLA (lb/d)	WLA (mg/L)	Comment
IN0000566	Auburn Gear Inc.	Cedar Creek	06 04	0.1	150	30	--
				storm water	1 - 104	30	--
IN0000868	Rieke Packaging Systems	Cedar Creek	06 04	storm water	1 - 104	30	--
IN0020664	Avila WWTP	UT to Kings Lake	07 05	0.2	150	30	--
IN0020672	Auburn WWTP	Cedar Creek	06 04	4.5	1,127	30	--
IN0020711	Waterloo Municipal STP	Cedar Creek	06 02	0.24	92	30	--
IN0022462	Butler WWTP	Big Run	05 02	2	751	30	--
IN0029969	Garrett WWTP	Garrett City Ditch	07 07	1.2	300	30	--
IN0032107	Indian Springs Rec Campground	Little Cedar Creek	07 05	0.04	10	30	summer recreation season discharge only
IN0032981	Pickle Properties, LLC	Hindman Ditch	08 01	0.036	6	30	--
IN0044369	Grabill Water Works	Witmer Ditch	08 04	0.035	13	30	--
IN0046043	Contech U.S., LLC	Grandstaff Ditch	06 04	storm water	1 - 10	30	--
IN0047473	Corunna WWTP	UT to John Diehl Ditch	07 01	0.024	14	70	NPDES permit limit of 70 mg/L.
IN0050822	Hamilton Lake Conservancy District	Hiram Sweet Ditch	04 04	0.3	113	30	--
IN0052035	Avila Water Department	UT to Kings Lake	07 05	0.034	9	30	--
IN0058441	St. Joe - Spencerville Regional Sewer District	St. Joseph River	08 02	0.17	43	30	--
IN0058611	La Otto Regional Sewer District	Black Creek	07 04	0.05	29	70	NPDES permit limit of 70 mg/L.
IN0059021	Steel Dynamics Inc.	Sol Shank Ditch	05 06	0.120	300	30	--
				storm water	1 - 108	30	--
IN0060216	Hamilton Water Works	William Egbert Ditch	04 04	0.058	15	30	--
IN0061263	Metal Technologies	Diehl Ditch	07 02	storm water	1 - 104	30	--
IN0063061	Fort Wayne Utilities – Honeysuckle Site	Schwartz-Carnahan Ditch	08 03	0.02	5	30	--
ING340037	Benchmark Distribution Terminals	Schwartz Ditch	06 01 06 02	storm water	1 - 104	30	--
ING490043	Stafford Gravel Inc.	Christoffel Ditch	05 05	0.04	10	30	--

Notes

Facilities are sorted alphanumerically by permit number.

The following facilities are not expected to discharge TSS and are excluded from this table: Eastside High School (IN0063061; NCCW) and Northcrest Shopping Center (ING080271; groundwater petroleum remediation systems); and Tower Automotive USA II (IN0046761; NCCW).

Specified waste-streams at the following facilities are not expected to discharge TSS and are excluded from this table: Auburn Gear Inc. (IN0000566; NCCW); Contech U.S., LLC (IN0046043; NCCW); Metal Technologies (IN0061263:NCCW) and Rieke Packaging Systems (IN0000868; NCCW).

Table I-3. Recommended implementation actions through the NPDES program for *E. coli*

NPDES ID	Facility	Receiving waterbody	HU	Design flow (mgd)	WLA (c/d)	WLA (c/hmL)	Recommended permit condition for *E. coli* (c/hmL)
IN0000566	Auburn Gear Inc.	Cedar Creek	06 04	0.1	$4.73 * 10^8$	125	Average monthly limit of 125
				storm water	$5.26 * 10^6$ to $3.59 * 10^8$	125	Average monthly limit of 125
IN0000868	Rieke Packaging Systems	Cedar Creek	06 04	storm water	$2.63 * 10^6$ to $3.57 * 10^8$	125	Average monthly limit of 125
IN0020664	Avila WWTP	UT to Kings Lake	07 05	0.2	$2.84 * 10^9$	125	Average monthly limit of 125
IN0020672	Auburn WWTP	Cedar Creek	06 04	4.5	$2.13 * 10^{10}$	125	Average monthly limit of 125
IN0020711	Waterloo Municipal STP	Cedar Creek	06 02	0.24	$1.75 * 10^9$	125	Average monthly limit of 125
IN0022462	Butler WWTP	Big Run	05 02	2	$1.42 * 10^{10}$	125	Average monthly limit of 125
IN0029969	Garrett WWTP	Garrett City Ditch	07 07	1.2	$5.68 * 10^9$	125	Average monthly limit of 125
IN0032107	Indian Springs Rec Campground	Little Cedar Creek	07 05	0.04	$1.89 * 10^8$	125	Average monthly limit of 125 Recreation season only
IN0046043	Contech U.S., LLC	Grandstaff Ditch	06 04	storm water	$1.36 * 10^6$ to $1.79 * 10^8$	125	Average monthly limit of 125
IN0047473	Corunna WWTP	UT to John Diehl Ditch	07 01	0.024	$1.14 * 10^8$	125	Average monthly limit of 125
IN0050822	Hamilton Lake Conservancy District	Hiram Sweet Ditch	04 04	0.3	$2.13 * 10^9$	125	Average monthly limit of 125
IN0058441	St. Joe - Spencerville Regional Sewer District	St. Joseph River	08 02	0.17	$8.04 * 10^8$	125	Average monthly limit of 125
IN0058611	La Otto Regional Sewer District	Black Creek	07 04	0.05	$2.37 * 10^8$	125	Average monthly limit of 125
IN0059021	Steel Dynamics Inc.	Sol Shank Ditch	05 06	0.120	$5.68 * 10^8$	125	Average monthly limit of 125
				storm water	$3.09 * 10^6$ to $5.13 * 10^8$	125	Average monthly limit of 125
IN0061263	Metal Technologies	Diehl Ditch	07 02	storm water	$4.09 * 10^6$ to $5.37 * 10^8$	125	Average monthly limit of 125
ING340037	Benchmark Distribution Terminals	Schwartz Ditch	06 01	storm water	$2.75 * 10^6$ to $2.88 * 10^8$	125	--
			06 02	storm water	$3.28 * 10^6$ to $2.89 * 10^8$	125	--

Notes

Facilities are sorted alphanumerically by permit number.

The following facilities are not expected to discharge *E. coli* and are excluded from this table: Avila Water Department (IN0052035; WTP); Eastside High School (IN0063061; NCCW); Fort Wayne Utilities – Honeysuckle Site (IN0063061; WTP); Grabill Water Works (IN0044369; WTP); Hamilton Water Works (IN0060216; WTP); Northcrest Shopping Center (ING080271; groundwater petroleum remediation systems); Pickle Properties. LLC (IN0032981); Stafford Gravel, Inc. (ING490043; dimension stone and crushed stone operations); and Tower Automotive USA II (IN0046761; NCCW).

Specified waste-streams at the following facilities are not expected to discharge *E. coli* and are excluded from this table: Auburn Gear Inc.(IN0000566; NCCW); Metal Technologies (IN0061263:NCCW) and Rieke Packaging Systems (IN0000868; NCCW).

Table I-4. Recommended implementation actions through the NPDES program for TP and TSS at combined sewer systems

NPDES ID	Facility	Receiving waterbody	HU	TP WLA (pound per day)	TSS WLA (pound per day)
IN0020672	Auburn WWTP	Cedar Creek	06 04	0*	0*
IN0022462	Butler WWTP	Big Run	05 02	0*	0*
IN0032191	Fort Wayne Municipal WWTP	St. Joseph River	08 06	0*	0*

Notes
*The WLAs for each permitee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP. Each permitee is working on Long-Term Control Plan implementation with IDEM and EPA to address long-term control of CSO discharges to the St. Joseph River. As the LTCPs are implemented, the annual impacts of CSOs upon water quality will be reduced considerably.

Table I-5. Recommended implementation actions through the NPDES program for *E. coli* at combined sewer systems

NPDES ID	Facility	Receiving waterbody	HU	*E. coli* WLA (counts per day)
IN0020672	Auburn WWTP	Cedar Creek	06 04	0*
		John Diehl Ditch		0*
IN0022462	Butler WWTP	Big Run	05 02	0*

Notes
*The WLAs for each permitee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP. Each permitee is working on Long-Term Control Plan implementation with IDEM and EPA to address long-term control of CSO discharges to the St. Joseph River. As the LTCPs are implemented, the annual impacts of CSOs upon water quality will be reduced considerably.

Table I-6. Recommended implementation actions through the NPDES program for MS4s for TP and TSS

NPDES ID	Permitee	HU	TP WLA (pounds per day)	TSS WLA (pounds per day)
INR040029	city of Fort Wayne [a,b] Indiana University-Purdue University – Fort Wayne Ivy Tech State College – Northeast Indiana Institute of Technology [c] University of Saint Francis [c]	08 06	0.84 to 182	48 to 11,711
INR040119	city of Auburn [b]	07 02	0.01 to 0.3	1 to 29
		07 07	0.08 to 29	35 to 2,681
INR040131	Allen County [d] town of Huntertown Town of Leo-Cedarville	07 05	--	1 to 56
		07 07	0.08 to 27	32 to 2,474
		08 06	0.47 to 103	27 to 6,601

Notes
Facilities are sorted alphanumerically by permit number.
Ranges of WLAs are totals for all tributaries within the regulated area of each MS4 within the specified HU.
a. Portions of Fort Wayne are outside of the SJRW.
b. Portions of these cities are also a combined sewer systems; such portions are not part of the regulated MS4s.
c. The Indiana Institute of Technology is in Maumee River watershed, downstream of the SJRW, and the University of Saint Francis is in the St. Mary's River watershed.
d. Excludes the city of Fort Wayne.

Table I-7. Recommended implementation actions through the NPDES program for MS4s for *E. coli*

NPDES ID	Permitee	HU	*E. coli* WLA (counts per day)
INR040119	city of Auburn [a]	06 04	$2.77 * 10^8$ to $3.79 * 10^{10}$
		07 02	$4.03 * 10^6$ to $5.30 * 10^8$
		07 07	$2.62 * 10^8$ to $1.04 * 10^{10}$
		08 03	$3.98 * 10^5$ to $6.64 * 10^8$
INR040131	Allen County [b] town of Huntertown Town of Leo-Cedarville	07 05	$1.16 * 10^7$ to $1.00 * 10^9$
		07 06	$2.82 * 10^8$ to $3.31 * 10^{10}$
		07 07	$3.21 * 10^8$ to $1.27 * 10^{10}$
		08 03	$7.16 * 10^6$ to $1.20 * 10^{10}$

Notes
Facilities are sorted alphanumerically by permit number.
Ranges of WLAs are totals for all tributaries within the regulated area of each MS4 within the specified HU.
a. Portions of the city of Auburn are also a combined sewer system; such portions are not part of the regulated MS4.
b. Excludes the city of Fort Wayne.