Total Maximum Daily Load (TMDL) for the Wabash River Watershed, Ohio

U.S. Environmental Protection Agency Region 5
Watersheds and Wetlands Branch
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ACRONYMS AND ABBREVIATIONS

AL	Aquatic life
AU	Assessment unit
cfs	Cubic feet per second
DO	Dissolved oxygen
EPA	Environmental Protection Agency
GIS	Geographic information system
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
L	Liter
LA	Load allocations
MIwb	Modified Index of Well-being
MOR	Monthly Operating Report
MOS	Margin of safety
MOU	Memorandum of Understanding
mg	Milligram
NN	Nitrate+nitrite
NPDES	National Pollutant Discharge Elimination System
OEPA	Ohio Environmental Protection Agency
QAPP	Quality assurance project plan
QHEI	Quality Habitat Evaluation Index
STORET	EPA Storage and Retrieval System
SWAT	Soil and Water Assessment Tool
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total suspended solids
WLA	Wasteload allocation
WQS	Water quality standard
WWH	Warmwater habitat

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting applicable water quality standards/guidelines or designated uses under technology-based controls. TMDLs specify the maximum amount of a pollutant which a waterbody can assimilate and still meet water quality standards. Based upon a calculation of total load of a specific pollutant that can be assimilated, TMDLs allocate pollutant loads to sources and a margin of safety (MOS). This study determines allowable limits for pollutant loadings to meet water quality standards and designated uses for the Wabash River, Ohio. Pollutant load reduction are allocated among sources and provide a scientific basis for restoring surface water quality in this waterbody. In this way, the TMDL process links the development and implementation of control actions to the attainment and maintenance of water quality standards and designated uses.

This TMDL has been developed by EPA, Region 5, rather than the state of Ohio. To remain in compliance with federal regulations for the development of modeling projects, this TMDL also has a Quality Assurance Project Plan (QAPP) for the Wabash River (USEPA, 2003) that was developed in conjunction with Tetra Tech, Inc.

2.0 IDENTIFICATION OF WATERBODY, POLLUTANT OF CONCERN, POLLUTANT SOURCES, AND PRIORITY RANKING

2.1 Identification of Waterbody

The Wabash River watershed is located in west-central Ohio, near the Indiana-Ohio border, and includes four assessment units (AUs) listed as impaired on the Ohio 2002 Section 303(d) list. These four AUs drain 323 square miles of mostly agricultural land intermixed with several small towns and cities. For this TMDL, the AUs of interest are 010, 030, and 040 as shown in Table 2-1 and Figure 2-1. Assessment unit 020 (not shown in Figure 2-1) and Grand Lake St. Mary's were not a direct focus of this study.

A detailed assessment of the Wabash River drainage basin in Ohio was conducted in 1999. The results of that assessment form the basis for the Section 303(d) listing of the AUs and for the work in this report.

Wabash River downstream of Vanderbush Ditch
(Photo by Tetra Tech, Inc.)

The waterbodies were listed both in the 2002 303(d) listing and the 2004 303(d) listing portion of Ohio's 2004 Integrated Report. The 2002 and 2004 Section 303(d) lists identify the impairments as other habitat alterations which encompasses nutrient and siltation impairments as well as non-pollutant issues such as loss of riparian habitat and flow alteration. The impairment decisions were made using the available chemical, habitat and biological data, such as the Qualitative Habitat Evaluation Index (QHEI), the Index of Biological Integrity (IBI), the modified Index of Well-being (MIWb), and the Invertebrate Community Index (ICI).

Table 2-1. Ohio 2002 Section 303(d) listings within the Wabash River watershed addressed by this TMDL.

Assessment Unit (AU)	Description	High Magnitude Causes	Sources
05120101 010	Wabash River (Headwaters of Wabash River to confluence with Beaver Creek)	Other Habitat Alterations	Minor Municipal Point Sources Nonirrigated Crop Production Animal Feeding Operations Channelization (Agriculture) Removal of Riparian Vegetation Streambank Destabilization
05120101 030	Beaver Creek	Other Habitat Alterations	Nonirrigated Crop Production Animal Feeding Operations Channelization (Agriculture) Removal of Riparian Vegetation Streambank Destabilization
05120101 040	Wabash River (Confluence of Beaver Creek to State Line)	Other Habitat Alterations	Nonirrigated Crop Production Animal Feeding Operations Channelization (Agriculture) Removal of Riparian Vegetation Streambank Destabilization

The purpose of this TMDL is to evaluate the magnitude of load reductions that are necessary to allow the nutrient and sediment water quality targets to be met. It is important to note the TMDL will not (and, in fact, cannot) identify loadings that can be directly compared to the biological targets. The assumption is that management efforts to address nutrient and sediment loadings, in combination with other activities to improve habitat, will result in the attainment of the biocriteria. (Biocriteria will be discussed in the next chapter on water quality standards).

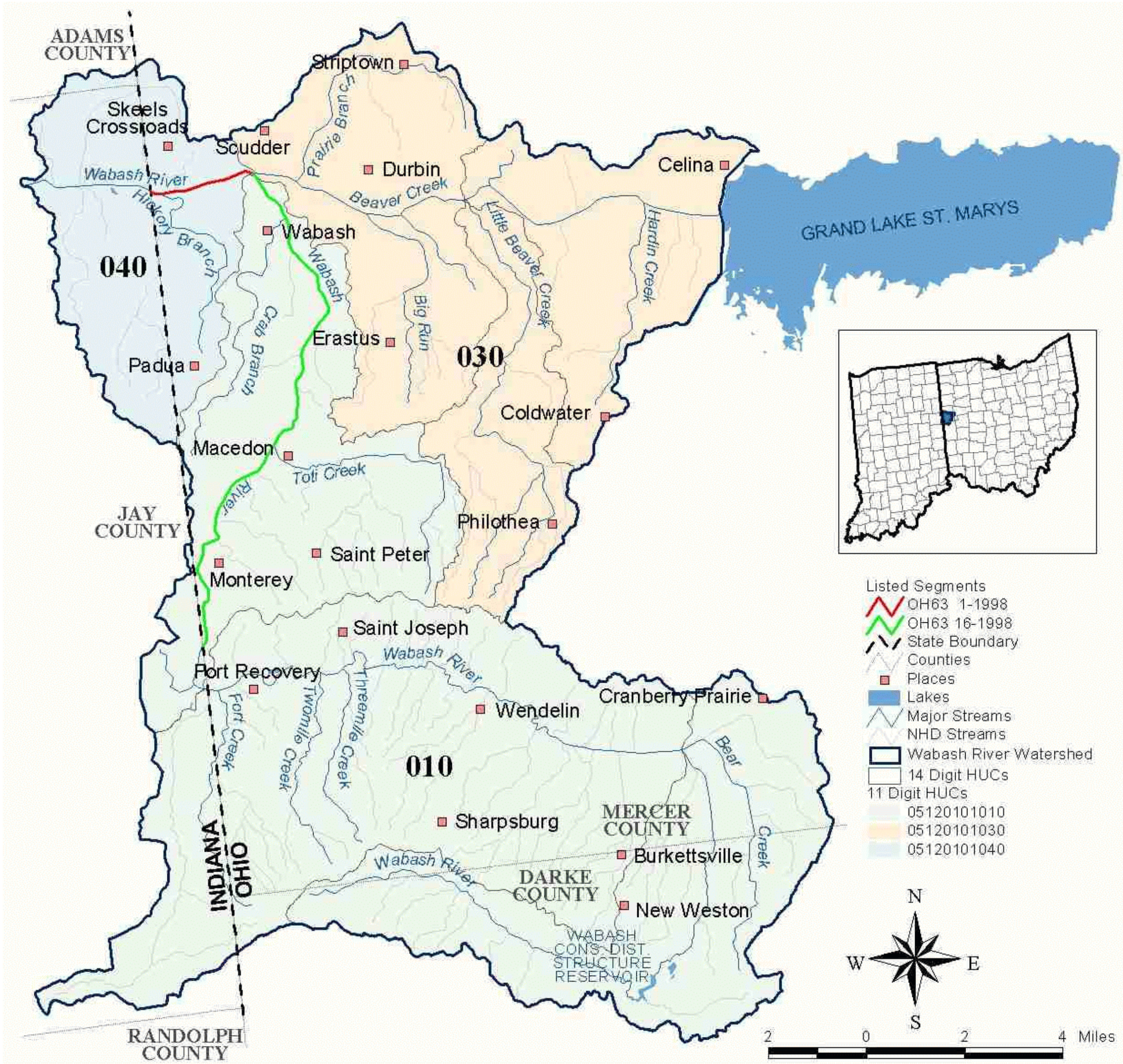

Figure 2-1. Location of the Wabash River watershed, Ohio.

2.2 Pollutants of Concern

The TMDL addresses the sediment and nutrient loadings in the Wabash River and includes recommendations for improving instream habitat. The specific nutrients addressed are nitrate+nitrite and total phosphorus. The riparian habitat and flow alterations are severe stressors, but only sediment and nutrient loadings are directly addressed in this TMDL.

2.3 Pollutant Sources

Many small streams in the Wabash River watershed are degraded by excessive nutrient levels from farm fertilizer runoff, poorly managed livestock waste, home septic systems, and some municipal wastewater. Few wooded areas exist next to these streams. Without vegetation to trap eroded soil, bottom substrate are often smothered with silt. High bedload delivery and transport are components of hydromodification and direct habit alterations.

There are also two industrial facilities and three wastewater treatment plants with National Pollutant Discharge Elimination System (NPDES) permits in the Wabash River watershed that contribute to the sediment and nutrient loadings (Table 2-2). Additionally, there are 29 large concentrated animal feeding operations (CAFOs) in the watershed that are individually listed in Appendix A. CAFOs are point sources as defined by the Clean Water Act 33 USC Section 136.2 (14) and Section 502(14) and are therefore also subject to the NPDES program.

Table 2-2. Industrial facilities and wastewater treatment plants in the Wabash River watershed.

NPDES ID	Facility Name	Standard Industrial Code Description
OH0009482	Stoneco Incorporated Karch Quarry Plant	Cut stone and stone products
OH0010138	Fort Recovery Industries Incorporated	Electroplating, plating, polishing, anodizing, and coloring
OH0025160	Fort Recovery Wastewater Treatment Plant	Sewerage system
OH0020320	Celina Wastewater Treatment Plant	Sewerage system
OH0024694	Coldwater Wastewater Treatment Plant	Sewerage system

2.4 Priority Ranking

The Wabash River is one of the most degraded watersheds in the state. Its priority ranking for TMDL development is High on the 2002 Section 303(d) list.

3.0 DESCRIPTION OF WATER QUALITY STANDARDS, NUMERIC WATER QUALITY TARGETS, AND EXISTING WATER QUALITY

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive and still achieve water quality standards. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. Ohio's water quality standards are summarized in Table 3-1 and explained in greater detail below.

Table 3-1. Ohio water quality standards.

Component	Description
Designated Use	Designated use reflects how the water can potentially be used by humans and how well it supports a biological community. Every water in Ohio 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 use of the waterbody. Biological criteria indicate the health of the in-stream biological community by using one of three indices: • Index of Biotic Integrity (IBI) (measures fish health). • Modified Index of well being (MIwb) (measures fish health). • Invertebrate Community Index (ICI) (measures bug or macroinvertebrate 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 may cause algal blooms.
Antidegradation Policy	This policy establishes situations under which OEPA may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need. Refer to <http://www.epa.state.oh.us/dsw/wqs/wqs.html> for more information.

3.1 Biocriteria

The Ohio water quality standards (Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the narrative goals specified by each use designation. Use designations consist of two broad groups: aquatic and nonaquatic life. In applications of the Ohio water quality standards to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently control the resulting protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting aquatic life generally results in water quality suitable for all uses.

All of the waterbody segments in the Wabash River drainage except Grand Lake St. Marys (which is automatically designated exceptional warmwater habitat (EWH) because it is a public lake), are designated for warmwater habitat (WWH). WWH is the use designation that defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams and represents the principal restoration target for the majority of water resource management efforts in the state.

OEPA has evaluated the biological health and water quality of the Wabash River watershed and determined that the WWH aquatic life use was not met in any assessment unit. Impairment determinations were made using the following biological indices: the Index of Biological Integrity (IBI) for fish, the modified Index of Well-being (MIwb) for fish, and the Invertebrate Community Index (ICI) for aquatic insects. The Qualitative Habitat Evaluation Index (QHEI) and chemical criteria were used to substantiate the suspected causes and sources of impairment.

3.2 Numeric Water Quality Targets

The ultimate goal of this TMDL is to attain the appropriate biocriteria. Targets have been established to link water chemistry to the biocriteria. The water quality targets are quantitative measures that are equivalent to attainment of water quality standards.

Ohio does not have nutrient or sediment criteria as part of their formal water quality standards. However, OEPA has established nutrient targets that are linked to the biocriteria (Tables 3-2 and Table 3-3) (OEPA, 1999). Additionally, a site-specific sediment guideline has been selected for the Wabash River based on the available data. Meeting these targets is expected to be one important component of achieving water quality standards in the Wabash River watershed. The purpose of the modeling effort conducted for this TMDL was to evaluate load reduction efforts that will allow the nutrient and sediment guidelines to be met. It is important to note that the modeling effort did not produce output that can be directly compared to the biocriteria. The assumption is that management efforts to address nutrient and sediment concentrations, in combination with other activities to improve habitat, will result in the attainment of the biocriteria.

Table 3-2. Statewide nitrite-nitrate targets (mg/L) for Ohio rivers and streams with the value chosen for the Wabash River TMDLs highlighted.

Watershed Size	Aquatic Life Designations		
	EWH	WWH	MWH
Headwaters (drainage area < 20 mi^2)	0.5	1	1
Wadeable rivers (20 mi^2 < drainage area < 200 mi^2)	0.5	1	1.6
Small rivers (200 mi^2 < drainage area < 1,000 mi^2)	1	1.5	2.2
Large rivers (drainage area > 1,000 mi^2)	1.5	2	2.4

WWH = Warmwater Habitat; EWH = Exceptional Warmwater Habitat; MWH = Modified Warmwater Habitat.
Source: OEPA, 1999.

Table 3-3. Statewide total phosphorus targets (mg/L) for Ohio rivers and streams with the value used for the Wabash River TMDLs highlighted.

Watershed Size	Aquatic Life Designations		
	EWH	WWH	MWH
Headwaters (drainage area < 20 mi^2)	0.05	0.08	0.34
Wadeable rivers (20 mi^2 < drainage area < 200 mi^2)	0.05	0.10	0.28
Small rivers (200 mi^2 < drainage area < 1,000 mi^2)	0.10	0.17	0.25
Large rivers (drainage area > 1,000 mi^2)	0.15	0.30	0.32

WWH = Warmwater Habitat; EWH = Exceptional Warmwater Habitat; MWH = Modified Warmwater Habitat.
Source: OEPA, 1999.

3.3 Existing Water Quality

This section of the document summarizes the available nutrient and sediment water quality data for the Wabash River watershed.

3.3.1 Nutrients

The term nutrients refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Streams draining larger areas are also expected to have higher nutrient concentrations.

Various forms of nitrogen and phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate. Common nitrogen sampling parameters are total nitrogen (TN), nitrite (NO2), nitrate (NO3), nitrate+nitrite (NN), total Kjeldahl nitrogen (TKN), and ammonia (NH3). Concentrations are measured in the lab and are typically reported in milligrams per liter.

Nutrients generally do not pose a direct threat to the designated uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth and this process is called eutrophication. Eutrophication can have many effects on a stream. One possible effect is low dissolved oxygen concentrations caused by excessive plant respiration and/or decay. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Dissolved oxygen concentrations are measured in the field and are typically reported in milligrams per liter. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. For these reasons, excessive nutrients can result in the non-attainment of biocriteria and impairment of the designated use.

It should be noted that the impact of nutrients can be moderated by riparian habitat conditions. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal, and assimilation of nutrients from or by the water column. Therefore a stream with good riparian habitat is better able to moderate the impacts of high nutrient loads than is a stream with poor habitat. High nutrient concentrations in the Wabash River watershed are therefore compounded by the fact that the natural habitat of many of the streams has been reduced or eliminated.

A 30-day average TP target of 0.17 mg/L has been identified for the Wabash River watershed based on *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999). This value corresponds to the protection of WWH waters in small river watersheds (those draining areas between 200 and 1000 square miles). The target is to be applied as a maximum 30-day sliding average applied year-round.

Figure 3-1, Figure 3-2, and Table 3-4 indicate that the TP target is routinely exceeded in the Wabash River watershed. TP concentrations at State Line Road, the most downstream station and the one with the most data, have historically been well above the target. Concentrations steadily decrease during the winter and then begin to increase in May. Average values in June, July, August, and September are all above the target, with values between 0.40 mg/L and 0.60 mg/L. Appendix B summarizes all available TP data for the watershed.

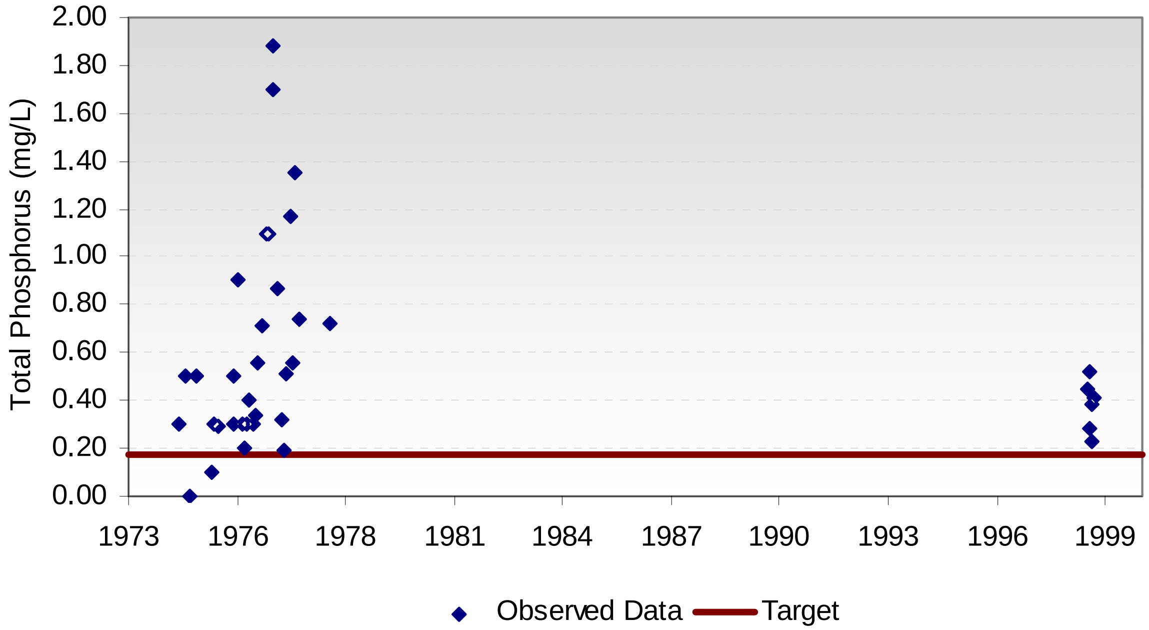

Figure 3-1. All Wabash River total phosphorus data at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

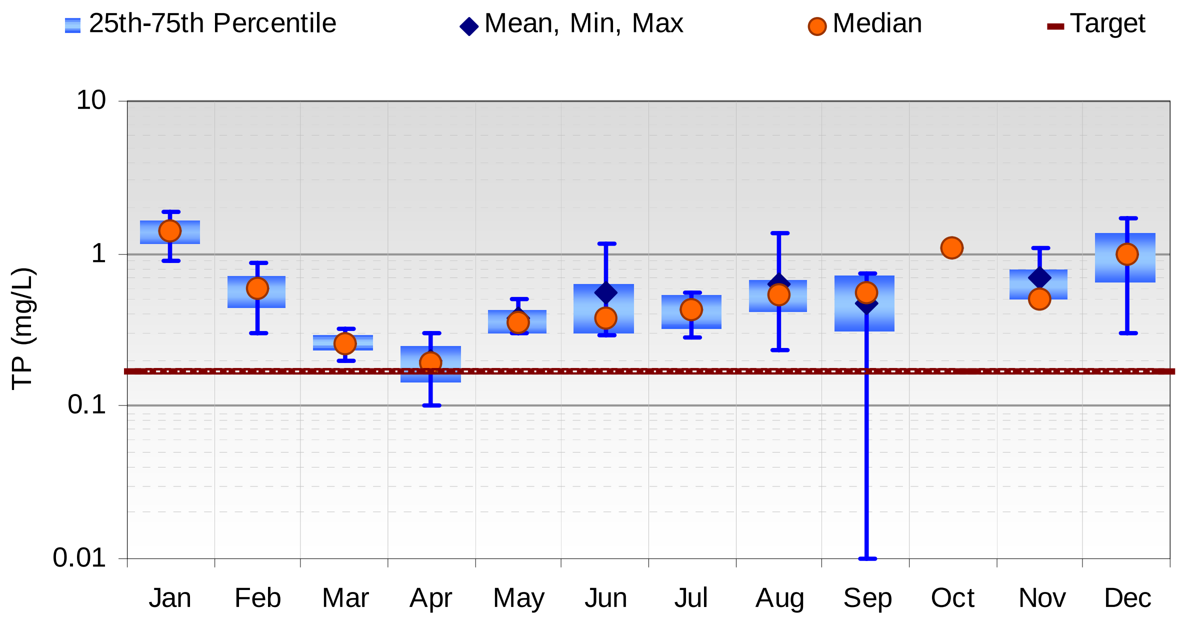

Figure 3-2. Wabash River average monthly total phosphorus data at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

Table 3-4. Summary total phosphorus statistics for the Wabash River at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

Month	Mean	Median	Min	Max	25th	75th	Exceedances: Total # Samples	Percent Exceeding
Jan	1.39	1.39	0.90	1.88	1.15	1.64	2:2	100%
Feb	0.59	0.59	0.30	0.87	0.44	0.73	2:2	100%
Mar	0.26	0.26	0.20	0.32	0.23	0.29	2:2	100%
Apr	0.20	0.19	0.10	0.30	0.15	0.25	2:3	67%
May	0.38	0.35	0.30	0.51	0.30	0.43	4:4	100%
Jun	0.55	0.38	0.29	1.17	0.30	0.63	4:4	100%
Jul	0.43	0.43	0.28	0.56	0.33	0.53	4:4	100%
Aug	0.62	0.53	0.23	1.35	0.41	0.68	6:6	100%
Sep	0.47	0.56	0.01	0.74	0.31	0.72	3:4	75%
Oct	1.10	1.10	1.10	1.10	1.10	1.10	1:1	100%
Nov	0.70	0.50	0.50	1.10	0.50	0.80	3:3	100%
Dec	1.00	1.00	0.30	1.70	0.65	1.35	2:2	100%

A 30-day average nitrate+nitrite (NN) target of 1.5 mg/L has been identified for the Wabash River watershed based on *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999). This value corresponds to the protection of WWH waters in small river watersheds (those draining areas between 200 and 1000 square miles). As with TP, the target is to be applied as a maximum 30-day sliding average applied year-round.

Figure 3-3, Figure 3-4, and Table 3-5 indicate that the NN target is occasionally exceeded in the Wabash River watershed. Numerous concentrations taken at State Line Road in the 1970s were above the target whereas limited data taken in 1999 were below the target. An analysis of all the sampling data from throughout the watershed, however, indicates that 19 percent of all 1999 observations exceeded 1.5 mg/L.

Evaluating the combined 1970s and 1999 data for the State Line Road station indicates that NN concentrations steadily decrease during the winter and then begin to increase in June. Average values in June and July are above the target, while values in August and September are below the target.

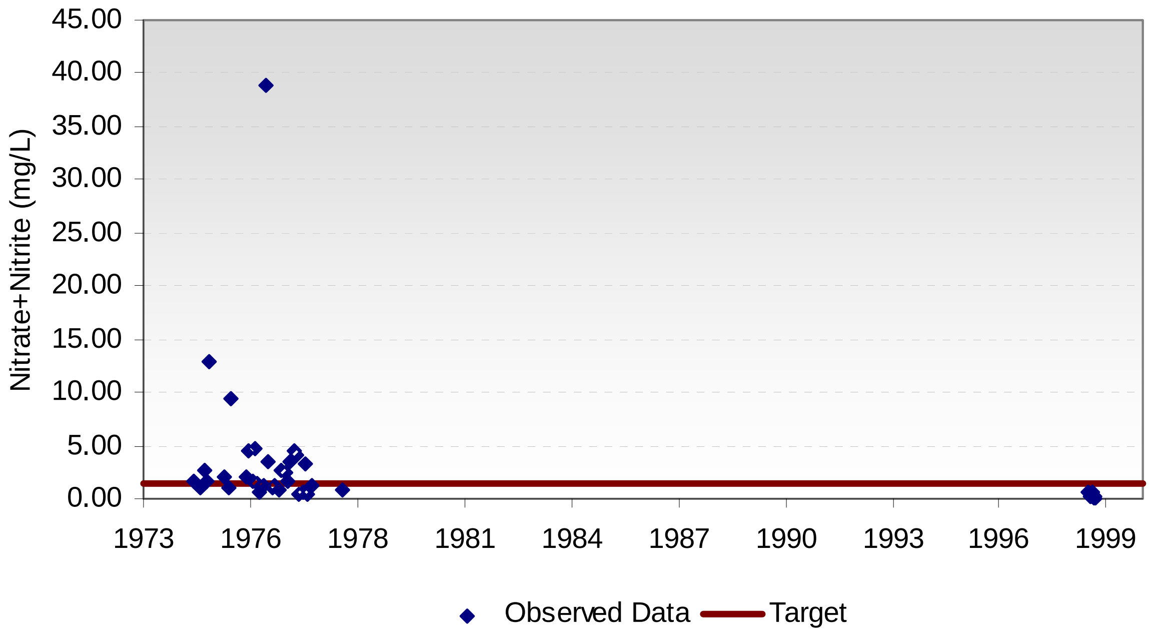

Figure 3-3. All Wabash River nitrate+nitrite data at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

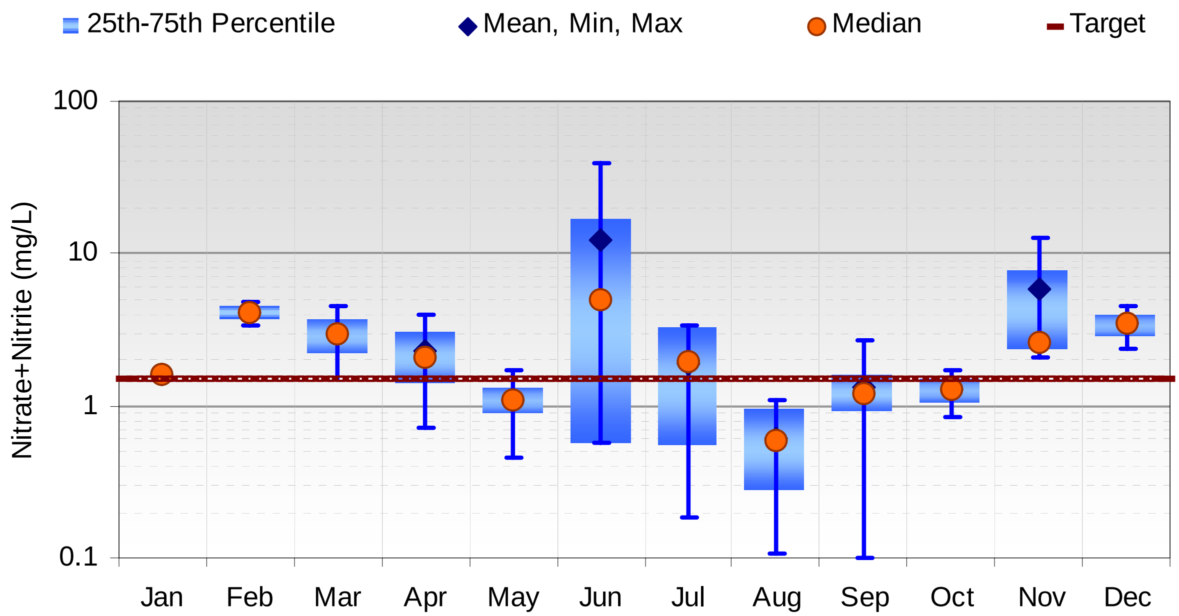

Figure 3-4. Wabash River monthly nitrate+nitrite data at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

Table 3-5. Summary NN statistics for the Wabash River at the State Line Road sampling station. The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999.

Month	Mean	Median	Min	Max	25th	75th	Exceedances: Total # Samples	Percent Exceeding
Jan	1.61	1.61	1.60	1.62	1.61	1.62	2:2	100%
Feb	4.10	4.10	3.41	4.79	3.76	4.45	2:2	100%
Mar	2.98	2.98	1.51	4.44	2.24	3.71	2:2	100%
Apr	2.27	2.10	0.71	3.99	1.41	3.05	2:3	67%
May	1.09	1.11	0.45	1.70	0.89	1.30	1:4	25%
Jun	12.34	4.99	0.57	38.80	0.58	16.75	2:4	50%
Jul	1.88	1.96	0.19	3.40	0.55	3.29	2:4	50%
Aug	0.61	0.60	0.11	1.10	0.28	0.95	0:6	0%
Sep	1.30	1.21	0.10	2.70	0.93	1.58	1:4	25%
Oct	1.27	1.27	0.84	1.70	1.06	1.49	1:2	50%
Nov	5.85	2.60	2.10	12.84	2.35	7.72	3:3	100%
Dec	3.43	3.43	2.36	4.50	2.90	3.97	2:2	100%

3.3.2 Sediments

Excess total suspended solids (TSS) in a stream can pose a threat to aquatic organisms. Turbid waters created by excess TSS concentrations reduce light penetration, which can adversely affect aquatic organisms. Also, TSS can interfere with fish feeding patterns because of the turbidity. Prolonged periods of very high TSS concentrations can be fatal to aquatic organisms (Newcombe and Jensen, 1996). As TSS settles to the bottom of a stream, critical habitats such as spawning sites and macroinvertebrate habitats can be covered in sediment. This is referred to as siltation. Excess sediment in a stream bottom can reduce dissolved oxygen concentrations in stream bottom substrates, and it can reduce the quality and quantity of habitats for aquatic organisms. For these reasons, excessive TSS can result in non-attainment of biocriteria and impairment of the designated use.

Erosion and overland flow contribute some natural TSS to most streams. In watersheds with highly erodible soils and steep slopes, natural TSS concentrations can be very high. Excess TSS in overland flow can occur when poor land use and land cover practices are in place. This potentially includes grazing, row crops, construction activities, road runoff, and mining. Grazing and other practices that can degrade stream channels are other possible sources of TSS.

TSS is also a concern because of its ability to transport TP to a waterbody. When anthropogenic sources of phosphorus are delivered to a stream the ratio of dissolved phosphorus immediately available to algae may be high relative to particulate forms of phosphorus (e.g., attached to soil particles; Robinson et al. 1992). Total phosphorus (TP; the form measured in this study) consists of both dissolved phosphorus (DP), which is mostly orthophosphate, and particulate phosphorus (PP), including both inorganic and organic forms (Sharpley et al. 1994). Runoff from conventional tillage is generally dominated by PP; however, the proportion of TP as DP increases where erosion is comparatively low such as with no-till fields or pasture (Sharpley et al. 1994). Streams with low gradients and a morphology that enhances deposition of sediments in the low flow channel (e.g., channelized streams) may continually release dissolved phosphorus from sediments.

OEPA does not have numeric targets for TSS and no statewide recommendations have been published. The reference stream approach is often used in such instances to identify site-specific targets for the development of a TMDL. With the reference stream approach, TSS concentrations in a similar, but unimpaired, watershed are evaluated and used as the basis for meeting water quality standards. No appropriate reference stream for the Wabash River has been identified.

Therefore, the approach for this TMDL is to evaluate the existing TSS data for the Wabash River watershed and select the 25th percentile as the target condition (USEPA, 2000). This number is calculated by using the regional concentrations from the total stream population in the Wabash River watershed. First, a TSS concentration distribution was determined using observed values. Then, the lowest 25th percentile of the distribution produces a concentration, in this case a TSS of 32 mg/l, as the target or threshold point. (This lowest 25th percentile may also be interpreted as using the least contaminated 25 percent of all the observed values as the target). This target relies to some extent on best professional judgement because, to reiterate, there are no reference conditions available in this highly developed agricultural area. The 25th percentile methodology results in a target that is within the range of natural conditions within the watershed, and is believed to be protective of the aquatic community. To choose a lower number would result in values closer to a reference stream, which is not a reasonable target in this area. The target is subject to modification as new data are generated. The target will be expressed as a maximum average value over any 30-day period and may be subject to modification as more information becomes available.

Figure 3-5, Figure 3-6, and Table 3-3 indicate that the TSS target is exceeded in the Wabash River watershed during most of the spring, summer, and winter. The limiting sampling in the fall indicates the target is not exceeded.

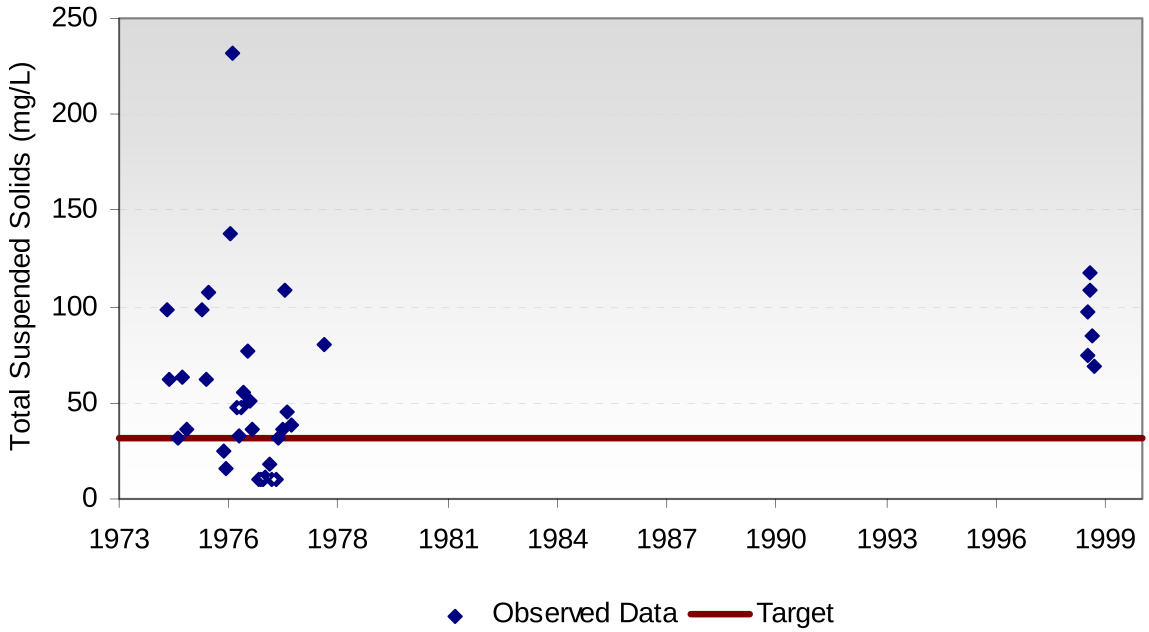

Figure 3-5. All Wabash River total suspended solids data at the State Line Road sampling station. The first sample was collected April 16, 1974 and the last sample was collected September 2, 1999.

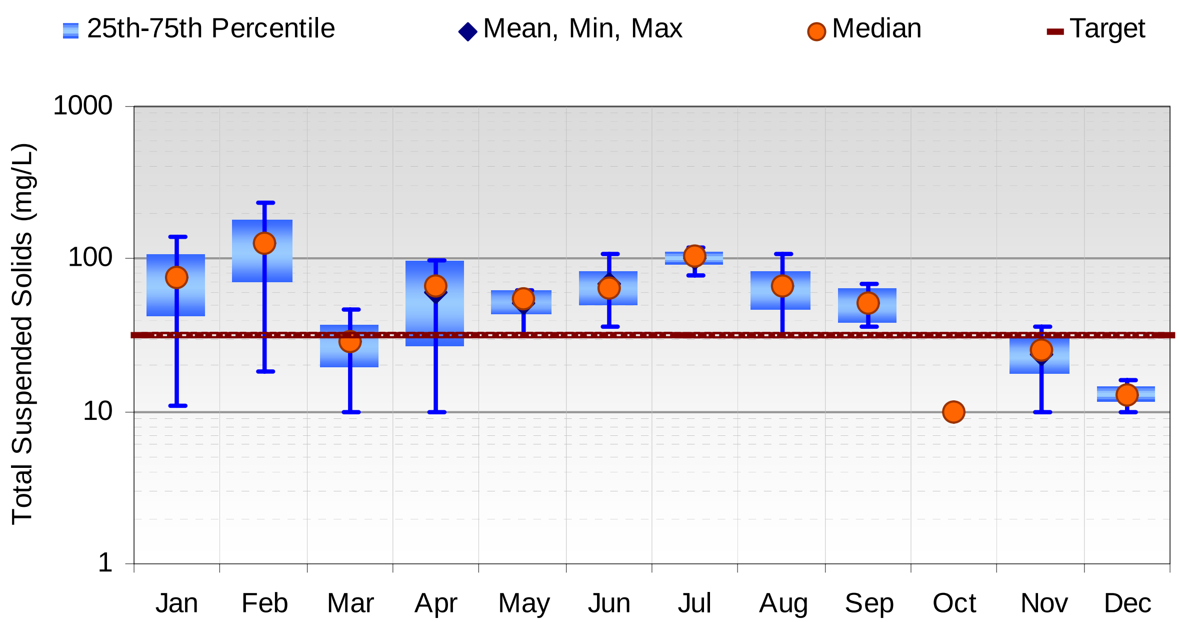

Figure 3-6. Wabash River monthly total suspended solids data at the State Line Road sampling station. The first sample was collected April 16, 1974 and the last sample was collected September 2, 1999.

Table 3-6. Summary TSS (mg/L) statistics for the Wabash River at the State Line Road sampling station. The first sample was collected April 16, 1974 and the last sample was collected September 2, 1999.

Month	Mean	Median	Min	Max	25th	75th	Exceedances: # of Samples	Percent Violating
Jan	75	75	11	138	43	106	1:2	50%
Feb	125	125	18	232	72	179	1:2	50%
Mar	29	29	10	47	19	38	1:2	50%
Apr	60	66	10	98	27	98	3:4	75%
May	51	55	32	62	43	62	3:4	75%
Jun	69	65	36	108	50	83	4:4	100%
Jul	100	103	77	118	92	111	4:4	100%
Aug	67	66	32	109	47	83	5:6	83%
Sep	52	51	36	69	38	65	4:4	100%
Oct	10	10	10	10	10	10	0:1	0%
Nov	24	25	10	36	18	31	1:3	33%
Dec	13	13	10	16	12	15	0:2	0%

4.0 LOADING CAPACITY

The cause-and-effect relationship between pollutant sources (stressor indicators), receiving water chemistry (exposure indicators), and biology was completed using a modeling approach in which pollutant loads from the watershed are transported to the waterbody and then downstream. The linkage between water chemistry and biology is established through the adoption of nutrient and sediment targets associated with the desired biocriteria.

Several factors were considered in choosing a methodology by which to estimate sediment and nutrient loadings. These included identifying the various types of sources (e.g., point, nonpoint, background, atmospheric), the relative location of each of the sources with respect to the impaired waterbody, the transport mechanisms of concern (e.g., direct discharge, storm-event runoff), and the time scale of loading to the waterbody (i.e., duration and frequency of loading to the receiving waters). Based on these considerations the Soil Water Assessment Tool (SWAT) model was chosen for this application.

SWAT was developed by the Agricultural Research Service, the main research agency within the U.S. Department of Agriculture. The model predicts the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. SWAT can analyze large watersheds and river basins (greater than 100 square miles) by subdividing the area into homogenous subwatersheds. The model uses a daily time step, and can perform continuous simulation for a period of one to 100 years. SWAT simulates hydrology, pesticide and nutrient cycling, erosion and sediment transport.

The SWAT modeling approach was used for the Wabash River TMDLs for the following reasons:

- It models the constituents of concern (total phosphorus, nitrate and nitrite, and sediments).
- It is designed for primarily agricultural watersheds.
- It provides daily output to allow for direct comparison to the water quality targets.
- It provides the ability to directly evaluate management practices (such as altering fertilizer application rates).
- It has been used elsewhere in Ohio for TMDL development.
- It has higher acceptance with the agricultural community because it was developed by the U.S. Department of Agriculture, Agricultural Research Service.

The model was used to allocate loads to determine what implementation measures may be taken to decrease the input levels of sediments and nutrients to the system, with the long term goal of achieving the appropriate biocriteria. SWAT was calibrated and validated by representing source contributions and in-stream response. Calibration consisted of comparing the model results to observed data and adjusting the appropriate model parameters to obtain an acceptable fit between simulated and observed data. After calibration, the parameters were validated, or tested to an independent data set to ensure that the model works under a full range of conditions. Validation was performed using an available appropriate data set independent of the calibration data set. Appendix C provides a complete discussion of the modeling process.

It is important to point out that the model is only capable of predicting nutrient and sediment concentrations and loads (stressors) rather than response variables (such as biological conditions). As described above, the Wabash River TMDL will therefore be based on quantified instream nutrient and sediment targets that are linked to biological indicators. The TMDL also acknowledges the necessity of addressing other stressors (such as habitat) to fully restore beneficial uses.

4.1 Strengths and Weaknesses

There are several strengths associated with using SWAT to determine the loading capacity of the Wabash River. These including the following:

- Detailed consideration of all the factors affecting nutrient and sediment loading and transport, such as soil types, topography, land use, human activities, stream channel conditions, and weather.
- Ability to estimate loads from various source categories, such as by subwatershed or land use type.
- Ability to directly evaluate the effect of various land management practices on instream water quality.
- Ability to predict water quality during critical conditions (e.g., extremely low or high stream flows) when observed data might not be available.

There are also several weaknesses associated with using SWAT, such as:

- The model is fairly intensive in terms of data needs and complexity, resulting in a longer schedule than would have been required with a simpler approach.
- The model's instream capabilities (i.e., ability to simulate pollutant fate and transport within the Wabash River) is not as advanced as some other receiving water models, such as the Water Quality Analysis Simulation Program (WASP).

These two shortcomings are not believed to be significant weaknesses for this project and it is believed that the SWAT model is acceptable for development of the TMDL.

4.2 Critical Conditions

Critical conditions for the nutrient impairments are during the late summer when low stream flows and abundant sunshine are most likely to lead to excessive plant growths. However, loadings throughout the year potentially contribute to high nutrient concentrations during the critical period because of desorption from the sediment. The nutrient targets therefore apply year-round.

Critical conditions for the sediment impairments are not as straightforward. Loadings are highest during wet weather events which lead to sheet erosion and scouring of the streambank. The impacts of excessive siltation and turbidity can occur at various times, however, such as during the late summer when they might contribute to depleted dissolved oxygen concentrations or during the early spring when they might affect spawning. The TSS targets therefore apply year-round.

4.3 Loading Capacity

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water 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. Conceptually, this is defined by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

To develop TMDLs for the Wabash River watershed the following approach was taken:

- Simulate baseline conditions
- Assess source loading alternatives
- Determine the TMDL and source allocations

The calibrated model provided the basis for performing the allocation analysis and was first used to project baseline conditions. Baseline conditions represent existing nonpoint source loading conditions and permitted point source discharge conditions. The baseline conditions allow for an evaluation of in-stream water quality under the "worst currently allowable" scenario.

Simulation of baseline conditions provided the basis for evaluating stream response to variations in source contributions. The simulations revealed that stormwater runoff from manured agricultural lands are the largest source of nutrients and sheet and rill erosion from agricultural lands are the largest source of sediments. WWTP effluent is also a significant source of TP in the Beaver Creek subwatershed. These results facilitated developing an effective allocation strategy.

The calibrated SWAT model was used to determine the allowable loads of TP, NN, and TSS for the Wabash River watershed. TSS loads were reduced first because reducing them also resulted in reducing TP. Loads were reduced through a variety of means (e.g., reduced manure application, modifying modeling parameters to simulate reduced streambank and sheet/rill erosion) until the predicted 30-day running average concentrations at the outlet of the watershed were at or below the TMDL targets. It should be noted that most of the load reduction scenarios that were utilized resulted in year-round load reductions such that predicted water quality concentrations are below the targets except for the critical conditions. Some of the best management practices likely to be implemented (e.g., conservation buffers, two-stage ditch design) will in fact result in year-round load reductions, while others (e.g., nutrient management plans) could be timed to occur during critical periods while allowing larger loads during non-critical periods.

The results of the modeling runs are summarized in Figures 4-1 to 4-3. Figure 4-1 indicates that the 30-day average existing TP concentration is above the TMDL target, shown by the target line at 0.17 mg/L, and remains high most months of the year except from about December 1999 to June 2000. There are a few exceedances above the target in the 2000 spring months, but in the winter and spring months in 1999 exceedances occur frequently. Figure 4-1 also shows the 30-day average modeled TP that could be allowed and remain under the target value. When comparing the existing TP and the average modeled TP below the target values, the greatest difference occurs approximately between June through September and therefore the greatest percentage reductions would need to occur in those months. Table 5-1 generally reflects these reductions that are needed in 10 out of 12 months of the year.

Figure 4-2 indicates that the 30-day average existing NN concentration is above the TMDL target, shown by the target line at 1.5 mg/L, and fluctuates above and below the target line in both years. Most exceedances occur primarily from June through October. Figure 4-2 also shows the 30-day average modeled NN that could be allowed and remain under the target value. When comparing the existing NN and the average modeled NN plot, the target is exceeded throughout the year. In order to maintain levels of NN below the target, reductions would have to occur throughout the year. This reduction is generally reflected in the load allocations in Table 5-2, where reductions are needed throughout the year.

Figure 4- 3 indicates that the 30-day average existing TSS is above the TMDL target, shown by the target line at 32 mg/L, most of the time. Figure 4-3 also shows the 30-day average modeled TSS that could be allowed and remain under the target value. When comparing the existing TSS and the average modeled TSS plot, the existing TSS is rarely below the target value. Overall, the TSS values are above the target more frequently than are the TP or NN concentrations. Significant reductions would have to occur throughout the year to maintain levels of TSS below the target. The greater reductions needed in TSS are indicated in the allocations in Table 5-3, where reduction are indicated in all months of the year and at a greater percentage than the TP or NN reductions.

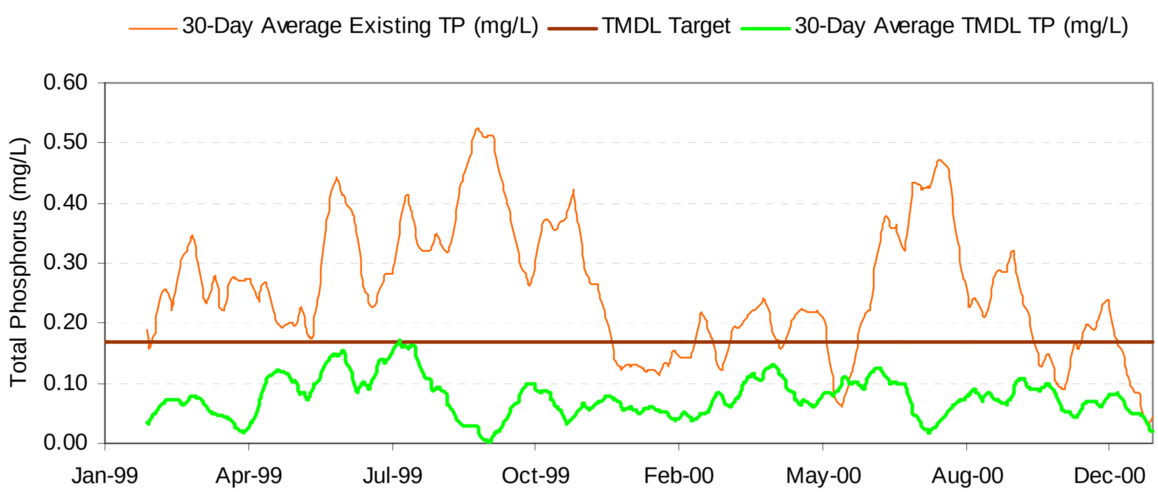

Figure 4-1. Existing total phosphorus conditions and proposed TMDL for the Wabash River watershed.

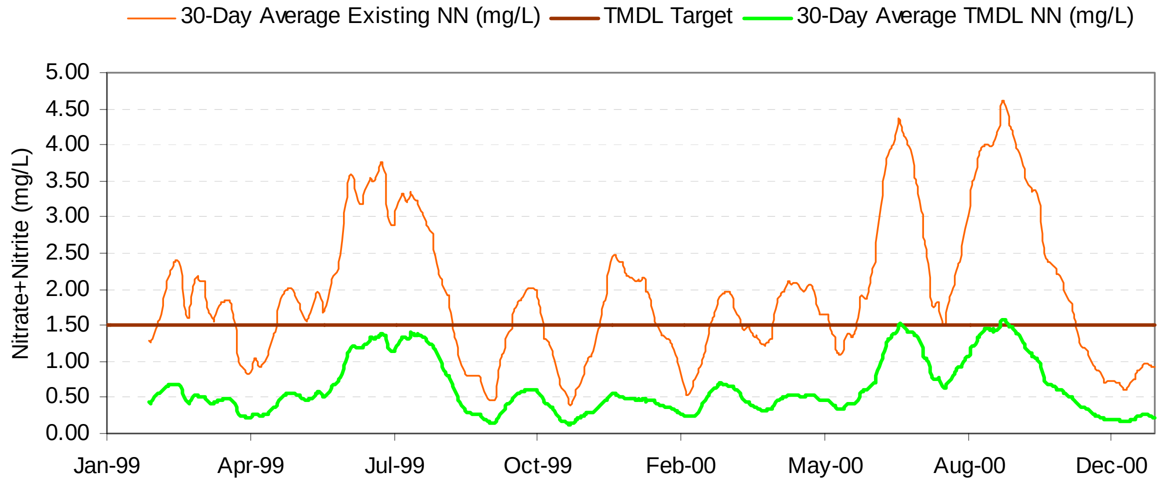

Figure 4-2. Existing nitrate+nitrite conditions and proposed TMDL for the Wabash River watershed.

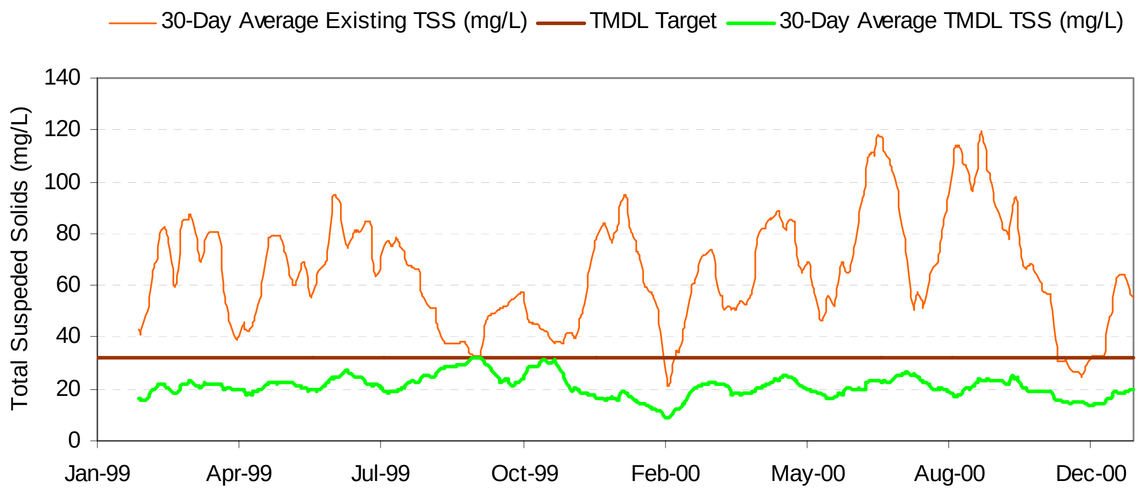

Figure 4-3. Existing total suspended solids conditions and proposed TMDL for the Wabash River watershed.

5.0 LOAD ALLOCATIONS

Load allocations (LAs) are identified for nonpoint source and natural background loading of pollutants in support of final TMDL allocations that will lead to attainment of water quality standards. Allocation analysis was performed by applying the model to identify the assimilative capacity of the receiving water and determine how the allowable loading capacity will be allocated among the various sources. The results are presented in Tables 5-1 to 5-3. The allocation analysis includes the loading capacity (or TMDL), load allocation, wasteload allocation, and margin of safety. The allocation also considers critical conditions and seasonal variation of the loading characteristics, hydrologic variability of the stream flow, and the stream's assimilative capacity.

The load allocations will be used to develop nonpoint source reduction plans based on meeting relevant sediment and nutrient targets. In general, these targets are set such that concentrations at or just less than the targets indicate a potential for unacceptable risks to aquatic life; exceedances are anticipated to produce impairment. If the calculated nonpoint source limit for the particular contaminant is exceeded, then the pollutants will continue to present a hazard by impairing the habitat. The ultimate goal is to improve the IBI, MIwb, and ICI scores so that the Wabash River can be removed from the impaired waters list.

Table 5-1. Total phosphorus TMDL for the Wabash River watershed.

Month	Existing Load (kg/month)	Loading Capacity (kg/month)	MOS (kg/month)	WLA (kg/month)	LA (kg/month)	Reduction
Jan	7,167	1,672	84	288	1,301	77%
Feb	3,916	1,487	74	491	922	62%
Mar	2,663	956	48	499	409	64%
Apr	2,287	1,185	59	717	409	48%
May	754	849	NA	NA	NA	0%
Jun	4,943	1,390	70	317	1,004	72%
Jul	1,546	498	25	346	127	68%
Aug	1,449	473	24	368	81	67%
Sep	4,299	643	32	178	433	85%
Oct	949	949	NA	NA	NA	0%
Nov	1075	429	21	399	9	60%
Dec	1294	669	33	582	54	48%

Table 5-2. Nitrate+nitrite TMDL for the Wabash River watershed.

Month	Existing Load (kg/month)	Loading Capacity (kg/month)	MOS (kg/month)	WLA (kg/month)	LA (kg/month)	Reduction
Jan	65,144	20,759	1,038	2902	16,819	68%
Feb	56,310	16,153	808	4920	10,425	71%
Mar	36,468	9,198	460	4335	4,403	75%
Apr	44,368	10,682	534	4999	5,149	76%
May	62,655	17,106	855	3678	12,573	73%
Jun	80,941	23,529	1,176	3954	18,399	71%
Jul	18,494	5,999	300	3374	2,325	68%
Aug	24,925	8,106	405	3338	4,363	67%
Sep	59,614	18,033	902	3499	13,632	70%
Oct	20,337	4,965	248	2646	2,071	76%
Nov	22,863	7,280	364	705	6,211	68%
Dec	25,389	6,595	330	3551	2,714	74%

Table 5-3. Total suspended solids TMDL for the Wabash River watershed.

Month	Existing Load (kg/month)	Loading Capacity (kg/month)	MOS (kg/month)	WLA (kg/month)	LA (kg/month)	Reduction
Jan	3,274,473	974,160	48,708	21,551	903,901	70%
Feb	3,141,973	728,379	36,419	22,370	669,590	77%
Mar	1,471,248	328,513	16,426	26,094	285,993	78%
Apr	2,168,021	522,655	26,133	28,755	467,767	76%
May	2,319,210	509,349	25,467	27,247	456,635	78%
Jun	2,470,399	496,043	24,802	23,367	447,874	80%
Jul	538,965	79,177	3,959	26,660	48,558	85%
Aug	858,088	118,973	5,949	33,287	79,737	86%
Sep	1,869,732	391,936	19,597	26,924	345,415	79%
Oct	891,717	220,914	11,046	24,532	185,336	75%
Nov	1,389,581	341,247	17,062	18,201	305,984	75%
Dec	1,887,444	461,579	23,079	20,459	418,041	76%

6.0 WASTELOAD ALLOCATIONS

There are two industries, three wastewater treatment plants, and 29 large CAFOs within the Wabash River watershed that are subject to the NPDES permit program. The existing loads from the wastewater treatment plants and industrial facilities have been estimated based on data reported in their monthly operating reports (MORs) or literature values for parameters that they are not required to report. Wasteload allocations for TP have been established based on estimated existing loads and the percent reductions shown in Table 5-1. Wasteload allocations for NN and TSS have been established equal to their estimated existing monthly loads and are shown in Tables 6-1 to 6-3.

The WLA for the Large CAFOs in the Wabash River TMDL are for zero load from production areas. The zero allocation is based on the Effluent Limitations Guidelines and New Source Performance Standards for Large CAFOs requiring, in general, zero discharge from these areas. This limit on load is reasonable due to the requirement for the proper design, construction, operation, and maintenance of the structures to contain all manure, litter, and process wastewater including the runoff and direct precipitation from a 25-year, 24-hour rainfall event. The allocation is also based on the requirement at 40 CFR section 122.42(e) that CAFOs have a nutrient management plan providing adequate storage of manure, litter, and process wastewater, including a volume needed to store material during the maximum length of time anticipated between emptying events. Further, the allocation is based on the conditions of Ohio's NPDES draft general permit for CAFOs providing that Ohio Water Quality Standards shall not be exceeded in the event of an overflow from CAFO production areas. Should there be any effluent from a discharge in a larger storm or rainfall event in wet weather conditions, the effluent limit may not exceed the Ohio water quality standards pertaining to fecal coliforms.

For application of manure, litter, or process wastewater to land under the control of the CAFO, the Waste Load Allocation is zero for discharges that are not agricultural storm water discharges. This limit on load is reasonable due to the conditions of Ohio's NPDES draft general permit for CAFOs providing that there shall be no discharge during the process of applying manure to land.

The Load Allocation (LA) for the CAFOs in the Wabash River TMDL is embedded within the LA columns of Table 5-1 to Table 5-3 and is for discharge of agricultural storm water from the land application of manure, litter, and process wastewater. For the purpose of this paragraph, where the manure, litter, or process wastewater has been applied in accordance with site-specific nutrient management practices that assure appropriate agricultural utilization of nutrients, as specified by conditions of a permit developed in accordance with 40 CFR section 122.42(e)(1)(vi) - (ix), the discharge is an agricultural storm water discharge.

Table 6-1. Total phosphorus wasteload allocations for the NPDES facilities in the Wabash River watershed[1].

Month	All CAFOs (kg/month)	OH0009482 (kg/month)	OH0010138 (kg/month)	OH0025160 (kg/month)	OH0020320 (kg/month)	OH0024694 (kg/month)	Total (kg/month)
Jan	0	0	0	7	186	95	288
Feb	0	0	0	12	322	157	491
Mar	0	0	0	12	302	185	499
Apr	0	0	0	18	484	215	717
May	0	0	0	34	758	529	1321
Jun	0	0	0	9	192	116	317
Jul	0	0	0	9	205	132	346
Aug	0	0	0	10	215	143	368
Sep	0	0	0	5	91	82	178
Oct	0	0	0	33	579	579	1191
Nov	0	0	0	13	220	166	399
Dec	0	0	0	17	347	218	582

[1]None of these facilities are required to report the TP concentrations in their effluent. Estimates of existing loads at the mouth of the watershed due to the wastewater treatment plants were therefore based on their reported monthly flows, a literature value for effluent of 4.0 mg/L TP (Litke, 1999), and a 25 percent loss in transit due to settling and plant uptake. No phosphorus was assumed to be discharged by the industries. WLAs were set based on reducing existing loads by the percent reduction identified in Table 5-1.

Table 6-2. Nitrate+nitrite wasteload allocations for the NPDES facilities in the Wabash River watershed.

Month	All CAFOs (kg/month)	OH0009482 (kg/month)	OH0010138 (kg/month)	OH0025160 (kg/month)	OH0020320 (kg/month)	OH0024694 (kg/month)	Total (kg/month)
Jan	0	0	0	130	2,557	215	2902
Feb	0	0	0	136	4,458	326	4920
Mar	0	0	0	165	3,866	304	4335
Apr	0	0	0	145	4,277	577	4999
May	0	0	0	148	3,186	344	3678
Jun	0	0	0	68	3,449	437	3954
Jul	0	0	0	124	2,830	420	3374
Aug	0	0	0	134	2,957	247	3338
Sep	0	0	0	141	3,032	326	3499
Oct	0	0	0	79	2,481	86	2646
Nov	0	0	0	29	371	305	705
Dec	0	0	0	92	3,187	272	3551

Table 6-3. Total suspended solids wasteload allocations for the NPDES facilities in the Wabash River watershed.

Month	All CAFOs (kg/month)	OH0009482 (kg/month)	OH0010138[1] (kg/month)	OH0025160 (kg/month)	OH0020320 (kg/month)	OH0024694 (kg/month)	Total
Jan	0	1,043	8,498	1,658	1,449	8,903	21,551
Feb	0	1,174	3,643	1,587	2,420	13,546	22,370
Mar	0	742	3,631	2,715	1,314	17,692	26,094
Apr	0	932	9,458	3,151	1,576	13,638	28,755
May	0	1,377	8,452	3,206	714	13,498	27,247
Jun	0	445	8,557	1,339	995	12,031	23,367
Jul	0	476	8,591	5,383	814	11,396	26,660
Aug	0	539	9,969	4,561	607	17,611	33,287
Sep	0	812	9,789	3,632	574	12,117	26,924
Oct	0	1,071	3,919	1,862	577	17,103	24,532
Nov	0	742	3,626	1,812	543	11,478	18,201
Dec	0	1,934	0	2,187	1,433	14,905	20,459

[1]This facility reports total solids rather than total suspended solids. Total suspended solids were therefore estimated based on the assumption that 17 percent of total solids are suspended solids. This value is derived from the existing water quality within the watershed.

7.0 MARGIN OF SAFETY

The MOS accounts for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loading) or a combination of both. For the Wabash River TMDL, the MOS was included explicitly as 5 percent of the loading capacity. A relatively low margin of safety was chosen because the SWAT model relied on several conservative assumptions, such as low instream nutrient transformation rates. The SWAT model is also believed to be providing good information on the relationship between pollutant loadings and receiving water quality. For example, seasonal and annual differences between observed versus simulated stream flow are summarized in Table 7-1. The table shows that simulated flow for the ten-year modeling period agrees very well with observed stream flow data. The greatest errors occur in simulated summer storm volumes, yet these errors are within recommended calibration parameters (Lumb et al., 1994). In general, the hydrologic calibration appears adequate in that it reflects the total water yield, annual variability, and magnitude of individual storm events in the basin. All of the recommended hydrologic criteria are met. Additional information on the results of the modeling are shown in Appendix C and indicate good agreement between modeled and observed data.

Table 7-1. Wabash River Watershed Calibration Results for the Simulation Period October 1, 1977 to September 30, 1987. Units shown are inches.

Total Simulated In-stream Flow:	**102.17**	Total Observed In-stream Flow:	**98.26**
Total of highest 10% flows:	**57.54**	Total of Observed highest 10% flows:	**55.73**
Total of lowest 50% flows:	**6.46**	Total of Observed Lowest 50% flows:	**6.05**
Simulated Summer Flow Volume:	**11.08**	Observed Summer Flow Volume:	**7.82**
Simulated Fall Flow Volume:	**24.54**	Observed Fall Flow Volume:	**19.88**
Simulated Winter Flow Volume:	**36.52**	Observed Winter Flow Volume:	**38.50**
Simulated Spring Flow Volume:	**30.03**	Observed Spring Flow Volume:	**32.06**
Total Simulated Storm Volume:	**102.04**	Total Observed Storm Volume:	**95.66**
Simulated Summer Storm Volume:	**11.05**	Observed Summer Storm Volume:	**7.17**
Errors (Simulated-Observed)		*Recommended Criteria*[1]	
Error in total volume:	**3.83**	10	
Error in 50% lowest flows:	**6.24**	10	
Error in 10% highest flows:	**3.13**	15	
Seasonal volume error - Summer:	**29.39**	30	
Seasonal volume error - Fall:	**18.99**	30	
Seasonal volume error - Winter:	**-5.42**	30	
Seasonal volume error - Spring:	**-6.76**	30	
Error in storm volumes:	**6.25**	20	
Error in summer storm volumes:	**35.08**	50	

[1] Recommended criteria are from Lumb et al., 1994

Figures 7-1 to 7-3 present the results of the model calibration for TP, NN, and TSS. They indicate that the model is a reasonable description of the significant water quality processes in the watershed. The time series plots of modeled versus observed data indicate that the observed data are within the range of the modeled data and generally follow the same temporal pattern. Additional details regarding the modeling are available in Appendix B.

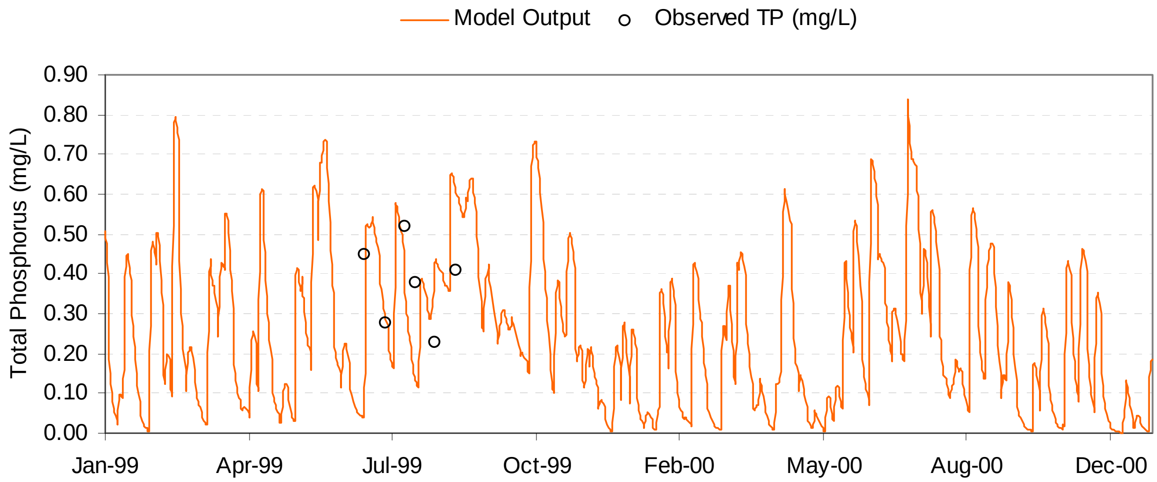

Figure 7-1. Comparison of predicted and observed total phosphorus data for the Wabash River at State Line Road.

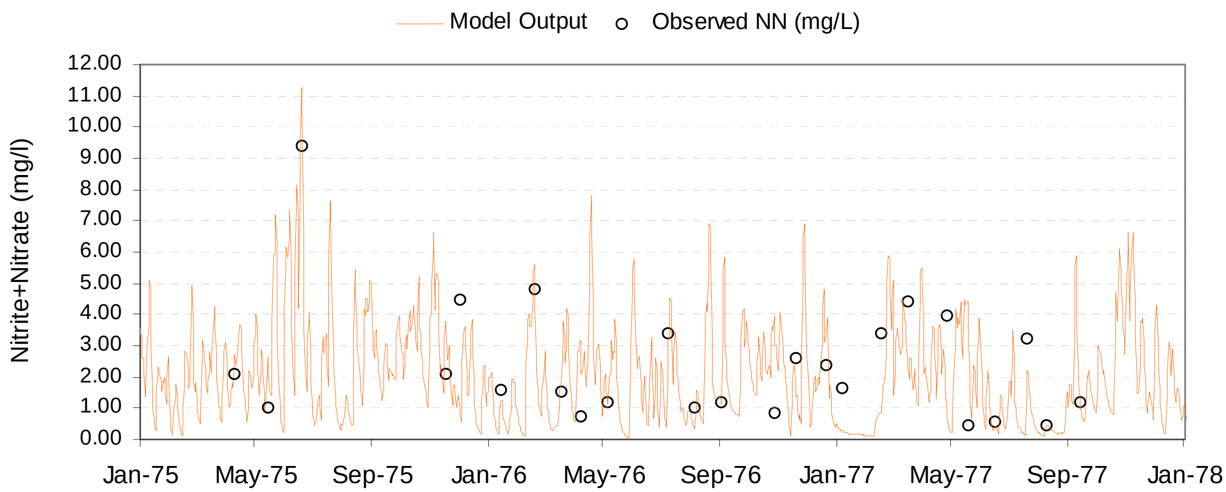

Figure 7-2. Comparison of predicted and observed nitrite+nitrate data for the Wabash River at State Line Road.

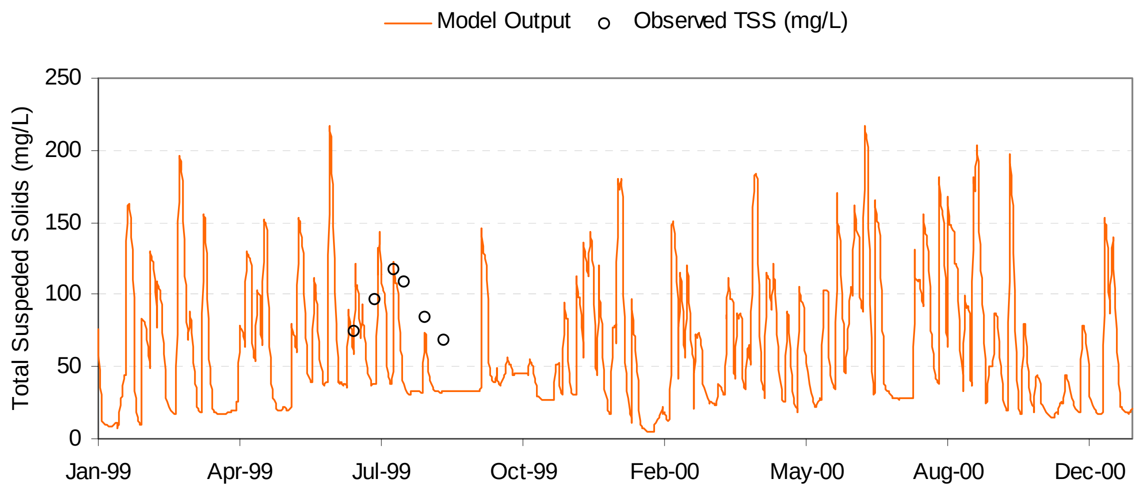

Figure 7-3. Comparison of predicted and observed total suspended solids data for the Wabash River at State Line Road.

8.0 SEASONAL VARIATION

Nutrient and sediment loading in the Wabash River watershed vary seasonally, due to variations in weather and source activity, especially as related to agricultural runoff from seasonal manure application. To account for this seasonality, this TMDL establishes monthly allocations. The allocations represent loads allocated to time periods of similar weather, runoff, and instream conditions and can help to identify times of greatest impairment. TMDL implementation can therefore focus efforts by identifying time periods needing greater load reductions. Tables 5-1 to 5-3 show the load allocations by month and Tables 6-1 through 6-3 provide the monthly wasteload allocations.

9.0 MONITORING PLAN

The watershed will be re-evaluated as part of the rotating basin monitoring schedule established by the OEPA. The monitoring will also be incorporated into the Watershed Action Plan (WAP) for the Wabash River which is scheduled for completion by December 31, 2004. The plans will include the local watershed group volunteer monitoring efforts to collect chemical, physical, and possibly biological samples in the watershed. The WAP will incorporate this TMDL report and serve as a primary means of implementation. The watershed group plans to monitor best management practices (BMPs) upon implementation and confirm TMDL targets.

10.0 REASONABLE ASSURANCE

As part of an implementation plan, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. As proposed in the WAP, stakeholders will implement BMPs that directly correlate to water quality goals and attainment standards. As outlined in the monitoring plan above, chemical sampling will be done by the watershed group to confirm load reduction calculations. BMP implementation is dependent on availability of funding from State, local, and Federal sources including, but not limited to, 319 nonpoint source grants and USDA 2002 Farm Bill conservation programs. Reasonable assurances for planned point source controls, such as wastewater treatment plant upgrades and changes to NPDES permits, include a schedule for implementation of planned NPDES permit actions. In the regulatory framework, basin-wide limits for NPDES dischargers will be an available tool to reduce the discharge. For non-enforceable actions (certain nonpoint source activities), assurances must include 1) demonstration of adequate funding; 2) process by which agreements/arrangements between appropriate parties (e.g., governmental bodies, private landowners) will be reached; 3) assessment of the future of government programs which contribute to implementation actions; and 4) demonstration of anticipated effectiveness of the actions. It will be important to coordinate activities with those governmental entities that have jurisdiction and programs in place to implement the nonpoint source actions (e.g., county soil and water conservation district offices, county health departments, local Natural Resource Conservation Service offices of the U.S. Department of Agriculture, municipalities and local governmental offices).

Non-regulatory actions would include finalization of an implementation plan, discussed further in the next section, which includes education activities, stormwater management, agricultural BMPs, stream channel restoration and periodic stream monitoring to measure progress. BMPs include but are not limited to fertilizer reduction, riparian buffer, two-stage channel ditch design, increased no-till farming, manure/nutrient management, etc.

Incentive-based projects would include 319 projects, funding a watershed coordinator for public outreach and education, and various loan opportunities for agriculture practices and riparian/habitat improvements.

11.0 IMPLEMENTATION

The primary implementation tool will be the locally-lead watershed group and the WAP. This plan will incorporate this TMDL report and serve as a primary means of implementation. The plan will incorporate TMDL results and additional data collected within the community to develop a specific set of action items designed to help meet the TMDL targets. It is intended that this plan be endorsed by the ODNR Division of Soil and Water and the OEPA Division of Surface Water, thus making it eligible and more competitive for Section 319 Implementation Grants, State Revolving Fund (SRF) monies, USDA funds, and potentially other funding sources.

The Wabash River Watershed has had a watershed coordinator since January, 2003, who coordinates local support and implements BMPs for the control of erosion and nutrient runoff, purchases conservation easements, and educates within the watershed. This effort has been funded through a combination of grants from OEPA (CWA Section 319), Ohio DNR (Watershed Management, Streambanking, Manure Nutrient Management, Geographic Information Systems and Watershed Coordinator), and USDA (as outlined in the conservation titles of the 2002 Farm Bill). Funding within the watershed has been going directly to landowners for BMP installation and/or conservation easements. While the results have been noticeable in both land management and water quality much remains to be accomplished.

Generally, implementation of BMPs relies on voluntary and incentive programs, such as government cost-sharing. Therefore, the implementation plan should show there is reasonable assurance that nonpoint source controls will be implemented and maintained. Long-term watershed water quality monitoring will also be important in evaluating the effectiveness of BMPs. The implementation plan will include a time schedule describing when the activities necessary to implement the TMDL will occur. This would include a time line for implementation of BMPs and/or control actions.

Committees were formed to develop implementation strategies, including actions and management measures, time lines, reasonable assurances, and monitoring plans. Stakeholder meetings were held in various parts of the watershed to gather feedback for the WAP. A conservation buffer information session was sponsored by the watershed group to encourage implementation. The Wabash Conservancy District sponsored a lunch meeting to promote low maintenance ditch design. Watershed group members have been actively going door-to-door promoting BMP implementation and gathering feedback for the WAP. Current community capacity was analyzed, and a plan for structuring the TMDL implementation effort was established. Groups consisted of local stakeholders, agricultural producers, and consultants, as well as soil and water conservation staff.

Animal waste is a significant contributor to nonpoint source pollution in the Wabash watershed. Implementation actions include the voluntary development of manure nutrient management plans, promotion of evolving technologies for safe land application of manure, grid soil sampling of lands proposed for manure application, establishment of grassed filter strips, building of manure storage facilities according to NRCS specifications, exclusion of livestock from streams with alternate water supplies, and certification of manure applicators. Assessment units were ranked based on total phosphorus reduction required and willingness of landowner participation.

Urban issues are not a major a problem in the Wabash River watershed, but there are two permitted wastewater treatment plants and two industrial facilities. Nutrients are delivered to the river through normal permitted discharge. As NPDES permits are renewed, limits will be established for phosphorus and nitrogen to levels that supplement reductions from nonpoint sources. Requirements for best available control technology will be the primary mechanism used for reaching the desired limits.

12.0 PUBLIC PARTICIPATION

Public participation is an ongoing process in the watershed. The watershed coordinator has been responsible for hosting numerous meetings on outreach and education, and updating the stakeholders on various issues described in the previous sections. This TMDL "The Total Maximum Daily Load (TMDL) report for the Wabash River, Ohio, Watershed" is completed by the USEPA in conjunction with the OEPA and Tetra Tech, Inc., under Section 303(d) of the Clean Water Act, and was put on public notice on February 26, 2004. The TMDL report includes the name and location of the waterbody segments and the pollutants of concern (nutrients and sediments). The Wabash River watershed was identified as a priority impaired water on Ohio's 2002 303(d) list (OEPA, 2002). Public comments and the responsiveness summary are included in Appendix E.

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Appendix A: Large CAFOs in the Wabash River Watershed

Table A-1. Large CAFOs in the Wabash River Watershed, Ohio. All large CAFOs will be covered under an NPDES permit by the federal deadline of April 14, 2006. By December 2006, all large CAFOs will be operating under a manure management plan that includes phosphorus consideration. Also, prior to permit coverage any discharge of sanitary wastewater or industrial/process wastewater must be eliminated and/or covered under an NPDES permit that is in compliance with the TMDL.

#	Facility Name	Receiving Stream
1	Acheson Poultry	UT Wabash
2	Badgett Poultry	Fort Creek or Two Mile
3	Brunswick Farms	UT Wabash
4	Eichenauer Farms	Wabash or Two Mile
5	Sunny Side, Ft. Recovery	Henry Ditch
6	E&J Farms	UT Wabash
7	Guggenbiller Brothers Poultry	UT Wabash
8	Huelskamp	UT Wabash
9	Hummel Hog Farm	Wabash
10	JMJ Poultry Farm	Fort Creek
11	John Boeckman	Big Run
12	John Will Farm	Wabash
13	Langenkamp Poultry	Wabash
14	Lennartz	UT Toti Creek
15	Lochtefeld	Fort Creek
16	Meiring Poultry Farm	UT Wabash
17	Muhlenkamp	Hickory Branch
18	Paul Fortkamp	UT Wabash
19	Rindler Poultry Farm	Bear Creek
20	Rose Brothers Poultry Farm	UT Wabash
21	Rose Brothers Swine Farm	UT Wabash
22	Schwieterman Egg Farm	UT Wabash
23	T and N Farm	Toti Creek
24	Terry Linn Poultry Farm	Scherman Ditch
25	Tobe Poultry Farm	Twomile Creek
26	Weitzel Farms	Fort Creek
27	Wenning Poultry Farm	UT Fort Creek
28	Ron Post	UT Wabash
29	WB Poultry	UT Bear Creek

Appendix B: Summary of Available Total Phosphorus, Nitrate+Nitrite, and Total Suspended Solids Data for the Wabash River Watershed, Ohio

Table B-1. Summary of available total phosphorus data in the Wabash River watershed.

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
TSITE13-1	BEAR CK ADJ DULL RD	06/29/99	09/01/99	6	1.08	3.05	1.98
TSITE13-2	BEAR CK AT WATKINS RD	06/29/99	09/01/99	6	2.23	9.43	4.69
TSITE21	BEAVER CK AT ERASTUS-DURBIN RD	05/08/74	08/30/99	9	0.31	0.9	0.55
TSITE25	BEAVER CK AT RR TRESTLE	09/01/94	08/30/99	7	0.06	0.39	0.21
TSITE23	BEAVER CK AT SR 118	08/27/84	08/30/99	10	0.2	3.52	1.12
TSITE24	BEAVER CRK AT MEYER RD	03/18/76	10/28/99	19	0.2	5.8	1.83
TSITE211	BIG RUN AT SR 29	06/28/99	08/30/99	6	0.05	0.14	0.11
TSITE12-1	BURKETTSVILLE CR AT WATKINS RD	08/04/99	08/25/99	3	1.3	5	3.39
TSITE31	CRAB BRANCH AT SR 29	06/30/99	09/02/99	6	0.54	4.56	2.53
TSITE63	EAST BRANCH FORT CR AT BENNER RD	08/04/99	08/11/99	0			
TSITE62	FORT CK AT BARGER RD	06/30/99	09/02/99	4	0.63	0.97	0.77
TSITE61	FORT CK AT SR 119	06/30/99	08/19/99	5	0.28	1.39	0.92
TSITE232	HARDIN CK AT BUSCHOR RD	05/22/74	08/30/99	8	0.16	7	1.69
TSITE231	HARDIN CK AT FLEETFOOT RD	09/18/74	08/30/99	10	0.225	3.5	1.27
TSITE511	HENRY DITCH AT SOUTH ROAD	08/04/99	08/11/99	2	1.92	2.41	2.17
TSITE10	HICKORY BRANCH AT SR 49	06/30/99	09/02/99	6	0.14	0.73	0.38
TSITE221	LITTLE BEAR CK AT SR 219	06/28/99	08/30/99	6	1.29	3.64	2.06
TSITE22	LITTLE BEAVER CK AT MENCHHOFER RD	06/28/99	08/30/99	6	0.74	1.62	1.28
TSITE11-1	OXBOW CRK AT TOBE RD	08/04/99	08/11/99	1	0.76	0.76	0.76
TSITE202	PRAIRIE CK AT ERASTUS-DURBIN RD	06/28/99	08/02/99	3	0.15	1.61	0.85
TSITE201	PRAIRIE CK AT MUD PIKE	06/28/99	08/30/99	6	0.07	0.18	0.11
TSITE10-1	SHARPSBURG CRK AT POST RD	08/04/99	08/11/99	2	2.62	3.17	2.90
TSITE51	STONY CK AT SR 119	06/30/99	09/02/99	6	0.1	0.35	0.18
TSITE81	THREE MILE CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	0			
TSITE42	TOTI CK AT BURRVILLE RD	06/30/99	09/02/99	6	0.3	1.14	0.79
TSITE41	TOTI CK AT SR 219	09/18/74	09/02/99	8	0	0.45	0.18
TSITE241	TRIB TO BEAVER CK AT MONROE RD	06/28/99	06/28/99	1	0.29	0.29	0.29
TSITE71	TWO MILE CK AT SHARPSBURG RD	08/04/99	08/11/99	1	1.04	1.04	1.04
SITE8	WABASH R ADJ DULL RD	06/29/99	09/01/99	6	0.17	0.5	0.26
SITE4	WABASH R AT PARK RD	05/08/74	09/02/99	14	0	1.39	0.44
SITE7	WABASH R AT POST RD	06/29/99	09/01/99	6	0.8	2.03	1.14

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
SITE9	WABASH R AT RHYNARD-FINK RD	06/29/99	08/18/99	4	0.35	0.6	0.47
SITE12	WABASH R AT SR 49	03/18/76	09/02/99	10	0.16	0.78	0.47
SITE10	WABASH R AT SR 705	06/29/99	08/18/99	5	0.2	0.68	0.50
SITE6	WABASH R AT ST PETER RD	07/31/85	09/02/99	9	0.07	1.04	0.48
SITE1	WABASH R AT STATE LINE RD	05/22/74	09/02/99	37	0	1.88	0.58
SITE2	WABASH R AT WABASH RD NR WABASH	09/10/84	09/02/99	8	0.14	1.34	0.41
SITE5	WABASH RV AT FT RECOVERY AT PARK CAMPGROUND	05/22/74	10/28/99	14	0	0.43	0.22
SITE11	WABASH RV AT MEIRING RD	08/04/99	08/11/99	2	1.14	2.13	1.64
SITE3	WABASH RV AT WABASH RD	09/02/99	10/28/99	0			
TSITE14-1	WARD DITCH AT DULL RD	08/04/99	08/25/99	2	0.53	1.05	0.79
TSITE91	WENDELIN CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	2	0.54	4.24	2.39

Table B-2. Summary of available nitrate+nitrite data in the Wabash River watershed.

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
TSITE13-1	BEAR CK ADJ DULL RD	06/29/99	09/01/99	6	0.1	0.41	0.20
TSITE13-2	BEAR CK AT WATKINS RD	06/29/99	09/01/99	6	0.193	11.5	2.29
TSITE21	BEAVER CK AT ERASTUS-DURBIN RD	05/08/74	08/30/99	9	0.194	9.1	1.76
TSITE25	BEAVER CK AT RR TRESTLE	08/07/84	08/30/99	8	0.1	1.87	0.35
TSITE23	BEAVER CK AT SR 118	08/15/84	08/30/99	11	0.1	4.73	2.03
TSITE24	BEAVER CRK AT MEYER RD	03/18/76	10/28/99	21	0.06	8.66	2.36
TSITE211	BIG RUN AT SR 29	06/28/99	08/30/99	6	0.1	0.1	0.10
TSITE12-1	BURKETTSVILLE CR AT WATKINS RD	08/04/99	08/25/99	3	0.1	0.751	0.32
TSITE31	CRAB BRANCH AT SR 29	06/30/99	09/02/99	6	0.1	1.76	0.44
TSITE63	EAST BRANCH FORT CR AT BENNER RD	08/04/99	08/11/99	0			
TSITE62	FORT CK AT BARGER RD	06/30/99	09/02/99	4	0.1	9.34	3.04
TSITE61	FORT CK AT SR 119	06/30/99	08/19/99	5	0.1	11.2	2.61
TSITE232	HARDIN CK AT BUSCHOR RD	05/22/74	08/30/99	8	0.1	4.5	1.30
TSITE231	HARDIN CK AT FLEETFOOT RD	09/18/74	08/30/99	11	0.1	9.1	2.39
TSITE511	HENRY DITCH AT SOUTH ROAD	08/04/99	08/11/99	2	0.1	0.25	0.18
TSITE10	HICKORY BRANCH AT SR 49	06/30/99	09/02/99	6	0.1	0.751	0.31
TSITE221	LITTLE BEAR CK AT SR 219	06/28/99	08/30/99	6	0.1	13.5	3.60
TSITE22	LITTLE BEAVER CK AT MENCHHOFER RD	06/28/99	08/30/99	6	0.1	0.896	0.38
TSITE11-1	OXBOW CRK AT TOBE RD	08/04/99	08/11/99	1	0.855	0.855	0.86
TSITE202	PRAIRIE CK AT ERASTUS-DURBIN RD	06/28/99	08/02/99	3	0.1	0.301	0.18
TSITE201	PRAIRIE CK AT MUD PIKE	06/28/99	08/30/99	6	0.1	606	101.10
TSITE10-1	SHARPSBURG CRK AT POST RD	08/04/99	08/11/99	2	0.1	0.1	0.10
TSITE51	STONY CK AT SR 119	06/30/99	09/02/99	6	0.1	4.13	0.88
TSITE81	THREE MILE CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	0			
TSITE42	TOTI CK AT BURRVILLE RD	06/30/99	09/02/99	6	0.1	0.464	0.21
TSITE41	TOTI CK AT SR 219	09/18/74	09/02/99	8	0.1	11.26	1.80
TSITE241	TRIB TO BEAVER CK AT MONROE RD	06/28/99	06/28/99	1	1.59	1.59	1.59
TSITE71	TWO MILE CK AT SHARPSBURG RD	08/04/99	08/11/99	1	3.49	3.49	3.49
SITE8	WABASH R ADJ DULL RD	06/29/99	09/01/99	6	0.1	0.575	0.20
SITE4	WABASH R AT PARK RD	05/08/74	09/02/99	14	0.1	10.65	1.71
SITE7	WABASH R AT POST RD	06/29/99	09/01/99	6	0.1	2.91	0.72
SITE9	WABASH R AT RHYNARD-	06/29/99	08/18/99	4	0.1	19.7	5.06

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
	FINK RD						
SITE12	WABASH R AT SR 49	03/18/76	09/02/99	10	0.1	7.12	1.62
SITE10	WABASH R AT SR 705	06/29/99	08/18/99	5	0.1	20.3	4.14
SITE6	WABASH R AT ST PETER RD	07/31/85	09/02/99	9	0.1	6.13	0.82
SITE1	WABASH R AT STATE LINE RD	05/22/74	09/02/99	38	0.1	38.8	3.19
SITE2	WABASH R AT WABASH RD NR WABASH	09/10/84	09/02/99	8	0.1	2.29	0.54
SITE5	WABASH RV AT FT RECOVERY AT PARK CAMPGROUND	05/22/74	10/28/99	14	0.1	13.15	1.92
SITE11	WABASH RV AT MEIRING RD	08/04/99	08/11/99	2	0.1	0.1	0.10
SITE3	WABASH RV AT WABASH RD	09/02/99	10/28/99	0			
TSITE14-1	WARD DITCH AT DULL RD	08/04/99	08/25/99	2	0.701	1.2	0.95
TSITE91	WENDELIN CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	2	0.1	0.172	0.14

Table B-3. Summary of available total suspended solids data in the Wabash River watershed.

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
TSITE13-1	BEAR CK ADJ DULL RD	06/29/99	09/01/99	6	49	420	248.50
TSITE13-2	BEAR CK AT WATKINS RD	06/29/99	09/01/99	6	17.5	172	61.92
TSITE21	BEAVER CK AT ERASTUS-DURBIN RD	05/08/74	08/30/99	9	10	120	70.76
TSITE25	BEAVER CK AT RR TRESTLE	08/07/84	08/30/99	8	18	89	59.06
TSITE23	BEAVER CK AT SR 118	08/31/94	08/30/99	7	62	116	96.14
TSITE24	BEAVER CRK AT MEYER RD	03/18/76	10/28/99	21	10	84	50.67
TSITE211	BIG RUN AT SR 29	06/28/99	08/30/99	5	11.5	35.5	21.80
TSITE12-1	BURKETTSVILLE CR AT WATKINS RD	08/04/99	08/25/99	3	88	264	155.67
TSITE31	CRAB BRANCH AT SR 29	06/30/99	09/02/99	6	6.5	52.5	18.42
TSITE63	EAST BRANCH FORT CR AT BENNER RD	08/04/99	08/11/99	0			
TSITE62	FORT CK AT BARGER RD	06/30/99	09/02/99	4	16	46	32.25
TSITE61	FORT CK AT SR 119	06/30/99	08/19/99	5	5	26	12.10
TSITE232	HARDIN CK AT BUSCHOR RD	05/22/74	08/30/99	8	5	18.5	8.31
TSITE231	HARDIN CK AT FLEETFOOT RD	11/07/74	08/30/99	10	10	33	19.55
TSITE511	HENRY DITCH AT SOUTH ROAD	08/04/99	08/11/99	2	18	56	37.00
TSITE10	HICKORY BRANCH AT SR 49	06/30/99	09/02/99	6	5	161	34.67
TSITE221	LITTLE BEAR CK AT SR 219	06/28/99	08/30/99	6	12	175	61.00
TSITE22	LITTLE BEAVER CK AT MENCHHOFER RD	06/28/99	08/30/99	6	20.2	95	52.78
TSITE11-1	OXBOW CRK AT TOBE RD	08/04/99	08/11/99	1	125	125	125.00
TSITE202	PRAIRIE CK AT ERASTUS-DURBIN RD	06/28/99	08/02/99	3	7	143	63.33
TSITE201	PRAIRIE CK AT MUD PIKE	06/28/99	08/30/99	6	5	63	22.17
TSITE10-1	SHARPSBURG CRK AT POST RD	08/04/99	08/11/99	2	50	64	57.00
TSITE51	STONY CK AT SR 119	06/30/99	09/02/99	6	5	39	12.67
TSITE81	THREE MILE CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	0			
TSITE42	TOTI CK AT BURRVILLE RD	06/30/99	09/02/99	6	5	38.5	15.67
TSITE41	TOTI CK AT SR 219	04/16/74	09/02/99	8	5	23.5	14.47
TSITE241	TRIB TO BEAVER CK AT MONROE RD	06/28/99	06/28/99	1	6.5	6.5	6.50
TSITE71	TWO MILE CK AT SHARPSBURG RD	08/04/99	08/11/99	1	23	23	23.00
SITE8	WABASH R ADJ DULL RD	06/29/99	09/01/99	5	13	184	65.20
SITE4	WABASH R AT PARK RD	04/16/74	09/02/99	12	10	178	44.89
SITE7	WABASH R AT POST RD	06/29/99	09/01/99	6	9.5	110	58.67
SITE9	WABASH R AT RHYNARD-	06/29/99	08/18/99	4	8.5	27	17.63

Unique Site ID	Description	First Date	Last Date	# of Obser-vations	Min (mg/L)	Max (mg/L)	Average (mg/L)
	FINK RD						
SITE12	WABASH R AT SR 49	03/18/76	09/02/99	7	5	85	30.86
SITE10	WABASH R AT SR 705	06/29/99	08/18/99	5	5	13.5	9.00
SITE6	WABASH R AT ST PETER RD	06/30/99	09/02/99	6	41.2	88	60.03
SITE1	WABASH R AT STATE LINE RD	04/16/74	09/02/99	38	10	232	60.22
SITE2	WABASH R AT WABASH RD NR WABASH	09/10/84	09/02/99	7	15	59	30.43
SITE5	WABASH RV AT FT RECOVERY AT PARK CAMPGROUND	05/22/74	10/28/99	18	5	88	20.33
SITE11	WABASH RV AT MEIRING RD	08/04/99	08/11/99	2	27	44.5	35.75
SITE3	WABASH RV AT WABASH RD	09/02/99	10/28/99	9	5	11.5	6.39
TSITE14-1	WARD DITCH AT DULL RD	08/04/99	08/25/99	2	55	156	105.50
TSITE91	WENDELIN CK AT FT RECOVERY MINSTER RD	08/04/99	08/11/99	2	28	95	61.50

Appendix C: Application of the Soil Water Assessment Tool (SWAT) to the Wabash River Watershed, Ohio

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Introduction

The Soil Water Assessment Tool (SWAT) model was developed by the Agricultural Research Service, the main research agency within the U.S. Department of Agriculture. The model predicts the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. SWAT can analyze large watersheds and river basins (greater than 100 square miles) by subdividing the area into homogenous subwatersheds. The model uses a daily time step, and can perform continuous simulation for a period of one to 100 years. SWAT simulates hydrology, pesticide and nutrient cycling, erosion and sediment transport. SWAT was applied to the Wabash River watershed in Ohio to support the development of total maximum daily loads (TMDLs) for nutrients and sediments. This appendix provides an overview of the model and a description of the modeling process.

Hydrology

The hydrology component of SWAT is based on the water balance equation. A distributed curve number is generated for the computation of overland flow runoff volume, given by the standard Soil Conservation Service (SCS, now the Natural Resources Conservation Service (NRCS)) runoff equation (USDA, 1986). The curve number method is empirically based and relates runoff potential to land use and soil characteristics. The curve number method combines infiltration losses, depression storage, and interception into a potential maximum storage parameter called S. Runoff depth is given by the following set of empirical relationships:

$$Q = \frac{(P - 0.2S)^\wedge 2}{P + 0.8S}$$

where Q is the accumulated runoff depth or rainfall excess (inches), P is the accumulated precipitation (inches), and S is a maximum soil water retention parameter given by

$$S = \frac{1000}{CN} - 10$$

where CN is known as the curve number.

The equation above indicates that precipitation, P, must exceed 0.2S before any runoff is generated. Furthermore, this equation yields a depth of runoff. To calculate runoff volume, the computed depth must be multiplied by area.

The curve number indicates the runoff potential of an area for the combination of land use characteristics and soil type. Higher curve numbers translate into greater runoff. Curve numbers are a function of hydrologic soil group, vegetation, land use, cultivation practice, and antecedent moisture conditions. The NRCS has classified more than 4000 soils into four hydrologic soil groups according to their minimum infiltration rate for bare soil after prolonged wetting. The characteristics associated with each hydrologic soil group are given in Table 1. The amount of moisture present in the soil is known to affect the volume and the rate of runoff. Consequently, the NRCS developed three antecedent soil moisture conditions:

- dryer antecedent conditions (Condition I) reflect soils that are dry but not to the wilting point.

- wetter conditions (Condition III) characterize soils that have experienced heavy rainfall, light rainfall and low temperatures within the last five days (saturated soils).
- Condition II is the average condition.

Curve numbers for dryer antecedent conditions (Condition I) and for wetter antecedent conditions (Condition III) are found in Table 2.

Table 1. Characteristics of Hydrologic Soil Groups.

Soil Group	Characteristics	Minimum Infiltration Capacity (in./hr)
A	Sandy, deep, well drained soils; deep loess; aggregated silty soils	0.30-0.45
B	Sandy loams, shallow loess, moderately deep and moderately well drained soils	0.15-0.30
C	Clay loam soils, shallow sandy loams with a low permeability horizon impeding drainage (soils with a high clay content), soils low in organic content	0.05-0.15
D	Heavy clay soils with swelling potential (heavy plastic clays), water-logged soils, certain saline soils, or shallow soils over an impermeable layer	0.00-0.05

Source: NRCS, 1972

Table 2. Curve Number Adjustments from Antecedent Moisture Conditions I, II, and III.

CN for Antecedent Moisture Condition II	CN for Antecedent Moisture Condition I	CN for Antecedent Moisture Condition III
100	100	100
95	87	99
90	78	98
85	70	97
80	63	94
75	57	91
70	51	87
65	45	83
60	40	79
55	35	75
50	31	70
45	27	65
40	23	60
35	19	55
30	15	50
25	12	45
20	9	39
15	7	33
10	4	26
5	2	17
0	0	0

Source: NRCS, 1972

Curve numbers in SWAT are updated daily as a function of initial soil moisture storage. A soil database is used to obtain information on soil type, texture, depth, and hydrologic classification. In SWAT, soil profiles can be divided into 10 layers. Infiltration, defined in SWAT as precipitation minus runoff, moves into the soil profile where it is routed through the soil layers. A storage routing flow coefficient is used to predict flow through each soil layer, with flow occurring when a layer exceeds field capacity. When water percolates past the bottom layer, it enters the shallow aquifer zone (Arnold et al., 1993). Channel transmission loss and pond/reservoir seepage replenish the shallow aquifer while it interacts directly with the stream. Flow to the deep aquifer system is effectively lost and cannot return to the stream (Arnold et al., 1993). Based on surface runoff calculated using the runoff equation, excess surface runoff not lost to other functions makes its way to the channels where it is routed downstream. Figure 1 displays the pathways for water movement within SWAT.

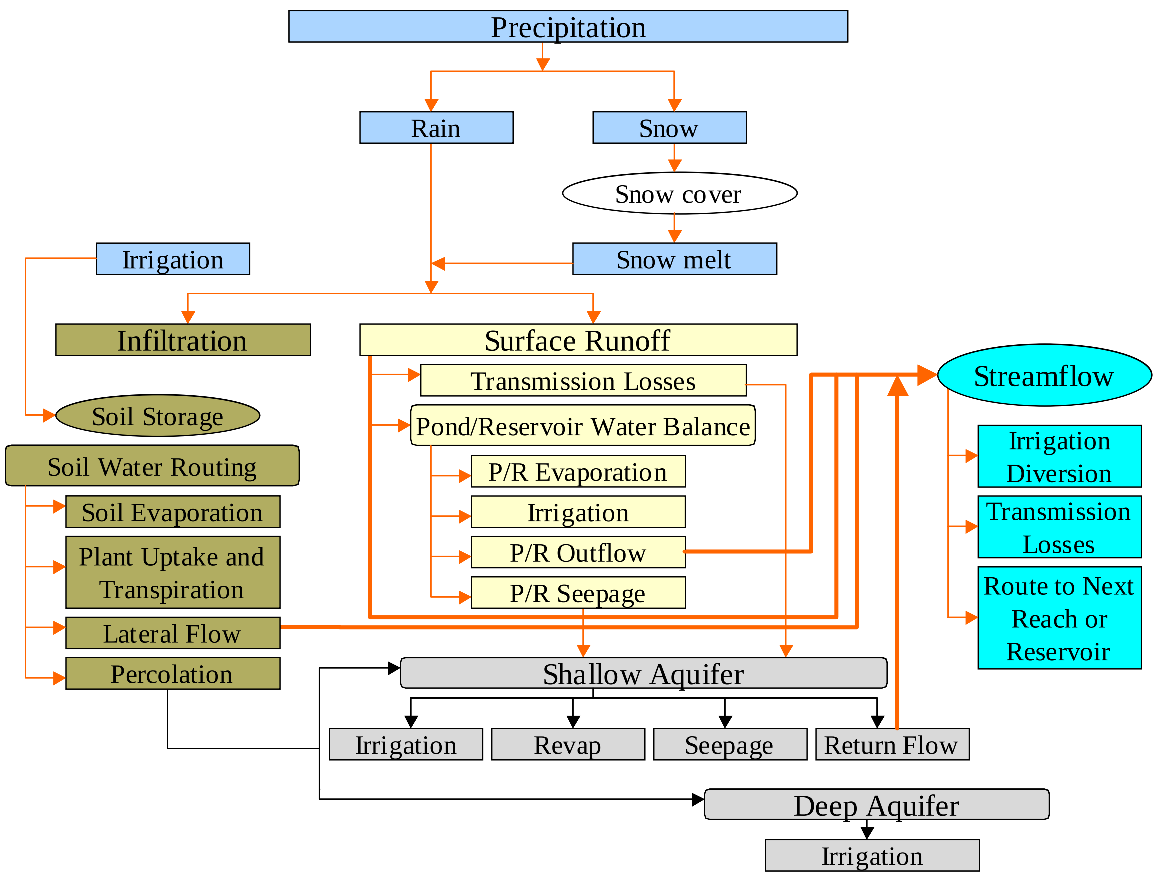

Figure 1. Pathways for water movement within SWAT.

An important consideration in modeling the hydrology of the Wabash River watershed is that agricultural land in the basin is heavily tiled, as many of the soils are naturally poorly drained. The presence of tile drains has altered the natural hydrology of the area. Precipitation is routed to the streams through the tiles, rather than running over the land surface, which results in a shorter time-of-travel and less ability for pollutants to be naturally filtered through the process of groundwater infiltration.

It is not feasible to simulate individual tile drain systems at the large basin scale with currently available watershed scale models and neither the location nor the total density of tile drainage is known throughout the basin. In most areas, only the ditches are documented in spatial coverages, and the extent of private tile drains is known only for limited areas. Furthermore, the SWAT model has limited routines for the explicit representation of tile.

To address these factors several model parameters were adjusted to simulate the effects of tiling on watershed hydrology. For example, NRCS curve numbers for tiled soils were set lower than for non-tiled soils to simulate the effect of greater infiltration. The storage routing flow coefficient within SWAT was also adjusted during model calibration to address the effects of tiling. These adjustments, in combination with other calibration activities, resulted in acceptable performance of the model as measured by recommended modeling criteria (see below).

Upland Erosion

Another important model parameter obtained from the soils database is the Universal Soil Loss Equation (USLE) erodibility factor, k. The erodibility factor is an empirically derived unitless value reflecting a soil's inherent erodibility. The USLE is used in SWAT to estimate initial soil detachment and upland erosion. Sediment yield used for in-stream transport is determined from the Modified Universal Soil Loss Equation (MUSLE) (Arnold, 1992). For sediment routing in SWAT, deposition calculation is based on fall velocities of various sediment sizes. Rates of channel degradation are determined from Bagnold's (1977) stream power equation. Stream power is a useful index for describing the erosive capacity of streams, and has been related to the shape of the longitudinal profile, channel pattern, the development of bed forms, and sediment transport. As stream slopes become steeper and/or velocities increase, stream power increases as does stream erosivity.

Sediment size is estimated from the primary particle size distribution (Foster et al.,1980) for soils that the SWAT model obtains from the State Soil Geographic (STATSGO)(USDA, 1995) database. Stream power is also accounted for in the sediment routing routine, and is used for calculation of re-entrainment of loose and deposited material in the system until all of the material has been removed.

Description of the ArcView-SWAT Interface

An ArcView interface for SWAT (DiLuzio et al., 2001) was employed to efficiently derive and build the input files for the SWAT modeling of the Wabash River watershed. The interface requires digital elevation data (DEM), land use/land cover, soils, and meteorological data. Thirty-meter DEM representing 7.5 minute U.S. Geological Survey (USGS) quadrangles were downloaded from GEOCommunity <www.geocomm.com>, the current distribution center for USGS DEM. Watershed and subbasin delineation is based on a DEM of the watershed coupled with a "burn-in" of EPA's National Hydrography Database spatial database of stream reaches. This approach ensures that the subbasins conform to topography while requiring that catalogued stream segments connect in the proper order and direction.

The interface allows a user to select multiple subbasin outlets, thereby defining multiple subbasins for modeling analysis purposes. The interface then uses the DEM to calculate the upstream area, defined by the total number of up-slope cells, which could contribute flow to each point, thus defining the area of each subbasin. For the Wabash River watershed, the USGS 14-digit Hydrologic Unit Code (HUC) served as the basis for subbasin definition. Additional subbasins were delineated to obtain model output at key locations (e.g., sampling stations). This resulted in a total of 54 subbasins as shown in Figure 2.

After computing watershed topographic parameters for each subbasin, the interface uses land cover and soils data in an overlay process to assign soil parameters and SCS curve numbers. The land cover for the watershed area was extracted from the Multi-Resolution Land Characterization database for the state of Ohio (MRLC, 1992). This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data known to be available for the watershed. Each 100-foot by 100-foot pixel contained within the satellite image is classified according to its reflective characteristics.

The MRLC land cover data must be reclassified to equal land cover and land use classes used by the SWAT2000 model. General soils data and map unit delineations for the United States are provided as part of the State Soil Geographic (STATSGO) database (USDA, 1995). The STATSGO data set was created to provide a general understanding of soils data to be used with large-scale analyses. Small, site-specific analyses with the STATSGO data are not appropriate. GIS coverages provide accurate locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverages can be linked to a database that provides information on chemical and physical soil characteristics.

The user may decide whether or not to use multiple hydrologic response units (HRUs) in the modeling application. An HRU is a combination of land use/land cover and soil characteristics, and represents areas of similar hydrologic response. If multiple HRUs are not employed, the interface will use the dominant land use and soil characteristic for the entire watershed. To model multiple HRUs, the user must determine a threshold level used to eliminate minor land uses in each subbasin. Land uses that cover a percentage of the subbasin area less than the threshold level are eliminated and the area of the land uses is reapportioned so that 100 percent of the land area in the subbasin is included in the simulation.

The ArcView SWAT interface user's manual suggests that a 20 percent land use threshold and a 10 percent soil threshold are adequate for most modeling applications. For the Wabash River watershed, a 10 percent land use threshold and a 10 percent soil threshold were employed. These threshold values resulted in a detailed land use and soil SWAT database, containing many HRUs, which in turn represent a very heterogeneous watershed. Figure 2 shows the SWAT land use distribution in the watershed. Table 3 lists the SCS curve numbers used in the Wabash River watershed. Table 5 summarizes the land use characteristics of the watershed.

Table 3. SCS Curve Numbers (CN-II) for Land Use and Land Cover in the Wabash River Watershed.

SWAT Land Use/Land Cover Classification	SCS Curve Numbers for Land Use and Hydrologic Soil Group			
	A	B	C	D
Water	100	100	100	100
Low Density Urban Residential	46	65	77	82
High Density Urban Residential	63	77	85	88
Urban Commercial	89	92	94	96
Deciduous Forest	45	66	77	83
Pasture	49	69	79	84
Corn/Soybean	67	78	85	89
Grasslands	31	59	72	79
Forested Wetlands	45	66	77	83

Figure 2 and Table 4 show that row crops (corn and soybean) are by far the most dominant land use in the watershed, representing nearly 81 percent of the total land use. It is assumed that corn and soybean crops are rotated on an annual basis. Pasture is the second largest land use, representing 11 percent of the total watershed. Deciduous forest accounts for nearly 6 percent. All other land use classes each represent less than 1 percent of total land use/land cover in the watershed.

Several USLE parameters are used in AVSWAT, including the K-factor, length-slope factor, C-factor, and the P-factor. The K-factor and length-slope factors were derived from the STATSGO soils database and topographic data, respectively, and are automatically determined in AVSWAT. Figure 3 displays the K-factors by subbasin. For the Wabash River watershed, C-factors for corn/soybean and pasture were assumed to be 0.20 and 0.003, respectively and the P-factor was set to 1.0. These values were chosen based on recommendations within the SWAT user's manual.

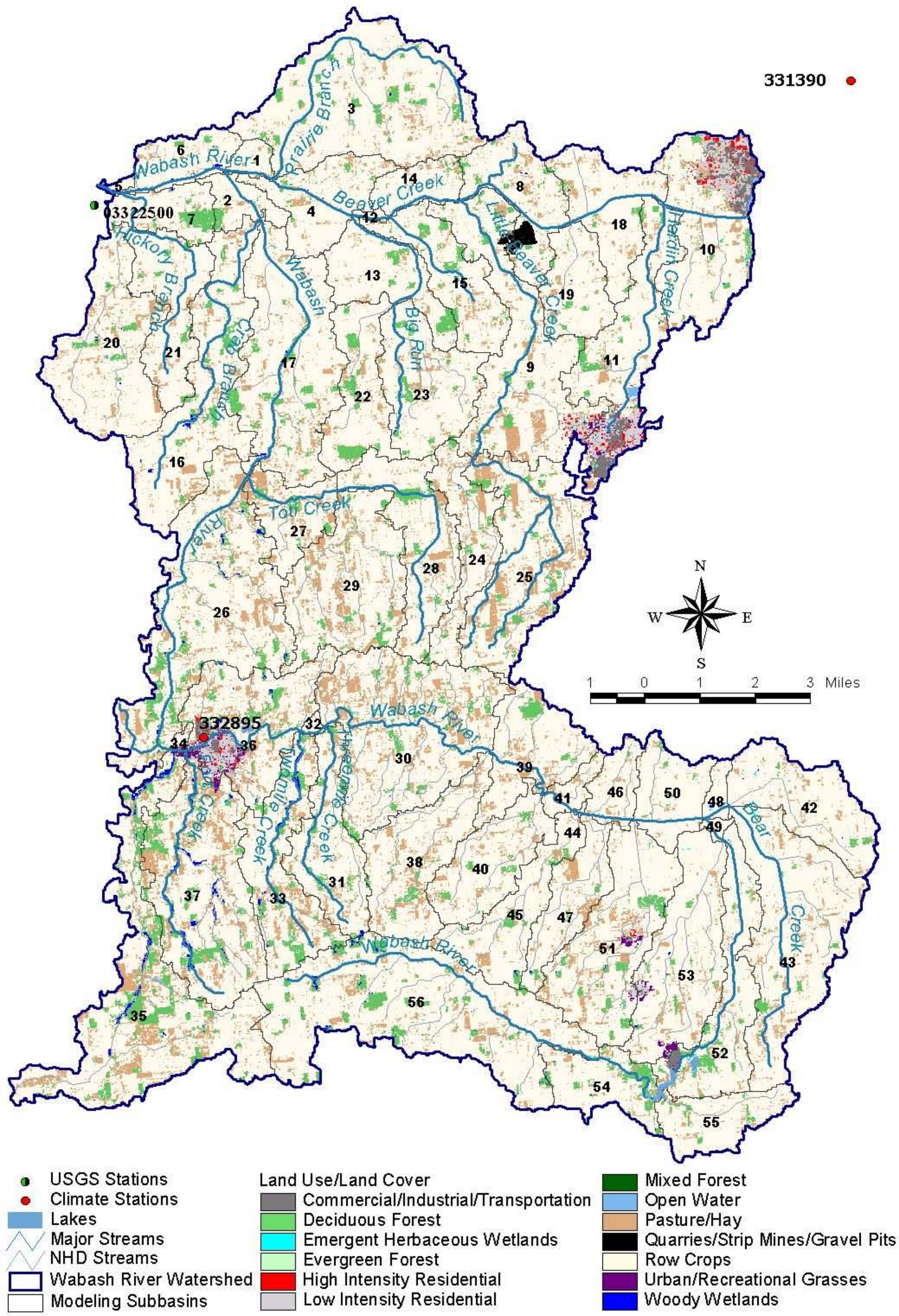

Figure 2. Subbasins and Land Use/Land Cover in the Wabash River Watershed.

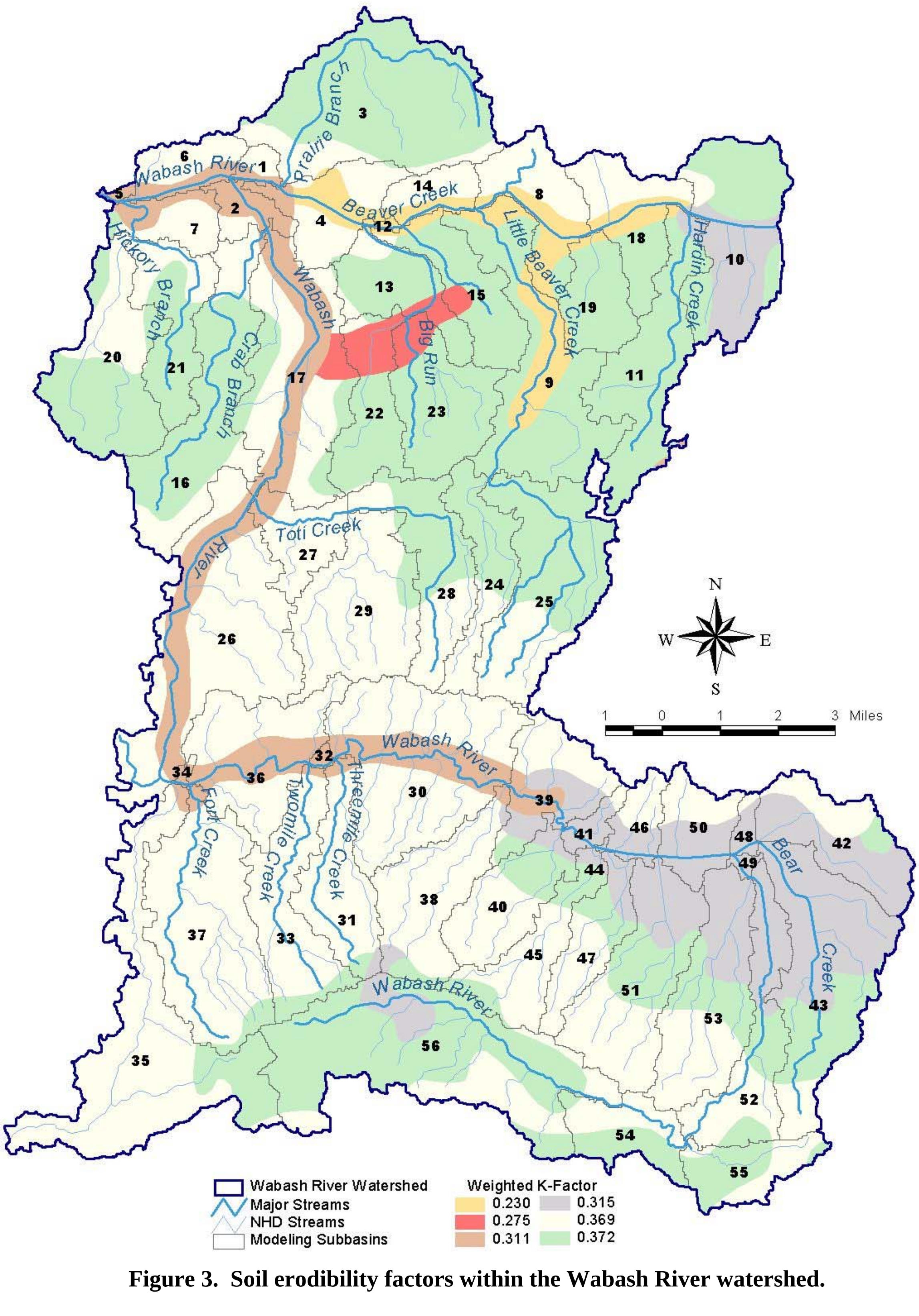

Figure 3. Soil erodibility factors within the Wabash River watershed.

Table 4. Summary of land use characteristics for the Wabash River watershed.

Land Use Land Cover (MRLC)	Area (Acres)	Percent
Row Crops	99,630.0	80.63
Pasture/Hay	13,990.4	11.32
Deciduous Forest	7,091.3	5.74
Low Intensity Residential	1,023.0	0.83
Commercial/Industrial/Transportation	610.7	0.49
Woody Wetlands	399.4	0.32
High Intensity Residential	228.8	0.19
Urban/Recreational Grasses	216.2	0.17
Open Water	173.5	0.14
Quarries/Strip Mines/Gravel Pits	135.2	0.11
Emergent Herbaceous Wetlands	42.3	0.03
Evergreen Forest	16.0	0.01
Mixed Forest	6.4	0.01
Total	**123,563.2**	**100.00**

Meteorological Data

SWAT2000 requires daily precipitation, temperature, relative humidity, solar radiation, and wind speed data. These parameters may be given in a site-specific, user-specified file, estimated using a climate simulator, or a combination of the two. The interface will search and find the station closest to the mean center of each subbasin, and assign that station's meteorological parameters to the subbasin. Daily precipitation and temperature data were obtained from the National Climatic Data Center (NCDC) for the Celina 3NE (ID 331390) and Fort Recovery (ID 332895) stations (see Figure 2). Daily data are available for Celina for the period January 1, 1956 to December 31, 2002. Daily data are only available for the Fort Recovery station for the period January 1, 1997 to December 31, 2002. Relative humidity, solar radiation and wind speed were simulated using a climate simulator available in SWAT2000. The climate simulator uses historical data collected from surrounding National Weather Service sites to estimate parameters. It is believed that these stations are quite adequate for estimating relative humidity, solar radiation, and wind speed for the Wabash River watershed.

Reservoir Impact on Hydrology and Water Quality

Two reservoirs in the Wabash River watershed affect downstream streamflows. Streamflow in Beaver Creek is impacted by the volume of water releases from Grand Lake St. Marys. The daily volume of released water was not available for input to the model and was therefore estimated based on existing information. Grand Lake St Mary’s has a surface area of approximately 12,813 acres at normal pool and the principal spillway is 500 foot spillway with a 50 foot notch, 11 inches deep. Discharge from the lake was estimated using available data relating lake elevation and flow.

Information on the conservation district reservoir located in the southern portion of the watershed was provided by the Mercer County Soil and Water Conservation District. The surface area of the reservoir is 152 acres and the reservoir volume is approximately 1,550 acre-feet. The average annual outflow is 5.3 acre-feet per year. It should be noted that the conservation district reservoir provides limited ability to trap sediments, a characteristic often association with other reservoirs. This is due to the extremely fine-grained nature of the soils upstream of the reservoir which have very long settling times.

Model Calibration and Validation: Hydrology

After initially configuring SWAT, model calibration and validation were performed. Calibration refers to the adjustment or fine-tuning of modeling parameters to reproduce observations. The calibration was performed for different SWAT subbasins at multiple locations throughout the watershed. This approach ensured that landscape heterogeneities were represented. The model validation was performed to test the calibrated parameters at different locations and for different time periods, without further adjustment. Upon completion of the calibration and validation at selected locations, a calibrated dataset containing parameter values for each modeled land use and pollutant was developed.

Calibration and validation were completed by comparing time-series model results to monitoring data. Output from the watershed model are in the form of daily average flow and daily average concentrations for the modeled pollutants for each of the subwatersheds.

Hydrology was the first model component calibrated, and it involved a comparison of observed data from an in-stream USGS flow gauging station to modeled in-stream flow and an adjustment of key hydrologic parameters. Among the modeling parameters that proved to be most sensitive were those governing the partitioning of precipitation between surface and groundwater flows, possibly because of the presence of tiling. The specific parameters were the threshold depth of the shallow aquifer before evaporation can occur and the groundwater revaporation coefficient.

The model was calibrated for the Wabash River watershed to simulate conditions during the period 1977 to 1987. This time period corresponds to the most recent data available at the USGS Wabash River stream gage near New Corydon, Indiana (ID 03322500), which is located near the Ohio/Indiana state line (see Figure 2). Data at this station cover the period April 1, 1951 to September 30, 1988.

Key considerations in the hydrology calibration were the overall water balance, the high-flow to low-flow distribution, storm flows, and seasonal variation. Two criteria for goodness of fit were used for calibration: graphical comparison and the relative error method. 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 primarily assessed through interpretation of the time-variable plots. The relative error method was used to support the goodness of fit evaluation through a quantitative comparison. A small relative error indicates a better goodness of fit for calibration.

An example of the calibration results for a year with average streamflows is given below in Figure 4 for the 1981 water year. Figure 4 shows a comparison of the observed versus the simulated daily stream flow for the entire year. Figure 5 provides a comparison of the observed versus the simulated monthly and weekly stream flows in 1981. Figures 4 and 5 show a good level of agreement between observed and simulated stream flow, as well as the timing of peak storm flow.

An example of the calibration results for a year with above-average streamflows is given below in Figure 6 for the 1986 water year. Figure 6 shows a comparison of the observed versus the simulated daily stream flow for the entire year. Figure 7 provides a comparison of the observed versus the simulated monthly and weekly stream flows in 1986. Figures 6 and 7 do not show as good a level of agreement between observed and simulated stream flow as Figures 4 and 5, but are still considered acceptable.

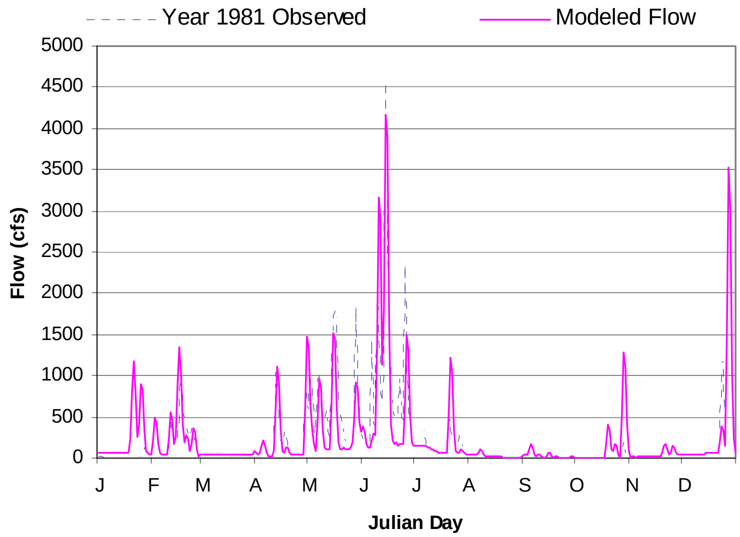

Figure 4. Observed Versus Simulated Daily Stream Flow, 1981.

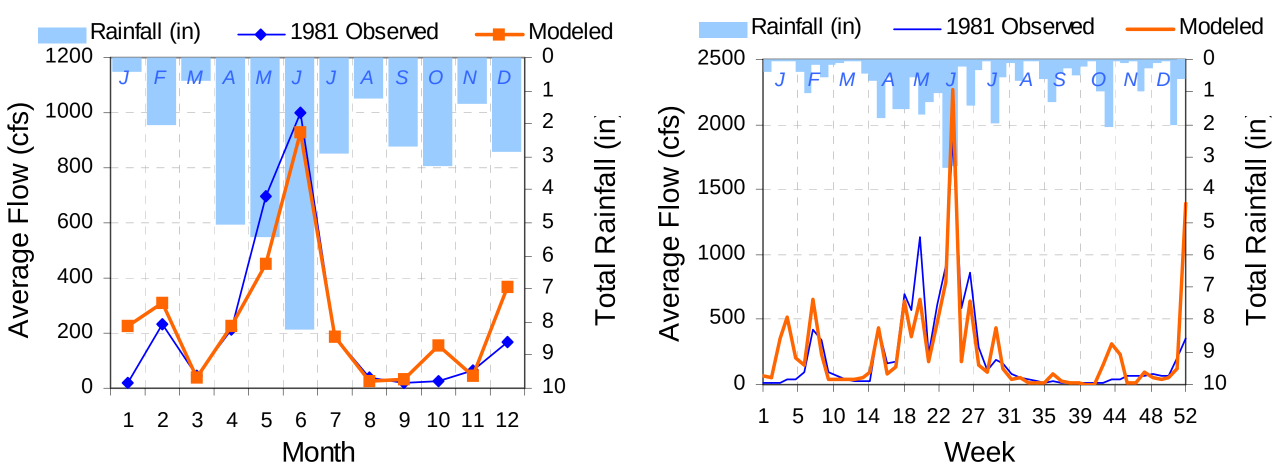

Figure 5. Observed Versus Simulated Monthly and Weekly Stream Flow, 1981.

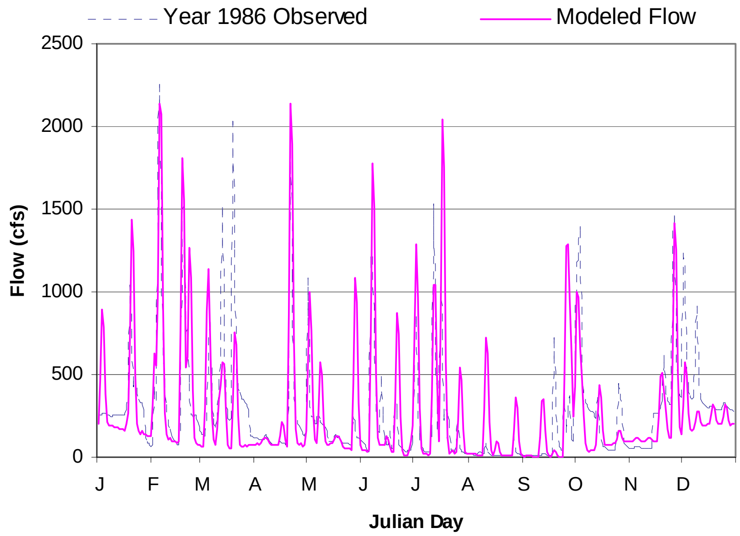

Figure 6. Observed Versus Simulated Daily Stream Flow, 1986.

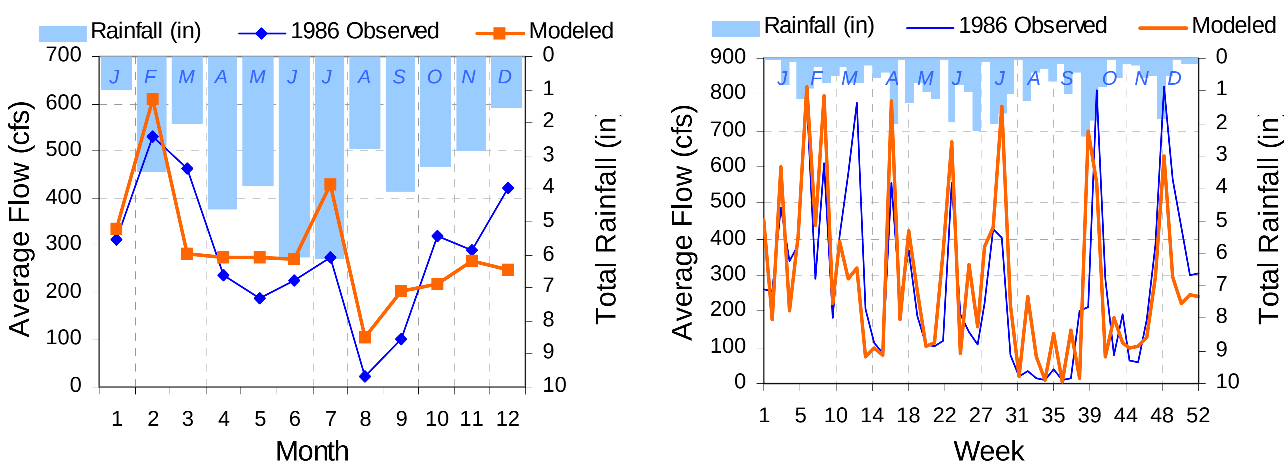

Figure 7. Observed Versus Simulated Monthly and Weekly Stream Flow, 1986.

The ten year flow comparison is summarized in Figure 8 and Table 5. Figure 8 shows that the level of agreement between monthly observed versus monthly simulated stream flow is good (R^2 = 0.76).

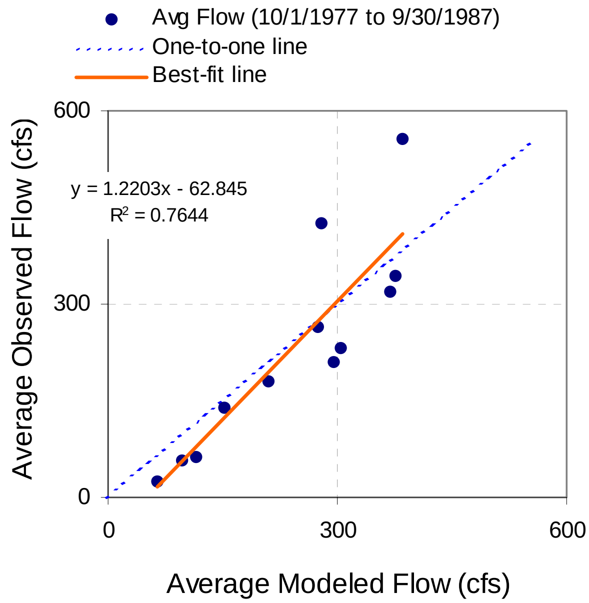

Figure 8. Statistical Comparison of Observed Versus Simulated Annual Stream Flow, 1977 to 1987.

Seasonal and annual differences between observed versus simulated stream flow are summarized in Table 5. The table shows that simulated flow for the ten-year period agrees well with observed stream flow data. The greatest errors occur in simulated summer storm volumes, yet these errors are within recommended calibration parameters (Lumb et al., 1994). In general, the hydrologic calibration appears adequate in that it reflects the total water yield, annual variability, and magnitude of individual storm events in the basin. All recommended criteria are met.

Table 6. Wabash River Watershed Calibration Results for the Simulation Period October 1, 1977 to September 30, 1987. Units shown are inches.

Total Simulated In-stream Flow:	**102.17**	Total Observed In-stream Flow:	**98.26**
Total of highest 10% flows:	**57.54**	Total of Observed highest 10% flows:	**55.73**
Total of lowest 50% flows:	**6.46**	Total of Observed Lowest 50% flows:	**6.05**
Simulated Summer Flow Volume:	**11.08**	Observed Summer Flow Volume:	**7.82**
Simulated Fall Flow Volume:	**24.54**	Observed Fall Flow Volume:	**19.88**
Simulated Winter Flow Volume:	**36.52**	Observed Winter Flow Volume:	**38.50**
Simulated Spring Flow Volume:	**30.03**	Observed Spring Flow Volume:	**32.06**
Total Simulated Storm Volume:	**102.04**	Total Observed Storm Volume:	**95.66**
Simulated Summer Storm Volume:	**11.05**	Observed Summer Storm Volume:	**7.17**
Errors (Simulated-Observed)		*Recommended Criteria*[1]	
Error in total volume:	**3.83**	10	
Error in 50% lowest flows:	**6.24**	10	
Error in 10% highest flows:	**3.13**	15	
Seasonal volume error - Summer:	**29.39**	30	
Seasonal volume error - Fall:	**18.99**	30	
Seasonal volume error - Winter:	**-5.42**	30	
Seasonal volume error - Spring:	**-6.76**	30	
Error in storm volumes:	**6.25**	20	
Error in summer storm volumes:	**35.08**	50	

[1] Recommended criteria are form Lumb et al., 1994

Model Calibration and Validation: Water Quality

After hydrology was sufficiently calibrated, water quality calibration was performed. Modeled versus observed in-stream concentrations were directly compared during model calibration. The water quality calibration consisted of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting pollutant loading and in-stream water quality parameters within a reasonable range. The objective was to best simulate the observed data, as well as to obtain modeling output within the range of all observations (i.e., the observed minimum and maximum water quality concentrations should be within the range of the simulated minimum and maximums).

Several assumptions had to be made regarding agricultural practices in the watershed to provide appropriate input to the model. These assumptions are summarized below and were based on personal observations made during a site visit, discussions with the Wabash River watershed coordinator, and SWAT default values.

- Minimal conservation tillage is practiced in the watershed due to the large amounts of manure application.
- Manure application typically occurs in the spring (April), fall (October), and winter (January) but can occur at other times of the year due inadequate storage facilities.
- Phosphorus can build up on the land surface because plant uptake is not always able to utilize all of the applied phosphorus.

Adjusted water quality parameters within the model included USLE P and C factors, instream decay rates, and denitrificaiton coefficients. Water quality calibration adequacy was primarily assessed through review of time-series plots. Looking at a time series plot of modeled versus observed data provides more insight into the nature of the system and is more useful in water quality calibration than a statistical comparison. Flow (or rainfall) and water quality can be compared simultaneously, and thus can provide insight into conditions during the monitoring period (dry period versus storm event). The response of the model to storm events can be studied and compared to observations (data permitting). Ensuring that the storm events are represented within the range of the data over time is the most practical and meaningful means of assessing the quality of a calibration. Furthermore, due to the relative lack of water quality monitoring data, it was not possible to make statistical comparisons of the predicted and observed data.

Figures 9, 10, and 11 present the results of the model calibration for TP, NN, and TSS. They indicate that the model is a reasonable description of the significant water quality processes in the watershed and is suitable for use in TMDL development.

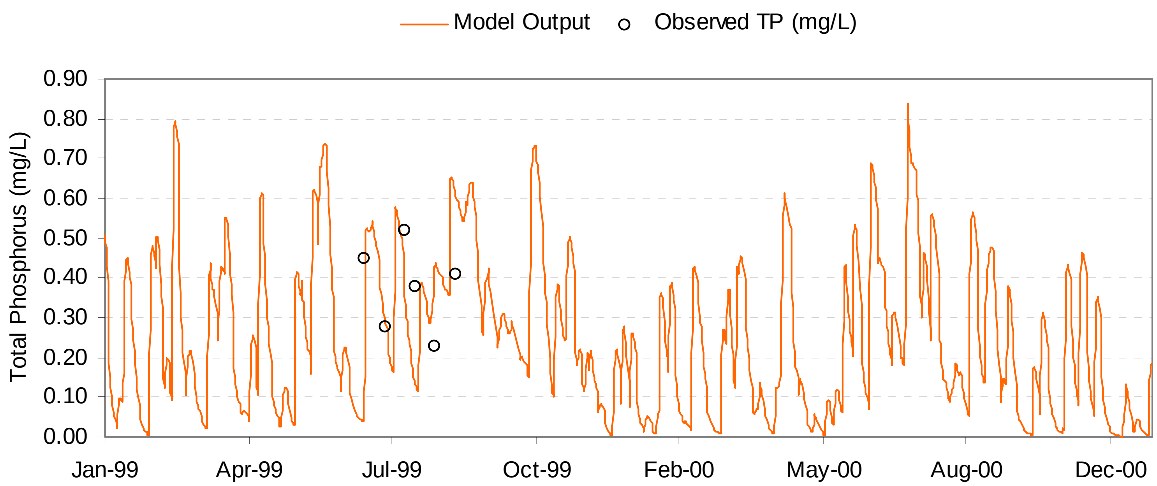

Figure 9. Comparison of predicted and observed total phosphorus data for the Wabash River at State Line Road.

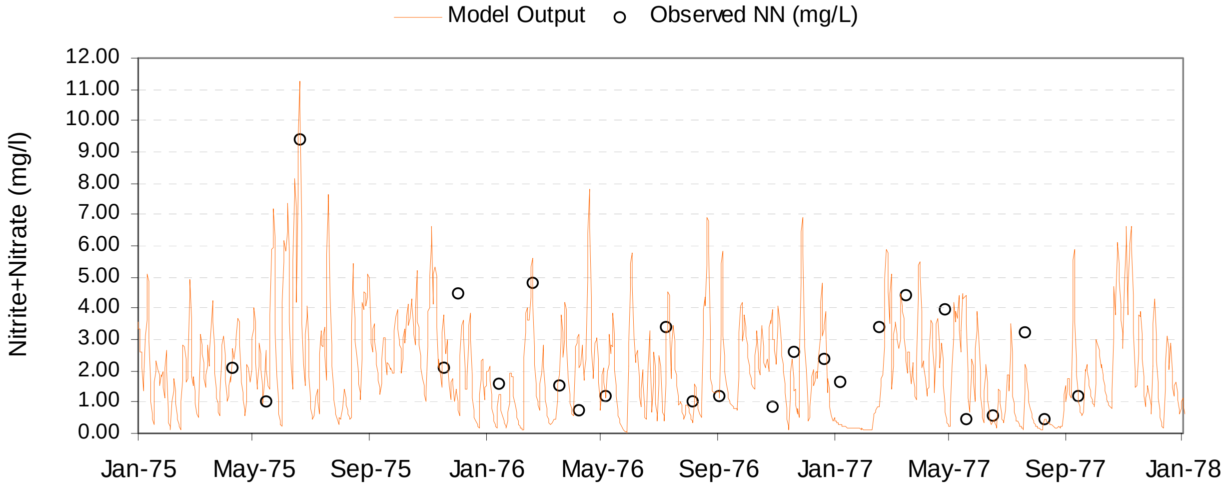

Figure 10. Comparison of predicted and observed nitrite+nitrate data for the Wabash River at State Line Road.

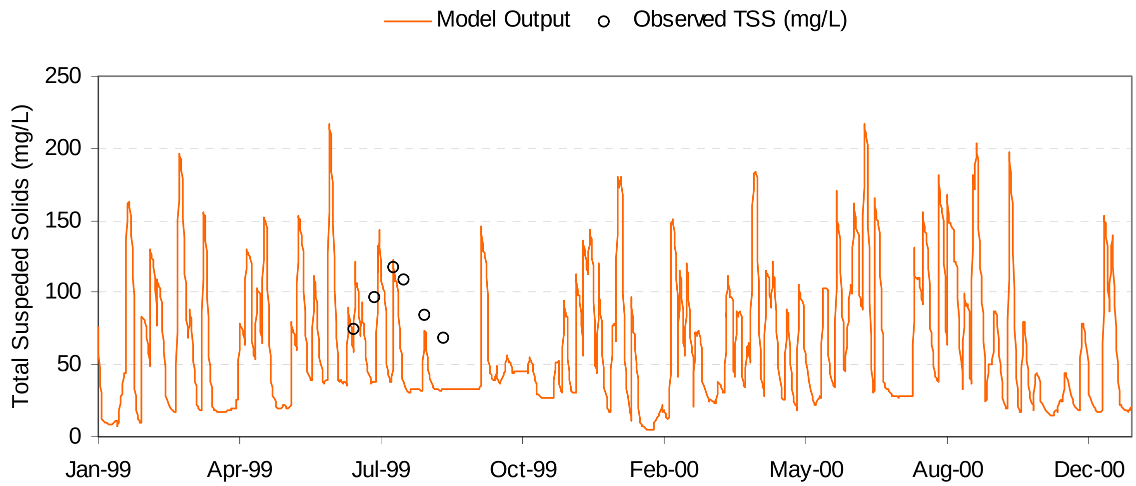

Figure 11. Comparison of predicted and observed total suspended solids data for the Wabash River at State Line Road.

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Appendix D
Assessment Unit
Load and Wasteload Allocations

Nitrate + Nitrite TMDL for the Wabash River Watershed

Month	Existing Load (kg/mo)				Loading Capacity				Margin of Safety				WLA				LA			
Month	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*
Jan	35,044	23,277	6,823	*65,144*	10,012	8,560	2,186	*20,759*	500.61	428.02	109.31	*1,038*	130	2,772	0	*2,902*	9,382	5,360	2,077	*16,819*
Feb	28,962	21,714	5,634	*56,310*	6,249	8,480	1,424	*16,153*	312.43	423.98	71.22	*808*	136	4,784	0	*4,920*	5,800	3,272	1,353	*10,425*
Mar	18,190	14,756	3,523	*36,468*	2,740	5,800	658	*9,198*	136.98	290.02	32.90	*460*	165	4,170	0	*4,335*	2,438	1,340	625	*4,403*
Apr	22,228	17,824	4,316	*44,368*	3,151	6,752	779	*10,682*	157.55	337.60	38.96	*534*	145	4,854	0	*4,999*	2,849	1,560	740	*5,149*
May	33,230	22,959	6,465	*62,655*	9,615	5,703	1,787	*17,106*	480.76	285.17	89.37	***855***	148	3,530	0	*3,678*	8,986	1,888	1,698	***12,573***
Jun	43,253	29,249	8,440	*80,941*	10,864	10,226	2,440	*23,529*	543.19	511.30	121.99	*1,176*	68	3,886	0	*3,954*	10,253	5,829	2,318	*18,399*
Jul	8,605	8,231	1,658	*18,494*	1,488	4,174	337	*5,999*	74.38	208.69	16.87	*300*	124	3,250	0	*3,374*	1,289	715	321	*2,325*
Aug	12,243	10,316	2,366	*24,925*	2,696	4,814	597	*8,106*	134.81	240.68	29.83	*405*	134	3,204	0	*3,338*	2,427	1,369	567	*4,363*
Sep	31,618	21,845	6,152	*59,614*	8,146	8,084	1,803	*18,033*	407.28	404.22	90.13	*902*	141	3,358	0	*3,499*	7,597	4,322	1,713	*13,632*
Oct	10,003	8,395	1,939	*20,337*	1,287	3,355	323	*4,965*	64.34	167.75	16.17	*248*	79	2,567	0	*2,646*	1,144	620	307	*2,071*
Nov	12,458	7,976	2,429	*22,863*	4,092	2,427	761	*7,280*	204.60	121.36	38.03	***364***	29	676	0	*705*	3,858	1,630	723	***6,211***
Dec	12,342	10,653	2,394	*25,389*	1,676	4,502	417	*6,595*	83.80	225.11	20.83	*330*	92	3,459	0	*3,551*	1,500	818	396	*2,714*

TP TMDL for the Wabash River Watershed

TP	Existing Load (kg/mo)				Loading Capacity				Margin of Safety				WLA				LA			
Month	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*
Jan	3,866	2,547	754	*7,167*	769	724	180	*1,672*	38.44	36.18	8.99	*84*	7	281	0	*288*	723	406	171	*1,301*
Feb	1,933	1,607	375	*3,916*	554	813	120	*1,487*	27.70	40.67	5.98	*74*	12	479	0	*491*	514	294	114	*922*
Mar	1,226	1,200	237	*2,663*	252	647	57	*956*	12.60	32.36	2.83	*48*	12	487	0	*499*	227	128	54	*409*
Apr	899	1,216	172	*2,287*	259	873	53	*1,185*	12.95	43.64	2.67	*59*	18	699	0	*717*	228	130	51	*409*
May	423	248	83	*754*	477	283	89	*849*	NA	NA	NA	NA	NA	NA	NA	*NA*	NA	NA	NA	*NA*
Jun	2,604	1,832	507	*4,943*	598	657	135	*1,390*	29.89	32.86	6.75	*70*	9	308	0	*317*	559	316	128	*1,004*
Jul	682	732	132	*1,546*	83	394	20	*498*	4.16	19.71	1.02	*25*	9	337	0	*346*	70	38	19	*127*
Aug	616	714	119	*1,449*	57	401	15	*473*	2.86	20.04	0.73	*24*	10	358	0	*368*	44	23	14	*81*
Sep	2,317	1,531	452	*4,299*	256	317	70	*643*	12.82	15.84	3.48	*32*	5	173	0	*178*	239	128	66	*433*
Oct	532	313	104	*949*	533	316	99	*949*	NA	NA	NA	*NA*	NA	NA	NA	*NA*	NA	NA	NA	*NA*
Nov	392	609	74	*1,075*	18	407	5	*429*	0.91	20.33	0.23	*21*	13	386	0	*399*	4	0	4	*9*
Dec	416	800	78	*1,294*	49	611	10	*669*	2.45	30.54	0.49	*33*	17	565	0	*582*	30	15	9	*54*

TSS TMDL for Wabash River

TSS	Existing Load (kg/mo)				Loading Capacity				Margin of Safety				WLA				LA			
Month	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*	010	030	040	*Total*
Jan	1,834,836	1,083,041	356,596	*3,274,473*	549,143	321,842	103,175	*974,160*	27,457.17	16,092.08	5,158.75	*48,708*	10,156	11,395	0	*21,551*	511,530	294,354	98,016	*903,901*
Feb	1,755,127	1,044,865	341,982	*3,141,973*	405,811	246,479	76,089	*728,379*	20,290.55	12,323.97	3,804.43	*36,419*	5,230	17,140	0	*22,370*	380,290	217,015	72,284	*669,590*
Mar	816,984	495,841	158,423	*1,471,248*	177,884	118,184	32,445	*328,513*	8,894.22	5,909.18	1,622.23	*16,426*	6,346	19,748	0	*26,094*	162,644	92,526	30,822	*285,993*
Apr	1,212,600	720,908	234,514	*2,168,021*	292,840	176,641	53,174	*522,655*	14,642.01	8,832.03	2,658.69	*26,133*	12,609	16,146	0	*28,755*	265,589	151,663	50,515	*467,767*
May	1,297,302	770,655	251,253	*2,319,210*	284,736	168,544	56,069	*509,349*	14,236.81	8,427.18	2,803.46	***25,467***	11,658	15,589	0	*27,247*	258,841	144,527	53,266	***456,635***
Jun	1,382,524	819,623	268,252	*2,470,399*	278,899	166,423	50,721	*496,043*	13,944.96	8,321.16	2,536.04	*24,802*	9,896	13,471	0	*23,367*	255,058	144,631	48,185	*447,874*
Jul	301,344	181,460	56,161	*538,965*	44,316	29,480	5,380	*79,177*	2,215.81	1,474.02	269.02	*3,959*	13,974	12,686	0	*26,660*	28,126	15,320	5,111	*48,558*
Aug	477,190	290,480	90,418	*858,088*	63,879	46,251	8,843	*118,973*	3,193.93	2,312.55	442.15	*5,949*	14,530	18,757	0	*33,287*	46,155	25,181	8,401	*79,737*
Sep	1,047,118	620,599	202,015	*1,869,732*	221,100	131,697	39,139	*391,936*	11,055.01	6,584.84	1,956.94	*19,597*	13,421	13,503	0	*26,924*	196,624	111,609	37,182	*345,415*
Oct	492,216	304,437	95,064	*891,717*	116,893	82,961	21,059	*220,914*	5,844.67	4,148.07	1,052.94	*11,046*	5,781	18,751	0	*24,532*	105,268	60,062	20,006	*185,336*
Nov	774,694	464,552	150,335	*1,389,581*	190,764	112,919	37,564	*341,247*	9,538.19	5,645.93	1,878.22	***17,062***	5,438	12,763	0	*18,201*	175,788	94,510	35,686	***305,984***
Dec	1,049,446	633,333	204,665	*1,887,444*	252,060	161,976	47,543	*461,579*	12,602.99	8,098.82	2,377.13	*23,079*	2,187	18,272	0	*20,459*	237,270	135,606	45,166	*418,041*

Appendix E
Response to Comments

WW-16J

Re: Response to Public Comments - Comment Period ending March 27, 2004
Wabash River Watershed Total Maximum Daily Load (TMDL), Ohio

Dear Sir/Madam:

Thank you for your recent comments regarding the Draft Wabash River Total Maximum Daily Load (TMDL) document dated February 2004. The U.S. EPA has responded to your comments below. We first address the comments related to designated use and then address all remaining comments.

In 1999, Ohio EPA completed a thorough examination of habitat and biological and chemical conditions in the Wabash River watershed. Ohio EPA found that Wabash River watershed's Warmwater Habitat use designation was still appropriate. Consequently, we used the nutrient and sediment targets associated with the Warmwater Habitat use designation in this TMDL.[1]

Comments from: Ohio Department of Agriculture

Comment: Page 23, the first sentence is a repeat of the last sentence at the bottom of page 22.

Response: This typo does not exist in the PDF version of the report that was made available on U. S. EPA's Web page.

Comment: Page 23, the footnote "plans" should be "plants"

Response: Comment addressed.

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[1]The State expects to propose Water Quality Standards (WQS) rules changes based on the 1999 work study later this year. Their rule-making process includes an opportunity for public comment. The use designations and the 1999 study results for the areas upstream of the state line provide useful information that should be taken into consideration when recommending implementation strategies to restore the watershed.

Comment: Page 25, the footnote at the bottom of table 7-1 should be "from " instead of "form"

Response: Comment addressed.

Comment: I counted 20 additional communities on the map on page 4, Figure 2-1, but failed to see how they were included in the impact or TMDL plan to improve the Wabash.

Response: We included loads from these communities, in terms of wastewater disposal and stormwater runoff, in the development of the TMDL. Although loads from these communities are not as significant as loads from other sources, efforts should still be focused on improving treatment of stormwater and wastewater to help meet water quality standards. It is our understanding that the Watershed Coordinator, Lance Schwarzkopf of the Wabash Watershed Alliance, has already explored several options for addressing urban issues.

Comment: The Wabash in Ohio is probably one of the most heavily agricultural and intensively drained for crop production in the state. Many of the tributaries and even the main stem are under Petition Drainage Law projects requiring maintenance. Warm Water Habitat designation is not appropriate or achievable. If any watershed/stream in the state deserves a Modified Warm Water Designation it would be the Wabash River Watershed.

Response: OEPA conducted a thorough review of habitat and biological conditions in the Wabash River watershed several years ago and determined that Warm Water Habitat is the appropriate use designation. The TMDL was therefore developed based on the premise that the Warm Water Habitat use designation must be met. Any potential use designation change is not a part of this study and would be an issue on which OEPA would comment.

Comment: Table 3-3 on page 8, the values for total phosphorus targets on MWH designations do not appear to be correct in following the comparable levels for WWH and EWH.

Response: We confirmed that these values are the ones published in Table 2 of:

> *OEPA (Ohio Environmental Protection Agency). 1999.* Association Between Nutrients, Habitat and the Aquatic Biota in Ohio Rivers and Streams. *Technical Bulletin MAS/1999 1-1. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, OH.*

Comment: The use of data with a gap of over 20 years is a very questionable scientific practice.

Response: We used the older data in Section 3 of the report to provide background information on the Wabash River watershed because there exists limited data on the watershed. The seasonal patterns in the older and recent data are similar and so it was considered appropriate to display them together. We only used the recent data in making impairment determinations and developing the TMDL.

Comment: Page 17, 4.2 Critical Conditions indicates conditions for nutrient impairments occurring during late summer related to desorption of phosphorus from sediments and high temperatures and low flows. Studies done by Heidelberg Water Quality lab indicate that loadings from low flow sources such as Wastewater plants and discharging septic systems contribute more of the impairment than sediment.

Response: The effects of constant sources of phosphorus such as Wastewater Treatment Plants (WWTPs) and discharging septic systems are certainly more pronounced during summer low flow conditions. This is especially true in AU -030, which contains both the Celina and Coldwater wastewater treatment plants.

Comment: We have an updated list of the permitted large CAFO facilities that we will provide you in another attachment to utilize in Appendix A.

Response: Appendix A can be replaced if the updated list is received prior to the TMDL report being finalized.

Comments from: Ohio Farm Bureau

Comment: It is disappointing to see that the Wabash River TMDL document lacks any discussion regarding model inputs and the assumptions made by the contract modeler Tetra Tech. It is extremely unprofessional to assume that the public is not interested in reviewing and providing comments on this information. How does U.S. EPA expect the public to conduct a comprehensive document review when the most important and critical information is not provided?

Response: In Appendix C of the TMDL report, we provide a detailed discussion of the SWAT modeling that was conducted for the Wabash River watershed. We discussed model inputs and assumptions regarding land use, curve numbers, the Universal Soil Loss Equation (USLE) factors, climate data, reservoir characteristics, manure application, tillage practices, and calibration parameters. The model is at http://www3.baylor.edu/cagsr/swat/. *A CD with the Wabash data used for this model is also enclosed with this response for those who requested the data.*

Comment: The Wabash River TMDL states that the 2002 Section 303(d) Report identifies the cause of the aquatic life impairment in the Wabash River basin as habitat alteration. It goes on to state that the measure of attainment of water quality standards will be based on numeric biocriteria because Ohio does not have numeric nutrient and sediment criteria as part of the formal water quality standards. Why has this report focused on nutrients and suspended sediment when habitat has been identified as the cause of impairment?

Response: As specified in the Clean Water Act and consistent with U.S. EPA guidance and regulations, TMDLs are to be developed for pollutants that have loads associated with them such as, but not limited to, sediments, nutrients, and metals. Although habitat alterations are *recognized as contributing to the impairment, one cannot truly develop a habitat TMDL. Consequently, we developed TMDLs for the pollutants contributing to the impairments (i.e., sediment and nutrients) and focused on, among other things, improving habitat conditions in the implementation strategy. We recognize that there is a link between pollutant and habitat conditions, such as assimilative capacity of an altered stream diminishing its ability to utilize some of the nutrient load. But again, for the purposes of this TMDL, we are concentrating on load-based impairments.*

Comment: A review of the field data from the 1999 detailed Ohio EPA assessment of the Wabash River basin reveals that only 2 out of 62 habitat assessment scores (QHEI) are at or above 60, the value accepted as being conducive to supporting warmwater faunas. In fact, 48 of the 62 QHEI scores are below 45, the value accepted as an indication that the stream will not be able to support a warmwater fauna. These data raise serious questions regarding the likelihood that the aquatic life will be restored to meet a warmwater aquatic life biological target. Why hasn't a more appropriate aquatic life use designation, such as modified warmwater habitat (MWH), been assigned and used as the target for the TMDL?

Response: We recognize that habitat conditions in the Wabash River watershed are poor. However, we developed the TMDL based on the premise that the Warm Water Habitat use designation must be met. OEPA conducted a thorough review of habitat and biological conditions in the Wabash River watershed several years ago and determined that Warm Water Habitat is the appropriate use designation. The TMDL was therefore developed based on the premise that the Warm Water Habitat use designation must be met. Any potential use designation change is not a part of this study and would be an issue on which OEPA would comment.

Comment: The QHEI is a multimetric tool used to evaluate the quality of a stream's habitat. Six variables evaluating both the stream and the riparian zone are scored and combined to obtain a numeric value for the overall health of the stream. Investigation of the scores for each of the individual metrics can be a useful tool to help in the identification of the principal factors limiting habitat quality. The analysis would also lead to the identification of the types of possible remediation actions that could take place. For example, if the riparian/erosion metrics score low, then the proposed remediation actions should focus on stream bank erosion control and riparian buffer establishment. Has such an analysis been conducted for the streams in the Wabash River basin? If so, how have the results of such an analysis been incorporated into the development of the TMDL report for the Wabash River?

Response: We did not conduct a detailed analysis of the QHEI scores for the Wabash River watershed as part of this project because it was not required or necessary for the TMDL process.

Comment: The stated goal of the Wabash River TMDL is the attainment of appropriate aquatic life uses. For the majority of the sampled locations in the basin, stream habitat quality (QHEI scores of less than 60) is the most limiting factor to reaching this goal. The established target values for nutrients are based on protection of warmwater habitat (WWH) biological criteria. If the stream has a low restorability potential for WWH, a more appropriate aquatic life use designation, such as modified warmwater habitat (MWH), must be assigned. The target values for nutrients in the TMDL calculations need to be adjusted accordingly. How does the assignment of a more appropriate aquatic life habitat designated use factor into the TMDL development process?

Response: We developed the TMDL based on the premise that the Warm Water Habitat use designation must be met. If the MWH use designation is to apply, we would use alternative total phosphorus and nitrate+nitrite targets to determine the necessary load reductions. OEPA conducted a thorough review of habitat and biological conditions in the Wabash River watershed several years ago and determined that Warm Water Habitat is the appropriate use designation. The TMDL was therefore developed based on the premise that the Warm Water Habitat use designation must be met. Any potential use designation change is not a part of this study and would be an issue on which OEPA would comment.

Comment: The TMDL document is silent when it comes to the identification and quantification of existing nutrient sources and loads. How were the nitrogen and phosphorus loads partitioned among the various sources? How were home sewage treatment and disposal systems accounted for? What is the contribution from commercial fertilizer and livestock? How were the model inputs distributed across the 54 subbasins?

Response: We included all of the significant sources in the modeling. These sources included, but were not limited to, failing/illicitly connected: onsite sewage disposal systems, wastewater treatment plants, livestock, manure application, commercial fertilizer application, and stormwater runoff. We made estimates of loads from onsite sewage systems based on the number of systems, literature values for the characteristics of wastewater, and best professional judgment regarding the percentage of failing/illicit systems. The estimated load from these systems is not a very large proportion of the total observed load in the watershed, even when conservatively estimating the percentage of failing systems. The model inputs were distributed across the 54 subbasins based on the best available data regarding the location of each source. For example, we used land use data to estimate the location of agriculture, and Census data to estimate the number of onsite systems in each subbasin. We knew where the wastewater treatment plants were located.

Comment: Total phosphorus and nitrate+nitrite data at State Line Road over the period May 22, 1974 to September 2, 1999 are presented in Figures 3-1 and 3-3 on pages 9 and 11 of the report, respectively. The monitored concentrations of both constituents decrease significantly (4 to 10 fold) over the time period. In fact, there is a 20-year gap in available water chemistry over the time period. Given the disparity between the two data sets from the 1970s and 1990s, how can you justify combining the two and generating monthly summary statistics?

Response: We used the older data in Section 3 of the report to provide background information on the Wabash River watershed as there exists limited recent data on the watershed. The seasonal patterns in the older and recent data are similar and so it was considered appropriate *to display them together. We only used the recent data in making impairment determinations and developing the TMDL.*

Comment: The TMDL document states that there are 39 large concentrated animal feeding operations (CAFOs) in the Wabash River watershed. It goes on to state that by 2006 all of the facilities will be operating under a NPDES Permit and manure management plan and at that point in time, the wasteload allocations for these facilities will be zero. The document does not indicate how many of the facilities are currently covered by the NPDES permit program nor does it quantify the amount of the existing load that is due to those facilities not currently under the NPDES program. If the wasteload allocation for the large CAFOs in the Wabash River TMDL will be zero, how much will the existing load be reduced when all of the operations are covered under the NPDES program and operating under a manure management plan. What impact will this have on the model and the projected necessary load reductions?

Response: We did not separately estimate the loads from each individual CAFO facility because of the difficulty in accurately doing so. For example, inadequate information is available regarding the size or location of the applied manure from each facility or the timing and magnitude of runoff from production areas. It is therefore not possible to estimate the impact of the load from these facilities being reduced to zero.

Comments from: Wabash Watershed Alliance

Comment: 2.1 Identification of Waterbody: The first paragraph in this section is a little confusing. Stony Creek divides the 14-digit subwatershed of the lower mainstem of the Wabash River from the upper main stem, located near Fort Recovery.

Response: The sentence was modified to read "For this TMDL, the AUs of interest are 010, 030, and 040" so that AU 010 is not divided.

Comment: It is mentioned, assessment unit 020 and Grand Lake St. Mary's was not a focus of the study. It might be easier to exclude this area from the map in figure 2-1. If the purpose of the figure is to simply show the location of the Wabash River watershed in Ohio all of the 020 drainage unit should be included. However, to avoid confusion it might be easier to note it on the map as not a focus of the study or another label to distinguish it from the study area.

Response: Figure 2-1 was updated so that it does not include AU 020.

Comment: A minor error, the caption on the photo on page 2 is misspelled as Vanderbrush Creek. The correct spelling is Vanderbush Ditch.

Response: Comment addressed.

Comment: Table 2-1 goes along with our earlier comments about Stony Creek. It might be easier to describe the area as headwaters west of S.R. 49 to Beaver Creek or simply headwaters.

The description of 040 is also somewhat confusing. If the intended study area is below the Grand Lake St. Marys spillway then this would be a more appropriate description.

Response: The table entries were changed to be more clear.

Comment: Figure 2-1 should show all of the Wabash Watershed or only the focus area.

Response: Figure 2-1 updated, does not include AU 020.

Comment: 2.3 Pollutant Sources: Table 2-2 should more than likely include the municipal point sources of the Villages of Coldwater and Philothea.

Response: We included the Coldwater wastewater treatment plant in the modeling but mistakenly left it out of the report. The village of Philothea is a new waste water treatment plant, a lagoon system. There is no information in PCS because the facility plans to use land application to dispose of their treated effluent. The village has not yet discharged to the waters of the State.

Comment: 3.0 Description of Water Quality Standards, Numeric Water Quality Targets, and Existing Water Quality: Introduction to 3.2 is easy to understand and the tables are very helpful.

Response: No response necessary.

Comment: Figure 3-1. Is it appropriate to say sampling conducted in 1974 and 1999 covers the entire time period between the two?

Response: No, the figure was re-titled to state, "The first sample was collected May 22, 1974 and the last sample was collected September 2, 1999." Similar changes were made to the other figure captions.

Comment: Sections on nutrients are clear and concise. Tables are helpful.

Response: No response necessary.

Comment: 4.3 Loading Capacity: An understanding of the SWAT modeling system will be important to meeting suggested reductions. It would be helpful for the watershed group to have access to this computer model to test BMP practices for future implementation strategies.

Response: The model is at http://www3.baylor.edu/cagsr/swat/. *A CD with the Wabash data used for this model is also enclosed with this response for those who requested the data.*

Comment: 6.0 Waste Load Allocations: Will the addition of two WWTPs change these allocations?

Response: The wasteload allocations for Coldwater will change the allocations. The village of Philothea is a new waste water treatment plant, a lagoon system. There is no information in PCS because the facility plans to use land application to dispose of their treated effluent. The village has not yet discharged to the waters of the State.

Comment: 11.0 Implementation: Paragraph 2, The Wabash Watershed is not yet eligible for OEPA's Division of Environmental & Financial Assistance (DEFA) linked deposit low interest loan program. This eligibility requires a state endorsed watershed management plan.

Response: We deleted the language from the text.

Comment: Appendix A: Some CAFOs listed are in the 020 drainage area which is not a focus of this study.

Response: The CAFOs in AU 020 were removed from the Appendix.

Comment: The WWA is concerned with the impact Grand Lake St. Mary's has on Beaver Creek and also the section of the Wabash after the confluence of Beaver Creek to the Indiana state line. Improvements in water quality in these areas will be difficult to measure because of the influence from Grand Lake.

Response: Discharge from Grand Lake does have a significant impact on the water quality of Beaver Creek and the Wabash River to the Indiana state line. The 1999 sampling data shows that values of TP and TSS in Beaver Creek below Grand Lake St. Mary's are well above the TMDL targets. We recommend routine sampling along Beaver Creek after its confluence with the Wabash River by either OEPA or other interested groups to allow for an evaluation of the impact of the lake on the Wabash River below Beaver Creek.

Comments from: Mercer Soil and Water Conservation District

Comment: Page 2. In the discussion on the identification of the waterbody, mention is made of 4 AU's. It would be good to identify AU's 030 and 020. It also says that AU 030 was included in the modeling for the TMDL. Does that mean that the TMDL does include AU 030? The section needs to better define exactly what is being covered.

Response: Figure 2-1 updated, does not include AU 020.

Comment: Page 3. Table 2-1 should include AU 030 if it is being included in the modeling. This would reduce confusion.

Response: AU 030 was added to the table.

Comment: Page 4. Figure 2-1 shows only part of AU 020. It also includes the parts of the watershed located in Indiana. If this is to show the entire watershed then the rest of AU 020 should be included. It would also be good to designate that part of the watershed that is being addressed in this TMDL.

Response: Figure 2-1 updated, does not include AU 020.

Comment: Page 5. There is a mention of CAFOs listed in the appendix. Several of these are located in AU 020. If they remain in the report, then the wastewater treatment plants in St. Henry and Montezuma as well as the proposed plant in Chickasaw should be included.

Response: The CAFOs in AU 020 were removed from the Appendix.

Comment: Page 13. In the absence of an appropriate reference stream to compare stream loadings in the Wabash, is it reasonable to use monitoring data from the mid-1970's to help establish the 25^{th} percentile goal?

Response: The use of older data in setting the target (25^{th} percentile goal) is not ideal because of the changes that have occurred in the watershed since the data was collected. However, not enough data was collected during the 1999 sampling effort to establish a statistically robust database. As was stated in the report, the target is subject to modification as new data is generated. Also, we only used the older data in Section 3 of the report to provide background information on the Wabash River watershed. The seasonal patterns in the older and recent data are similar and so it was considered appropriate to display them together. We only used the recent data in making impairment determinations and developing the TMDL.

Comment: Page 16. Paragraph 5 states "model was used to allocate loads to determine what implementation measures may be taken to decrease the input of levels of sediments and nutrients." It is necessary to know if these implementation measures to achieve the goals are realistic and possible. Nowhere in the report does it mention what these measures are, other than they will be contained in the action plan, which is not written. How can we rely on the unknown to achieve a certain goal?

Response: We discuss, on page 18 of the report, the types of implementation measures that were used to reduce loads (reduced manure application, reduced streambank erosion, reduced sheet/rill erosion, conservation buffers). Implementation of these measures will need to be widespread because of the large load reductions that are necessary to meet the TMDL targets.

Comment: Section 5. Load Allocations. These tables need to be redone if the additional wastewater treatment plants are added.
Response: The tables were updated.

Comment: Sections 9, 10, and 11 refer to various items that local watershed groups will do. Has there been any interaction with the WWA board to explain their responsibilities and actions as outlined in this report?

Response: We anticipate activities in the Wabash River watershed that are similar to activities in other watersheds participating in Ohio's 319-funded watershed coordinator program. The local watershed coordinator, Lance Schwarzkopf of the Wabash Watershed Alliance, will include in the Wabash River Watershed Action Plan (due in late December 2004) a final set of activities and responsibilities best fitted to the unique aspects of the Wabash watershed. The Area Assistance Team, comprised of regional representatives of Ohio EPA, Ohio State University Extension, and ODNR Division of Soil and Water Conservation, will continue to work with local watershed interests throughout the development and implementation of the Watershed Action Plan and the TMDL.

Comment: Appendix A-1. If AU 020 is not considered in this report, the CAFO's in this area should not be included in the report.

Response: The CAFOs in AU 020 were removed from the Appendix.

Comment: Appendix C page 10. There is no longer a 39 foot wide spillway on the lake. It has been replaced with a 500 foot spillway with a 50 foot notch, 11 inches deep. The Wabash Conservancy District also maintains 2 dry dams in addition to the dam at Elora.

Response: The corrected information was inserted into the report.

Comment: If this report is to be used by the people in the watershed, a much more detailed explanation of the technical aspects of the report needs to be made.

Response: Appendix C is intended to describe the modeling process in as much detail as possible given the time and resources available for the project. It is unclear which aspects of the technical analysis require additional explanation. A CD with the data is also enclosed with this response.

Comments from: Grand Lake St. Mary's Lake Improvement Association

Comment: we represent over 600 members of the grand lake st. marys lake improvement association. as a group we have been very active in developing a grass roots organization aimed at restoring this historical lake and its environs. our experience and research shows that 50% of the degradation to our ohio waters has been effectively eliminated through strong legislation and enforcement. the remaining 50% has been left to the general public to solve through organizations (swcd, watershed coordinators, health boards, etc.) relying on cooperation and education. this has been ineffective at best. Agriculture is a very large industry in the wabash watershed. As such it stands to reason that this industry should be regulated just as other industries have been no matter what the size. Currently cafos are not permitted to pollute the waters of the state. This should apply to all afos.

mercer county has the largest concentration of afo's in ohio. with little supervision or oversite manure is allowed to be applied to the ground in amounts that far exceed the recommended rates.

nearly 700,000 tons of manure is generated in the glsm w/s alone. this would require over 80,000 acres of land. there is only 56,000 acres available and not all land owners will permit the application of manure on their land. manure is spread on frozen ground ignoring nrcs standard 633.

cafo's are regulated. why would we not regulate all afo's regardless of their size? this only makes sense to those observing the poor use of best management practices.

Response: We have addressed the impact of both AFOs and CAFOs in the Wabash River TMDL report and recommended reducing nutrient loads from manure application. However, the regulation of AFOs is outside the scope of the TMDL study. We concur with the spirit of your comment in that everyone in the watershed should be concerned with implementing the best management practices in compliance with existing standards, and should avoid excessive application or frozen ground application of manure.

Comment: according to the epa 10-30% of all septic systems are failing at any given time. in auglaize and mercer co. septic systems are being installed that will fail in less than 2 years. this is because the soil stability in these counties is not suitable for normal on-site treatment. less than 2% of our soils are suitable for traditional leach systems.

Response: We have addressed the impact of failing and illicitly connected septic systems in the Wabash River TMDL report and made recommendations for reducing nutrient loads from these sources. The local health department is responsible for the proper siting and construction of new systems.

Comment: wastewater from our large county treatment plants provide the most beneficial water introduced into the watershed.

there is a prevailing attitude here that there are good reasons why a landowner should not follow regulations, guidelines, advisories and best management practices. extensive field edge plowing down to and into roadside rights of way, extensive tiling, failure to use tile plugs, over application of manure and the channelizing of streams and removal of stream side riparian buffers creates the opportunity to discharge sediments and nutrients into the water.

There are other sources of non-point pollution, but the overwhelming land use for agriculture dictates that is where we need to concentrate our efforts.

your draft tmdl confirms a major problem exists in the wabash watershed. all indicators point toward continued degradation and full non-use attainment of same.
a national treasure is at stake!

this is the bad news. the good news is that the solutions and funding to solve these problems are at hand, but cannot be implemented on a voluntary basis.

our organization has provided thousands of hours identifying and monitoring the problem and stand ready to help in any effort to restore the lake and environs. we must get past the defensive attitudes and deal with the facts. we feel that without legislation and enforcement there can be no meaningful improvement in the continual assault on the waters of the wabash watershed.

Response: We have addressed, in the development of the Wabash River watershed TMDL, the impact of both regulated and unregulated activities. Under the Clean Water Act, we cannot create new regulations when developing a TMDL. Consequently, voluntary actions will be needed to achieve many of the recommended load reductions. Any need for new State regulation and enforcement is a legislative issue that local citizens would have to communicate to their representatives.

If you have any further questions, please contact Jean Chruscicki, TMDL specialist in the Watersheds and Wetlands Branch, at 312-353-1435.

Sincerely yours,

Jo Lynn Traub
Director, Water Division

Enclosure

cc:
John C. Fisher, Ohio Farm Bureau
Nicole G. Hawk, Mercer Soil and Water Conservation District
Lance Schwarzkopf, Wabash Watershed Alliance
Bill Ringo, Grand Lake St. Marys Lake Improvement Association
Kevin H. Elder, Ohio Department of Agriculture

Errata and Additions

The addition of Appendix D is a division of the allocations into assessement units rather than the entire watershed, as presented in the draft and final TMDL for the Wabash River watershed found in Section 5.0, Tables 5-1, 5-2, and 5-3. Further, AUs 010 and 040 were listed in the 2002 303(d) list, but AU 030 was not. Allocations were developed for AU 030 because it was integral to the modeling effort and contributes significant hydrological input to the uppermost portions of AU 010. Reductions are needed in all three assessment units to meet the standards (even if the segment was not listed).

Page	**errors**	**correction**
2	photo caption Vanderbush Creek	Vanderbush Ditch
2		Add: The waterbodies were listed both in the 2002 303(d) listing and the 2004 303(d) listing portion of Ohio's 2004 Integrated Report.
11	Figure 3-3 nitrate + nitrate	nitrate + nitrite
12	Figure 3-4 nitrate + nitrate	nitrate + nitrite
13	Sharpely	Sharpley
17	4.1 These including the following:	These include the following:
21	Table 5-1 Existing load Oct = 944	949
	Table 5-1 Loading Capacity Jan = 1,673	1,672
	Table 5-1 Loading Capacity Jun = 1,391	1,390
	Table 5-1 Loading Capacity Dec = 667	669
	Table 5-1 Loading Capacity Dec = 31	33
	Table 5-2 May MOS = 186	855
	Table 5-2 Nov MOS = 32	364
	Table 5-2 May LA = 13,242	12,573
	Table 5-2 Nov LA = 6,543	6,211
22	Table 5-3 May MOS = 4,729	25,467
	Table 5-3 Nov MOS = 1,446	17,062
	Table 5-3 May LA = 477,373	456,635
	Table 5-3 Nov LA = 321,600	305,984

Page	**errors**	**correction**
31	[INSERT DATE}	February 26, 2004
31	Appendix D	Appendix E
31	[to be added after the public comment period].	Omit phrase in [ ]
NA		Added Appendix A Large CAFOs in the Wabash River Watershed
NA		Appendix B Summary of Available Total Phosphorus, Nitrate+Nitrite, and Total Suspended Solids Data for the Wabash River Watershed, Ohio
NA		Added Appendix D Assessment Unit Load and Wasteload Allocations
NA		Added Appendix E Response to Comments