3 Watershed Inventory- Part II

3.1 Water Quality Standards

Under the Clean Water Act (CWA), 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 CWA goal of "swimmable/fishable" waters. Water quality standards consist of three 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. The designated uses for streams within the Deep River-Portage Burns Waterway include aquatic life support and full body contact recreational 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. Numeric criteria for *E. coli*, nutrients, and TSS were used as the basis of the Deep River-Portage Burns Waterway TMDLs.
- **Antidegradation** policies protect existing uses and provide extra protection for high-quality or unique waters.

The water quality standards and targets in Indiana pertaining to *E. coli*, dissolved oxygen, nutrients, and suspended solids are described below.

E. coli is an indicator of the possible presence of pathogenic organisms such as pathogenic bacteria, viruses, protozoa, and parasites which may cause human illness. The direct monitoring of these pathogens is difficult; therefore, *E. coli* is used as an indicator of potential fecal contamination. *E. coli* is a sub-group of fecal coliform, the presence of *E. coli* in a water sample indicates recent fecal contamination is likely. Concentrations are typically reported as the count of organisms in 100 milliliters of water (count/100 mL) and may vary at a particular site depending on the baseline *E. coli* level already in the river, inputs from other sources, dilution due to precipitation events, and die-off or multiplication of the organism within the river water and sediments.

The numeric *E. coli* criteria associated with protecting the recreational use:

> *"The criteria in this subsection are to be used to evaluate waters for full body contact recreational uses, to establish wastewater treatment requirements, and to establish effluent limits during the recreational season, which is defined as the months of April through October, inclusive. E. coli bacteria, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period..."* [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2 Section 1-6(d) (3)]

The numeric dissolved oxygen criteria associated with protecting aquatic life use:

> *"Concentrations of dissolved oxygen shall:*
> *(A) average at least five (5.0) milligrams per liter per calendar day; and*
> *(B) not be less than four (4.0) milligrams per liter at any time. "* [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2. Section 1-6(a).]

Additionally the Indiana consolidated assessment and listing methodology (CALM) identifies dissolved oxygen levels greater than 12 mg/l as a potential indicator of nutrient impairment when combined with other factors such as high nitrogen and phosphorus concentrations, pH, and algae presence.

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

Nutrients, in general are not directly toxic to aquatic communities. However, excess nutrients primarily nitrogen (N) and phosphorus (P) have been linked to nutrient enrichment of aquatic systems. Nutrient enrichment can lead to shifts in species composition, reduced dissolved oxygen concentrations, fish kills, and toxic algae blooms; and also results in taste and odor problems if the system is used as a drinking water source. For these reasons, excessive nutrients can result in the non-attainment of biological criteria and impairment of the designated use.

Indiana has not yet adopted numeric water quality criteria for nutrients. The relevant narrative criteria that apply to the Deep River-Portage Burns Waterway TMDLs 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)]*
>
> *"are 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)]*
>
> *"are 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)]*

IDEM has not yet adopted numeric water quality criteria for total suspended solids (TSS). The relevant narrative criteria that apply to the Deep River-Portage Burns Waterway TMDLs 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)]*
>
> *"are 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)]*
>
> *"are 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)]*

In addition, the narrative biological criterion [327 IAC 2-1-3(2)] states the following:

"All waters, except those designated as limited use, will be capable of supporting a well-balanced, warm water aquatic community."

The water quality regulatory definition of a "well-balanced aquatic community" is "*an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species*" [327 IAC 2-1-9(49)]. Table 37 presents the criteria associated with the fish community Index of Biotic Integrity (IBI) and benthic aquatic macroinvertebrate community Index of Biotic Integrity (mIBI) that indicates whether a watershed is fully supporting or not supporting the aquatic life use.

Biotic Index		Integrity Class	Corresponding Integrity Class	Attributes
Fish community Index of Biotic Integrity (IBI) Scores (Range of possible scores is 0-60)	Fully Supporting IBI ≥ 36	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species
		Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present
		Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure
	Not Supporting IBI < 36	Poor	23-35	Many expected species absent or rare, tolerant species dominant
		Very Poor	12-22	Few species and individuals present, tolerant species dominant
		No Organisms	12	No fish captured during sampling.
Benthic aquatic macroinvertebrate community Index of Biotic Integrity (mIBI) Scores Multihabitat MHAB methods (Range of possible scores is 12-60)	Fully Supporting mIBI ≥ 36	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species
		Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present
		Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure
	Not Supporting mIBI < 36	Poor	23-35	Many expected species absent or rare, tolerant species dominant
		Very Poor	12-22	Few species and individuals present, tolerant species dominant
		No Organisms	12	No macroinvertebrates captured during sampling.

Table 37 Aquatic Life Use Support Criteria

TIERED AQUATIC LIFE USE

If Indiana were to move towards a Tiered Aquatic Life Use designation in the future, similar to Ohio, revision of this watershed plan should be strongly considered. The tiered system provides for different levels of protection that reflect the choices of reconciling the "ideal" (represented by least impacted reference conditions) with the "reality" of ongoing effects of 200+ years of intensive human use. As an example, Ohio's biological criteria for a wadable stream in the Huron/Erie Lake Plains ecoregion using the IBI is 50 for "exceptional warmwater habitat", 32 for "warmwater habitat", and 22 for "modified warmwater habitat". Under current Indiana Administrative Code, we essentially expect natural streams, manmade channels and modified stream channels to meet the same expectations.

3.2 Water Quality Parameters & Thresholds

Water quality thresholds were selected for our watershed based on applicable Indiana Administrative Code, the Deep River-Portage Burns Waterway TMDL, a nutrient-fish assemblage study by Morris and Simon (2012), and input from the watershed steering committee (Table 38). *E. coli* was monitored to determine if the streams met their designated use for full body contact recreation (i.e. is the waterbody swimmable) during the recreational season (April 1- Oct 31). Fish and macroinvertebrate communities were assessed to determine if the streams met their designated use for aquatic life support. The remaining parameters were assessed to evaluate potential candidate causes (stressors) contributing to biotic impairments.

Monitored to Assess	Parameter	Threshold Level	Source
Recreational Use	*E. coli*	Maximum: • 235 CFU/100 mL (single sample) • 125 CFU/100 mL (geomean)	Indiana Administrative Code (327 IAC 2-1.5-8)
Aquatic Life Use	Index of Biotic Integrity (IBI)	≥36 points	Aquatic Life Use Support Criteria
Aquatic Life Use	Macroinvertebrate Index of Biotic Integrity (mIBI)	≥36 points	Aquatic Life Use Support Criteria
Aquatic Life Use	Temperature	Dependent on time of year (varies by month)	Indiana Administrative Code (327 IAC 2-1-6)
Aquatic Life Use	Dissolved Oxygen (DO)	Minimum: 4.0 mg/L Maximum: 12 mg/L	Indiana Administrative Code (327 IAC 2-1-6)
Aquatic Life Use	Biological Oxygen Demand (BOD_5)	2 mg/L	Hoosier Riverwatch
Aquatic Life Use	Total Nitrogen	3.3 mg/L (fish community protection threshold)	Morris & Simon (2012)
Aquatic Life Use	Total Phosphorus (TP)	Maximum: 0.3 mg/L 0.07 mg/L (fish community protection threshold)	TMDL Morris & Simon (2012)

Monitored to Assess	Parameter	Threshold Level	Source
Aquatic Life Use	Nitrate + Nitrite	Maximum: 10 mg/L in waters designated as a drinking water source 1.09 mg/L (fish community protection threshold)	Indiana Administrative Code (327 IAC 2-1-6) Morris & Simon (2012)
Aquatic Life Use	Total Kjeldahl Nitrogen (TKN)	1.27 mg/L (2nd break point for observed community response) 0.68 mg/L (fish community protection threshold)	Morris & Simon (2012)
Aquatic Life Use	Ammonia	0 – 0.21 mg/L (pH & temperature dependent) 0.03 mg/L (fish community protection threshold)	Indiana Administrative Code (327 IAC 2-1-6) Morris & Simon (2012)
Aquatic Life Use	Total Suspended Solids (TSS)	Maximum: 30 mg/L	TMDL
Aquatic Life Use	Turbidity	10.4 NTU 25 NTU	EPA Recommendation Minnesota TMDL
Aquatic Life Use	Qualitative Habitat Evaluation Index (QHEI)	> 51 points	Aquatic Life Use Support Criteria

Table 38 Water Quality Targets for Watershed Improvement & Protection

The U.S. EPA's Causal Analysis Diagnosis Decision Information System (CADDIS) was used as a guide for this process (https://www3.epa.gov/caddis/index.html). The candidate causes for our watershed include increased stream temperatures, low dissolved oxygen levels, nutrient loading, ammonia toxicity, excessive sediment loading, and poor habitat quality. Conceptual diagrams illustrating causal pathways are include for each potential stressors.

The diagrams are presented to help visualize the potential links between human activities, the stressor, and the observed biotic impairment. Stressors are any physical, chemical, or biological parameters or entities that directly or indirectly result in one or more biotic responses of concern. Proximate stressors are directly responsible for these responses. Other stressors (interacting stressors) may be indirectly responsible for these responses by their effects on proximate stressors. Sources are activities, land uses, or entities that directly or indirectly result in one or more stressors. Responses are the biological results of exposure to proximate stressors.

A conceptual diagram is a visual representation of how a system works. In CADDIS, these diagrams are used to describe hypothesized relationships among sources, stressors, and biotic responses within aquatic systems. Conceptual diagrams and accompanying narrative descriptions are useful tools throughout the Stressor Identification process, from structuring initial brainstorming, to providing a framework for data collection and analysis, to organizing and presenting results.

These diagrams provide overviews of how specific stressors may be linked to sources and biological effects, by illustrating *potential* linkages among stressors (or candidate causes) and their likely sources and effects based on scientific literature and professional judgment. Inclusion of a linkage indicates that the linkage *can* occur, not that it *always* occurs.

Shape	Causal Relationship
human activity	Activity or land use that directly or indirectly leads to one or more sources
source	Entity that directly or indirectly leads to one or more proximate stressors
additional step in causal pathway	Process or state that causally connects a source to a proximate stressor
proximate stressor	Physical, chemical or biological entity that directly induces one or more biotic responses of concern
modifying factor	Process, state, or other factor that modifies delivery or expression of a stressor
interacting stressor	Physical, chemical, or biological entity that interacts with the focal (proximate) stressor
mode of action	Process or state that causally connects a proximate stressor to a response
response	Effect of proximate stressor on aquatic biota

Within each shape, ↑ indicates an increase, ↓ indicates a decrease, and Δ indicates a change in the given parameter, either through time or when compared to a reference site. Arrows leading from one shape to another indicate potential causal relationships, which can be interpreted as the originating shape resulting in or leading to the shape to which it points. Brackets leading from one shape to other shapes indicate hierarchical relationships, with the bracketed shapes being sub-categories of the originating shape.

3.2.1 *E. coli*

Escherichia coli (*E. coli*) is a bacteria commonly found in the intestines of warm blooded animals and humans. Its presence in water is a strong indicator of recent sewage (ex. combined sewer overflows or failing septic systems) or animal waste (ex. livestock or nuisance levels of geese and other waterfowl) contamination. While not necessarily pathogenic in itself, *E. coli* is relatively easy to test for and is used as an indicator other more severe waterborne disease causing organisms. The single sample water quality standard of 235 CFU/100 ml and geomean water quality standard of 125 CFU/100 ml are used to protect human health during the recreational season (full body contact) of April through October.

3.2.2 Biotic Communities: Fish & Macroinvertebrate Index of Biotic Integrity

The Index of Biotic Integrity (IBI) provides a measure of a stream's health based upon the fish species collected from that stream. The IBI is comprised of a series of metrics to evaluate the health of the fish community. The metrics included in the IBI change by ecoregion however they all generally consider species richness and composition, indicator species, trophic function, and reproduction function. When the metrics are added together you get a total IBI score. The higher the total score (maximum score of 60), the better the stream's health based upon the fishery. An IBI score great or equal to 36 is considered fully supporting.

The macroinvertebrate Index of Biotic Integrity (mIBI) provides a measure of a stream's health based upon the macroinvertebrate species collected from that stream. Like the IBI, the mIBI is comprised of a series of metrics to evaluate the health of the macroinvertebrate community. When the metrics are added together you get a total mIBI score. The higher the total score, the better the stream's health based upon the macroinvertebrate community. A mIBI score great or equal to 36 is considered fully supporting.

3.2.3 Water Temperature

Water temperature is important because it strongly influences the kinds of aquatic life that can live in a stream. Fish, aquatic insects, plankton, and other aquatic life all have a preferred temperature range. If temperatures get too far above or below this range, the number and variety species can begin to decline. Temperature also is important because it influences water chemistry. The rate of chemical reactions generally increases at higher temperatures, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen.

In addition to seasonal variations in stream temperature caused by changing air temperatures, many other physical aspects of a stream cause natural variation in temperature. The origin of the stream (ex. spring or wetland) determines its initial temperature. Inflowing tributaries may alter the stream temperature as they mix with the mainstem. Velocity also influences temperature. A stream shaded by trees and other vegetation reduces the impact of warming by the sun.

The process of watershed development also can affect stream temperatures. Streambank vegetation often is lost when land is cleared, thereby exposing the stream to increased warming by sunlight. Storm water runoff may be warmer, especially during the summer months when it flows over hot asphalt or concrete.

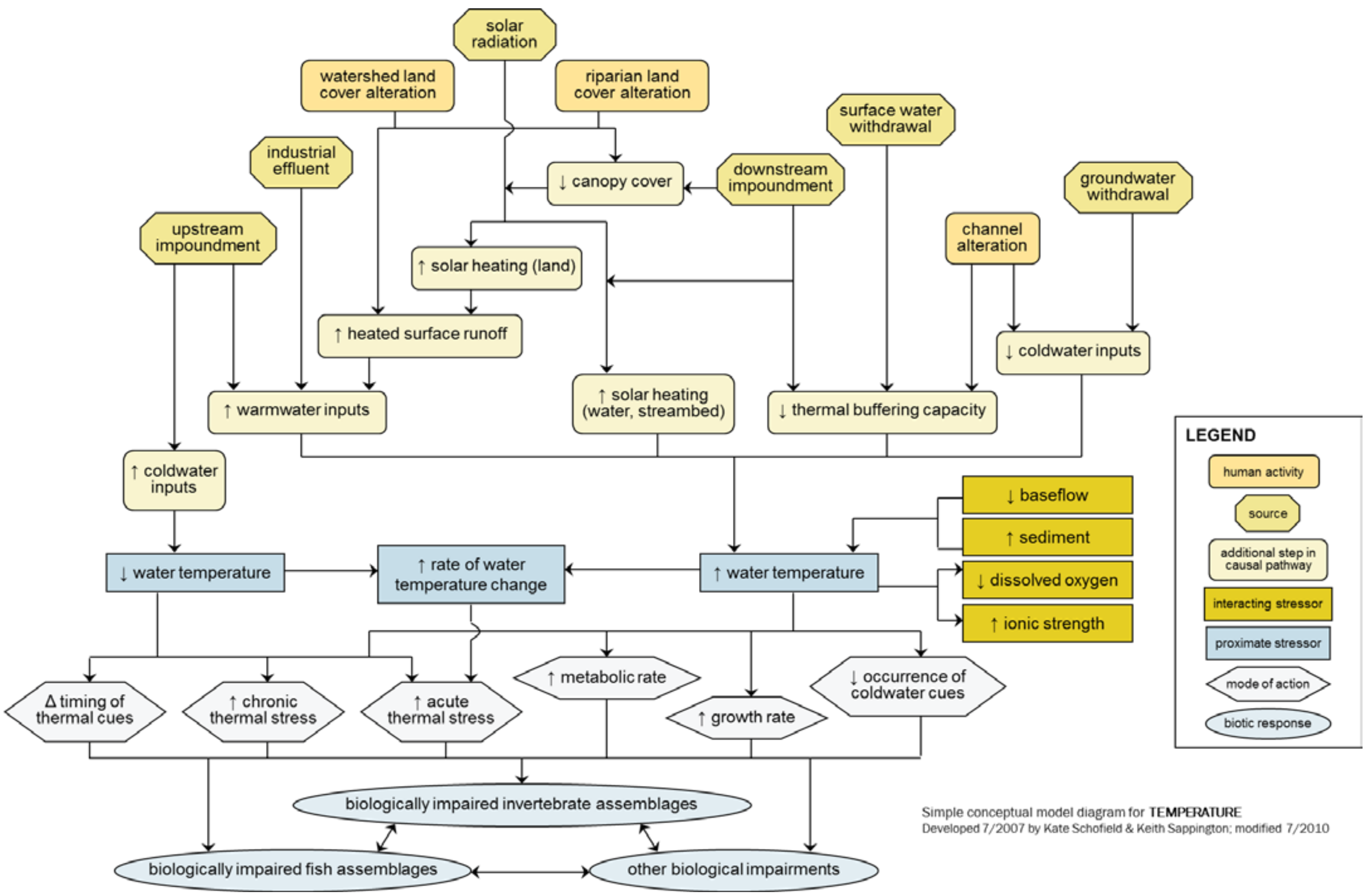

Figure 62 Conceptual diagram illustrating causal pathways, from sources to impairments, related to temperature

3.2.4 Dissolved Oxygen

Dissolved oxygen is a very important measure of how healthy a stream is. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. Many gamefish (ex. bass and bluegill) require dissolved oxygen levels between 4 to 12 mg/L. When levels drop below 4mg/L, fish become stressed and prone to disease. In severe cases fish kills can occur or the stream reach may become totally devoid of most if not all desirable aquatic life.

A number of natural and human influenced factors can effect a stream's dissolved oxygen levels including water temperature, stream flow, nutrient/organic material loading, and turbidity. For example, a stream reach that receives runoff high in sediment becomes turbid. The soil particles suspended in the water gather more of the sun's energy making it warmer. Warm water is physically unable to hold as much oxygen as cool water so dissolved oxygen levels begin to drop. Excess nutrients and organic materials often carried with the sediment only exacerbate the problem, as bacteria in the stream consume oxygen to breakdown the organic material depriving the fish and aquatic insects of oxygen. (Total Organic Carbon (TOC) was measured as an indicator of organic material loading. Generally, higher TOC concentrations indicate that more oxygen will be consumed as bacteria break down organic material, which may result in an oxygen deficient stream.)

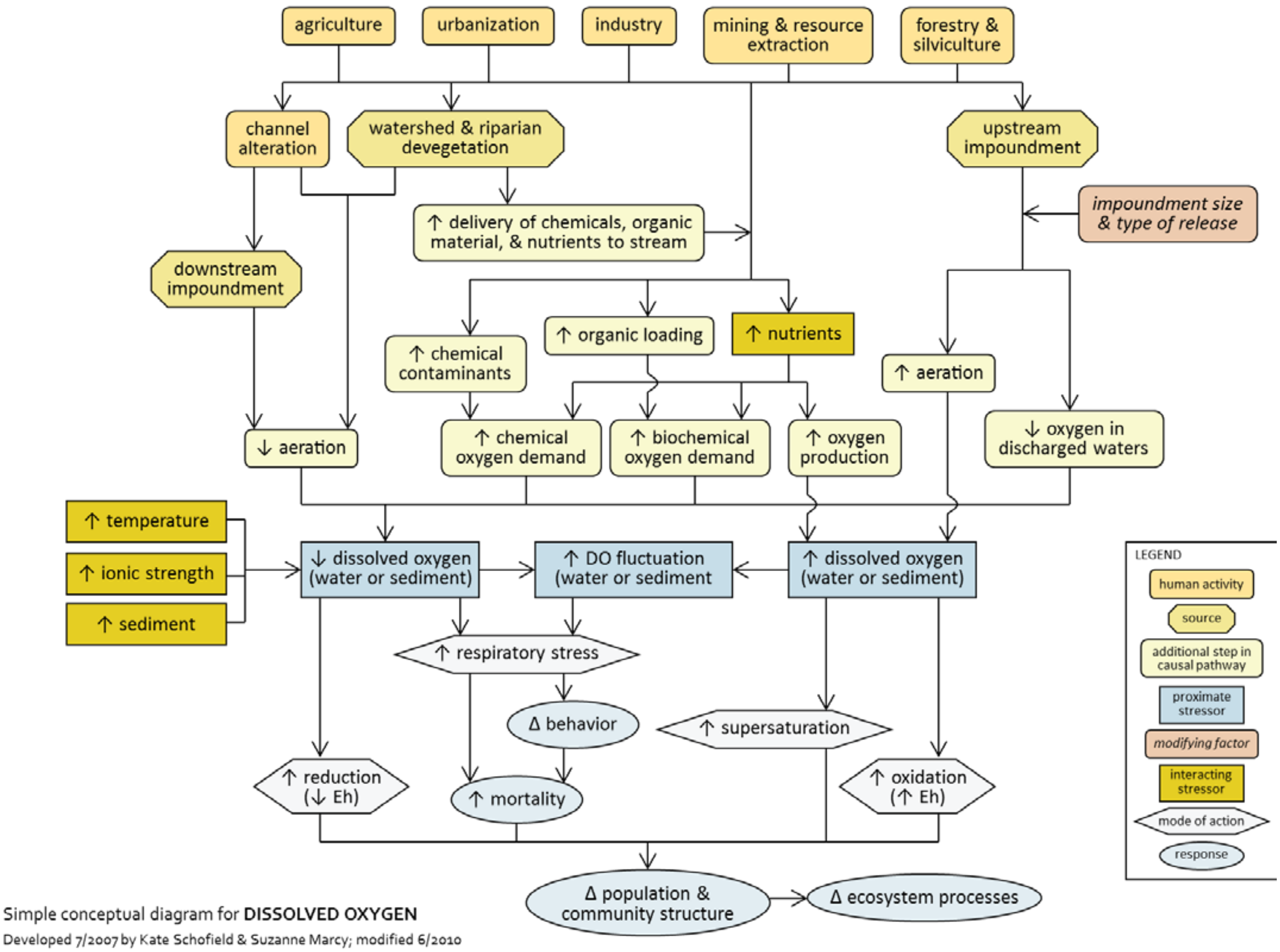

Figure 63 Conceptual diagram illustrating causal pathways, from sources to impairments, related to dissolved oxygen

3.2.5 Nutrients: Phosphorus & Nitrogen

Like nitrogen, phosphorous is essential for plant and animal life. In aquatic systems phosphorous occurs as organic or inorganic phosphate. Organic phosphate is associated with organic material such as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic and is the form required by plants. Unlike nitrogen, phosphorous does not have a gaseous phase. Once it is in an aquatic system it remains there and cycles through different form unless physically removed (e.g. plant harvesting or dredging).

Phosphorus is usually in short supply in freshwater lakes and streams. So even a small increase can lead to a series of water quality problems including accelerated plant and algae growth, low dissolved oxygen levels, and fish kills. Sources of phosphorus, both natural and human, include soils and rocks, wastewater treatment plants, fertilizer runoff, failing septic systems, and runoff from pastures or animal manure storage areas.

Nitrogen makes up about 80% of the air we breathe and is found in all living things. In water it occurs as nitrate (NO3), nitrite (NO2), and ammonia (NH3). Ammonia is a toxic form of nitrogen that forms when organic matter breaks down in water. Its level of toxicity depends on water temperature and pH. Nitrate is a very common form of nitrogen and is the most water-soluble and least attracted to soil particles. Nitrite is uncommon and usually converts to nitrate in surface waters. Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia in a water body.

Common human sources of nitrogen include runoff from fertilized lawns, cropped fields, animal manure application and storage areas, wastewater treatment plants, failing septic systems, industrial discharges, and decaying organic matter. Given it solubility in water, nitrate can move quite readily in runoff and through subsurface drainage (field tiles) to surface waters. In surface waters high nitrate levels can lead to excessive aquatic plant growth through a process known as eutrophication. Excessive algae growth can increase turbidity and biochemical oxygen demand and which negatively affects water temperature and dissolved oxygen levels. In severe cases of nutrient enrichment dissolved oxygen concentrations can drop below the levels needed to support aquatic life (<4 mg/l).

Morris & Simon (2012) evaluated nutrient and fish assemblage data collected from 1274 stream reaches between 1996 and 2007 with the Corn Belt and Northern Great Plain Nutrient Region of Indiana to help establish nutrient threshold concentrations above which fish assemblages showed alterations. We used these threshold concentrations to establish nutrient targets for the protection of aquatic life. (Note: The lab detection limit for ammonia was 0.05 mg/L, so any observation was considered an exceedance of the 0.03 mg/L threshold.)

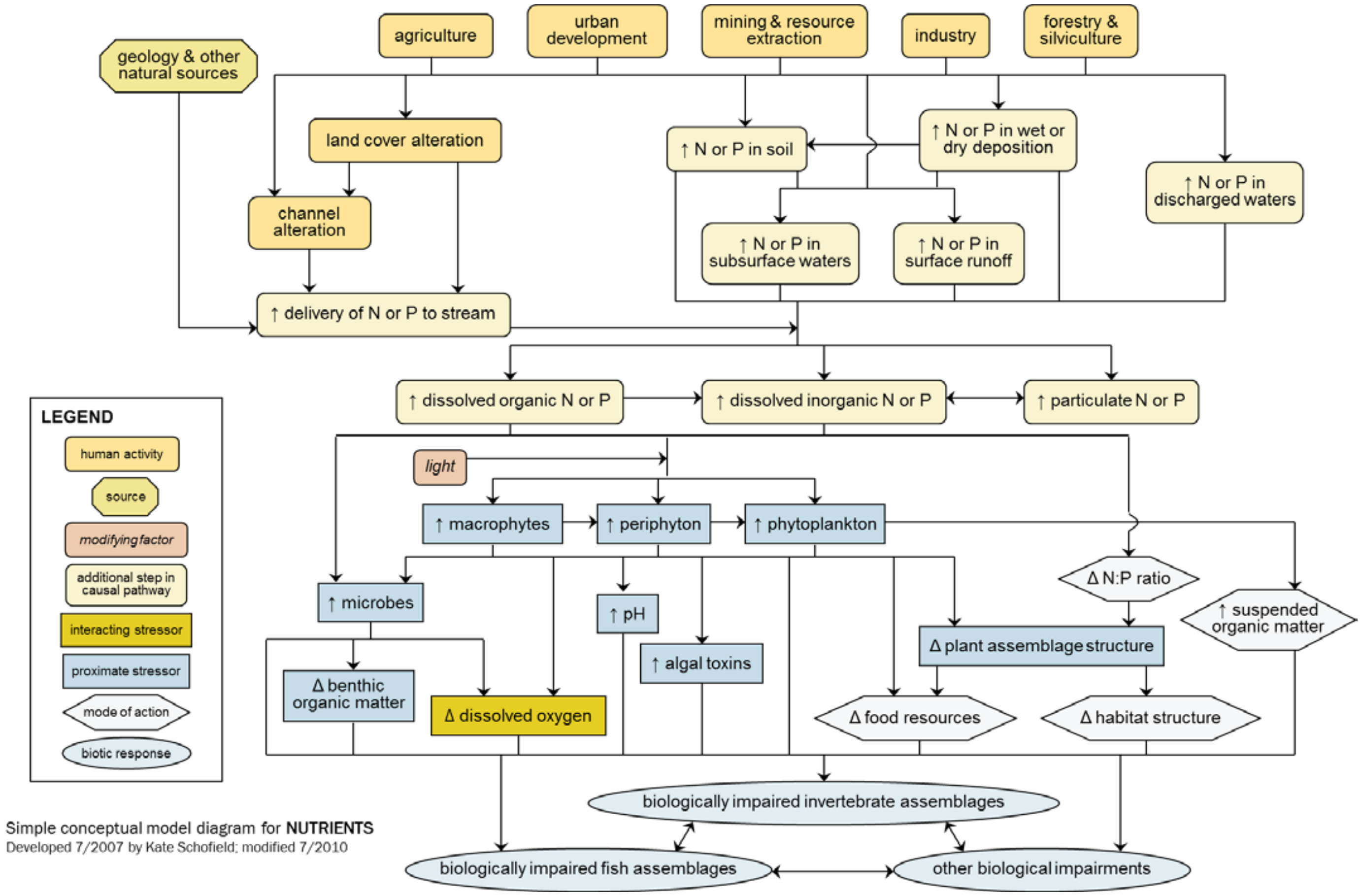

Figure 64 Conceptual diagram illustrating causal pathways, from sources to impairments, related to nutrients

3.2.6 Sediments: Suspended & Deposited

Total suspended solids (TSS) is a measure of the amount (weight per volume of water) of solids suspended in the water. Total suspended solids values vary for two main reasons – one physical, the other biological. Runoff from heavy rains can pick up sediment and debris from the surrounding landscape and carry them to nearby streams making them look muddy. Warm water temperatures, prolonged daylight, and release of nutrients from decomposing organic matter may cause algae blooms that also increase total suspended solid concentrations. High concentrations of particulate matter in water can affect light penetration and plant productivity, water temperature, recreational values, habitat quality, and cause lakes to fill in faster. The particles also provide attachment places for other pollutants like bacteria and nutrients.

Turbidity is another way to measure the amount of solids suspended in water. While total suspended solids measures of the actual weight of materials suspended in water, turbidity measures the amount of light scattered by those materials.

Embeddedness is a way to measure deposited and bedded sediment. Embeddedness is the degree to which interstitial spaces between course substrates like gravel and cobble are filled by finer particles. Results are typically expressed as a percentage. IDEM includes an evaluation of embeddedness when conducting habitat assessments using the Qualitative Habitat Evaluation Index (QHEI) as described below. The QHEI reports the results in a percent range that correspond to the level of severity of embeddedness. For example “moderate” corresponds to 50-75% of the sampling area being embedded.

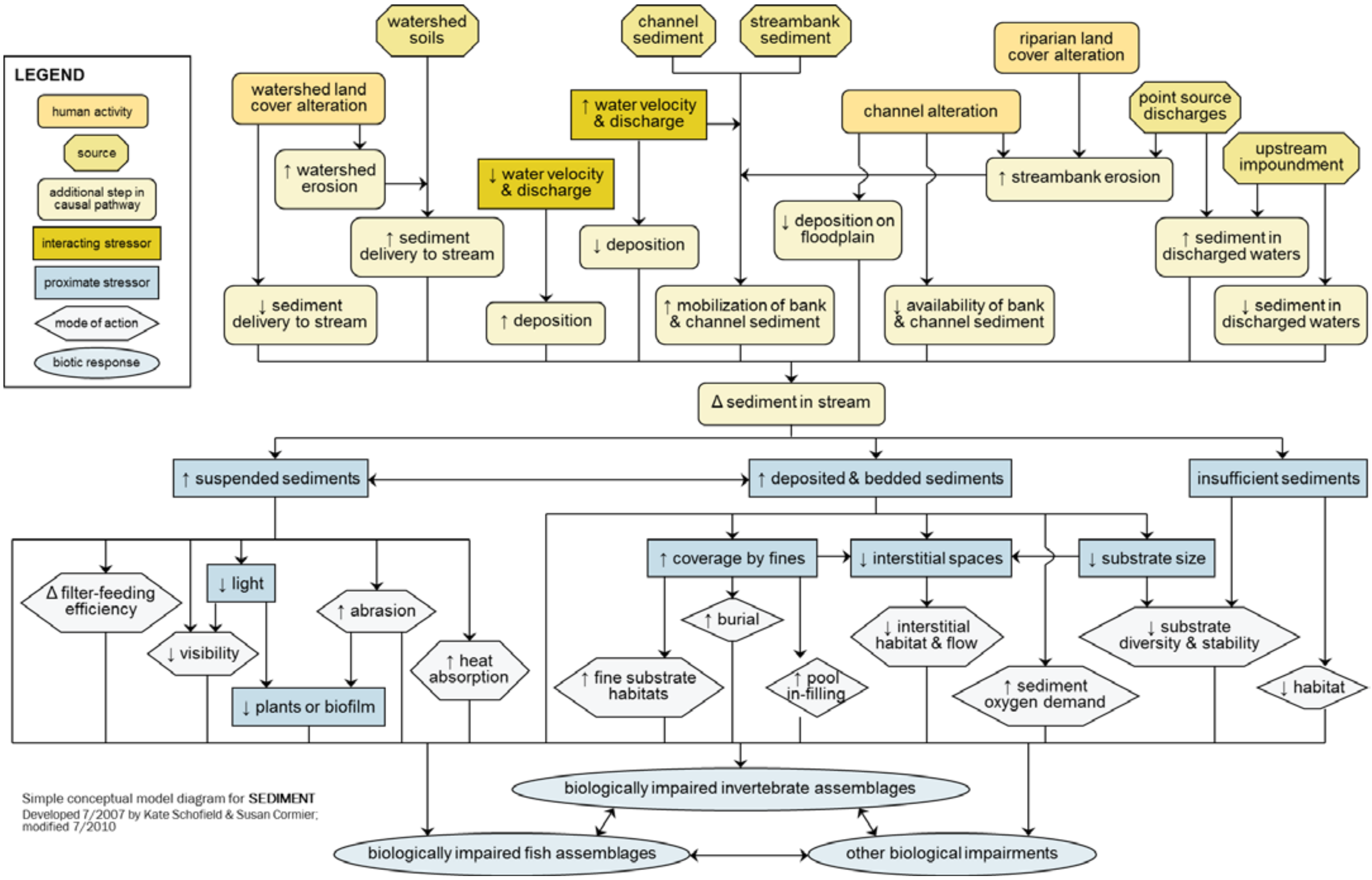

Figure 65 Conceptual diagram illustrating causal pathways, from sources to impairments, related to sediment

3.2.7 Habitat: Qualitative Habitat Evaluation Index

The Qualitative Habitat Evaluation Index (QHEI) provides information on a stream's ability to support healthy fish and macroinvertebrates communities by evaluating in-stream habitat and the land that surrounds it. The QHEI is composed of six separate metrics each designed to evaluate a different portion of a stream site. The metrics include substrate (20pts), in-stream cover (20pts), channel morphology (20pts), bank erosion and riparian zone (10pts), pool/current (12pts) and riffle/run quality (8pts), and gradient (10pts). When the six metrics are added together (maximum score of 100) you get a total QHEI score. The higher the total score, the better the habitat. For streams where the macroinvertebrate and/or fish community (mIBI and/or IBI) scores indicate impaired biotic communities (IBC), QHEI scores are evaluated to determine if habitat is the primary stressor on the aquatic communities or if there may be other stressors/pollutants causing the impairment. A stream reach receiving a score greater than 51 is generally conducive to supporting a healthy warm water fishery. The habitat evaluations conducted by IDEM during the TMDL fishery surveys were used the development of our watershed plan.

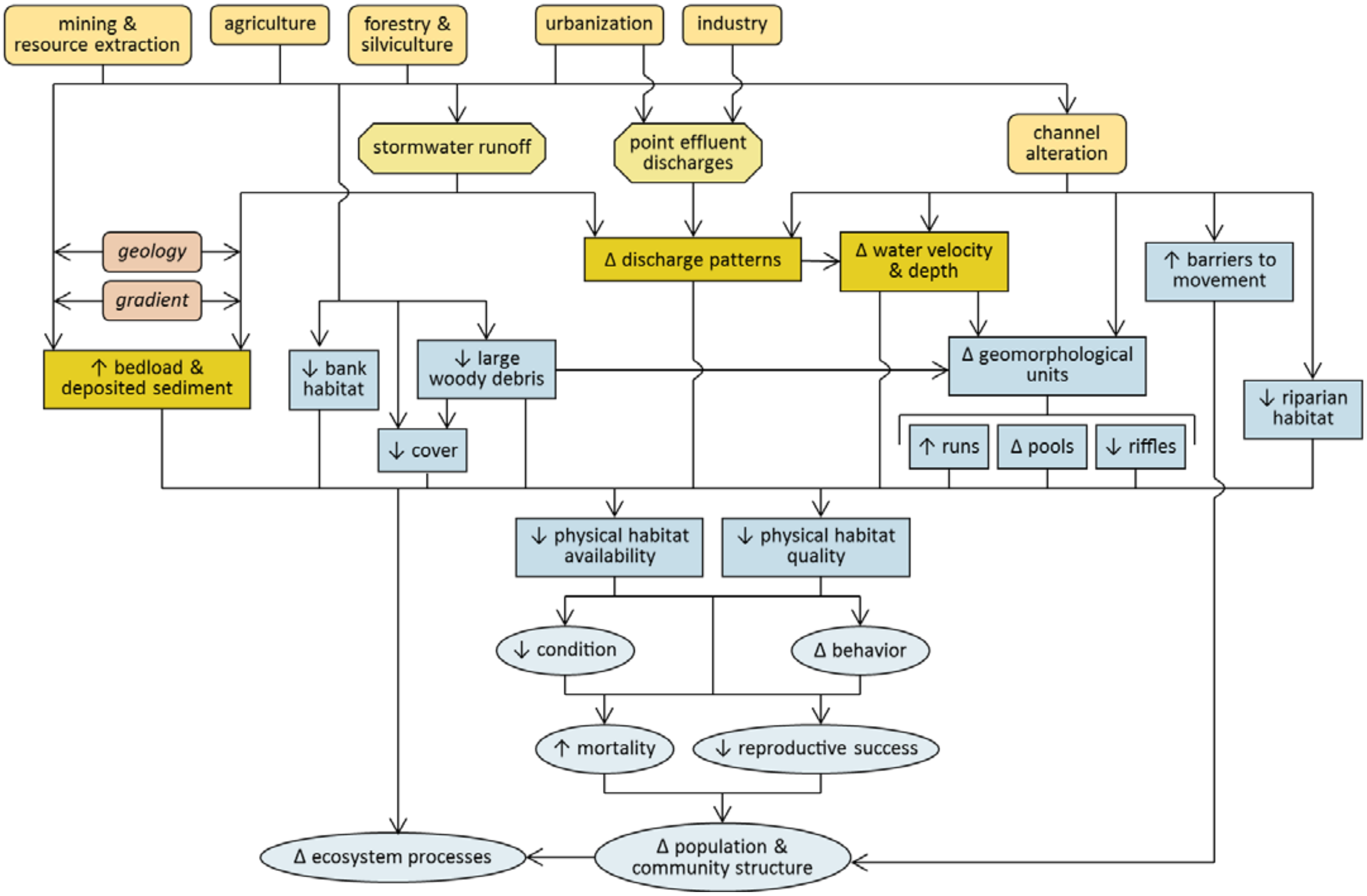

Figure 66 Conceptual diagram illustrating causal pathways, from sources to impairments, related to physical habitat

3.3 Water Quality Data

3.3.1 IDEM Baseline Assessment (2013-2014)

In April 2013, the Indiana Department of Environmental Management initiated a year-long baseline monitoring program to support the development of our watershed plan and a Total Maximum Daily Load (TMDL) study. IDEM field crews collected water chemistry, *E. coli*, habitat, fish and macroinvertebrate data from 35 stream sites located throughout the watershed (Table 39 and Figure 67). Stream flow data was also collected at nine sites considered representative of each subwatershed's drainage area. Water chemistry and *E. coli* samples were collected monthly during the recreational season (April-October) at all 35 sites. Outside the recreational season, monitoring was limited to the nine representative subwatershed (TMDL) sites. Water quality monitoring did not occur in January or February of 2014 because of ice cover. Habitat, fish and macroinvertebrate communities were evaluated once during the study period. For a description of the methodologies used by IDEM please see the Sampling and Analysis Work Plan for the Baseline Monitoring project available at www.in.gov/idem/nps/3893.htm.

Site #	IDEM Site #	Stream Name	Road Name	AUID 2012
1	LMG-05-0002	Burns Ditch	US 20	INC0159_01
2	LMG-05-0003	Willow Creek	Clem Road	INC0159_T1001
3	LMG-05-0004	Willow Creek	Stone Ave	INC0159_T1001
5	LMG-05-0006	Deep River	29th Ave	INC0158_01
6	LMG-05-0007	Deep River	Liverpool Road	INC0158_01
7	LMG-05-0008	Tributary of Deep River	Shelby Street	INC0158_T1002

Site #	IDEM Site #	Stream Name	Road Name	AUID 2012
8	LMG030-0008	Deep River	Ridge Road	INC0157_P1001
9	LMG-05-0009	Duck Creek	Front Street	INC0156_01
10	LMG-05-0010	Tributary of Duck Creek	10th Street	INC0156_T1003
11	LMG-05-0032	Duck Creek	750 W	INC0156_01
12	LMG-05-0011	Deep River	Arizona Street	INC0157_01
13	LMG-05-0033	Sprout Ditch	70th Ave	INC0157_T1002
14	LMG-05-0012	Deep River	Joliet Road	INC0157_01
15	LMG-05-0013	Tributary of Deep River	750 W	INC0154_T1005
16	LMG-05-0034	Tributary of Deep River	89th Avenue	INC0154_T1004
17	LMG-05-0014	Tributary of Deep River	93rd Avenue	INC0154_T1003
18	LMG-05-0015	Deep River	Clay Street	INC0152_04
19	LMG-05-0035	Deer Creek	97th Street	INC0154_T1001
20	LMG-05-0016	Niles Ditch	Colorado Street	INC0152_T1009
21	LMG-05-0017	Niles Ditch	121st Avenue	INC0152_T1009
22	LMG-05-0036	Smith Ditch	113th Street	INC0152_T1008
23	LMG-05-0018	Main Beaver Dam Ditch	Grant Street	INC0152_04
24	LMG-05-0019	Tributary of Main Beaver Dam Ditch	Summit Street	INC0151_T1003
25	LMG-05-0020	Main Beaver Dam Ditch	Clark Road	INC0151_01
26	LMG-05-0021	Tributary of Main Beaver Dam Ditch	77th Avenue	INC0151_T1001
27	LMG-05-0022	Main Beaver Dam Ditch	Blaine Street	INC0151_01
28	LMG-05-0023	Tributary of Turkey Creek	77th Avenue	INC0153_T1001
29	LMG-05-0024	Turkey Creek	Broad Street	INC0153_01
30	LMG-05-0025	Johnson Ditch	Oak Ridge Prairie Park	INC0153_T1003
31	LMG-05-0026	Tributary of Turkey Creek	W Old Lincoln Hwy	INC0153_T1004
32	LMG-05-0027	Turkey Creek	SR55	INC0153_01
33	LMG-05-0028	Tributary of Turkey Creek	73rd Avenue	INC0153_T1005
34	LMG-05-0029	Tributary of Turkey Creek	Arthur Street	INC0155_T1003
35	LMG-05-0030	Tributary of Turkey Creek	73rd Avenue	INC0155_T1002
36	LMG-05-0031	Turkey Creek	Liverpool Road	INC0155_01

Table 39 IDEM Stream Water Quality Monitoring Site Information

Catchment (drainage) areas were delineated for each monitoring site by NIRPC using the union tool in ArcMap and the original delineation GIS data provided by IDEM. Further refinement of the site drainage areas was necessary for analysis and pollutant load modeling using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). Site catchment areas are shown in Figure 67 and their drainage area size in Table 40.

Site	Area (ac)	Site	Area (ac)	Site	Area (ac)	Site	Area (ac)
1	9,287	10	2,325	19	1,895	28	1,808
2	2,046	11	4,846	20	4,110	29	1,355
3	3,414	12	1,857	21	1,783	30	1,690
4	106	13	1,508	22	1,615	31	1,438
5	4,120	14	2,240	23	3,188	32	3,578
6	2,473	15	7,943	24	1,499	33	2,541
7	4,695	16	3,765	25	4,599	34	3,977
8	5,405	17	1,788	26	5,420	35	1,978
9	9,287	18	4,615	27	1,813		

Table 40 Site catchment drainage area size

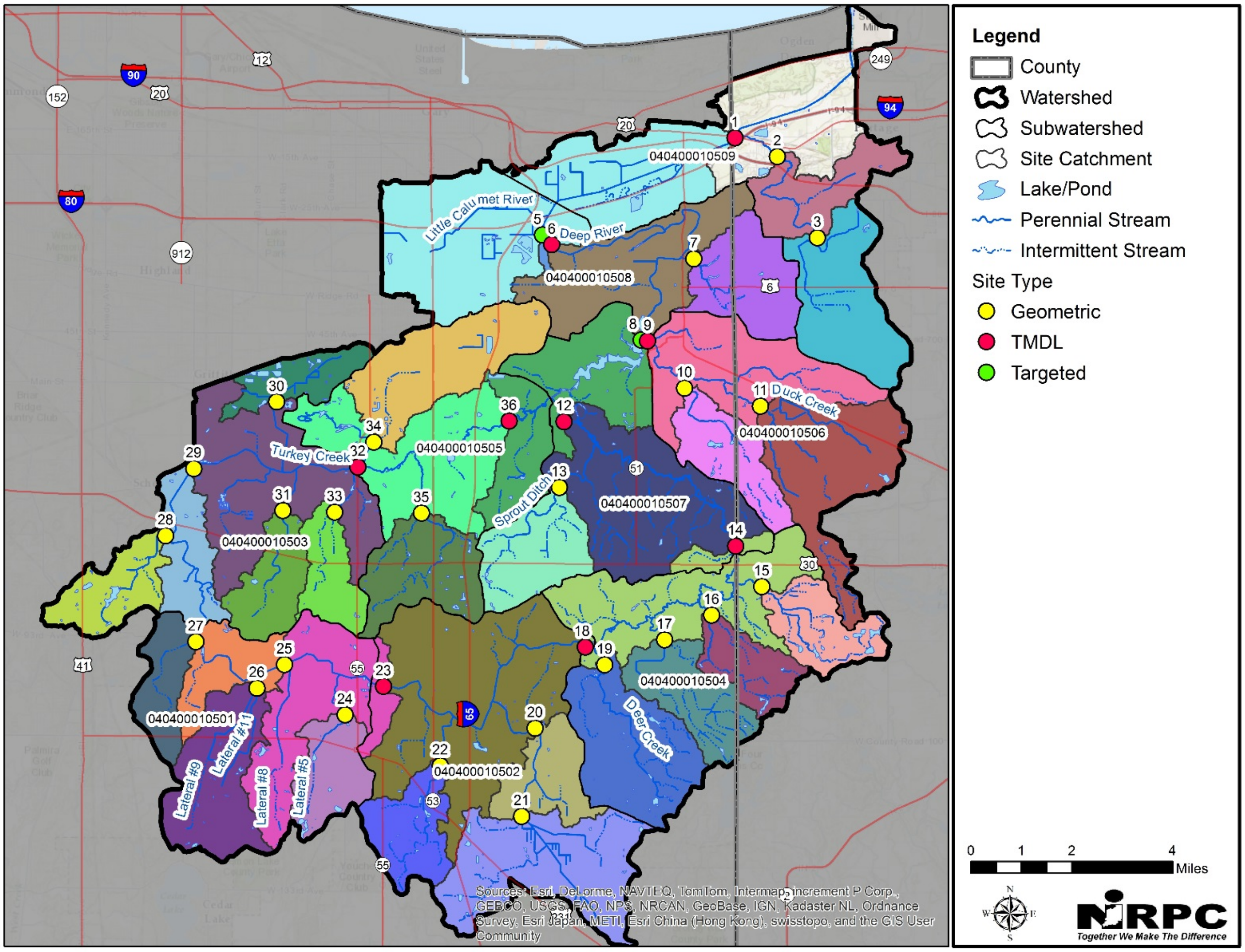

Figure 67 IDEM baseline assessment stream monitoring sites and their catchments

3.3.2 Historical Water Quality Data

The following section provides a brief summary of historical water quality data that was collected within the past 15 years. Because of the limited nature (spatial coverage, time period, parameters monitored, and sampling frequency), this data was not considered further for analysis but is presented as required by IDEM's watershed planning checklist.

3.3.2.1 *IDEM (2000-2010)*

Prior to its baseline assessment in 2013-2014, IDEM has previously monitored several sites throughout the watershed (Table 41 and Figure 68). However, given the limited nature of the data (spatial coverage, time period, parameters monitored, and sampling frequency), this data was not considered further. This was the primary reason that NIRPC requested IDEM complete a comprehensive baseline assessment for the watershed based on findings in the Northwest Indiana Watershed Framework. A review of the TMDL report also indicates IDEM did not include the historical site information into the TMDL process.

Station ID	Year(s)	Project Name	Events
LMG030-0002	2000	2000 Corvallis	3
LMG030-0006	2000	2000 E. coli	5

LMG030-0007	2000	2000 E. coli	5
LMG030-0008	2000, 2002-2006	Clean Sampling & Ultra-Clean Analysis	25
LMG030-0009	2000	2000 E. coli	5
LMG030-0010	2000	2000 E. coli	5
LMG030-0011	2000	2000 E. coli	5
LMG030-0022	2005	2005 Corvallis	8
LMG040-0001	2000	2000 Corvallis	4
LMG040-0003	1999-2010	Fixed station	140
LMG040-0004	2000	2000 E. coli	5
LMG040-0005	2000	2000 E. coli	5
LMG040-0008	2005	2005 Corvallis	8
LMG060-0006	2000	2000 Burns Ditch TMDL Assessment	5
LMG060-0007	1999-2010	Fixed Station	140
LMG060-0012	2000	2000 Burns Ditch TMDL Assessment	5

Table 41 IDEM historical stream monitoring site information

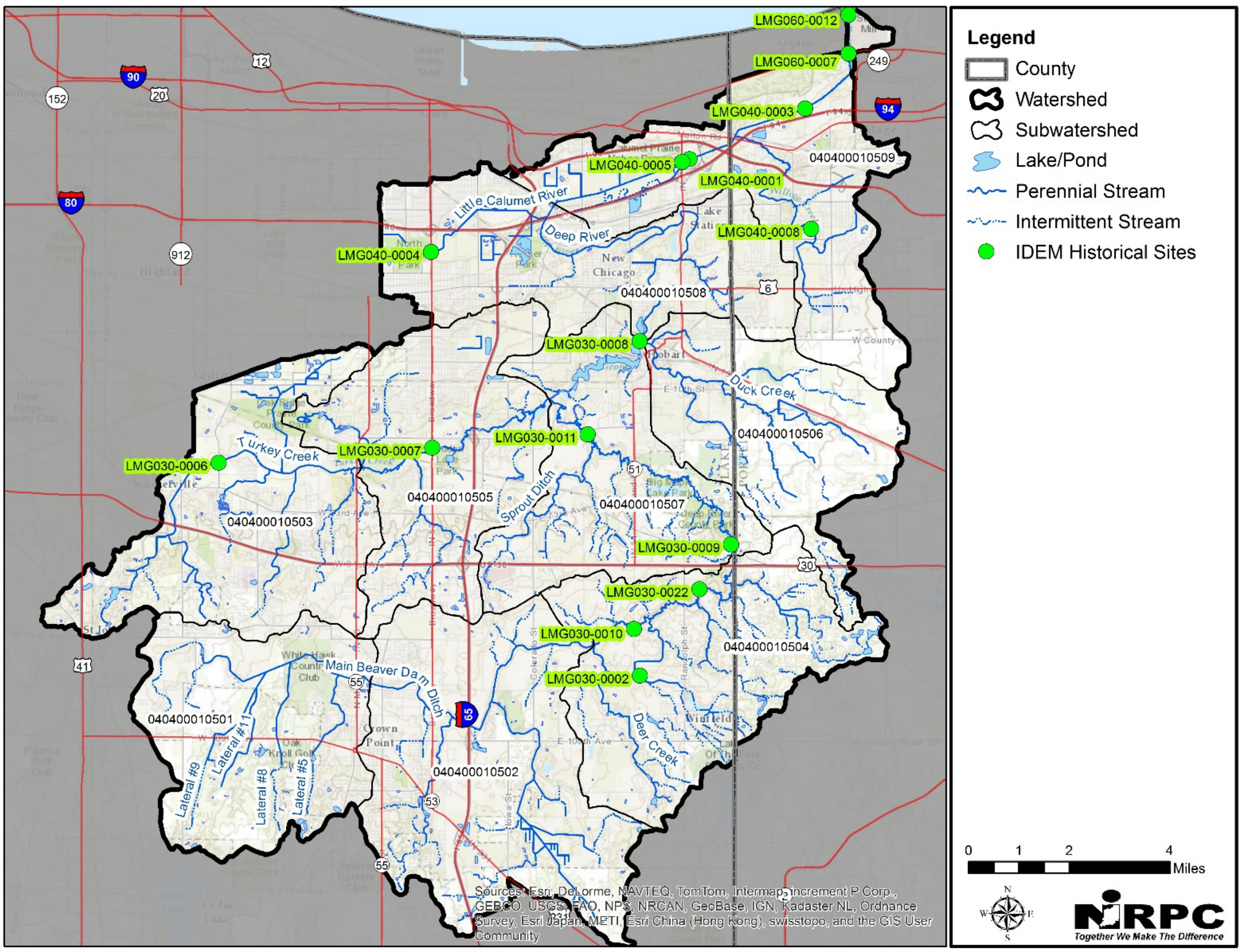

Figure 68 IDEM historical water quality monitoring sites

3.3.2.2 *Deep River-Turkey Creek Watershed Management Plan Data (2002)*

To facilitate the development of the 2002 Deep River-Turkey Creek Watershed Management Plan, an assessment of existing water quality from nine sites in the watershed was done to supplement historical water quality data (Figure 69). Sampling was generally focused around the Deep River-Lake George Dam subwatershed and limited to two dates. The first monitoring event on January 28, 2002 evaluated baseflow conditions following a period of little precipitation. The second monitoring event on April 3, 2002 evaluated stormflow conditions following two days of 1/2-1 inch of rain. Water quality data is from the study is presented in Table 42 and Table 43. Further discussion is available in the Deep River-Turkey Creek Watershed Management Plan.

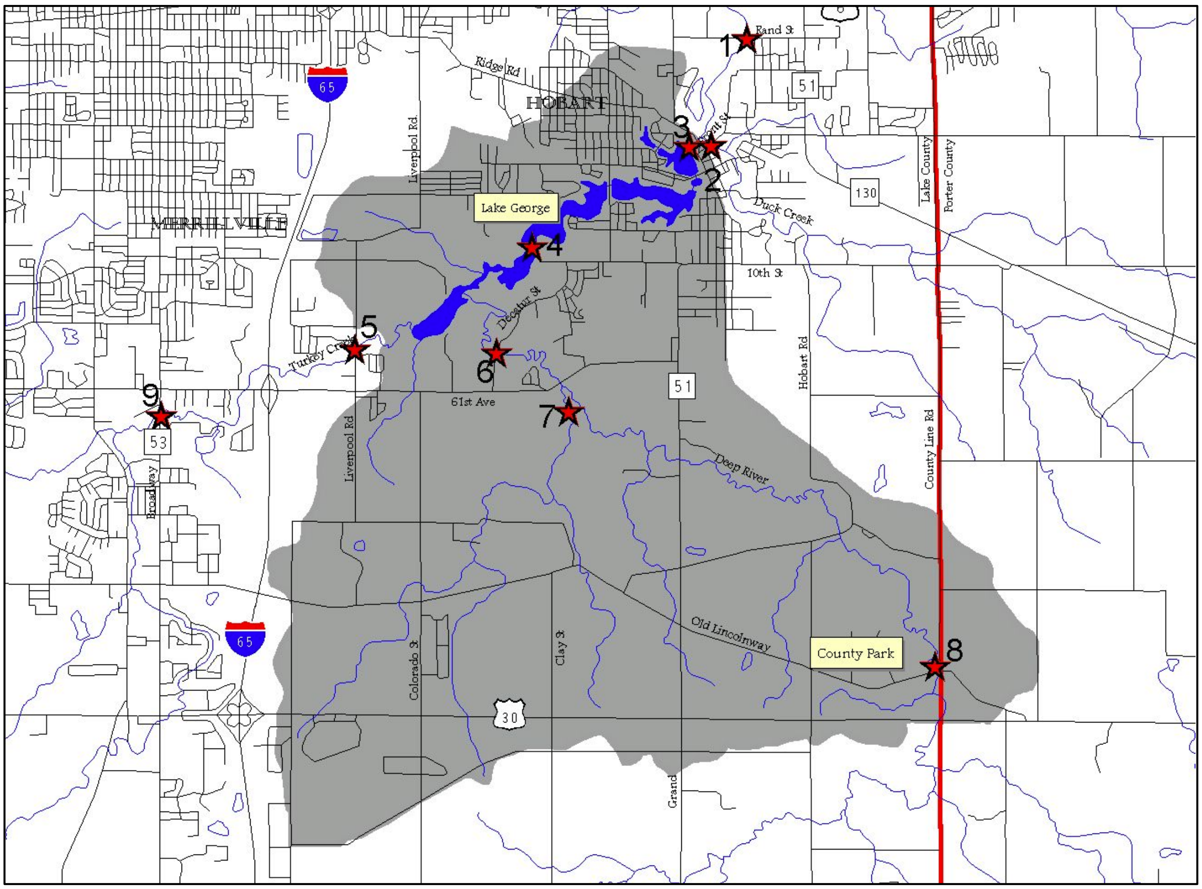

Figure 69 Stream sampling sites monitored during development of Deep River-Turkey Creek Watershed Plan

Site	Date	Timing	Flow (cfs)	Temp (ºC)	DO (mg/L)	DO Sat (%)	Conductivity (ųmho s/cm)	pH (SU)	BOD (mg/L)
1	1/28/2002	Base	53.43	3.0	12.20	92.0	900	6.9	2.3
	4/3/2002	Storm	525.99	6.0	10.72	84.9	900	8.1	<2.0
2	1/28/2002	Base	5.79	3.0	11.10	85.0	700	8.1	<2.0
	4/3/2002	Storm	78.83	5.0	9.70	75.3	400	8	<2.0
3	1/28/2002	Base	40.65	3.0	12.20	92.0	900	8.1	<2.0
	4/3/2002	Storm	592.52	7.0	10.96	89.4	900	8.5	<2.0
4	1/28/2002	Base	41.27	3.5	11.60	90.0	800	8.4	<2.0
	4/3/2002	Storm	633.50	6.0	9.98	78.5	500	7.8	4

5	1/28/2002	Base	8.32	5.5	9.20	75.0	900	8.3	<2.0
	4/3/2002	Storm	139.13	6.0	9.88	78.7	700	8.5	2.8
6	1/28/2002	Base	18.11	5.0	11.00	88.0	800	8.4	<2.0
	4/3/2002	Storm	335.34	6.0	9.95	79.1	400	8.5	3.2
7	1/28/2002	Base	0.75	5.5	10.80	88.0	1200	8.2	<2.0
	4/3/2002	Storm	--	--	--	--	--	--	--
8	1/28/2002	Base	1.30	5.0	11.20	90.0	700	8.1	3.6
	4/3/2002	Storm	364.17	6.0	10.56	83.8	500	8.7	3.3
9	1/28/2002	Base	11.25	6.0	10.80	89.0	800	6.8	<2.0
	4/3/2002	Storm	87.48	6.0	10.01	80.5	700	8.1	3.4

Table 42 Physical water quality parameter data collected for Deep River-Turkey Creek Watershed Plan

Site	Date	Timing	Nitrate (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E. coli (col/100mL)
1	1/28/2002	Base	1.62	0.07	1.30	0.17	5.2	48
	4/3/2002	Storm	0.55	0.39	0.55	<0.10	43.0	180
2	1/28/2002	Base	2.37	0.04	1.00	<0.10	22.0	140
	4/3/2002	Storm	1.20	0.13	1.20	0.24	48.0	760
3	1/28/2002	Base	1.53	0.07	1.60	0.14	14.0	42
	4/3/2002	Storm	0.71	0.36	0.71	<0.10	29.0	80
4	1/28/2002	Base	0.88	0.10	1.00	<0.10	18.0	48
	4/3/2002	Storm	1.10	0.27	1.10	0.26	150.0	800
5	1/28/2002	Base	0.21	0.10	1.10	<0.10	13.0	94
	4/3/2002	Storm	0.77	0.16	0.77	0.11	56.0	440
6	1/28/2002	Base	1.75	0.24	1.80	<0.10	8.4	24
	4/3/2002	Storm	1.00	0.31	1.00	0.28	120.0	1,000
7	1/28/2002	Base	0.36	<0.01	0.71	<0.10	<5.0	50
	4/3/2002	Storm	--	--	--	--	--	--
8	1/28/2002	Base	2.23	1.50	5.20	0.18	<5.0	110
	4/3/2002	Storm	1.30	0.40	1.30	0.30	120.0	2,100
9	1/28/2002	Base	0.19	0.15	1.30	<0.10	8.0	480
	4/3/2002	Storm	0.71	0.36	0.71	0.10	62.0	310

Table 43 Chemical and bacterial data collected for Deep River-Turkey Creek Watershed Plan

3.3.2.3 *West Branch Little Calumet River Watershed Management Plan Data (2007)*

Water quality sampling was also conducted to facilitate the development of the West Branch Little Calumet River Watershed Management Plan. Seven (7) monitoring sites were sampled once during stormflow conditions and once during baseflow in 2007. The water quality parameters measured included ammonia, nitrate, total phosphorus, orthophosphate, total suspended solids, dissolved oxygen, pH, and *E. coli*. An additional forty (42) sites were sampled for *E. coli* four times in 2007. Sampling location are shown in the figure below and the results are presented in Table 44 and Table 45. Further discussion is available in the West Branch Little Calumet River Watershed Management Plan.

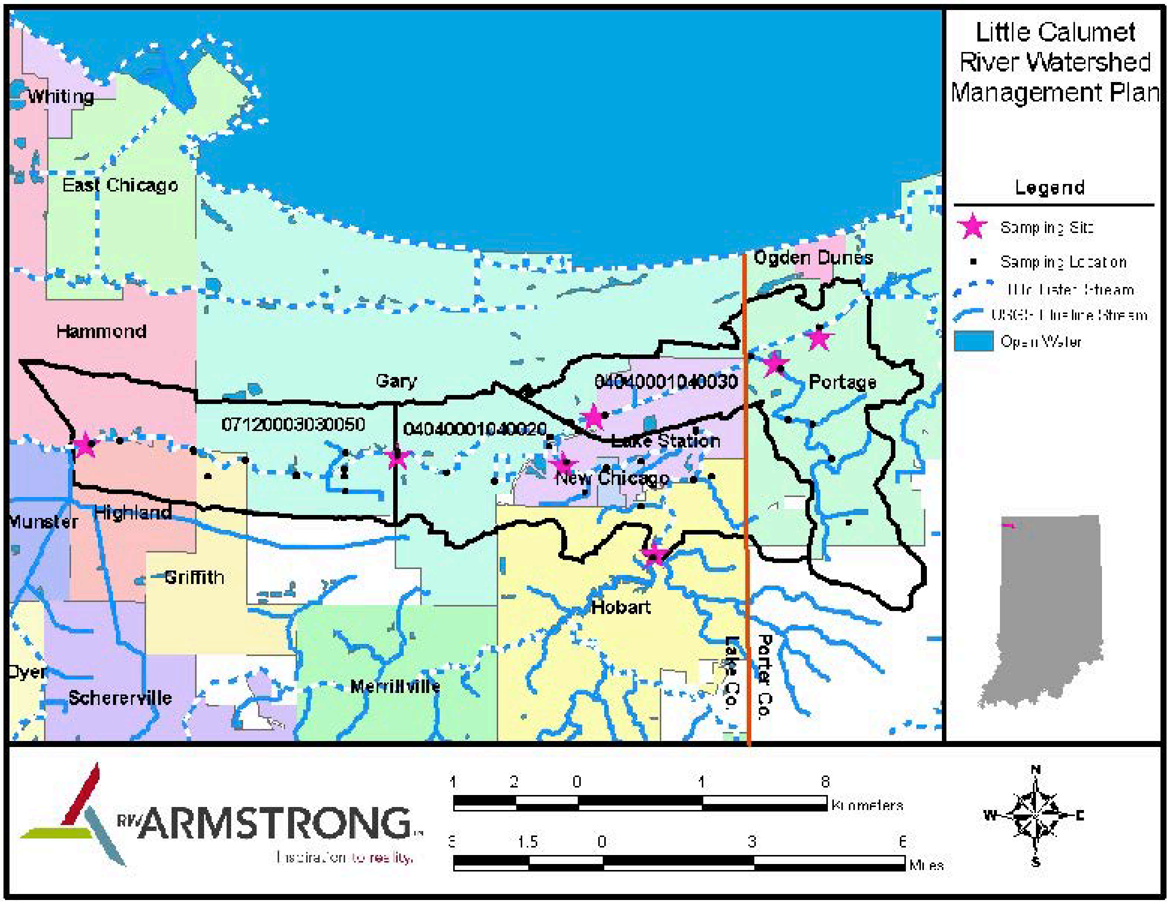

Figure 70 Stream monitoring sites for West Branch Little Calumet River Watershed Plan

Site	Timing	Flow (cfs)	E.coli (cfu/100mL)	pH SU	DO (mg/L)	NH3 (mg/L)	NO3 (mg/L)	TP (mg/L)	Ortho- P (mg/L)	TSS (mg/L)
1*	Base	2.0	3,150	7.4	6.7	0.5	8.5	4.8	2.7	11.0
	Storm	52	1,820	7.1	0.3	1.0	1.5	0.2	0.2	23.5
2	Base	2.7	255	7.6	3.4	0.9	2.8	0.13	0.12	93.0
	Storm	70	1,320	7.3	2.9	0.9	1.4	0.10	0.09	16.0
3**	Base	17.0	501	7.9	5.1	0.5	1.2	0.24	0.15	22.0
	Storm	435	2,380	7.3	6.1	0.8	1.1	0.14	0.13	29.0
4	Base	20.6	61	7.5	3.3	0.5	0.9	0.26	0.13	26.0
	Storm	526	1,240	7.4	4.8	2.0	1.1	0.06	0.05	28.0
5	Base	23.3	118	7.5	3.1	0.3	1.2	0.13	0.09	13.0
	Storm	597	1,760	7.4	6.0	1.3	0.9	0.06	0.05	28.0
6	Base	1.2	927	7.7	7.6	0.9	1.4	0.18	0.15	6.0
	Storm	30	2,900	7.4	7.1	1.9	1.2	0.12	0.11	23.5
7	Base	24.5	125	7.5	6.2	0.5	3.0	0.24	0.22	9.0
	Storm	626	2,600	7.3	6.0	1.3	1.0	0.22	0.18	36.0

Table 44 Water quality data collected for West Branch Little Calumet River Watershed Plan

Sampling Location	*E. coli* (cfu/100ml)			
	Dry Weather (7/24/2007)	Wet Weather (8/21/2007)	Wet Weather (9/26/2007)	Dry Weather (10/30/2007)

1		695	2	225
2	1804	3890	0	341
3	448	465	4	190
4	25	1620	0	218
5	396	2570	6	174
6	94	220	2	52
7	2	200	0	3
8	3	1385	2	5
9	1	2775	0	32
10	228	910	6	15
11	207	11130	0	144
12	108	340	2	15
13	56	215	6	1
14	353	415	14	20
15	270	3760	0	46
16	692	2765	0	75
17	119	1010	982	78
18	345	695	0	58
19	1	345	0	428
20	88	310	0	113
21	51	720	0	79
22	111	130	6400	7
23	374	945	8	40
24	505	685	2	77
25	275	565	2540	48
26	68	2285	114	16
27	937	2145	182	445
28	375	1220	56	260
29	158	4120	170	5
30	168	735	6	18
31	5	2310	1030	72
32	72	1610	792	102
33	50	405	882	8
34	71	1065	110	19
35	129	1100	358	27
36	51	755	4	2
37	4	1600	654	92
38	3	4580	2700	79
39	36	4515	62	67
40	9	2375	292	2
41	86	105	2440	44
42	913	2040	3100	586

Table 45 E. coli data collected for West Branch Little Calumet River Watershed Plan