Busseron Creek Watershed
Total Maximum Daily Load Development

FINAL

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and Tetra Tech

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EXECUTIVE SUMMARY

The Busseron Creek watershed drains approximately 235 square miles of primarily agricultural, forested, and abandoned mine lands (Appendix A) in southwestern Indiana. Several waterbodies in the watershed do not meet water quality standards and appear on Indiana's Clean Water Act Section 303(d) list of impaired waters. Federal law and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for such impaired waters. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. This report presents the TMDLs for the Busseron Creek watershed and provides recommendations for activities that are necessary to restore water quality in the watershed. Pollutants for which TMDLs are presented in this report are total iron, total suspended solids, total phosphorus, dissolved oxygen, pH, total copper and total zinc. All of the TMDLs are intended to address the impaired biotic communities that have been observed at various locations in the watershed.

One of the first tasks of this project was to reassess the causes of impairment appearing on the 2006 Section 303(d) list for the Busseron Creek watershed. Such reassessments are frequently made at the beginning of TMDL projects to utilize any new information that might be available since the original listing decisions were made. As a result of the reassessment, the pollutants for which TMDLs were developed differ from the pollutants appearing on the 2006 Section 303(d) list for the following reasons:

- Sampling performed by the Indiana Department of Environmental Management (IDEM) in 2006 generated new water quality data that were not available at the time the 2006 Section 303(d) list was developed.
- Indiana revised its criteria for sulfates. Although many of the waterbodies in the watershed did not meet the old criteria, based on historic data, all waterbodies meet the revised criteria.
- Indiana's revised water quality standards no longer contain a numeric criterion for total dissolved solids. No TMDLs were therefore developed for total dissolved solids.
- Sampling performed by the U.S. Geological Survey in September 2007 documented more widespread biological impairments in the Busseron Creek watershed than were previously known to exist.

Public participation is an important and required component of the TMDL development process. The following public meetings and public comment periods were held to develop this project:

- A Kickoff Meeting was held at the Sullivan County Public Library on March 14, 2007, during which IDEM and Tetra Tech described the TMDL Program and provided a summary of the available data and the proposed modeling approach.
- A Draft TMDL Meeting was held at the Sullivan County 4-H Fairgrounds Meeting Room on January 31, 2008, during which IDEM and Tetra Tech described the TMDL Program and provided an overview of the draft TMDL results.
- An Initial Comment Period began January 23, 2008, and ended March 5, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.
- A Second Comment Period for a revised draft TMDL was held from June 16, 2008, to July 16, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.
- A Third Comment Period for another revised draft TMDL was held from September 2, 2008, to October 3, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.

Once the TMDL pollutants had been identified, the various potential sources were evaluated. The primary source of the metals is runoff from historic (abandoned) mining activities. Sources of other pollutants, such as phosphorus and total suspended solids, include runoff from row crops, livestock operations, and failing septic systems.

Load duration curves were used to calculate observed and allowable pollutant loads for each of the impaired waterbodies and the allowable loads were allocated to regulated and unregulated sources, as required by the Clean Water Act. Relatively large reductions in observed loads are needed to meet water quality standards for most pollutants for most waterbodies in the watershed. Because the majority of loading is originating from unregulated sources, the voluntary adoption of various best management practices will be needed to achieve the recommended reductions. Such practices should include filter strips, nutrient management plans, conservation tillage, and septic system maintenance programs. Current efforts by the Indiana Department of Natural Resources to address runoff from historic mining areas are also critical and should receive a high priority for continued funding. Periodic monitoring of the watershed should be conducted to track progress toward meeting water quality standards, and to adjust implementation strategies to prioritize those activities found to be most cost effective.

1.0 INTRODUCTION

The Busseron Creek watershed drains approximately 235 square miles of primarily agricultural, forested, and abandoned mine lands in southwestern Indiana. A majority of the watershed is located in Sullivan County with smaller portions in Clay, Greene and Vigo counties (Figure 1). Tributaries to Busseron Creek include Sulpher Creek, Mud Creek, Big Branch, Kettle Creek, Buttermilk Creek and Robbins Creek. Indiana's 2006 Clean Water Act Section 303(d) list of impaired waters includes ten waterbody segments in the Busseron Creek watershed that were considered impaired due to total copper, total nickel, total zinc, sulfates, pH, impaired biotic communities, nutrients, low dissolved oxygen, and total dissolved solids (TDS). The listings and causes of impairment have been adjusted as a result of this study, due to new sampling results, changes in the water quality standards, and a reassessment of the new data. The updated information is shown in Table 1, which compares the 2006 listings with the causes of impairments addressed by the TMDLs. Pollutants for which TMDLs are presented in this report are total iron, total suspended solids, total phosphorus, dissolved oxygen, pH, total copper and total zinc. All of the TMDLs are intended to address the impaired biotic communities that have been observed at various locations in the watershed.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) lists. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis.

The overall goals and objectives of the TMDL study for the Busseron Creek watershed were to:

- Further assess the water quality of the Busseron Creek watershed and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science to determine the maximum load of the pollutants of concern that the streams can receive and still fully support all of their designated uses.
- Use the best available science to determine current loads and sources of the pollutants of concern.
- Determine the load reduction that is needed if current loads exceed the maximum allowable load.
- Identify feasible and cost-effective actions that can be taken to reduce loads.
- Inform and involve the stakeholders throughout the project to ensure that key concerns are addressed and the best available information is used.
- Submit a final TMDL report to EPA for review and approval.

This project was implemented in the following phases:

1) The first phase involved the compilation and review of all the historical data and an identification of any data gaps necessary for the completion of TMDLs.
2) The second phase involved the collection of additional data to fill the identified gaps. IDEM collected additional water chemistry at 25 monitoring locations from August 22nd through December 12, 2006 and the U.S. Geological Survey collected additional fish and water chemistry data from September 17th through September 19, 2007.
3) The third phase involved the review and assessment of the collected data to make a final determination on the most likely causes of impairment. A number of factors were considered during this step, including a better understanding of the extent of the biological impairment in the watershed as well as the revision to Indiana's water quality standard for sulfate.
4) The final phase of the project was to calculate the allowable loads of the pollutants confirmed as causing impairments and to allocate those loads to the appropriate sources.

This report describes the entire analysis and, once finalized, will be submitted to EPA for approval as required by the Clean Water Act.

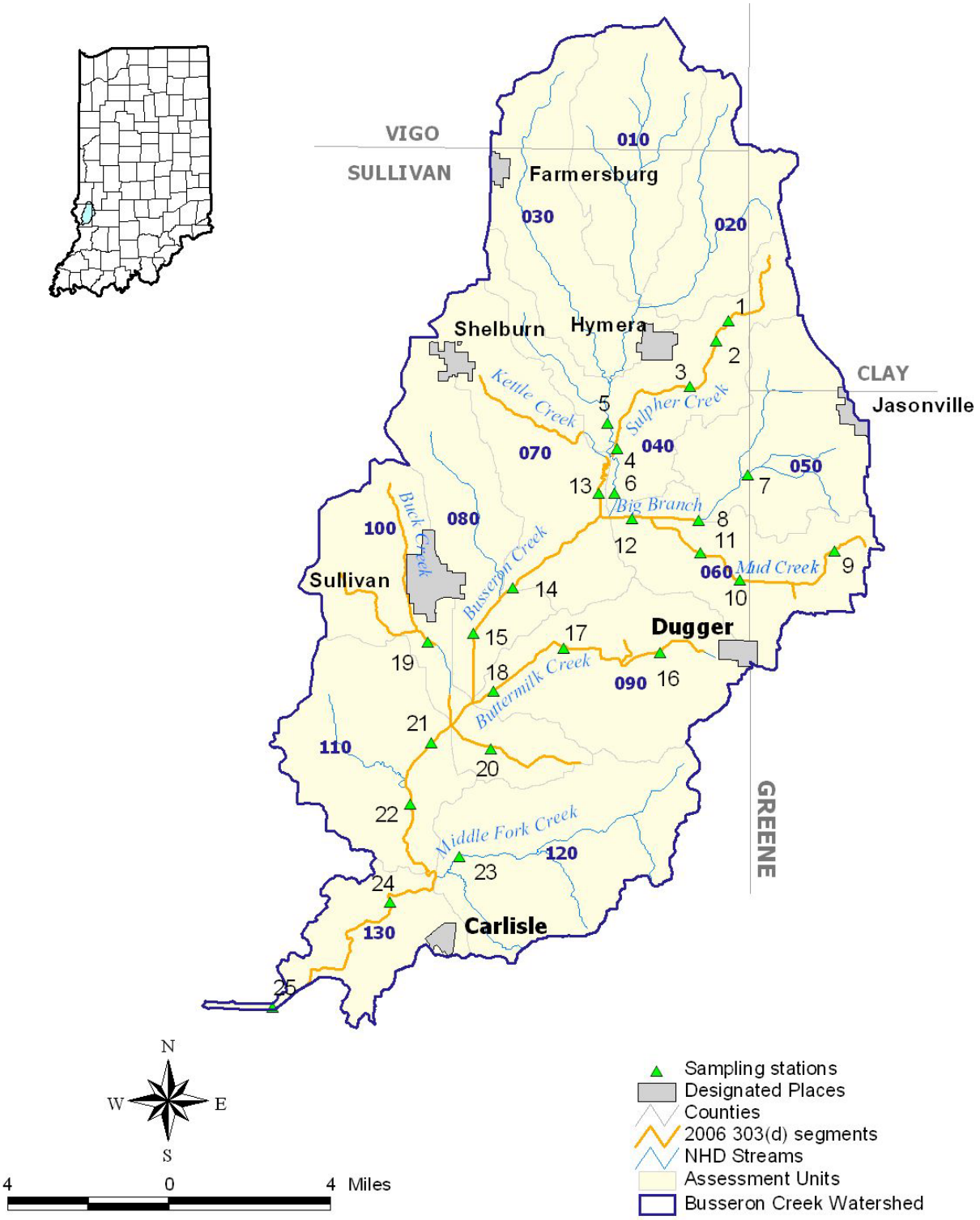


Figure 1. Location of the Busseron Creek Watershed and IDEM 2006 sampling stations.

Table 1. **2006 303(d) List Information for the Busseron Creek Watershed**

2006 Information			Updated Information Based on New Sampling		
Waterbody	**AUID**	**2006 Section 303 (d) Cause(s) of Impairment**	**Waterbody[1]**	**Updated AUID**	**Updated Cause(s) of Impairment**
Busseron Creek	INB11G4_00	None	Busseron Creek	INB11G4_01	Impaired Biotic Communities
				INB11G4_02	None
Sulpher Creek	INB11G4_T1024	Total Copper, Total Nickel, Total Zinc, Sulfates, pH, Biotic Communities, Low Dissolved Oxygen, Total Dissolved Solids	Sulpher Creek	INB11G4_T1003	Impaired Biotic Communities; pH; Total Zinc
				INB11G4_T1004	Impaired Biotic Communities; pH; Total Copper; Total Zinc
Big Branch	INB11G5_00	None	Big Branch	INB11G5_01	Impaired Biotic Communities
				INB11G5_02	
Big Branch - Mud Creek	INB11G6_00	Sulfates	Mud Creek	INB11G6_03	Impaired Biotic Communities; Dissolved Oxygen[2]; pH[2];
				INB11G6_04	Impaired Biotic Communities; Dissolved Oxygen[2]; pH[2]
				INB11G6_05	Impaired Biotic Communities
Kettle Creek	INB11G7_00	Dissolved Oxygen	Kettle Creek	INB11G7_01	Impaired Biotic Communities
Busseron Creek	INB11G7_T1035	Sulfates; Total Dissolved Solids	Busseron Creek		Impaired Biotic Communities; Dissolved Oxygen
Busseron Creek	INB11G8_T1036	Sulfates; Total Dissolved Solids	Busseron Creek	INB11G8_T1036	Impaired Biotic Communities

Buttermilk Creek	INB11G9_00	Sulfates; Total Dissolved Solids	Buttermilk Creek	INB11G9_01	Impaired Biotic Communities
				INB11G9_02	None
					Impaired Biotic Communities
Robbins Creek	INB11GA_00	Nutrients	Robbins Creek	INB11GA_03	Impaired Biotic Communities; Dissolved Oxygen[2]
			Buck Creek	INB11GA_T1003	Impaired Biotic Communities; Dissolved Oxygen[2]
Busseron Creek	INB11GB_T1037	Sulfates; Total Dissolved Solids	Busseron Creek	INB11GB_01	Impaired Biotic Communities
				INB11GB_02	Impaired Biotic Communities
Middle Fork Creek	INB11GC_00	None	Middle Fork Creek	INB11GC_03	None
Busseron Creek	INB11GD_00	Sulfates; Total Dissolved Solids	Busseron Creek	INB11GD_01	None
				INB11GD_02	

[1]Busseron Creek segment INB11G4_01, INB11G4_T1005, and INB11G6_02 appeared in this table during the previous public review period but were subsequently removed based on a reassessment of the data.

[2]Impairment based on data collected by USGS or IDNR in accordance with the IDEM Standard Operating Procedure (see Appendix B).

Waters are put on the 303(d) impaired waters list due to violations of the water quality standards. Some of these violations are due to parameters for which a loading cannot be derived (i.e. Impaired Biotic Community, Dissolved Oxygen, and pH). As loads cannot be derived for these parameters, other pollutants serve as surrogates as they can be tied to the causes of these impairments and are used to develop TMDL allocations (See Section 3.0 for more detailed information). All of these allowable daily pollutant loads are intended to control loadings and improve water quality such that water quality standards are met for the listed impaired segments. Table 1 above is the list of impaired segments and the WQS violation. Table 1A below lists the surrogate pollutants tied to those causes of impairments that do not lend themselves to a direct derivation of loading.

Table 1A: 2006 303(d) Impairment Causes List Information for the Busseron Creek Watershed

2006 Information			Updated Information Based on New Sampling		
Waterbody	**AUID**	**2006 Section 303 (d) Cause(s) of Impairment**	**Waterbody[1]**	**Updated AUID**	**Updated Cause(s) of Impairment**
Sulpher Creek	INB11G4_T1024	Total Copper, Total Nickel, Total Zinc, Sulfates, pH, Biotic Communities, Low Dissolved Oxygen, Total Dissolved Solids	Sulpher Creek	INB11G4_T1003	Total Iron; Total Phosphorus; Total Suspended Solids
				INB11G4_T1004	Total Iron; Total Phosphorus; Total Suspended Solids
Big Branch - Mud Creek	INB11G6_00	Sulfates	Mud Creek	INB11G6_03	Total Suspended Solids
				INB11G6_04	Total Iron; Total Suspended Solids
				INB11G6_05	Total Iron; Total Suspended Solids
Busseron Creek	INB11G7_T1035	Sulfates; Total Dissolved Solids	Busseron Creek	INB11G7_01	Total Phosphorus; Total Suspended Solids
Buttermilk Creek	INB11G9_00	Sulfates; Total Dissolved Solids	Buttermilk Creek	INB11G9_01	Total Suspended Solids
				INB11G9_02	Total Suspended Solids
Robbins Creek	INB11GA_00	Nutrients	Robbins Creek	INB11GA_03	Total Phosphorus
			Buck Creek	INB11GA_T1003	Total Phosphorus; Total Suspended Solids

Figure 2 depicts the new Assessment Unit IDs (AUIDs) within the Busseron Creek Watershed. The segmentation process identifies streams and stream reaches that are representative for the purposes of assessment. In practice, this process leads to grouping tributary streams into smaller catchment basins of similar hydrology, land use, and other characteristics such that all tributaries within the catchment basin can be expected to have similar potential impacts. Catchment basins, as defined by the aforementioned factors, are typically very small which significantly reduces the variability in the water quality one might expect from one stream or stream reach to another. Given this, all tributaries within a catchment basin are assigned a single AUID. Grouping tributary systems into smaller catchment basins also allows for better characterization of the larger watershed. Variability within the larger watershed will be accounted for by the differing AUIDs assigned to the different catchment basins.

Figure 2. Catchment Basins in the Busseron Creek Watershed

2.0 DESCRIPTION OF THE WATERSHED

The Busseron Creek watershed lies within the greater Lower Wabash watershed and flows to the southwest for about 30 miles before discharging into the Wabash River west of Carlisle. A large part of the watershed lies in Sullivan County which covers approximately 82 percent of the watershed (Figure 1). The remaining portions of the watershed lie in Greene (7.75%), Vigo (6.65%), and Clay (3.48%) counties. Incorporated cities within the watershed include Farmersburg, Shelburn, Sullivan, Hymera, Dugger, and Carlisle in Sullivan County and Jasonville in Greene County.

The following sections of this report provide information on the population, land uses, topography, and hydrology of the watershed.

2.1 Population

The population of the Busseron Creek watershed was not directly available but was estimated at approximately 15,400 based on U.S. Census (2000) data and the size of the watershed (Table 2). The City of Sullivan, with a population of 4,617, is the largest community in the watershed.

Table 2. **Population data for counties within the Busseron Creek Watershed**

County	Total Estimated Watershed Population	Percent of Total Watershed Population	Non-urban Population	Urban Population
Clay	611	3.80	611	0
Greene	1347	8.36	491	856
Sullivan	9456	58.82	1478	7978
Vigo	4000	29.01	4000	0
Total	15414	100	6580	8834

Source: U.S. 2000 Census and geographic information system (GIS) analysis.

2.2 Topography and Soils

The Busseron Creek watershed is located in the Wabash Lowland physiographic region which is characterized by a broad lowland tract having an average elevation of 500 feet. The watershed is underlain by siltstone and shale of Pennsylvanian age and is comprised of extensive aggraded valleys and pockets of thick lacustrine, outwash, and alluvial sediments (USGS, 1983). Most soils in the watershed are classified as poorly draining C and D soils (61% and 6%, respectively), followed by moderately draining B soils (33%). Figure 3 shows the general topography within the watershed and indicates that elevations range from 415 to 677 feet with an average slope throughout the watershed of 5.4 ft per mile.

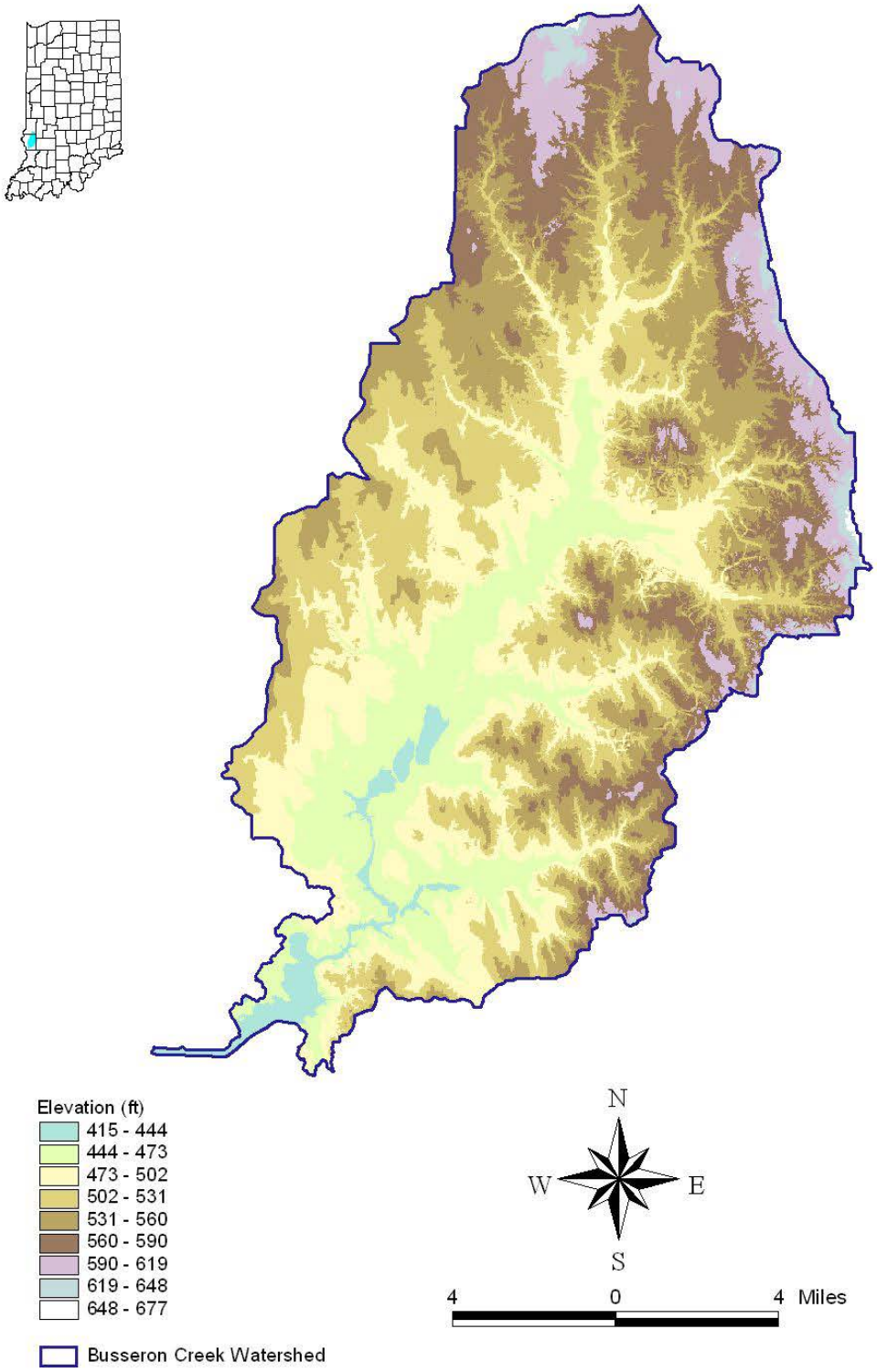


Figure 3. Topography in the Busseron Creek Watershed.

2.3 Land Use/Land Cover

Land use information for the Busseron Creek watershed is available from the Multi-Resolution Land Characteristics Consortium (MRLC)**.** These data categorize the land use for each 30 meters by 30 meters parcel of land in the watershed based on satellite imagery from circa 2000. Figure 4 displays the spatial distribution of the land uses and the data are summarized in Table 3. A majority of the land (65 percent) is classified as agricultural with another 20 percent of the watershed comprised of forest land.

Figure 5 shows the location of known abandoned mine lands in the watershed. A comparison of Figure 4 and Figure 5 indicates that many of the abandoned surface mining sites are classified as forest or agriculture in the land use/land cover database due to reclamation activities that create forests and croplands on abandoned mine areas. Therefore, the abandoned mine areas are not always calculated separately from the total square mileage of land use/land cover. They are often accounted for in other land uses such as forest and agriculture. Thus, they may be double-counted. The data used to create Figure 5 indicate that there are approximately 34 square miles of abandoned surface mine sites and 48 square miles of underground mines in the watershed, which represent 14.38 percent and 20.30 percent of the watershed area respectively.

Table 3. **Land Use and Land Cover in Busseron Creek Watershed**

Land Use/Land Cover	Watershed		
	Area		
	Acres	Square Miles[1]	Percent[1]
Urban Areas	3,749	5.86	2.50%
Forest	36,510	57.05	24.10%
Agriculture	97,791	152.8	64.60%
Water/Wetlands	11,867	18.54	7.80%
Grasslands	1,419	2.22	0.90%
Total	**151,336**	**236.47**	**100.00%**
Surface Mines		34	14.38%
Underground Mines		48	20.30%

[1]Abandoned mine areas were not always identified separately in the total square mileage or in the total percentage as many of these sites are classified as other land use/land cover such as forest in the database.

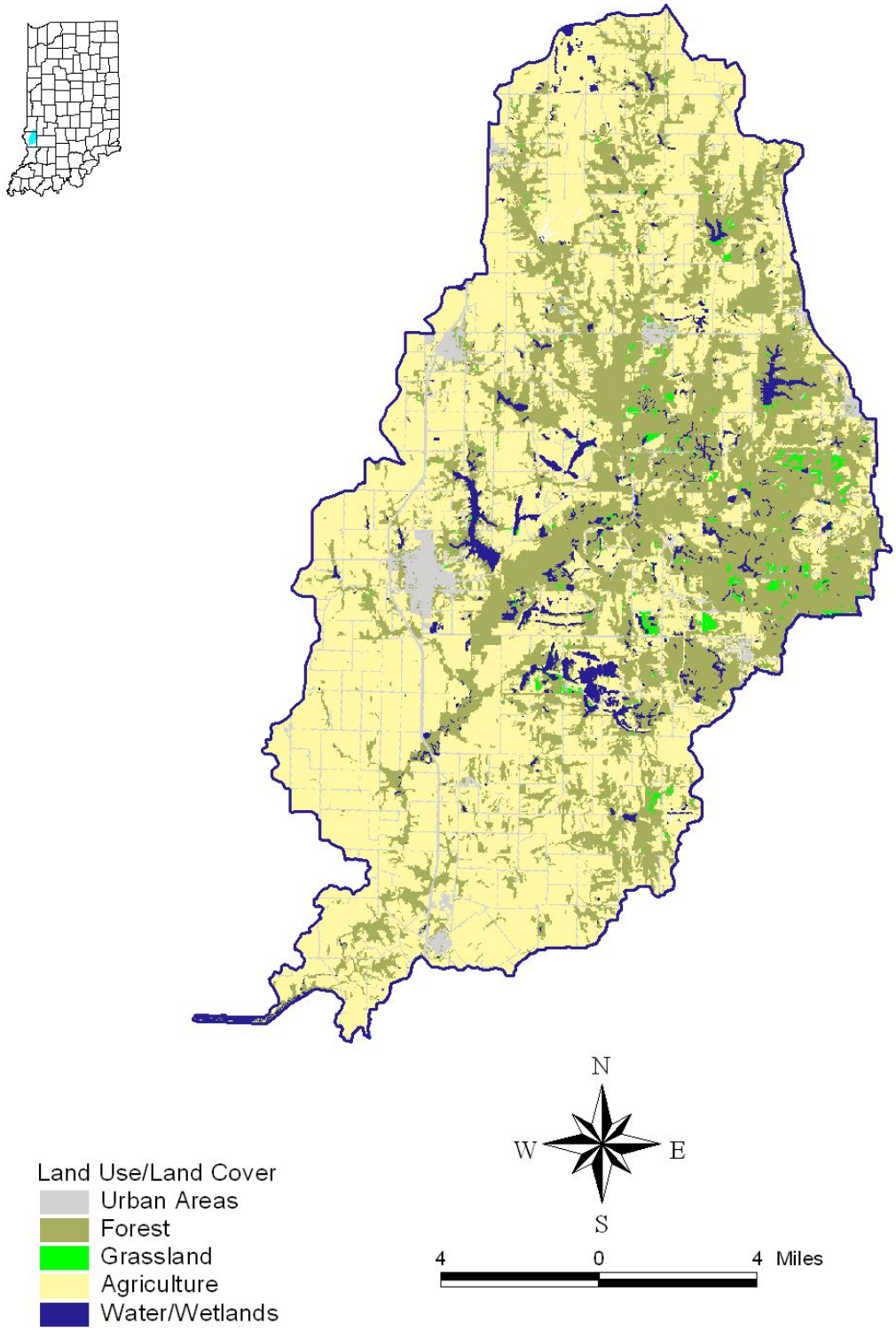


Figure 4. Land Use in the Busseron Creek Watershed.

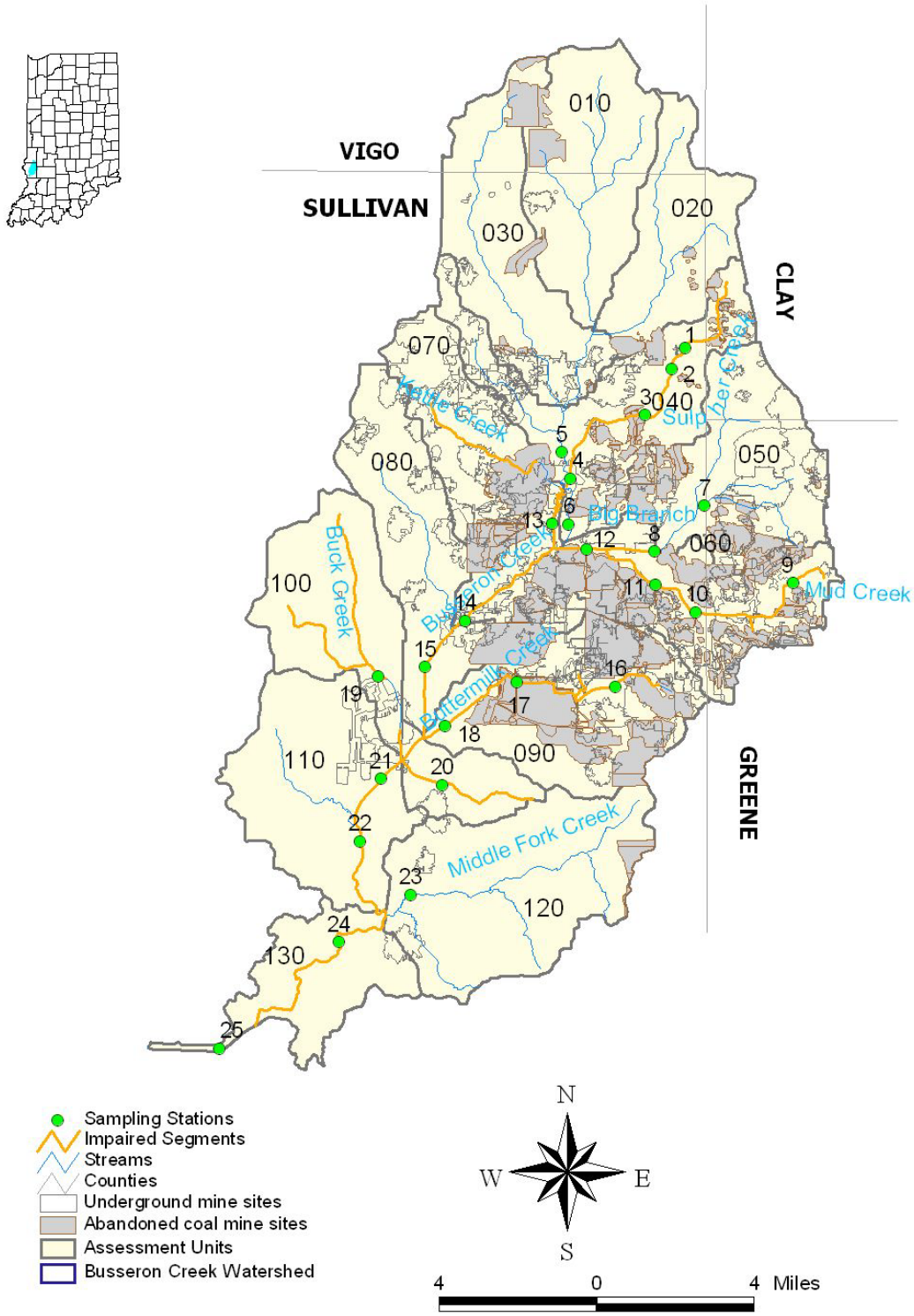


Figure 5. Abandoned mine lands in the Busseron Creek watershed.

2.4 Hydrology

There is one active flow gaging station (U.S. Geological Survey (USGS) gage ID 03342500) on Busseron Creek located near Carlisle. The average daily flows for this gage from the period 1970 to 2007 are shown in Figure 6 and indicate that flows are typically the greatest during winter and spring (December through April) and least during late summer and fall (August through October).

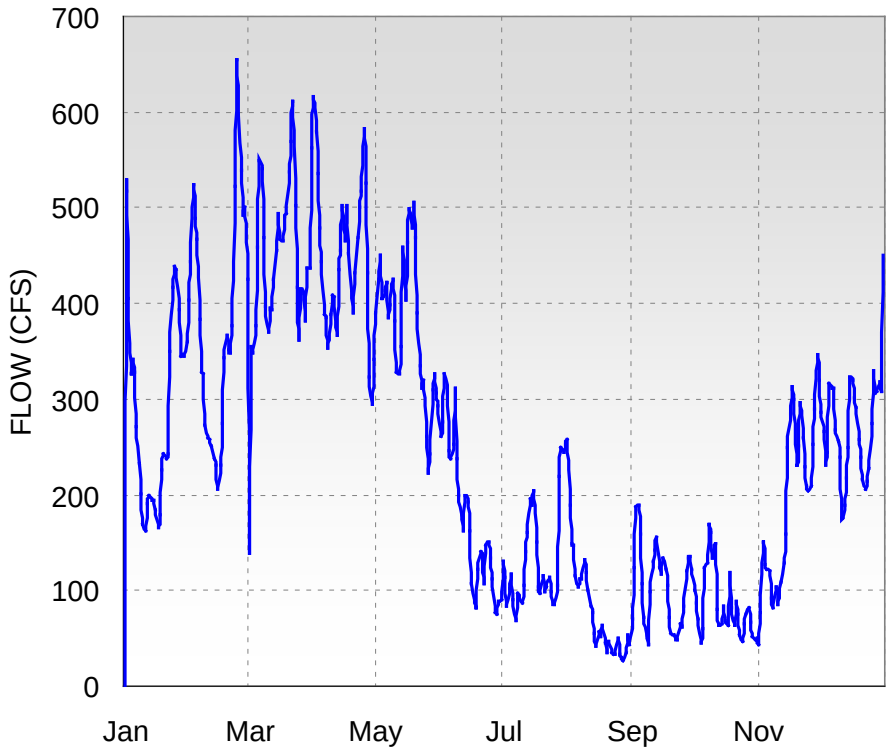


Figure 6. Average Daily Flow at Busseron Creek near Carlisle, IN, USGS Station 03342500 (1970 to 2007; note that no flows recorded for period December 2, 2003 to May 2, 2007).

3.0 INVENTORY AND ASSESSMENTOF WATER QUALITY INFORMATION

This section of the report provides information on the water quality standards that apply to the impaired streams in the Busseron Creek watershed and provides a summary of existing water quality.

3.1 Water Quality Standards and TMDL Target Values

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 several different components:

- **Designated uses** reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and full body contact recreation. Every waterbody in Indiana has a designated use or uses; however, not all uses apply to all waters. All surface waters in the Busseron Creek watershed have been designated to support a well-balanced, warm water aquatic community (327 IAC 2-1-3).
- **Criteria** express the condition of the water that is necessary to support the designated uses. **Numeric criteria** represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. **Narrative criteria** are the general water quality criteria that apply to all surface waters. The relevant narrative criteria that apply to the TMDLs presented in this report state the following:

> *"All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:" [327 IAC 2-1-6. Sec. 6. (a)(1)]…*
>
> *(a)re in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses." [327 IAC 2-1-6. Sec. 6. (a) (1)(D)]*
>
> *(a)re in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans." [327 IAC 2-1-6. Sec. 6. (a) (1)(E)]*

3.2 Target Values

Target values are used for the development of TMDLs to calculate allowable daily loads. For parameters that have numeric criteria, the numeric criteria are used as the TMDL target value. For example, numeric criteria (that vary by hardness) exist for copper and zinc and equations that specify the criteria can be found in the Indiana Administrative Code at 2-1-6 Table 6-2.

For parameters covered only by narrative criteria, target values must be identified from another source. For example, Indiana has established a 0.30 mg/L target for total phosphorus to quantify the narrative criteria that requires that waters shall be free from substances that "contribute to the growth of nuisance

aquatic plants or algae." Additional information on the total phosphorus target value and how it was derived are presented in Appendix C.

The target value for total iron was derived from the effluent guideline at 40 CFR 434.3. These guidelines were also used to develop the permit limitations in the general permit for all NPDES permitted facilities with iron identified in their effluent. The permit limitations are outlined in 327 IAC 15-7.

Table 4 summarizes the target values used for the Busseron Creek watershed TMDLs along with an explanation of how they were derived. All of these target values are intended to improve water quality so that a well-balanced, warm water aquatic community may exist in the waterbody. The target values for pH, total iron, and total zinc, are intended to reduce the toxicity caused by elevated levels of these pollutants. The targets are developed to protect aquatic organisms from death, slower growth, reduced reproduction, and the accumulation of harmful levels of toxic chemicals in their tissues that may adversely affect consumers of such organisms.

Loads cannot be calculated for pH; instead, the metals' TMDLs are expected to result in attainment of the pH targets. This is due to the fact that, in watersheds such as Busseron Creek that are affected by historic abandoned mine lands, low pH is generally caused by water with elevated concentrations of metals that have oxidized and precipitated making the water acidic. Therefore, meeting the targets for the concentrations of metals should also result in meeting the pH targets.

The target value for total phosphorus is intended to limit the negative effects on aquatic ecosystems that can occur due to increasing algal and aquatic plant life production associated with higher nutrient concentrations (Sharpley et al., 1994). Increased plant production increases turbidity, decreases average dissolved oxygen concentrations, and increases fluctuations in diurnal dissolved oxygen and pH levels. Such changes shift aquatic species composition away from functional assemblages comprised of pollution intolerant species, benthic insectivores, and top carnivores that are typical of high quality streams towards less desirable assemblages of pollution tolerant species, generalists, omnivores, and detritivores that are typical of degraded streams (OEPA, 1999). Such a shift in community structure lowers the diversity of the system.

The target value for total suspended solids (TSS) is included because TSS can reduce the amount of sunlight available to aquatic organisms and decrease water clarity. This leads to a number of effects including: reduction of aquatic plants available for consumption by higher level organisms, lower dissolved oxygen, and the impaired ability of fish to see and catch food. TSS particles can also hold heat, resulting in increased stream temperature. Further, TSS can clog fish gills, retard growth rates, decrease resistance to disease, and prevent egg and larval development. When TSS settles on the bottom of a waterbody, eggs of fish and invertebrates are smothered, larvae can suffocate, and habitat quality is degraded (OEPA, 1999).

Loads cannot be calculated for dissolved oxygen (DO) but instead the total phosphorus and TSS TMDLs are expected to result in attainment of the dissolved oxygen water quality standard. This is due to the interrelationship between these pollutants and dissolved oxygen as explained in the two preceding paragraphs.

Table 4. **Target values used for development of the Busseron Creek watershed TMDLs**

Parameter	Target Value	Source
Total phosphorus	No value should exceed 0.30 mg/L	This is a target used by IDEM to interpret the narrative nutrient criteria (327 IAC 2-1-6); see Appendix C for details.
pH	No pH values should be below six (6.0) or above nine (9.0), except daily fluctuations that exceed pH nine (9.0) and are correlated with photosynthetic activity, shall be permitted.	Numeric Criteria (327 IAC 2-1-6)
Dissolved Oxygen	Concentrations of dissolved oxygen shall average at least five (5.0) milligrams per liter per calendar day and shall not be less than four (4.0) milligrams per liter at any time.	Numeric Criteria (327 IAC 2-1-6)
Total Iron	No value should exceed 6.0 mg/L	National Effluent Guidelines 40 CFR 434.3, 327 IAC15-7
Total Suspended Solids	No value should exceed 30 mg/L	This is a target used by IDEM to interpret the narrative sediment criteria (327 IAC 2-1-6).
Total Copper	AAC (µg/L) = WER ($e^{(0.9422[\ln(hardness)]-1.464)}$) Conversion factor = 0.96[a] CAC (µg/L) = WER ($e^{(0.8545[\ln(hardness)]-1.465)}$) Conversion factor = 0.96 [a]	Numeric Standard (327 IAC 2-1-6). Table 6-2.
Total Zinc	AAC (µg/L) = WER ($e^{(0.8473[\ln(hardness)]+0.8604)}$) Conversion factor = 0.978 [a] CAC (µg/L) = WER ($e^{(0.8473[\ln(hardness)]+0.7614)}$) Conversion factor = 0.986 [a]	Numeric Standard (327 IAC 2-1-6). Table 6-2.

Notes: AAC = Acute Aquatic Criterion; CAC = Chronic Aquatic Criterion.
[a] Dissolved criteria for each of these parameters are computed by multiplying the AAC and CAC by the corresponding conversion factor.

3.3 Assessment of Water Quality

This section provides a summary of the water quality of the Busseron Creek watershed.

3.3.1 Biological Data

Sampling performed by USGS in September of 2007 documented widespread biological impairments in the Busseron Creek watershed as summarized in Table 5. Several potential reasons for the widespread impairments were identified through the TMDL effort including:

- The oxidation of iron may be consuming large amounts of oxygen which in turn stresses fish and other aquatic organisms.
- TSS can reduce plants available for consumption, lower dissolved oxygen levels, impair the ability of fish to see and catch food, increase stream temperature, clog fish gills, slow growth rates, decrease disease resistance, and prevent the development of eggs and larvae.
- Total phosphorus can cause increased plant production resulting in increased turbidity, decrease dissolved oxygen levels, and cause greater fluctuations in diurnal dissolved oxygen and pH levels resulting in lower stream diversity.

Attaining the targets shown in Table 4 will address these potential causes of impairment.

Table 5. **Impaired Biotic Community Stream Segments in the Busseron Creek Watershed Identified During September 2007 USGS Sampling**

Stream	Score	Sampling Site	IBI Integrity Class
Sulpher Creek	12	2	Very Poor
Busseron Creek	20	5	Very Poor
Busseron Creek	42	6	Fair
Big Branch	28	7	Poor
Big Branch	14	8	Very Poor
Mud Creek	12	9	Very Poor
Mud Creek	16	11	Very Poor
Big Branch	18	12	Very Poor
Busseron Creek	24	14	Very Poor
Busseron Creek	22	15	Very Poor
Buttermilk Creek	28	16	Poor
Buttermilk Creek	36	18	Poor
Buck Creek	16	19	Very Poor
Robbins Branch	36	20	Poor
Busseron Creek	22	22	Very Poor
Busseron Creek	46	25	Fair

Notes: IBI = Index of Biotic Integrity. Scores calculated using IDEM's *Summary of Protocols: Probability Based Site Assessment*. (IDEM, 2005).

3.3.2 Chemistry Data

Table 6 summarizes the water chemistry data within the Busseron Creek watershed by displaying the maximum concentrations at all impaired stations along with the reduction needed to meet the TMDL target values. The percent reductions were calculated as follows:

$$\%\,\text{Reduction} = \frac{(\text{Target Value} - \text{Maximum})}{\text{Maximum}}$$

The table indicates the following:

- Reductions of 71 percent or greater are needed to meet the TMDL target values for total iron, TSS, total copper and total zinc in Sulpher Creek.
- Reductions of 80 percent to 91 percent are needed to meet the TMDL target values for total iron in Mud Creek.
- Reductions varying from 40 to 82 percent are needed to meet the TMDL target value for total phosphorus in Sulpher, Kettle, and Robbins Creeks.

Appendix F shows the individual sample results and statistical summaries of all the water quality data for all 25 monitoring stations.

Table 6. **Summary of water chemistry data within the Busseron Creek watershed**

Stream Name	Station	Total Copper		Total Iron		Total Phosphorus		TSS		Total Zinc	
		Maximum (µg/L)	Reduction	Maximum (µg/L)	Reduction	Maximum (mg/L)	Reduction	Maximum (µg/L)	Reduction	Maximum (µg/L)	Reduction
Sulpher Creek	1	No TMDL		32400	81%	0.5	40%	No TMDL		1430	83%
	2	No TMDL		35900	83%	1.16	74%	150	80%	1070	83%
	3	43.4	73%	23600	75%	1.04	71%	No TMDL		632	83%
	4	No TMDL		No TMDL		No TMDL		No TMDL		No TMDL	
Mud Creek	9	No TMDL		No TMDL		No TMDL		No TMDL		No TMDL	
	10	No TMDL		69800	91%	No TMDL		61	50%	No TMDL	
	11	No TMDL		29300	80%	No TMDL		No TMDL		No TMDL	
Kettle Creek	13	No TMDL		No TMDL		1.76	82%	296	89%	No TMDL	
Buttermilk Creek	16	No TMDL		No TMDL		No TMDL		60	50%	No TMDL	
	17	No TMDL		11800	49%	No TMDL		41	26%	No TMDL	
Robbins Creek	19	No TMDL		No TMDL		0.6	50%	114	73%	No TMDL	
	20	No TMDL		No TMDL		0.5	40%	No TMDL		No TMDL	

Notes: "No TMDL" indicates that the stream at that station is not considered impaired for that pollutant and thus no TMDL is presented in this report.

3.3.3 Sulfates and Total Dissolved Solids Listings

As shown in Table 1, several waterbody segments within the Busseron Creek watershed were listed as impaired due to sulfates and total dissolved solids on the 2006 Section 303(d) list. No TMDLs were developed for these parameters because of the following:

- Sulfates – IDEM revised its sulfate criteria and the historic data have been reassessed using the revised criteria; the reassessment based on historic data indicates that none of the waterbodies within the Busseron Creek watershed are considered impaired for sulfates.

- Total Dissolved Solids – Indiana's revised water quality standards no longer contain a numeric criterion for this parameter. No target value has been identified to quantify the applicable narrative criteria and total dissolved solids are not considered to be a cause of the biological impairments.

4.0 SOURCE ASSESSMENT

This section summarizes the available information on significant sources of the pollutants of concern in the Busseron Creek watershed.

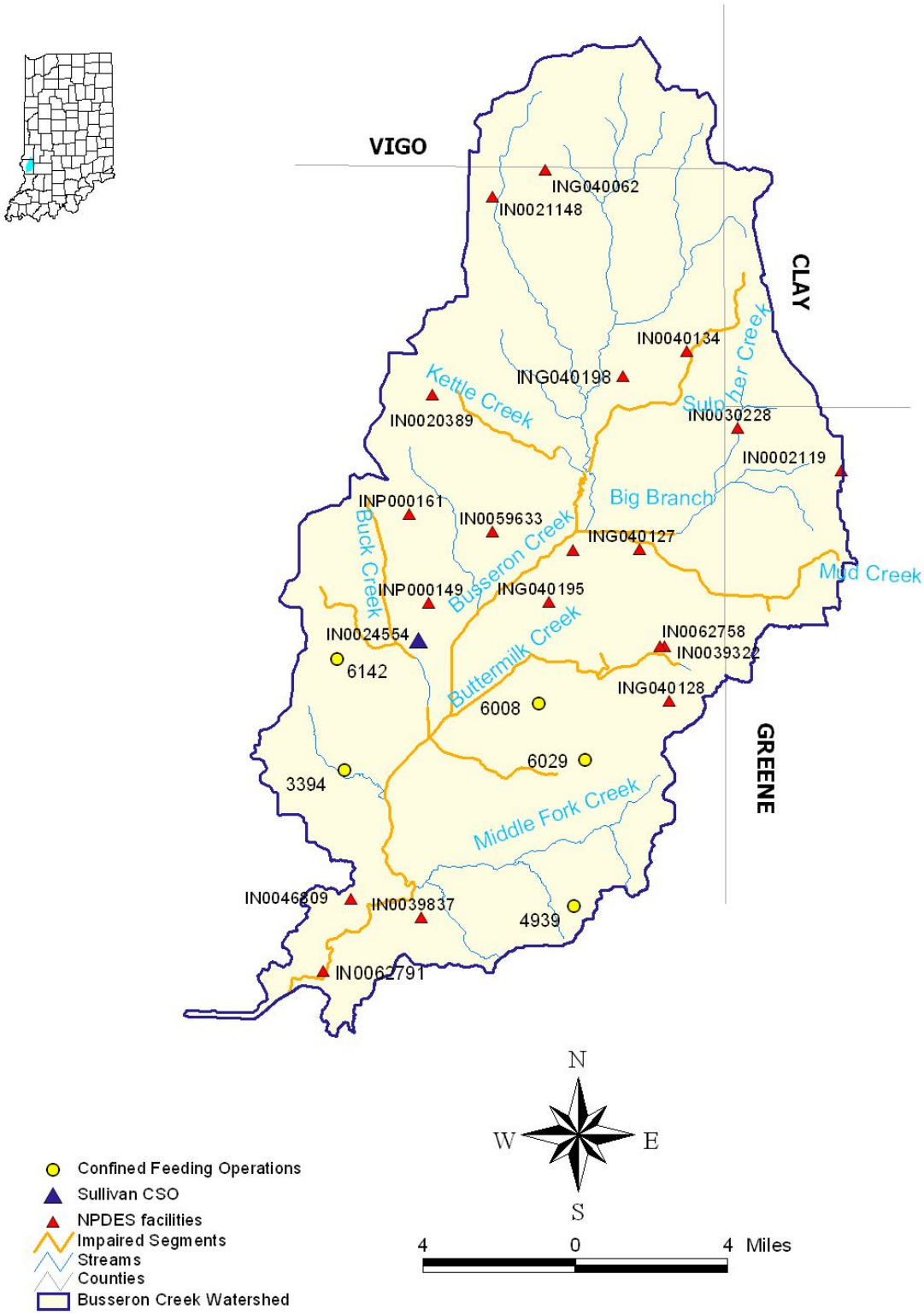
4.1 Permitted Point Sources

The term point source refers to any discernible, confined, and discrete conveyance, such as a pipe, ditch, channel, tunnel, or conduit, by which pollutants are transported to a waterbody. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term "point source" also includes concentrated animal feeding operations (CAFOs), which are places where animals are confined and fed; storm water runoff from Municipal Separate Storm Sewer Systems (MS4s); and illicitly connected "straight pipe" discharges of household waste. Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

4.1.1 Wastewater Treatment Plants (WWTPs) and Industrial Facilities

Facilities with NPDES permits to discharge wastewater within the Busseron Creek watershed include municipal WWTPs and industrial facilities. There are 19 active NPDES permitted facilities within the Busseron Creek watershed (Figure 7 and Table 7). Based on their permitted effluent, the seven municipal WWTPs (Shakamak State Park WWTP, Hymera Municipal WWTP, Sullivan Municipal WWTP, Shelburn WWTP, Dugger WWTP, Carlisle WWTP, and Farmersburg WWTP) in the watershed are potential sources of nutrients and TSS.

The six industrial dischargers associated with active mining (Appendix A) activities (Black Beauty Coal Farmersburg; Farmersburg Mine Bear Run East and West; Coal Field Development, Hymera Mine; Sunrise Coal; and Jericho, Sullivan County CMB Field) are potential sources of TSS, pH, and metals. The discharges at these facilities are the result of stormwater that is collected at the facility and discharged via the permitted discharge pipe. These discharges are permitted by rule under the general permit rule 327 IAC 15-7. These permits have varying discharge limits based on dry and wet weather discharge flow rates. For wet weather discharges, dilution rates are assumed and limits are suspended. Of the remaining six facilities, Latta Indiana Diesel House is a potential source of TSS, due to its effluent. The Town of Carlisle Water Department and the Glendora Test Facility are not considered potential sources for parameters of concern within this watershed. Atkinson Excavating Caledonia is inactive. Allomatic Products Co and North American Latex are pretreatment facilities, which discharge to a municipal wastewater treatment plant and therefore are not potential sources to the impairments. Table 8 summarizes permit violations for several of the facilities in the watershed and indicates that multiple facilities have had recurring violations for one or more pollutants.


VIGO
CLAY
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ING040062
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6142
IN0062758
IN0039322
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6008
6029
3394
IN0046809
IN0039837
4939
IN0062791
Kettle Creek
Sulpher Creek
Big Branch
Buck Creek
Busseron Creek
Mud Creek
Buttermilk Creek
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4 Miles
Confined Feeding Operations
Sullivan CSO
NPDES facilities
Impaired Segments
Streams
Counties
Busseron Creek Watershed

Figure 7. Location of NPDES facilities and confined feeding operations in the Busseron Creek Watershed.

Table 7. **NPDES Permitted Wastewater Dischargers within the Busseron Creek Watershed**

Facility	Permit Number	Receiving Stream
Shakamak State Park WWTP	IN0030228	Big Branch Creek
Hymera Municipal WWTP	IN0040134	Sulpher Creek
Sullivan Municipal WWTP	IN0024554	Busseron Creek via Buck Creek
Shelburn WWTP	IN0020389	Unnamed Tributary to Kettle Creek
Dugger WWTP	IN0039322	Buttermilk Creek
Carlisle WWTP	IN0039837	Busseron Creek
Town of Carlisle Water Department	IN0046809	Unnamed Ditch to Busseron Creek
Latta Indiana Diesel House	IN0002119	Busseron Creek via Big Branch
Glendora Test Facility	IN0059633	Unnamed ditch to Busseron Creek
Farmersburg WWTP	IN0021148	Busseron Creek (W FK) to Wabash River
Black Beauty Coal Farmersburg	ING040062	Busseron, Spunge and Turman Creeks
Farmersburg Mine Bear Run	ING040127	Kettle, Mud, Busseron, and Buttermilk Creeks
Farmersburg Mine Bear Run East	ING040239	Buttermilk and Middle Fork Creeks
Coal Field Development, Hymera Mine	ING040198	Located in Sulpher Creek Subwatershed
Sunrise Coal	IN0062791	Busseron Creek
Jericho, Sullivan County CBM Field	IN0062758	Buttermilk Creek, Busseron Creek
Allomatic Products Co	INP000149	Sullivan WWTP
Atkinson Excavating Caledonia	ING040195	Unnamed Tributary to Busseron Creek
North American Latex Corp	INP000161	Sullivan WWTP

Table 8. **Summary of Permit Violations for the NPDES Facilities in the Busseron Creek Watershed for the Five Year Period Ending October 2007**

Facility	Violations from October 2002 through October 2007
Dugger WWTP	19 dissolved oxygen violations; 11 TSS violations
Farmersburg Mine Bear Run	14 pH violations; and 3 TSS violations (multiple outfalls)
Farmersburg Mine Bear Run (East Pit)	6 iron violations (multiple outfalls)
Farmersburg WWTP	10 dissolved oxygen violations; 1 pH violation; 87 TSS violations
Hymera Municipal WWTP	9 dissolved oxygen violations; 2 pH violations; 55 TSS violations
Shakamak State Park WWTP	8 dissolved oxygen violations; 1 pH violation; 15 TSS violations
Shelburn WWTP	2 dissolved oxygen violations; 3 total phosphorus violations; 14 TSS violations
Sullivan Municipal WWTP	6 pH violations; 1 TSS violation

4.1.2 Concentrated Animal Feeding Operations/Confined Feeding Operations

Animal feeding operations that are not classified as CAFOs are known as confined feeding operations (CFOs) in Indiana. Non-CAFO animal feeding operations are considered nonpoint sources by U.S. EPA. CAFOs have federal permits and fall under the jurisdiction of the NPDES Program. Indiana's CFOs have state issued permits but are not under the jurisdiction of the federal NPDES Program and are therefore categorized as nonpoint sources for the purposes of this TMDL. Indiana's CFOs are not allowed to discharge under the state permits.

Like CAFOs, the animals raised in CFOs produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. CFOs and however, can pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure over application can adversely impact soil productivity.

There are five active confined feeding operations in Busseron Creek watershed, but none are large enough to be classified as CAFOs.

4.1.3 Combined Sewer Systems

Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater into the same pipe. Most of the time, combined sewer systems transport all of the wastewater to a sewage treatment plant, where it is treated and then discharged to a waterbody. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other waterbodies. These overflows, called combined sewer overflows (CSOs), can contain both storm water and untreated human and industrial waste. Because they are associated with wet weather events, CSOs typically discharge for short periods of time at random intervals.

The Sullivan Municipal WWTP operates the only combined sewer system in the watershed (Figure 7). CSO outfalls 002 and 003 were the only two that discharged for the period September of 2007 through March of 2008 (the most recent data available) and they are located along Buck Creek on the west side of the city. CSOs can contribute to nutrient and TSS impairments.

4.1.4 Storm Water Phase II Communities

Under Phase II of the NPDES storm water program, rules have been developed to regulate most Municipal Separate Storm Sewer Systems (MS4s). Operators of Phase II-designated small MS4s are required to apply for NPDES permit coverage and to implement storm water discharge management controls known as "best management practices" (BMPs). These communities can be potential sources of nutrients and TSS. There are no MS4s within the Busseron Creek watershed.

4.1.5 Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Busseron Creek watershed directly discharge to a stream or are illegally connected to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as nutrients and TSS to the stream. These systems are sometimes

referred to as "straight pipe" discharges. These systems are classified as point sources; however, since they are illegal, they receive a wasteload allocation of zero.

4.2 Nonpoint Sources

Nonpoint sources include all other categories not classified as point sources. In urban areas, nonpoint sources can include leaking or failing septic systems, runoff from lawn fertilizer applications, pet waste, storm water runoff outside of MS4 communities, and other sources. In more rural areas, major contributors can be runoff from agricultural lands and abandoned mine lands.

4.2.1 Agriculture

Both cropland and confined feeding operations are potential agricultural sources of pollutants in the Busseron Creek watershed.

4.2.1.1 Cropland

Approximately 45 percent of the land in the Busseron Creek watershed is classified as row crops and another 20 percent is classified as pasture and grasslands. These lands can be a source of both sediments and nutrients. Accumulation of nutrients on cropland occurs from decomposition of residual crop material, fertilization with chemical (e.g., anhydrous ammonia) and manure fertilizers, atmospheric deposition, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities. The majority of nutrient loading from cropland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). Use of manure for nitrogen supplementation often results in excessive phosphorus loads relative to crop requirements (USEPA, 2003).

4.2.1.2 Confined Feeding Operations

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of confined feeding operations falls under the regulations for confined feeding operations (CFOs) and concentrated animal feeding operations (CAFOs). The CFO regulations (327 IAC 16, 327 IAC 15) require that operations "not cause or contribute to an impairment of surface waters of the state." IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. The rules at 327 IAC 16, which implement the statute regulating confined feeding operations, were effective on March 10, 2002. The rule at 327 IAC 15-15, which regulates concentrated animal feeding operations and complies with most federal CAFO regulations, became effective on March 24, 2004, with two exceptions, 327 IAC 15-15-11 and 327 IAC 15-15-12 which became effective on December 28, 2006. CFO and CAFO rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04). The difference between the two feeding operations is that concentrated animal feeding operations fall under Federal regulation and confined feeding operations fall under State regulations. CAFO loads fall under wasteload allocations (WLA) and CFO loads fall under load allocations (LA) because they are considered nonpoint sources that do not require an NPDES permit.

The animals raised in confined feeding operations produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial reuse of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. Confined feeding operations, however, can also pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.

- Improper application of manure can contaminate surface or ground water.
- Manure over-application can adversely impact soil productivity.

These concerns can potentially contribute to nutrient and TSS impairment in a waterbody. The following five active confined feeding operations exist in the Busseron Creek watershed (Figure 7):

- Bowen Turkey Farm (ID 4939)
- Dear Creek Farm (ID 6008)
- Triple C Farms (ID 6029)
- Long Acre Farms (ID 6142)
- Willis (ID 3994)

4.2.2 Onsite Wastewater Treatment Systems

Onsite Wastewater Treatment Systems, also known as septic systems, can be a source of nutrients to surface waters. Septic systems that are properly designed and maintained should not serve as a source of contamination to surface waters; however, onsite systems do fail for a variety of reasons. Common soil-type limitations in Indiana that contribute to failure are seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When these septic systems fail hydraulically (surface breakouts) or hydro-geologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsely and Witten, 1996).

There are a significant number of old houses in the Busseron Creek watershed that either have septic systems that do not function properly or have not been updated to the current standards. Illegal dumping of sewage as well as septic failures are also a common phenomenon in the watershed (Cundiff, 2007), although no information on the specific number of failing systems is available. Failing septic systems are sources of nutrients that can reach nearby streams through both runoff and ground water flows.

4.2.3 Abandoned Surface and Underground Mining

There are approximately 34 square miles of abandoned surface (Appendix A) mine sites and 48 square miles of underground mines in the Busseron Creek watershed (Figure 5). The Busseron Creek watershed was extensively coal mined (surface and underground) from the late 1800's until the mid-1900's. Historic practices have had a significant impact on the streams and surrounding landscape of the watershed. Several of these impacts include:

- Residual strip mine ponds and mine waste piles (gob piles)
- Surface hydrology alteration
- Elimination of some headwater streams
- Altered topography and vegetation
- Increased stream bank erosion and sedimentation
- Alteration of fish habitat
- Increased in-stream metals concentrations

The residual effects of historic mining have had a significant influence on water quality as acid mine drainage (AMD) from seeps, mine tailings/gob piles, and exposed coal seams enter into Busseron Creek and its tributaries. AMD generally displays elevated levels of one or more of the following parameters (Bauers et al, 2006):

- Acidity
- Metals

- Sulfates
- Suspended Solids

A number of efforts to address abandoned mine lands in the watershed are already underway, as described in Section 8.1.

It should also be noted that there is an important distinction between abandoned mine lands and current mining practices. Current mines are required to comply with the Surface Mining Control and Reclamation Act of 1977, which addresses the water-quality problems associated with AMD and requires that extensive information about the probable hydrologic consequences of mining and reclamation be included in mining-permit application so that the regulatory authority can determine the probable cumulative impact of mining on the hydrology. Since the onset of the Act, best management practices have been employed at all current mine sites and are aimed at minimizing adverse affects to the hydrologic balance. As a result, the current mines in the Busseron Creek watershed are not considered significant sources of the impairments noted in this TMDL.

For purposes of this TMDL, point sources are identified as permitted discharge points or discharges having responsible parties, and nonpoint sources are identified as any pollution sources that are not point sources. There is not a single point of discharge associated with abandoned mine lands; therefore, runoff from these areas consists of overland flow. Abandoned mine lands were treated in the allocations as nonpoint sources. As such, the discharges associated with these land uses were assigned LAs. The decision to assign LAs to abandoned mine lands is not a determination by IDEM as to whether there are unpermitted point source discharges within these land uses. In addition, the assignment of LAs to mine drainage discharges is not a determination that these discharges are exempt from NPDES permitting requirements.

5.0 TECHNICAL APPROACH

Previous sections of the report have provided a description of the Busseron Creek watershed, summarized the applicable water quality standards and water quality data, and identified potential sources of the pollutants of concern. This section represents the technical approach used to estimate the current and allowable loads of the pollutants of concern in the Busseron Creek watershed.

Load reductions were determined through the use of load duration curves. The load duration curve calculates the allowable loadings of a pollutant at different flow regimes by multiplying each flow by the TMDL target value and an appropriate conversion factor. The following steps are taken:

1) A flow duration curve for the stream is developed by generating a flow frequency table and plotting the observed flows in order from highest (left portion of curve) to lowest (right portion of curve).

2) The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the TMDL target value and by a conversion factor and the resulting points are graphed. Conversion factors are used to convert the units of the target (e.g., mg/L) to loads (e.g., kg/day) with the following factors used for this TMDL:

   a) Flow (cfs) x TMDL Concentration Target (mg/L) x Conversion Factor (2.45) = Load (kg/day)
   b) Flow (cfs) x TMDL Concentration Target (μg/L) x Conversion Factor (0.00245) = Load (kg/day)

3) To estimate existing loads, each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected and the appropriate conversion factor. Then, the existing individual loads are plotted on the TMDL graph with the curve.

4) Points plotting above the curve represent deviations from the water quality standard and the daily allowable load. Those points plotting below the curve represent compliance with standards and the daily allowable load.

5) The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five “hydrologic zones” (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 9, which is not specific to any individual pollutant, summarizes the general relationship between the five hydrologic zones and potentially contributing source areas. For example, the table indicates that impacts from wastewater treatment plants are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their relatively constant loads. In contrast, impacts from channel bank erosion is most pronounced during high flow zones because

these are the periods during which stream velocities are high enough to cause erosion to occur. Impacts from abandoned mining areas can occur during all flow zones.

Table 9. **Relationship Between Load Duration Curve Zones and Contributing Sources**

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Wastewater treatment plants				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflows	H	H	H		
Abandoned Mining	H	H	H	H	H
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			
Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)					

5.1 Stream Flow Estimates

Daily stream flows are necessary to implement the load duration curve approach. These were estimated using the observed flows available at the USGS gage on Busseron Creek (gage ID 03342500) and drainage area weighting, using the following equation:

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} \times Q_{gaged}$$

Where,

$Q_{ungaged}$: Flow at the ungaged location
Q_{gaged}: Flow at surrogate USGS gage station
$A_{ungaged}$: Drainage area of the ungaged location
A_{gaged}: Drainage area of the gaged location

In this procedure, the drainage area of each of the load duration stations was divided by the drainage area (228 square miles) of gage 03342500. The flows for each of the stations were then calculated by multiplying the 03342500 flows by the drainage area ratios. Additional flows were added to certain locations to account for wastewater treatment plants and CSOs that discharge upstream and are not directly accounted for using the drainage area weighting method.

Gage 03342500 was inactive between December 2, 2003, and May 2, 2007, a period that includes the majority of the available water chemistry samples for the Busseron Creek watershed. Flows during this period were therefore estimated based on flows from the nearby Mill Creek watershed as outlined in Appendix G. The Mill Creek watershed was chosen as a “surrogate” gage due to its proximity to the Busseron Creek watershed and its similar hydrologic characteristics. Both watersheds are located in the lower Wabash River watershed; land use in both watersheds is mostly row crops, pasture/grasslands, and

deciduous forest (some of the abandoned mine land sites could also potentially be classified as other land uses/land cover); and both watersheds consist primarily of Group C soils. Furthermore, there is a relatively strong correlation between flow data collected concurrently at the two USGS gages ($R^2 = 0.74$; see Appendix G).

6.0 ALLOCATIONS

This section of the report presents the allowable and existing pollutant loads for the Busseron Creek watershed and allocates the allowable loads as required by the Clean Water Act.

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for unregulated 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:

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

6.1 Approach for Calculating General Permit Waste Load Allocations

A number of permittees in the Busseron Creek watershed have general rather than individual permits. An individual permit is site-specific and is developed to address discharges from a specific facility. A general permit is used to cover a category of similar discharges, rather than a specific site. IDEM may issue a general permit when there are several sources or activities involved in similar operations that may be adequately regulated with a standard set of conditions.

Calculating WLAs for facilities with individual permits in the Busseron Creek watershed is straightforward; all of the necessary information regarding allowable flows and effluent limits is contained within the permit. Calculating WLAs for facilities with general permits is more difficult because only limited information is available on historical flow and pollutant concentrations. For example, several of the current mines in the watershed have general permits for treating runoff; discharge is therefore related to precipitation events rather than a “design” flow as is available for WWTPs. WLAs were therefore calculated by using the drainage area of each permittee to estimate runoff flow volumes and using either existing permit limits or the TMDL targets to calculate the allowable loadings. For example, the size of the Farmersburg Bear Run mine is estimated at 2,427 acres[1], which is 1.6 percent of the 145,920 acres that drain to USGS gage 03342500. Average high flows from the mine were therefore estimated at approximately 16.5 cfs because average high flows at the USGS gage are 1,028 cfs (1.6 % *1,028 cfs = 16.5 cfs). High flow WLAs were thus calculated for this facility by multiplying 16.5 cfs by the following concentrations:

- Total Iron: 6 mg/L (general permit limit)
- TSS: 70 mg/L (general permit limit)
- Total Zinc: 0.23 mg/L (water quality standard assuming a hardness of 250 mg/L)

The same methodology was used to calculate WLAs for other facilities and flow zones, unless noted otherwise in Section 6.2. The current mines in the Busseron Creek watershed are not considered significant sources of the impairments noted in this TMDL, as they are in compliance with the limits of their permits.

[1] The Total Performance Acreage Ever Bonded as reported by the IDNR at http://www.in.gov/dnr/reclamation/5397.htm was used to estimate the size of the mines in the watershed.

6.2 TMDL Results for Each Impaired Segment

The following sections provide the TMDL results for the impaired segments of the Busseron Creek watershed. More details of the load duration curve analysis used to calculate existing and allowable loads are shown in Appendix H.

6.2.1 Sulpher Creek Station 1 (Segment INB11G4_T1003)

Sulpher Creek at Station 1 is impaired due to total iron, total phosphorus, pH, and total zinc (Table 10). Although historic data indicate that total copper also exceeded water quality standards, recent data do not suggest a total copper impairment so no total copper TMDL was developed.

Table 10. **Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1003 (Station 1)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Iron (µg/L)	9	3	33%	2330	32400	7400.00
Total Phosphorus (mg/L)	9	2	20%	0.031	0.503	0.15
pH	8	6	75%	3.79	7.49	5.30
Total Zinc (µg/L)	9	8	88%	45.5	1430	953.17

The TMDL for Sulpher Creek Station 1 is summarized in Table 11. The targets used to develop the TMDL were as follows (see Section 3.2 for details):

- Total Iron: 6,000 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Zinc: 239 µg/L

The pH impairment will be addressed by meeting the targets for total iron, and total zinc as explained in Section 3.2.

Abandoned underground and surface mines are located upstream of Station 1 and are considered the primary sources of the metals. As historic abandoned mine lands are considered nonpoint source, any discharge associated with these lands are accounted for in the LAs. Private sewage systems and agricultural activities are potential sources of phosphorus.

Table 11. **TMDL Summary for Sulpher Creek Station 1 (Segment INB11G4_T1003)**

Sulpher Creek Station 1 (Segment INB11G4_T1003)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Iron (kg/day)	High Flows	No Point Sources	178.93	0	189.45	21.05	210.51
	Moist Conditions		95.95	0	47.23	5.25	52.48
	Mid-Range Flows		11.99	0	15.91	1.77	17.68
	Dry Conditions		Unknown	0	5.75	0.64	6.39
	Low Flows		Unknown	0	1.18	0.13	1.31
Total Phosphorus (kg/day)	High Flows	No Point Sources	13.96	0	9.48	1.05	10.53
	Moist Conditions		5.66	0	3.04	0.34	3.38
	Mid-Range Flows		0.12	0	0.79	0.09	0.88
	Dry Conditions		Unknown	0	0.29	0.03	0.32
	Low Flows		Unknown	0	0.06	0.01	0.07
Total Zinc (kg/day)	High Flows	No Point Sources	1.6	0	7.54	0.84	8.38
	Moist Conditions		7.59	0	1.69	0.19	1.88
	Mid-Range Flows		4.17	0	0.63	0.07	0.70
	Dry Conditions		Unknown	0	0.22	0.03	0.25
	Low Flows		Unknown	0	0.04	0.01	0.05

Notes: Unknown indicates that no data are available to estimate existing loads.

6.2.2 Sulpher Creek Station 2 (Segment INB11G4_ T1004)

Sulpher Creek at Station 2 is impaired for total iron, total phosphorus, pH, TSS, and total zinc (Table 12) and the TMDLs are summarized in Table 13.

Table 12. **Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1004 (Station 2)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Iron (µg/L)	9	2	22%	943	35900	8106.64
Total Phosphorus (mg/L)	9	4	44%	0.068	1.16	0.35
pH	9	4	44%	4.64	7.52	6.18
TSS (mg/L)	1	1	100%	150	150	150
Total Zinc (µg/L)	9	7	77%	39	1070	593.11

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Iron: 6,000 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Suspended Solids: 30 mg/L
- Total Zinc: 178 µg/L

The pH impairment will be addressed by meeting the targets for total iron, and total zinc as explained in Section 3.2.

Abandoned underground and surface mines are located upstream of Station 2 and are considered the primary sources of the metals. Private sewage systems and agricultural activities are potential sources of phosphorus.

Table 13. **TMDL Summary for Sulpher Creek Station 2 (Segment INB11G4_T1004).**

Sulpher Creek Station 2 (Segment INB11G4_T1004)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Iron (kg/day)	High Flows	No Point Sources	211.50	0	247.75	27.53	275.28
	Moist Conditions		149.23	0	59.90	6.66	66.56
	Mid-Range Flows		4.24	0	20.80	2.31	23.11
	Dry Conditions		Unknown	0	7.52	0.84	8.36
	Low Flows		Unknown	0	1.54	0.17	1.71
Total Phosphorus (kg/day)	High Flows	No Point Sources	20.94	0	12.38	1.38	13.76
	Moist Conditions		8.74	0	3.05	0.34	3.39
	Mid-Range Flows		0.64	0	1.04	0.12	1.16
	Dry Conditions		Unknown	0	0.38	0.04	0.42
	Low Flows		Unknown	0	0.08	0.01	0.09
TSS (kg/day)	High Flows	No Point Sources	Unknown	0	6,895	766	7,661
	Moist Conditions		Unknown	0	752	84	836
	Mid-Range Flows		Unknown	0	144	16	160
	Dry Conditions		Unknown	0	63	7	70
	Low Flows		41	0	7	1	8
Total Zinc (kg/day)	High Flows	No Point Sources	2.05	0	7.34	0.81	8.15
	Moist Conditions		8.25	0	1.72	0.19	1.91
	Mid-Range Flows		4.03	0	0.61	0.07	0.68
	Dry Conditions		Unknown	0	0.23	0.02	0.25
	Low Flows		Unknown	0	0.04	0.01	0.05

6.2.3 Sulpher Creek Station 3 (Segment INB11G4_ T1004)

Sulpher Creek at Station 3 is impaired by total iron, total phosphorus, total copper and total zinc (Table 14) and the TMDL is summarized in Table 15.

Table 14. **Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1004 (Station 3)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Copper (µg/L)	9	1	11%	2.22	43.4	11.77
Total Iron (µg/L)	9	3	33%	476	23600	6831.73
Total Phosphorus (mg/L	9	2	22%	0.029	1.04	0.4
Total Zinc (µg/L)	9	5	55%	60.9	632	370.72

The targets and water quality standards used to develop the TMDL were as follows (see Section 3.1 and 3.2 for details):

- Total Iron: 6,000 µg/L
- Total Copper: 11 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Zinc: 102 µg/L

The following three NPDES facilities are located upstream of Station 3:

- Hymera Municipal WWTP (IN0040134)
- Coal Field Development, Hymera Mine (ING040198)

The Hymera Municipal WWTP is not a source of the metals impairment (WLAs equal zero). This was determined after a review of the current NPDES permit, which indicated no metals' dischargers in the collection system. However, Hymera Municipal WWTP is a potential source of phosphorus. The total phosphorus WLA allocation was therefore calculated by multiplying the design flow (0.125 MGD) by the TMDL target of 0.3 mg/L.

The Coal Field Development mine is a potential source of total iron, total copper and total zinc. The determination that this is a possible source was based upon the general permit that limits the discharge of TSS and total iron and requires the facility to monitor for total copper and total zinc. WLAs for the facility were calculated using the approach described in Section 6.1 and the estimated size of the facility of 91.6 acres. The primary sources of total copper, total iron, and total zinc within Sulpher Creek are abandoned mining areas. The Coal Field Development mine is not considered a source that is contributing to the impairment because:

- The types of impairments observed in at Station 3 exist upstream of the mine, as well as in many other areas of the Busseron Creek watershed.
- The available discharge monitoring report (DMR) data indicate the mine has historically met its permit limits.

Table 15. **TMDL Summary for Sulpher Creek Station 3 (Segment INB11G4_T1004)**

Sulpher Creek Station 3 (Segment INB11G4_T1004)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Copper (kg/day)	High Flows	Unknown	3.51	0.044	0.784	0.092	0.92
	Moist Conditions	Unknown	0.07	0.014	0.139	0.017	0.17
	Mid-Range Flows	Unknown	0.02	0.004	0.068	0.008	0.08
	Dry Conditions	Unknown	Unknown	0.001	0.026	0.003	0.03
	Low Flows	Unknown	Unknown	0	0.009	0.001	0.01
Total Iron (kg/day)	High Flows	Unknown	1, 910.74	9.425	427.78	48.58	485.78
	Moist Conditions	Unknown	55.22	2.748	92.65	10.60	106.00
	Mid-Range Flows	Unknown	4.58	0.818	35.81	4.07	40.70
	Dry Conditions	Unknown	Unknown	0.182	13.10	1.47	14.75
	Low Flows	Unknown	Unknown	0.068	2.65	0.30	3.02
Total Phosphorus (kg/day)	High Flows	Unknown	38.54	0.14	21.721	2.429	24.290
	Moist Conditions	Unknown	25.88	0.14	6.880	0.78	7.800
	Mid-Range Flows	Unknown	0.21	0.14	1.687	0.203	2.030
	Dry Conditions	Unknown	Unknown	0.14	0.526	0.074	0.740
	Low Flows	Unknown	Unknown	0.14	0.000	0.016	0.156
Total Zinc (kg/day)	High Flows	Unknown	15.63	0.361	7.091	0.828	8.28
	Moist Conditions	Unknown	9.67	0.105	1.587	0.188	1.88
	Mid-Range Flows	Unknown	3.13	0.031	0.59	0.069	0.69
	Dry Conditions	Unknown	Unknown	0.007	0.218	0.025	0.25
	Low Flows	Unknown	Unknown	0.003	0.042	0.005	0.05

6.2.4 Mud Creek Station 9 (Stream Segment INB11G6_ 03)

Mud Creek at Station 9 is impaired due to total iron, and pH (Table 16). The Indiana Department of Natural Resources (DNR) also samples at this location (station 931A) and the DNR data were therefore incorporated into the analysis (Appendix I).

It should be noted that pH loads cannot be calculated; instead, the metals TMDLs are expected to result in attainment of the pH targets. This is due to the fact that, in watersheds such as Busseron Creek that are impacted by historic mine lands that have been abandoned, low pH is generally caused by water with elevated concentrations of metals becoming acidic after oxidation and precipitation of the metals. Therefore, meeting the targets for metals concentrations should also result in meeting the pH targets. The pH impairment at Station 9 will be addressed in the allocations at Station 10.

Table 16. **Statistical Summary of TMDL parameters at Stream Segment INB11G6_03 (Station 9)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
pH	19	1	5%	5.99	7.70	7.17

The pH impairment at this location will be addressed by meeting the targets for total iron as explained in Section 3.2. There are no point sources located upstream of this station and historic mining areas are the primary source of total iron.

6.2.5 Mud Creek Station 10 (Stream Segment INB11G6_ 03)

Mud Creek Station 10 is impaired due to dissolved oxygen, total iron, and TSS (Table 17). DNR (station 931 B) and USGS (station B10) data are also available for this location and were included in the analysis (Appendix I).

Table 17. **Statistical Summary of TMDL parameters at Stream Segment INB11G6_03 (Station 10)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Iron (µg/L)	20	17	85%	1730	69800	19403.50
TSS (mg/L)	13	7	53%	4	61	36.9083
Dissolved Oxygen	8	1	13%	1.39	12.26	9.28

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Iron: 6,000 µg/L
- Total suspended solids: 30 mg/L

The TMDL is summarized in Table 18: abandoned mining areas are the primary source of total iron, and TSS.

The specific cause of the low dissolved oxygen at Mud Creek Station 10 is related to the abandoned mine issues. For example, studies have shown that the oxidation of iron can consume a significant volume of dissolved oxygen (USGS, 1986). IDEM has therefore determined that addressing the iron impairment will result in attaining the water quality standards for dissolved oxygen.

AML Site 931 (ING040200) was the only NPDES facility upstream of station 10; this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the LAs as discussed in section 4.2.3.

Table 18. **TMDL Summary for Mud Creek Station 10 (Segment INB11G6_03)**

Mud Creek Station 10 (Segment INB11G6_03)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Iron (kg/day)	High Flows	No Point Sources	733.39	0	526.64	58.52	585.16
	Moist Conditions		409.64	0	114.36	12.71	127.07
	Mid-Range Flows		225.31	0	52.29	5.81	58.10
	Dry Conditions		Unknown	0	17.26	1.92	19.18
	Low Flows		Unknown	0	3.53	0.39	3.92
TSS (kg/day)	High Flows		3,803.52	0	2633.204	292.578	2925.782
	Moist Condition		1,041.61	0	539.614	59.957	599.571
	Mid-Range Flows		425	0	310.138	34.460	344.598
	Dry Conditions		Unknown	0	86.309	9.590	95.899
	Low Flows		3.67	0	16.495	1.833	18.328

6.2.6 Mud Creek Station 11 (Stream Segment INB11G6_ 04).

Mud Creek at Station 11 is impaired due to total iron (Table 19) and the TMDL is summarized in Table 20. The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Iron: 6,000 µg/L

Non-reclaimed abandoned mine land areas are the primary source of total iron.

Table 19. **Statistical Summary of TMDL parameters at Stream Segment INB11G6_04 (Station 11)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Iron (µg/L)	8	2	25%	116	29300	7131.22

AML Site 931 (ING040200) was the only historic NPDES facility upstream of this station; this facility no longer has an active NPDES permit so any discharge associated with this land area is accounted for in the LAs as discussed in section 4.2.3.

Table 20. **TMDL Summary for Mud Creek Station 11 (Segment INB11G6_04).**

Mud Creek Station 11 (Segment INB11G6_04)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Iron (kg/day)	High Flows	No Point Sources	558.32	0	699.52	77.72	777.25
	Moist Conditions		471.16	0	169.14	18.79	187.93
	Mid-Range Flows		1.33	0	58.74	6.53	65.26
	Dry Conditions		Unknown	0	21.24	2.36	23.61
	Low Flows		Unknown	0	4.34	0.48	4.83

6.2.7 Kettle Creek Station 13 (Stream Segment INB11G7_ 02)

Kettle Creek at Station 13 is impaired due to total phosphorus and is impaired due to Total Suspended Solids (TSS) (Table 21). The targets used to develop the TMDL are listed below (see Section 3.0 for details) and the TMDL is summarized in Table 22:

- Total Phosphorus: 0.30 mg/L
- TSS: 30 mg/L

There are no NPDES permitted facilities upstream of this station and the primary sources of phosphorus and TSS are agricultural activities, failing septic systems, and land disturbance associated with historic mining activities.

Table 21. **Statistical Summary of TMDL parameters at Stream Segment INB11G7_02 (Station 13)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Phosphorus (mg/L)	9	4	44%	0.134	1.76	0.447
TSS (mg/L)	1	1	100%	296	296	296

Table 22. **TMDL Summary for Kettle Creek Station 13 (Segment INB11G7_02)**

Kettle Creek Station 13 (Segment INB11G7_02)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	No Point Sources	60.77	0	39.35	4.37	43.72
	Moist Conditions		9.61	0	7.23	0.80	8.03
	Mid-Range Flows		14.52	0	3.30	0.37	3.67
	Dry Conditions		Unknown	0	1.20	0.13	1.33
	Low Flows		Unknown	0	0.24	0.03	0.27
TSS (kg/day)	High Flows		Unknown	0	21,902	2,434	24,336
	Moist Conditions		Unknown	0	2,390	266	2,656
	Mid-Range Flows		Unknown	0	456	51	507
	Dry Conditions		Unknown	0	200	22	222
	Low Flows		250	0	22	3	25

6.2.8 Buttermilk Creek Station 16 (Stream Segment INB11G9_ 01).

Based on the available Department of Natural Resources (DNR) data, Buttermilk Creek at Station 16 (319 A) is impaired by TSS (Table 23) and the TMDL is summarized in Table 24. The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total suspended solids: 30 mg/L

Table 23. **Statistical Summary of TMDL parameters at Stream Segment INB11G9_01 (Station 16)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
TSS (mg/L)	12	2	16%	6	60	19.55

Abandoned (non-reclaimed) mining areas are the primary source of TSS.

There are three NPDES facilities upstream of this station:

- Farmersburg Bear Run (ING040239)
- Dugger Municipal STP (IN0039322)
- Jericho, LLC-Sullivan County CBM Field (IN0062758)

The NPDES permit for Farmersburg Bear Run (ING040128) is inactive; however, this mine has been reopened and the new permit number is ING040239. The Farmersburg Bear Run mine is a potential source of TSS. The determination that this facility is a possible source was based upon the general permit that limits the discharge of TSS. WLAs for the facility were calculated using the approach described in Section 6.1 and the estimated size of the facility of total 7682.69 acres with approximately 3841.35 in the watershed.

The Dugger Municipal STP has a weekly average TSS limit of 19 mg/L during the summer and 25 mg/L during the winter. These limits were multiplied by the design flow of 0.125 MGD to calculate the WLAs.

Table 24. **TMDL Summary for Buttermilk Creek Station 16 (Segment INB11G9_01)**

Buttermilk Creek Station 16 (Segment INB11G9_01)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
TSS (kg/day)	High Flows	12	918.81	57.702	1518.954	175.184	1751.84
	Moist Conditions	12	533.21	28.028	226.942	28.33	283.30
	Mid-Range Flows	12	324.35	28.028	178.612	22.96	229.60
	Dry Conditions	9	Unknown	25.189	49.439	8.292	82.92
	Low Flows	9	5.03	25.189	8.426	3.735	37.35

6.2.9 Buttermilk Creek Station 17 (Stream Segment INB11G9_ 03)

Based on the available DNR data, Buttermilk Creek at Station 17 (319 B) is impaired by total iron, and TSS (Table 25) and the TMDL is summarized in Table 26.

- Total Iron: 6,000 µg/L
- Total suspended solids: 30 mg/L

Table 25. **Statistical Summary of TMDL parameters at Stream Segment INB11G9_03 (Station 17)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Iron (µg/L)	12	6	50%	152	11800	5408.50
TSS (mg/L)	12	2	16%	9	41	22.83

Abandoned (non-reclaimed) mining areas are the primary source of all the pollutants.

The following three NPDES facilities are located upstream of Station 17:

- Farmersburg Bear Run (ING040239)
- Dugger Municipal STP (IN0039322)
- Jericho, LLC-Sullivan County CBM Field (IN0062758)

The NPDES permit for Farmersburg Bear Run (ING040128) is inactive; however, this mine has been reopened with the permit number ING040239. The Farmersburg Bear Run mine is a potential source of TSS and total iron. The determination that this facility is a possible source was based upon the general permit that limits the discharge of TSS and total iron. WLAs for the facility were calculated using the approach described in Section 6.1 and the estimated size of the facility of 7682.69 acres with approximately 3841.35 in the watershed.
WLAs for Dugger Municipal STP, and the Jericho CBM Field were calculated as described in Section 6.1.

AML Site 319 (ING040203) was upstream of this station; however, this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the LAs as discussed in section 4.2.3.

Table 26. **TMDL Summary for Buttermilk Creek Station 17 (Segment INB11G9_03)**

Buttermilk Creek 17 (Segment INB11G9_03)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Iron (kg/day)	High Flows	Unknown	433.22	6.881	951.88	106.53	1065.28
	Moist Conditions	Unknown	222.86	2.43	184.14	20.73	207.30
	Mid-Range Flows	Unknown	180.61	2.43	99.37	11.31	113.11
	Dry Conditions	Unknown	Unknown	2.43	29.00	3.49	34.92
	Low Flows	Unknown	Unknown	2.43	4.00	0.71	7.14
TSS (kg/day)	High Flows	12	3897.04	57.702	4759.818	535.28	5352.8
	Moist Condition	12	1107.89	28.028	731.221	84.361	843.61
	Mid-Range Flows	12	639.26	28.028	560.32	65.372	653.72
	Dry Conditions	9	Unknown	25.189	155.666	20.095	200.95
	Low Flows	9	Unknown	25.189	30.674	6.207	62.07

6.2.10 Buck Creek Station 19 (Stream Segment INB11GA_ T1003).

Buck Creek at Station 19 is impaired due to dissolved oxygen, TSS, and total phosphorus (Table 27).

Table 27. **Statistical Summary of TMDL parameters at Stream Segment INB11GA_T1003 (Station 19)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Dissolved Oxygen	7	1	14%	4.79	11.76	9.57
Total Phosphorus (mg/L)	9	5	55%	0.175	0.618	0.32
TSS (mg/L)	1	1	100%	114	114	114

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Phosphorus: 0.3 mg/L
- Total suspended solids: 30 mg/L

The Sullivan WWTP total phosphorus WLA was established based on the design flow (1.12 MGD) multiplied by the TMDL target value of 0.3 mg/L. This facility already has a permit limit for TSS and this value was used to set the TSS WLAs.

The Sullivan CSO WLAs were based on the TMDL target values of 0.3 mg/L total phosphorus and 30 mg/L TSS multiplied by the average overflow volume event recorded for the period September 2007 through March 2008 (3.96 million gallons). The reported overflow events were assumed to occur during one day and the WLAs were only assigned to the high flow zones.

The cause of the low dissolved oxygen at Station 19 is related to the total phosphorus impairment (i.e., excessive phosphorus is causing the excessive growth of algae which, in turn, are consuming too much oxygen during respiration and when they decay). Addressing the total phosphorus impairment will result in attaining the water quality standards for dissolved oxygen. The TMDL is summarized in Table 28.

Table 28. **TMDL Summary for Buck Creek Station 19 (Segment INB11GA_T1003)**

Robbins Creek 19 (Segment INB11GA_T1003)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	Unknown	84.34	5.80	35.13	4.5	45.43
	Moist Conditions	Unknown	12.82	1.30	8.64	1.10	11.04
	Mid-Range Flows	Unknown	2.97	1.30	2.84	0.46	4.60
	Dry Conditions	Unknown	Unknown	1.30	0.93	0.25	2.48
	Low Flows	Unknown	Unknown	1.30	0.07	0.15	1.52
TSS (kg/day)	High Flows	127	Unknown	577	19,816	2,266	22,659
	Moist Condition	127	Unknown	127	2,156	254	2,537
	Mid-Range Flows	127	Unknown	127	401	59	587
	Dry Conditions	127	Unknown	127	168	33	328
	Low Flows	127	570	127	8	15	150

6.2.11 Robbins Creek Station 20 (Stream Segment INB11GA_ 03).

Robbins Creek at Station 20 is impaired due to total phosphorus (Table 29) and the TMDL is summarized in Table 30. There are no NPDES facilities upstream of this station and sources of total phosphorus are livestock, agricultural activities, and septic systems.

Table 29. **Statistical Summary of TMDL parameters at Stream Segment INB11GA_03 (Station 20)**

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Phosphorus (mg/L)	9	2	22%	0.087	0.581	0.23

Table 30. **TMDL Summary for Robbins Creek Station 20 (Segment INB11GA_03)**

Robbins Creek 20 (Segment INB11GA_03)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	No Point Sources	17.72	0	10.20	1.13	11.33
	Moist Conditions		4.85	0	2.78	0.31	3.09
	Mid-Range Flows		0.31	0	0.85	0.10	0.95
	Dry Conditions		Unknown	0	0.31	0.03	0.34
	Low Flows		Unknown	0	0.06	0.01	0.07

6.2.12 Busseron Creek Stations 15, 21, and 22 (Stream Segments INB11G8_T1036, INB11GB_01, and INB11GB_02)

Busseron Creek segments INB11G8_T1036 (station 15), INB11GB_01, and INB11GB_02 (stations 21 and 22) are listed as impaired due to poor biotic communities. No pollutants or sources were identified in these segments at this time; therefore, no TMDL or allocations were made for these two segments. These impairments will be addressed by the upstream allocations and reductions. Improved water quality conditions resulting from the TMDLs developed for upstream locations are expected to result eventually in full support of the aquatic life use at segments INB11G8_T1036 and INB11GB_01, and INB11GB_02.

6.3 Margin of Safety (MOS)

Section 303(d) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991).

A ten percent explicit MOS was incorporated into all of the Busseron Creek TMDLs. The use of the load duration curve approach minimizes a great deal of uncertainty associated with the development of TMDLs because the calculation of the loading capacity is simply a function of flow multiplied by the target value. A ten percent MOS was considered appropriate because the target values used in this study. A ten percent MOS was also considered appropriate because the estimated flows are based on a USGS gage located within the watershed (see Section 5.1 and Appendix G for details).

Implicit margins of safety were also used for the metals TMDLs that have criteria that vary by hardness (total copper and total zinc) because the most stringent criteria were used to calculate all of the loading capacities. The most stringent criteria are the lowest of the criteria from among all samples that exceeded both the acute and chronic criteria.

6.4 Allocations

6.4.1 Wasteload Allocations

The WLAs developed for this TMDL are summarized in Section 6.2 for each impaired waterbody and are presented individually in Appendix J.

Because the total phosphorus loads from the Sullivan and Hymera Wastewater Treatment Plants had to be estimated, it is recommended that effluent monitoring for total phosphorus be added to these two wastewater treatment plant permits in the next permit renewal cycle. Additional in-stream monitoring should also be performed by IDEM. If the monitoring confirms that the wastewater treatment plant loads are contributing to the impairments, this will need to be addressed by IDEM and the individual facilities after the sampling results are available, interpreted, and subsequently incorporated into future permits.

Any illicitly connected "straight pipe" systems in the watershed receive a WLA of zero for all pollutants.

6.4.2 Load Allocations

The LAs developed for this TMDL are presented in Section 6.2 and vary for each waterbody and pollutant combination. No information is available with which to distinguish between the natural background sources of the LAs from the sources resulting from anthropogenic activities. Many of the TMDL pollutants such as total iron, total suspended solids, total phosphorus, total copper and total zinc are found naturally in either the soils or ground water of the watershed and would be present even in the absence of human activity. Abandoned mine lands were treated in the allocations as nonpoint sources. As such, the discharges associated with these land uses were assigned LAs.

6.5 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions for the parameters of concern are needed for specific flow conditions; the critical conditions (the periods when the greatest reductions are required) vary by parameter and location and are summarized in Table 31. The table indicates that critical conditions for most pollutants for most locations occur during high flow, precipitation-driven periods and therefore implementation of controls should be targeted for these conditions.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. The load duration approach accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow. Daily flows for the period 1970 to 2007 were used for the load duration analysis and cover the full range of low, average, and high flow periods. Figure 6 indicates that flows are typically the greatest during winter and spring, December through April, and least during late summer and fall, August through October.

Table 31. **Critical Conditions for TMDL Parameters**

Parameter	Station	Critical Condition				
		High flows	**Moist Conditions**	**Mid Range**	**Dry Conditions**	**Low Flows**
Copper, Total (μg/L)	3	X				
Iron, Total (μg/L)	3	X				
	5		X			
	9		X			
	10			X		
	11		X			
	12			X		
	17			X		
Phosphorus, Total (mg/L)	1		X			
	2		X			
	3		X			
	13			X		
	19	X				
	20	X				
Total Suspended Solids (mg/L)	2					X*
	10		X			
	13					X*
	16		X			
	17		X			
	19					X*
Zinc, Total (μg/L)	1			X		
	3		X			

Note that limited samples, only available during low flow periods, are available at these locations to calculate observed loads.

7.0 PUBLIC PARTICIPATION

Public participation is an important and required component of the TMDL development process. The following public meetings have been held in the watershed to discuss this project:

- A **Kickoff Meeting** was held at the Sullivan County Public Library on March 14, 2007, during which IDEM and Tetra Tech described the TMDL Program and provided a summary of the available data and the proposed modeling approach.
- A **Draft TMDL Meeting** was held at the Sullivan County 4-H Fairgrounds Meeting Room on January 31, 2008, during which IDEM and Tetra Tech described the TMDL Program and provided an overview of the draft TMDL results.
- An **Initial Comment Period** began January 23, 2008, and ended March 5, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.
- A **Second Comment Period** for a revised draft TMDL was held from June 16, 2008, to July 16, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.
- A **Third Comment Period** for another revised draft TMDL was held from September 2, 2008, to October 3, 2008. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.
- A **Fourth Comment Period** for the final draft TMDL was held from January 13, 2012 to February 13, 2012. Stakeholders were notified via hard copy letters, electronic mail, and web postings to IDEM's website.

8.0 IMPLEMENTATION

A variety of controls will need to be implemented to address the sources of impairment in the Busseron Creek watershed. A brief summary of the issues and progress already made for some of the most significant sources is provided below. IDEM has Watershed Specialists assigned to different areas of the state and these Watershed Specialists are available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the watershed.

8.1 Abandoned Mine Lands

Indiana Department of Natural Resources (DNR) has a number of watershed projects ongoing throughout the Busseron Creek watershed, primarily to address the issues with abandoned mines. For example, as shown in Table 32, approximately 32,200 tons of lime has been applied to six different sites to neutralize acidic runoff and almost 500 acres of land has been reclaimed by addressing gob piles, slurry spoils, and unvegetated areas (Mark Stacy, DNR, personal communication dated June 15, 2007). Several wetland treatment projects have also been installed to treat acid mine drainage.

Table 32. **Summary of DNR mine reclamation projects within the Busseron Creek watershed.**

Site	Name	Construction Dates	Amount ($)	Tons of Lime Applied	Total Acres Reclaimed
317	Big Branch	3/9/01 - 4/10/01	254,348.91	1400	22.5
318	Peabody 48	4/7/03 - 8/22/03	76,652.32	200	6.5
319	Vandalia	9/7/04 - 10/12/05	1,441,984.81	2900	102
322	Pandora	10/16/89 - 7/2/90	165,250.93	500	22.5
931	Big Bertha	7/22/04 - 5/24/05	609,051.19	2200	32
287	Friar Tuck	3/30/89 - 5/9/05	1,758,688.49	25,000	295.7

8.2 Agriculture

Nonpoint source pollution from agricultural areas can be reduced by the implementation of best management practices (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, changing a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Landowners can implement BMPs outside of a watershed management plan, but the success of BMPs is typically enhanced if coordinated as part of a watershed management plan. Examples follow of BMPs that may be appropriate for the Busseron Creek watershed.

8.2.1 Vegetated Filter Strips

Vegetated filter strips are used to reduce the amount of nutrients and sediments that enter a waterbody, reduce erosion around a stream channel, and protect a waterbody from encroachment. Targeted placement of vegetated filter strips can play an important role in reducing pollutants in the watershed.

If vegetated buffers are designed correctly, they can prevent suspended solids, nitrogen, and phosphorus from entering a stream. The ability of the buffer to uptake phosphorus depends on the filter strip design,

residence time of the water, and slope of the land. Suspended solids, which can transport phosphorus, are more easily removed by vegetated buffers through settling.

Pennsylvania State University (1992) estimates that the preferred filter strip width for phosphorus will remove 50–75 percent of total phosphorus. Local NRCS personnel and soil and water conservation districts should be consulted to determine the most appropriate design criteria and placement of filter strips in the Busseron Creek watershed.

8.2.2 Nutrient Management Plans

Nutrient management plans are often implemented to help maximize crop yields while using nutrient resources in the most efficient, environmentally sound manner. The plans help guide landowners by analyzing agricultural practices and suggesting appropriate nutrient reduction techniques. This is often done by managing the amount and timing of nutrient fertilizers on agricultural land in the watershed. Nutrient management plans are tailored for specific fields and crops. Because of this, they require site specific sampling and planning. USEPA (1993) suggests that the nutrient management plan include:

- Maps and data regarding the farm size and type of crops grown
- Realistic yield expectations based on soils and past crop yields
- Summary of the nutrient resources available
- An evaluation of field limitations and hazards
- Use of the limiting nutrient concept to apply nutrients based on realistic crop expectations
- Specific timing and application data for nutrients
- Provisions for proper calibration and operation of nutrient application equipment
- Annual reviews and monitoring

Using these plans, a landowner can apply fertilizers based on the limiting nutrient in the soils and realistic crop yields.

Limited information is available on the effectiveness of nutrient management plans to reduce loads of phosphorus. The effectiveness will vary a great deal depending on the application rate prior to implementation of the plan and site-specific factors such as crop types and soil characteristics.

Landowners/operators should contact their local soil and water conservation district to obtain information about obtaining funding. Funding for agricultural BMPs can come from Section 319, the Conservation Reserve Enhancement Program (CREP), the Conservation Reserve Program (CRP), and the Environmental Quality Incentives Program (EQIP).

8.3 Septic Systems

Septic systems provide an economically feasible way of disposing of household wastewater where other means of wastewater treatment such as public or private treatment facilities, are unavailable. However, failing septic systems can contribute to excessive nitrogen, bacteria, and phosphorus loads, the latter of which is a TMDL pollutant in the Busseron Creek watershed.

Septic system failure can occur when one or more components of the septic system does not work properly and untreated waste or wastewater leaves the system. The waste may pond in the leach field and ultimately run off into nearby streams or may percolate into the groundwater system. The most common reason for failure is improper maintenance. Other reasons include improper installation, poor location, and incorrect design of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste.

Many homeowners do not realize they have a failing septic system. One recommendation is to initiate an outreach program to educate residents about septic systems. The components of an example outreach program are illustrated below:

- Make homeowners aware of the age, location, type, capacity, and condition of their septic system.
- Teach homeowners to recognize a failing septic system.
- Teach homeowners about proper septic system maintenance.
- Provide information about different types of septic systems, and their costs, advantages, and disadvantages.
- Provide consultation and inspection services to homeowners.
- Teach homeowners about water quality concerns in their watershed.

In addition to conducting a public outreach campaign, an effort should be made to identify and repair failing systems. In some cases systems might need to be replaced. Systems located in close proximity to streams impaired by nutrients should be targeted first. This effort should be coordinated by the appropriate county health department.

Finally, an effort needs to be made to ensure that septic systems are properly maintained. Homeowners should pump out or inspect their septic tanks on a regular schedule. Septic tanks should be pumped when the solids in the tank accumulate to a point where the effluent no longer has enough time to settle and clarify. The timing of the pump-out depends on the tank and household size.

8.4 Monitoring Plan

Future monitoring of the Busseron Creek watershed will take place during IDEM's rotating basin schedule and/or once TMDL implementation methods are in place. Monitoring will be adjusted as needed to assist in continued source identification and elimination. IDEM will monitor at an appropriate frequency to determine whether Indiana's water quality standards are being met. When these results indicate that the waterbody is meeting the water quality standards, the waterbody will then be removed from the 303(d) list.

To help determine whether a waterbody meets the water quality standards, IDEM will supplement water quality data collected with data received or supplied by permittees, state/federal agencies, or other qualified entities. Currently, third party data is being accepted and reviewed for incorporation into assessment decisions. In the future, third party data that meets the data quality objectives for use in assessment decisions will aid in source identification and the determination of whether Indiana's water quality standards are being met.

8.5 Watershed Projects

The Sullivan County SWCD has produced an IDEM-approved watershed management plan (WMP), funded with a Section 319 grant in 2007, for the Busseron Creek watershed, Hydrologic Unit Code (HUC) 05120111160. A monitoring program, which was built based on the TMDL sampling and constructed to investigate water quality concerns in the watershed, is ongoing. Since the completion of the WMP, the District has received additional CWA Section 319 funding and has leveraged several other funding sources to implement a cost-share program to install best management practices in critical areas in the watershed as identified in the plan.

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