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.

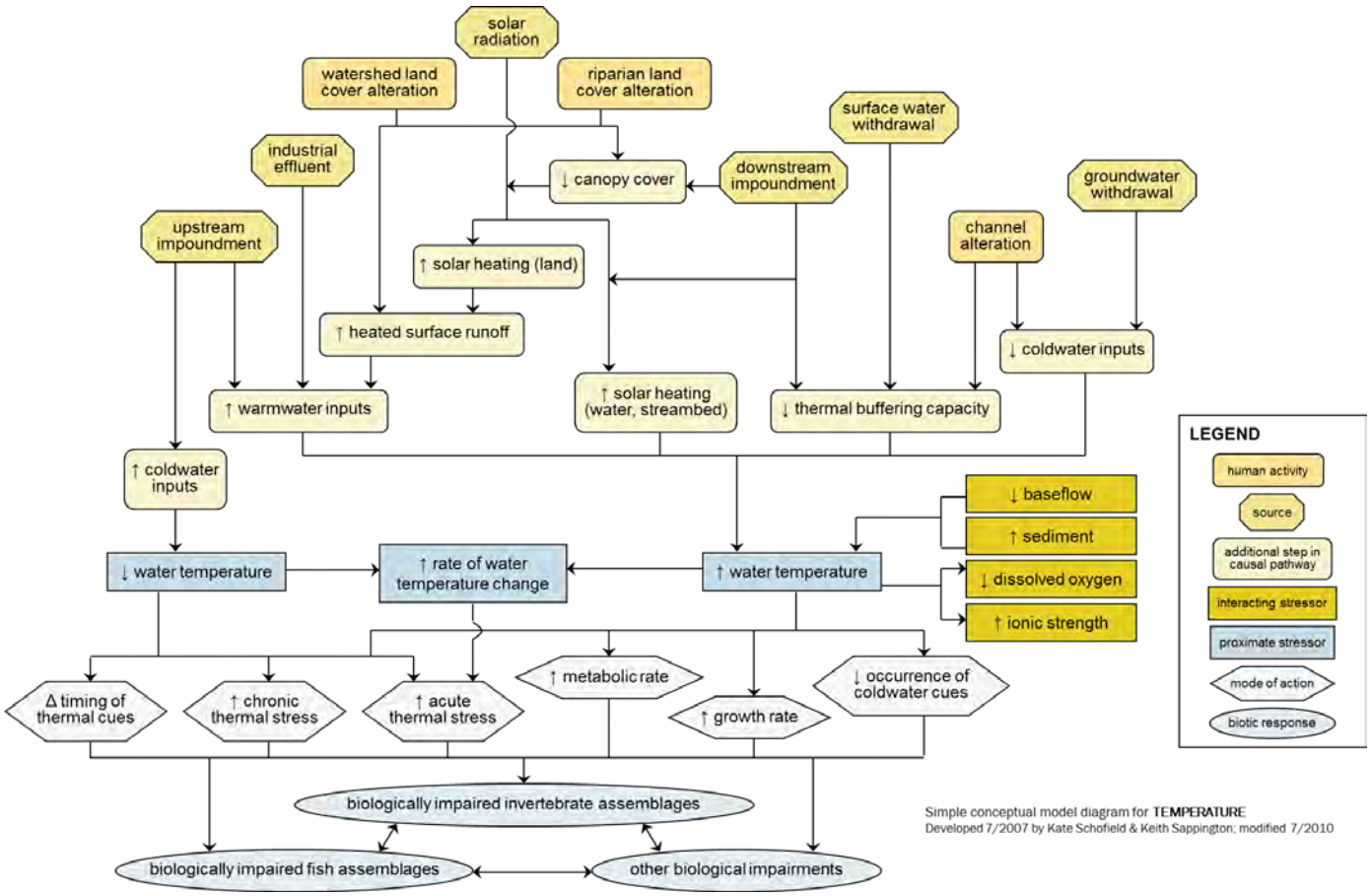

Figure 62 Conceptual diagram illustrating causal pathways, from sources to impairments, related to temperature

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.)

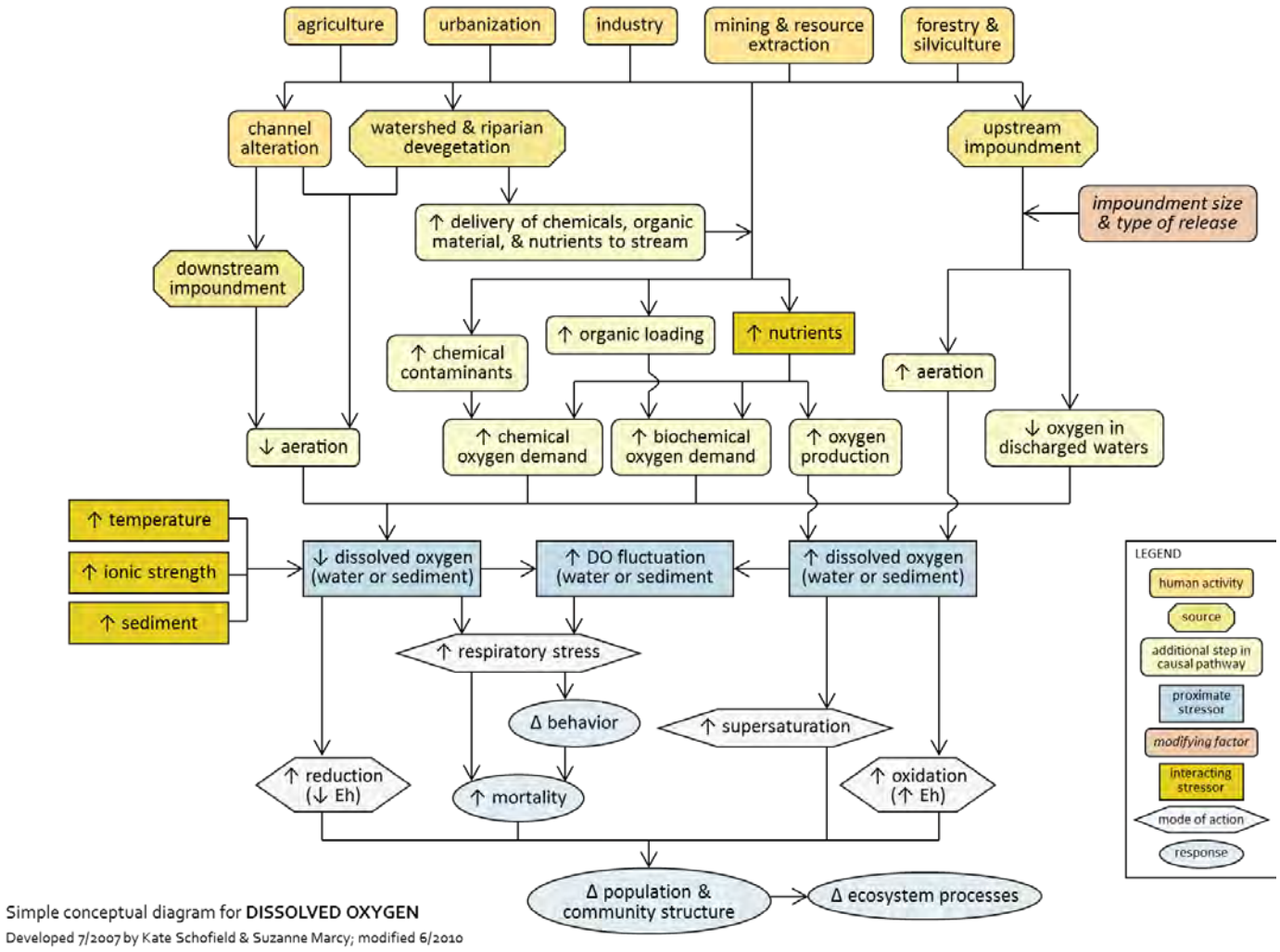

Figure 63 Conceptual diagram illustrating causal pathways, from sources to impairments, related to dissolved oxygen

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.)

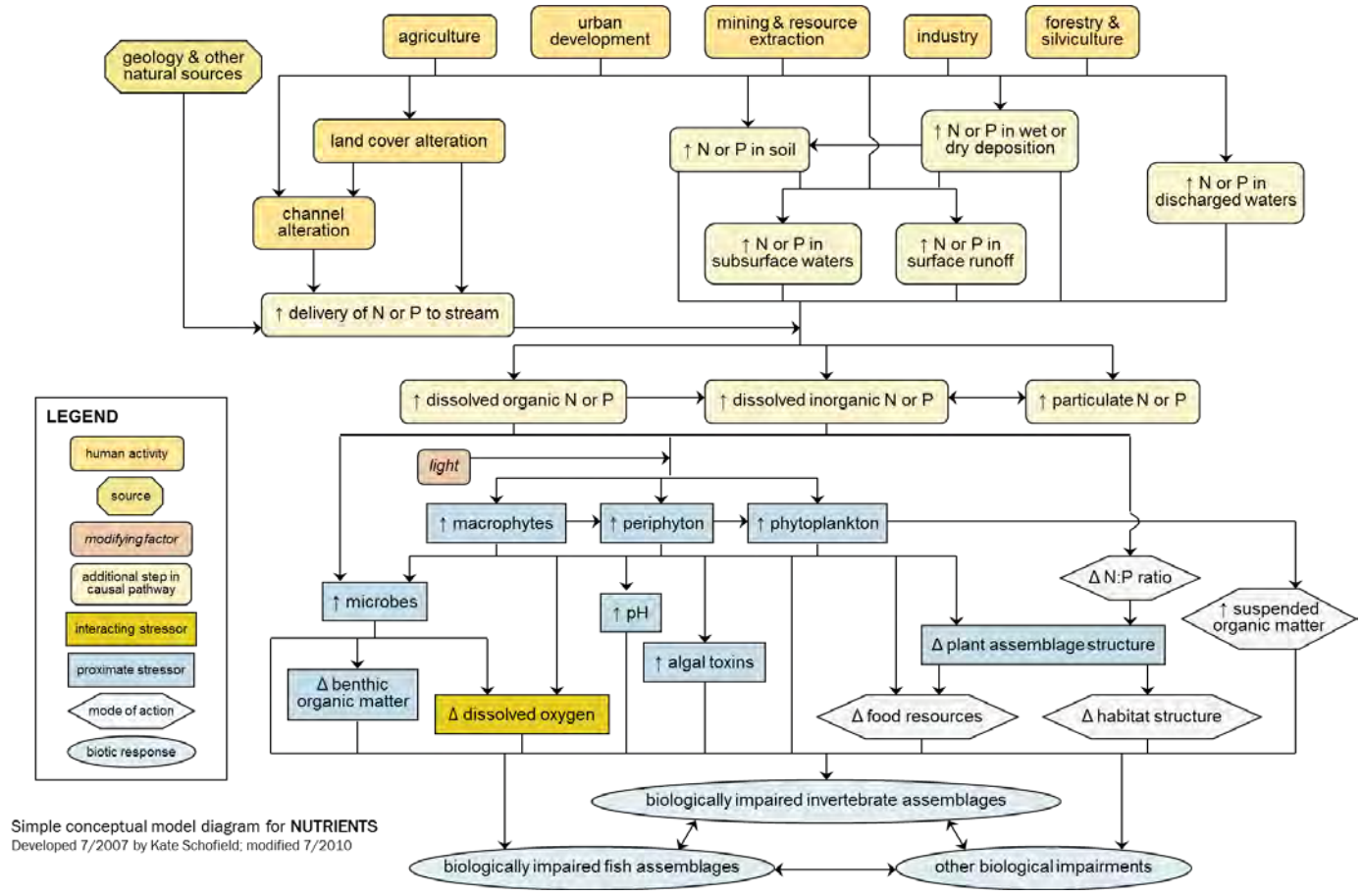

Figure 64 Conceptual diagram illustrating causal pathways, from sources to impairments, related to nutrients

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.

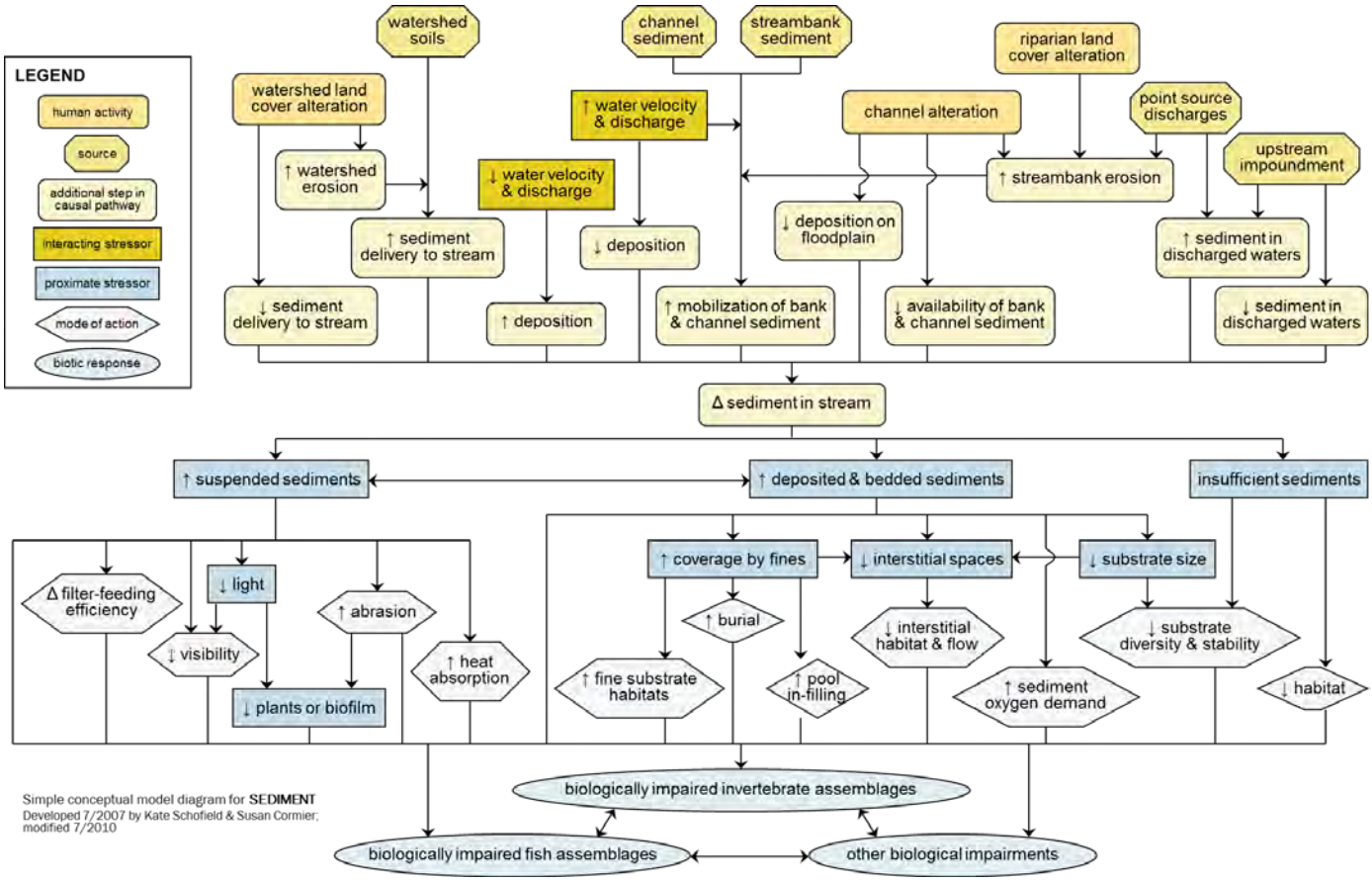

Figure 65 Conceptual diagram illustrating causal pathways, from sources to impairments, related to sediment

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.

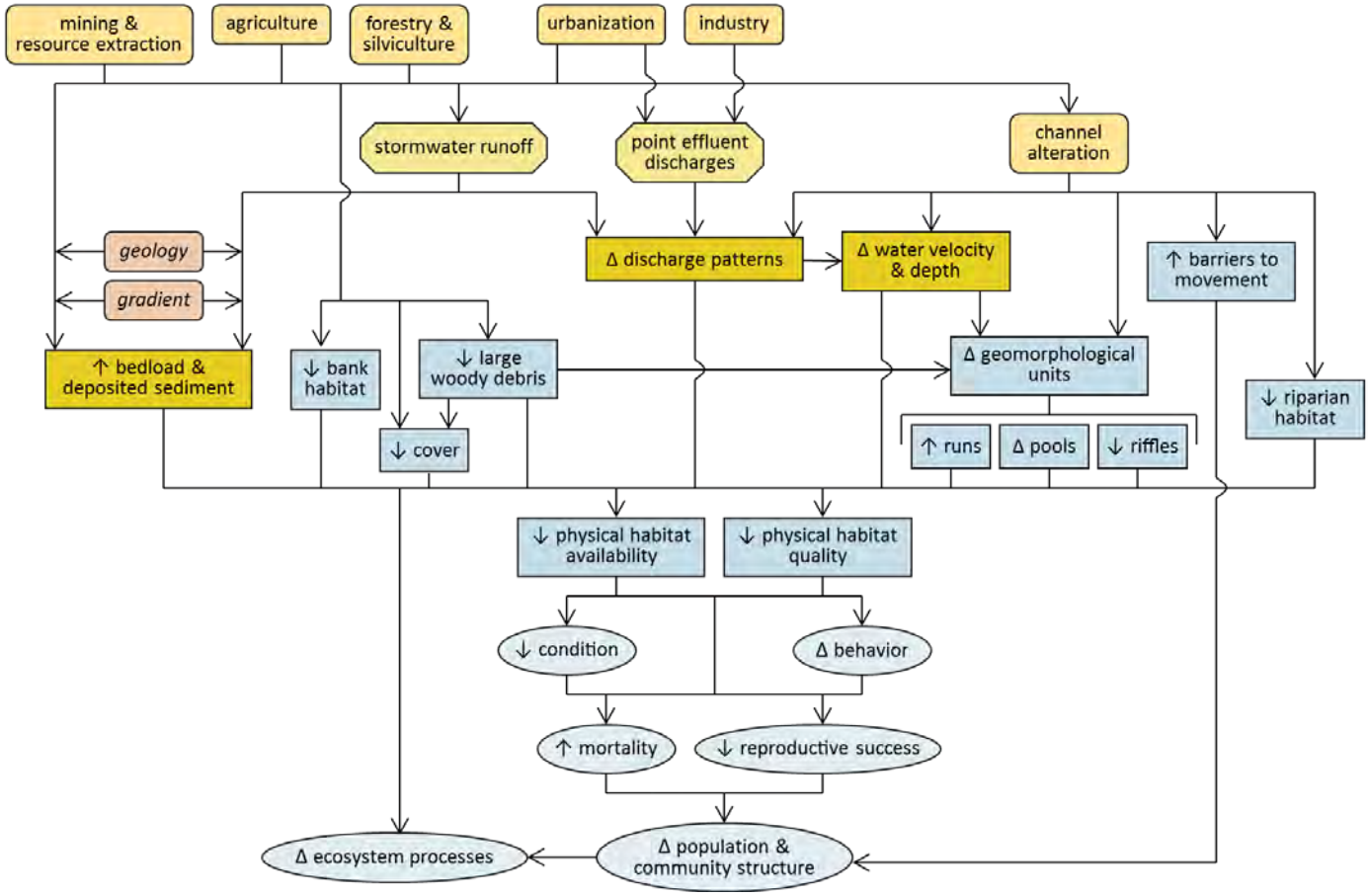

Figure 66 Conceptual diagram illustrating causal pathways, from sources to impairments, related to physical habitat

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

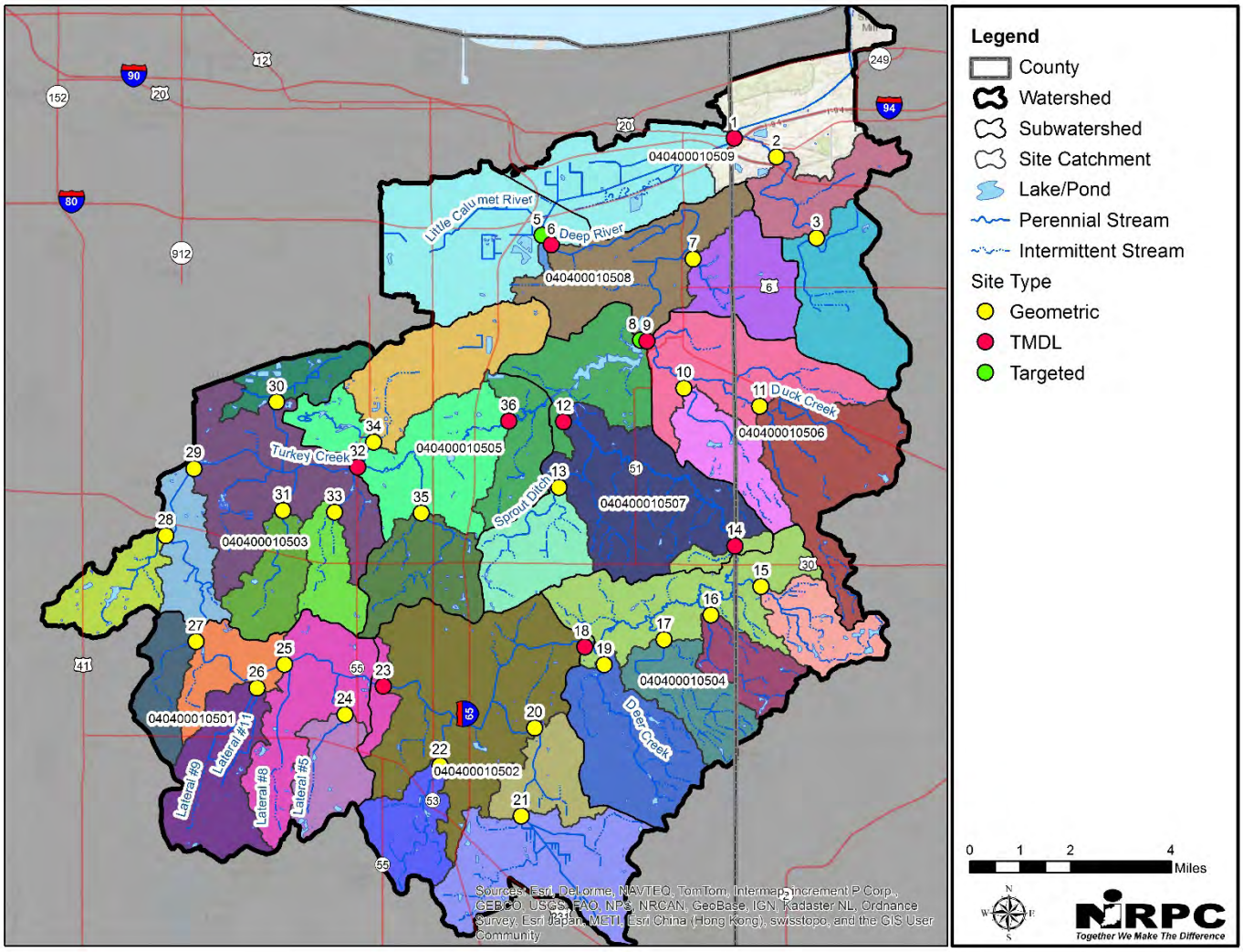

Figure 67 IDEM baseline assessment stream monitoring sites and their catchments

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

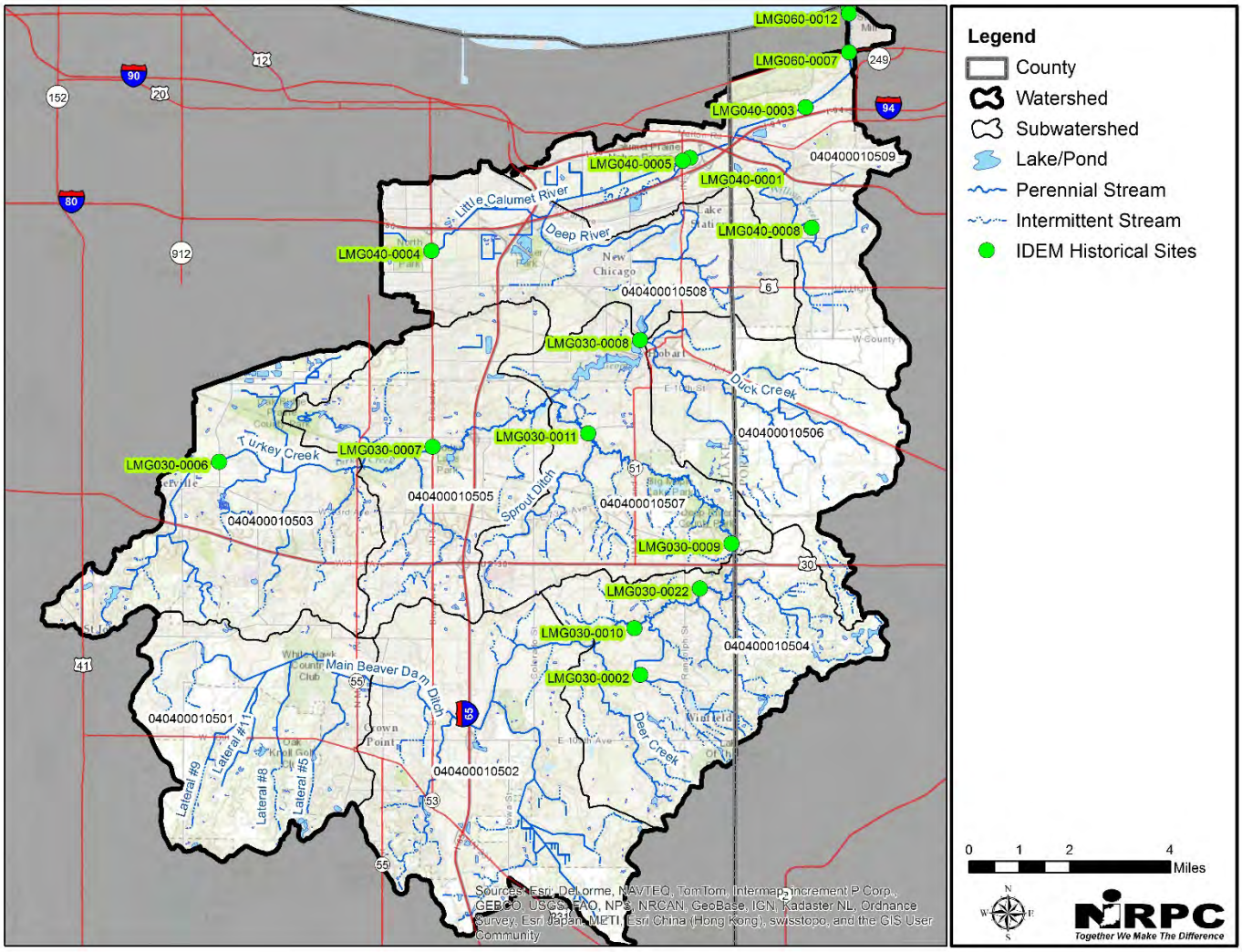

Figure 68 IDEM historical water quality monitoring sites

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.

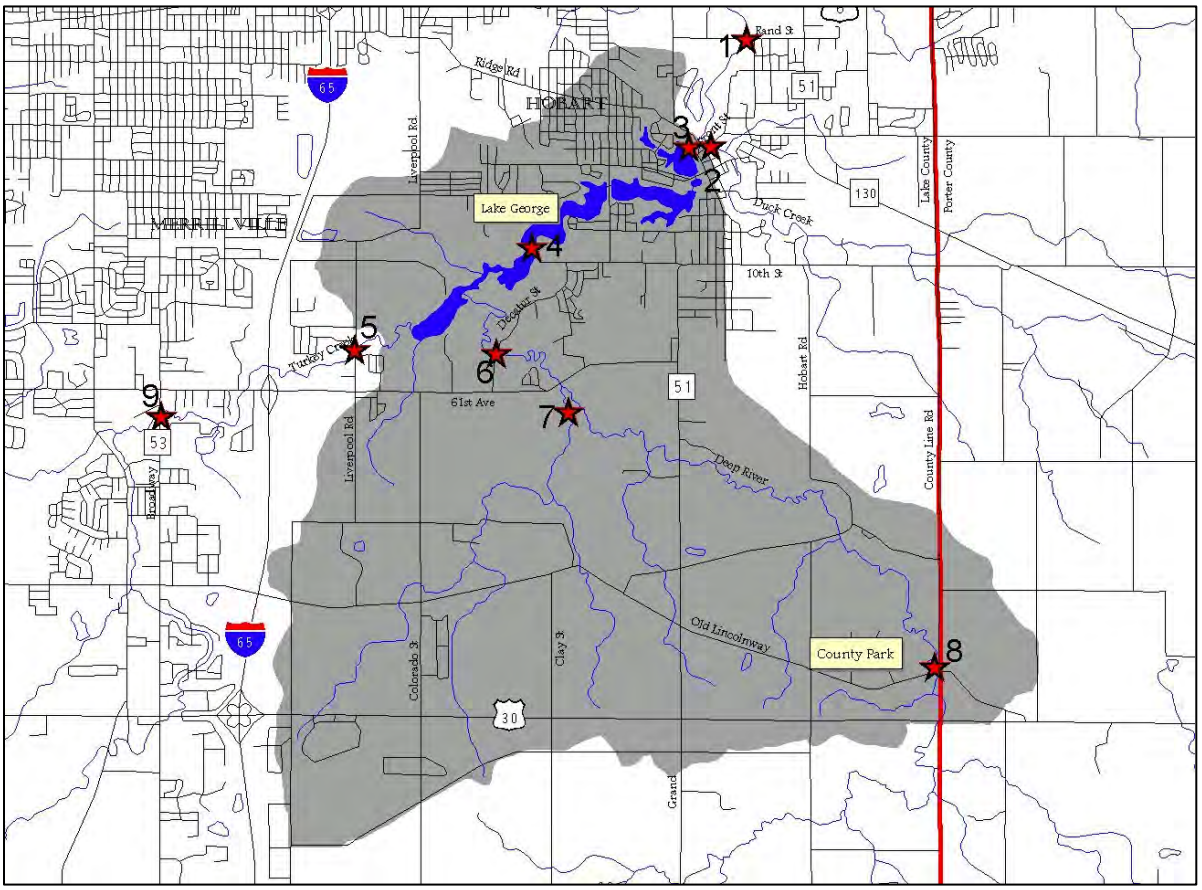

Figure 69 Stream sampling sites monitored during development of Deep River-Turkey Creek Watershed Plan

Site	Date	Timing	Flow (cfs)	Temp (ºC)	DO (mg/L)	DO Sat (%)	Conductivity (µmho 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.

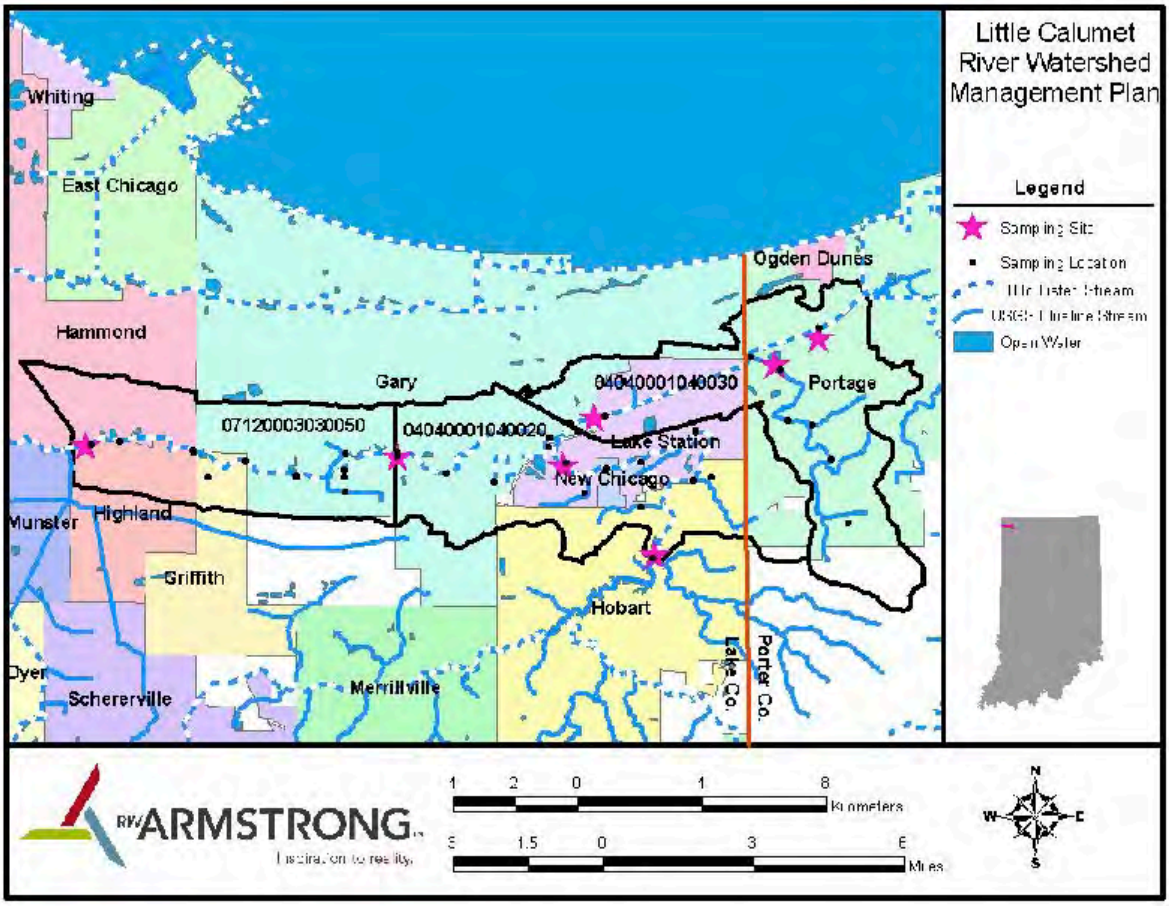

Figure 70 Stream monitoring sites for West Branch Little Calumet River Watershed Plan

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

4 Subwatersheds of the Deep River-Portage Burns Waterway Watershed

The following section provides a summary of water quality, habitat, biological, and land use information for each of Deep River-Portage Burns Waterway's subwatersheds.

4.1 Headwaters Main Beaver Dam Ditch (HUC 040400010501)

4.1.1 Overview

The Headwaters Main Beaver Dam Ditch subwatershed is located in the southwestern portion of the watershed. It drains approximately 18.3 mi² of primarily developed (39%) and agricultural (26%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, and high nutrient and *E. coli* levels.

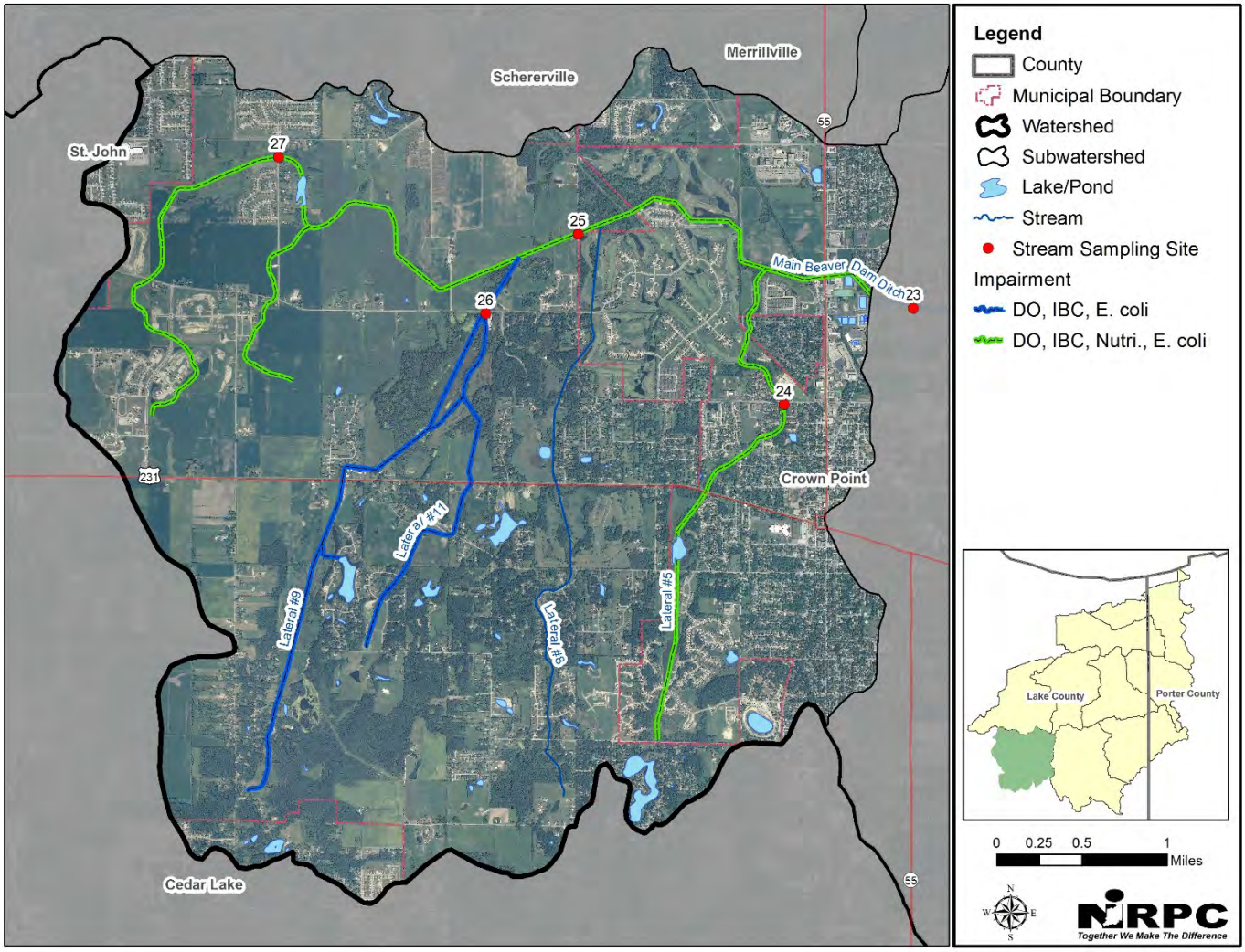

Figure 71 Stream Impairments within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 27-24) within the subwatershed (Figure 71). Site 23 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.1.2.1 *Pathogens*

Water quality sampling at Sites 23-27 show that any full body contact recreational use would be threatened by high pathogen levels (Figure 72). Each site at least occasionally failed to meet the water quality standard of 235 CFU/mL. Site 24 stands out in having the highest frequency of exceedances (>90%) and concentrations observed. Exceedances at Sites 23, 24 and 27 occurred across high to dry stream flow conditions indicating contributions from nonpoint and point sources from within their respective drainage areas. Exceedances at Sites 25 and 26 typically occurred when stream flows were high indicating nonpoint source contributions.

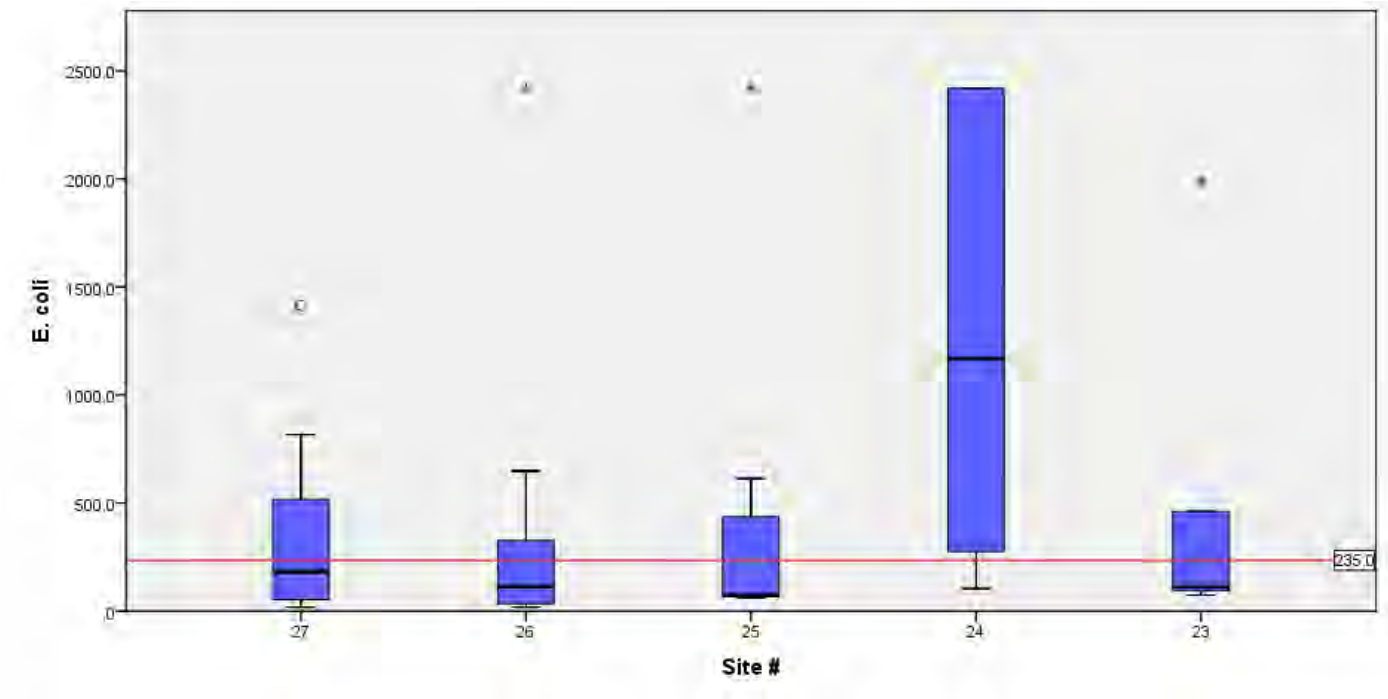

Figure 72 Box plot illustrating site E. coli concentrations within the Headwaters Main Beave Dam Ditch Subwatershed

4.1.2.2 *Fish*

An assessment of fish community structure showed that the stream reaches represented by Sites 24-26 do not fully supporting their Aquatic Life Use designation (Table 46). While Sites 27 and 23 were found to be fully supporting, they only received an integrity classification of "fair". The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking and numbers of fish collected was extremely low. Fish species that require clean gravel/cobble substrates to spawn were also lacking. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated some degree of environmental degradation at Sites 26-23.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
27	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
26	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
25	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
24	14	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 46 Site fish index of biotic integrity scores within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that none of the sites were supporting of Aquatic Life Use and received "poor" integrity classifications (Table 47). All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
27	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
26	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
25	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
24	24	Not Supporting	Poor	Few species and individuals present, tolerant species dominant
23	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 47 Site macroinvertebrate index of biotic integrity scores within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.4 *Water Temperature*

No site had any water temperature observations that exceeded the monthly maximum water quality standard. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-21°C (63-70°F). Figure 73 shows a subtle decreasing trend in water temperature, in both maximum and median values, moving from upstream to downstream locations. Site 24 stands out in having the lowest maximum water temperature observed and least variability in temperature.

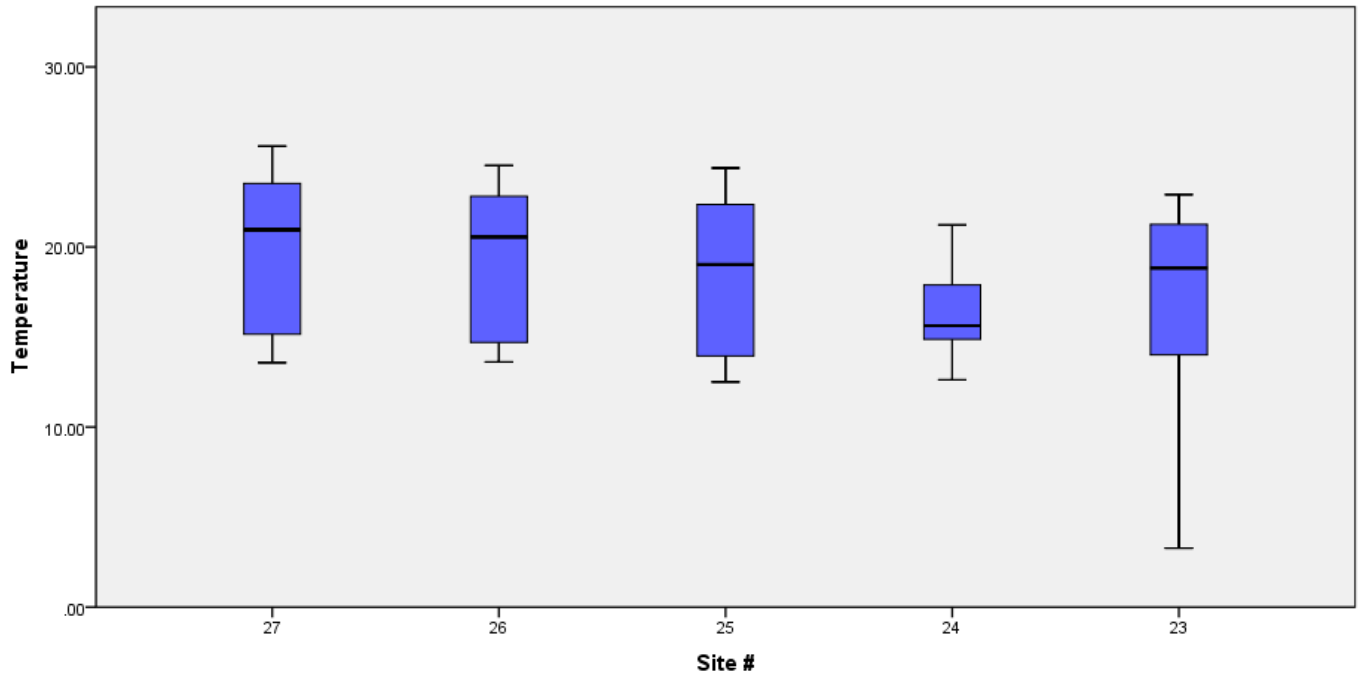

Figure 73 Box plot illustrating site water temperature observations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.5 *Dissolved Oxygen*

Figure 74 shows that Sites 24-27 all had periods in which they failed to meet the dissolved oxygen water quality standard of 4-12mg/L. Median dissolved oxygen concentrations fell below 4 mg/L for Sites 24-26. The median concentration was only slightly higher than 4 mg/L at Site 27. Violations most frequently occurred during the summer and fall when water temperatures are at or near their warmest.

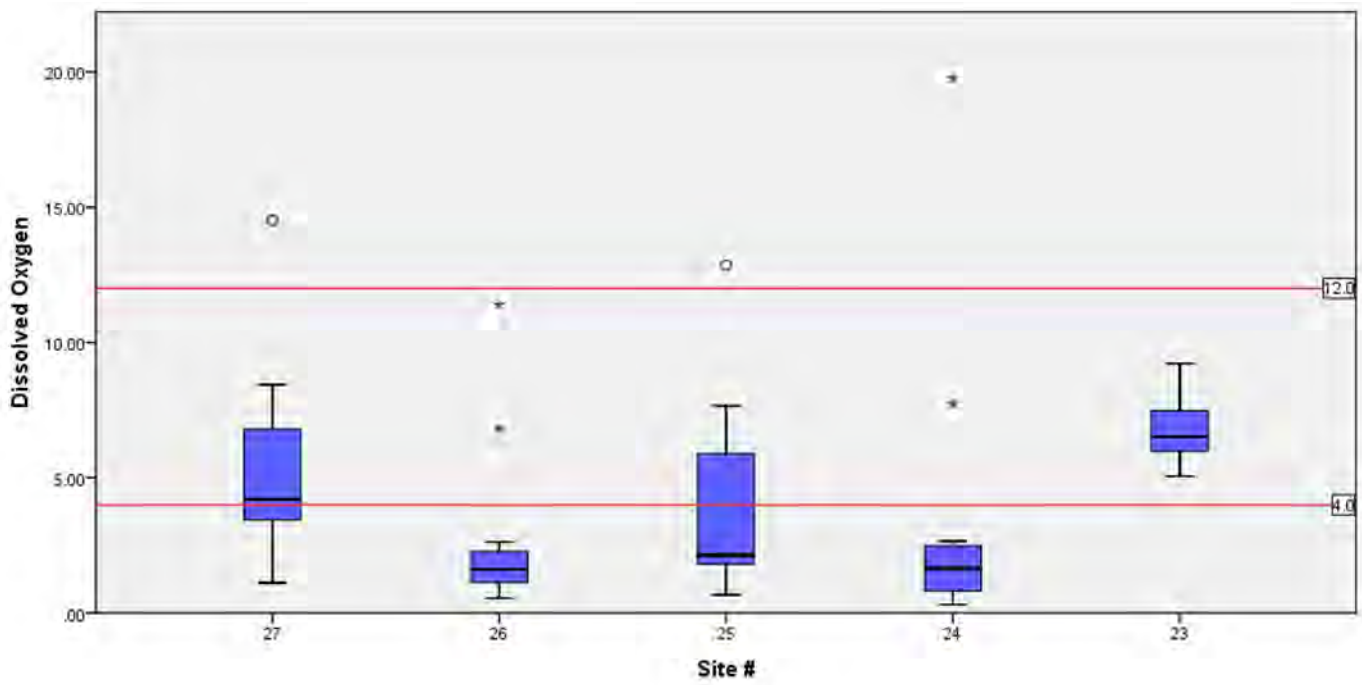

Figure 74 Box plot illustrating site dissolved oxygen concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.6 *Total Organic Carbon*

Figure 75 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Sites 24-27.

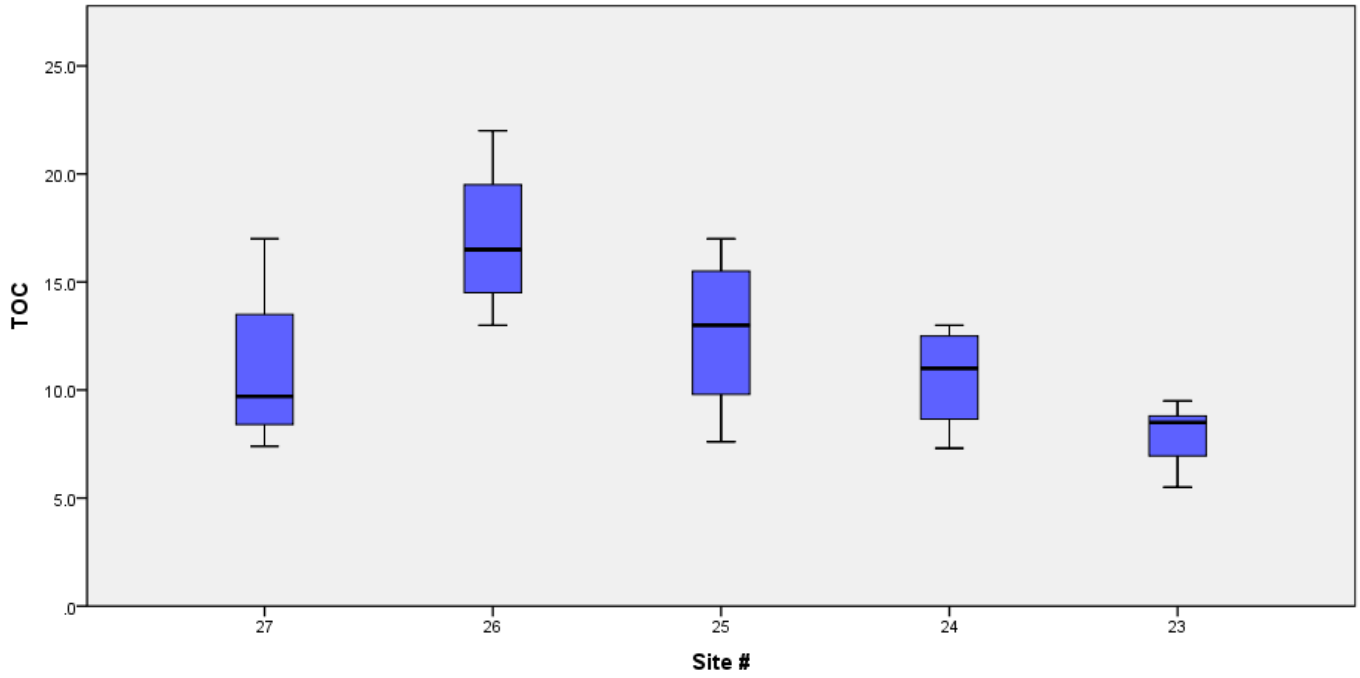

Figure 75 Box plot illustrating site TOC concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.7 *Nutrients*

Figure 76 shows that all sites consistently exceeded the 0.07mg/L total phosphorus threshold. Sites 23 and 26 had the highest median concentrations, exceeding the 0.3mg/L threshold. Seasonally, mean total phosphorus concentrations were highest during the fall for Sites 23 (0.89 mg/L), 25 (0.32 mg/L), and 26 (0.62 mg/L) and the summer for Sites 24 (0.24 mg/L) and 27 (0.34 mg/L). However, the distribution of total phosphorus concentrations was not found to be statistically different across seasons.

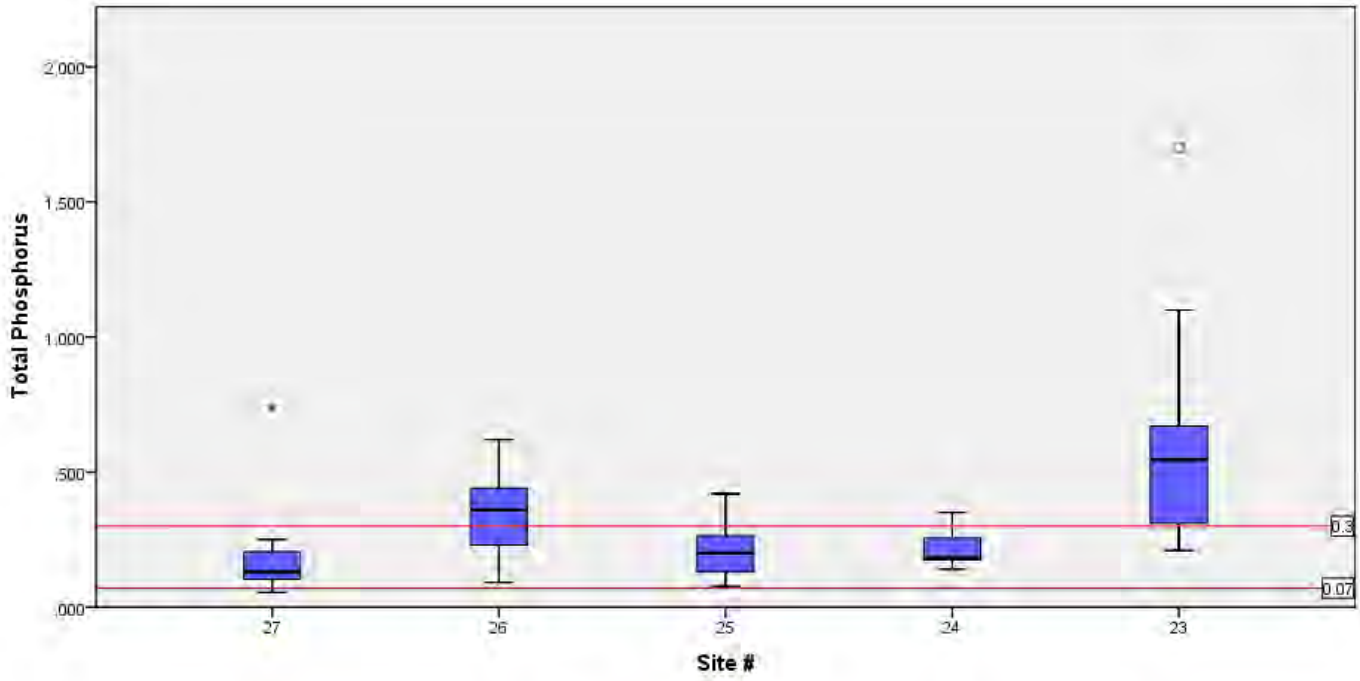

Figure 76 Box plot illustrating site total phosphorus concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 77 shows that Site 23 had a median nitrate concentration in excess of 10mg/L. If Main Beaver Dam Ditch was a designated drinking water supply this would be a considered a violation of the state water quality standard. More than 25% of the samples at Site 25 exceeded the 1.09 mg/L nitrate threshold while 100% of the samples exceeded this threshold at Site 23.

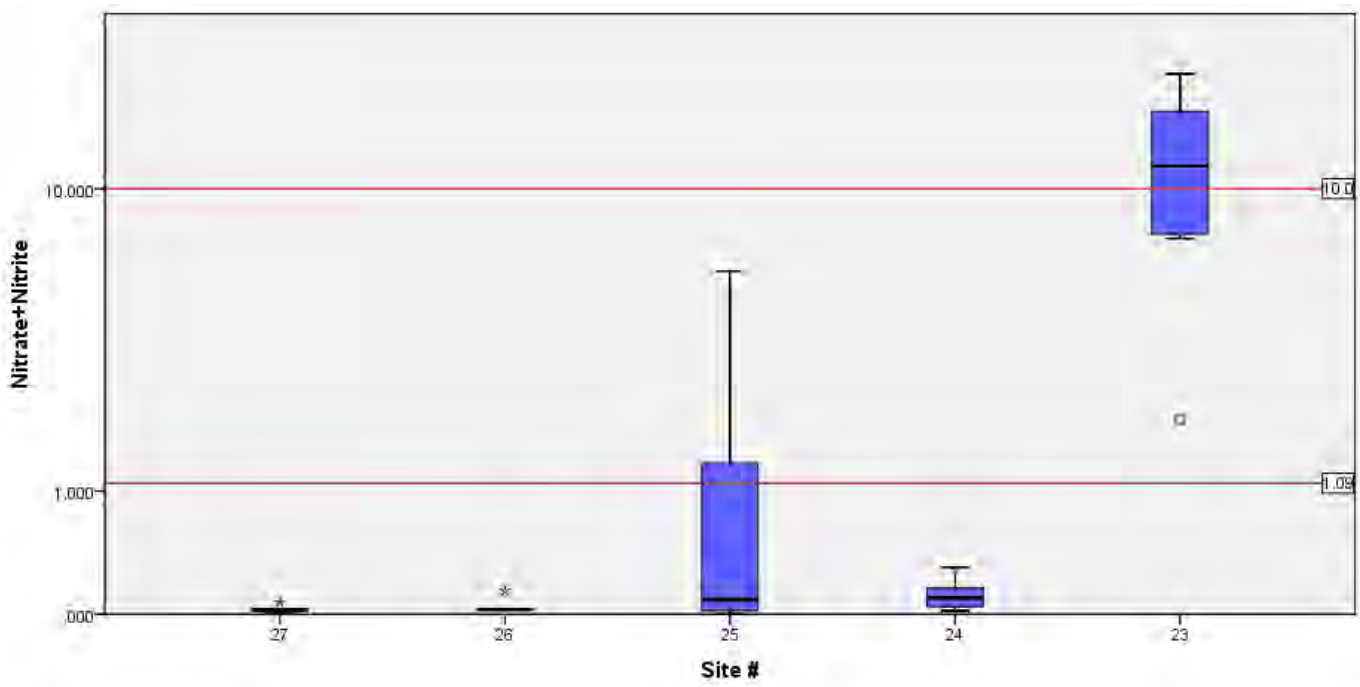

Figure 77 Box plot illustrating site nitrate concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 78 shows that Sites 23-26 had median total Kjeldahl nitrogen concentrations that exceeded the 1.27 mg/L threshold. Over 75% of the samples at Sites 24 and 26 exceeded this threshold. Approximately 25% of the samples from Site 27 exceeded 1.27 mg/L threshold.

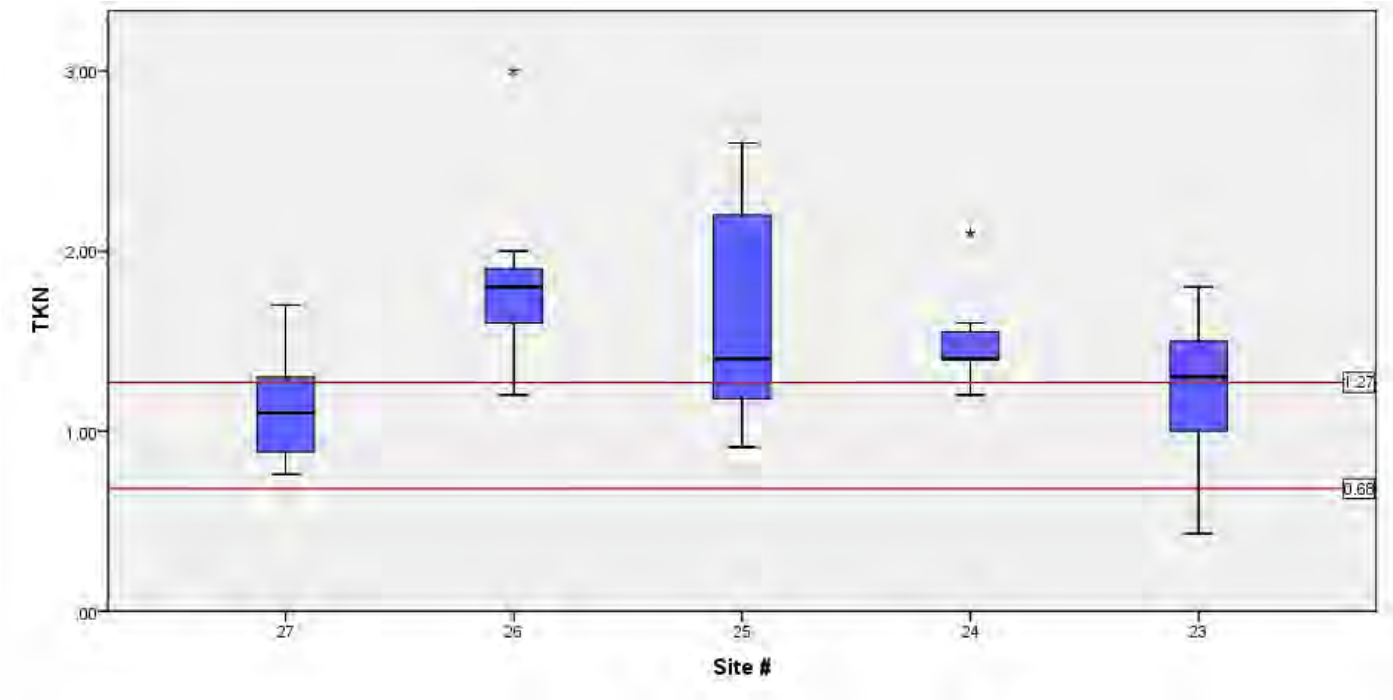

Figure 78 Box plot illustrating site total kjehldahl nitrogen concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 79 shows that ammonia concentrations at Site 24 frequently exceeded (>75%) the 0.21 mg/L maximum threshold. Sites 23, 25 and 26 also occasionally exceeded this threshold. All sites had at least one exceedance of the 0.03 mg/L threshold.

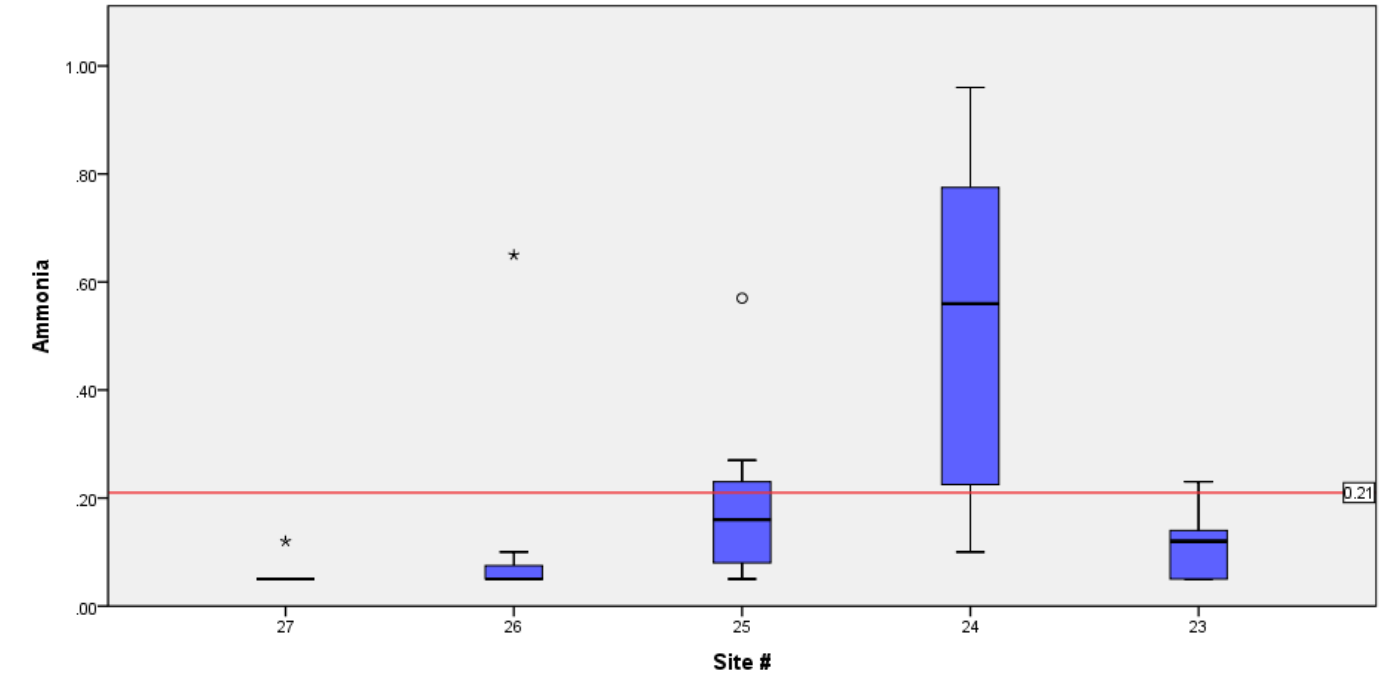

Figure 79 Box plot illustrating site ammonia concentrations within the Headwatershed Main Beaver Dam Ditch Subwatershed

4.1.2.8 *Suspended Solids & Turbidity*

Figure 80 shows that all sites had median total suspended solids concentrations well below the 30 mg/L threshold. Sites 27 had the highest frequency of exceedances (>25%). The single observation at Site 26 is considered an outlier in the dataset. The exceedances generally corresponded to rain events a few days prior to sampling and higher stream flows with the exception of an exceedance at Site 27 which occurred during dry/low flow conditions in late summer. This could be linked to an algal bloom observed at the site.

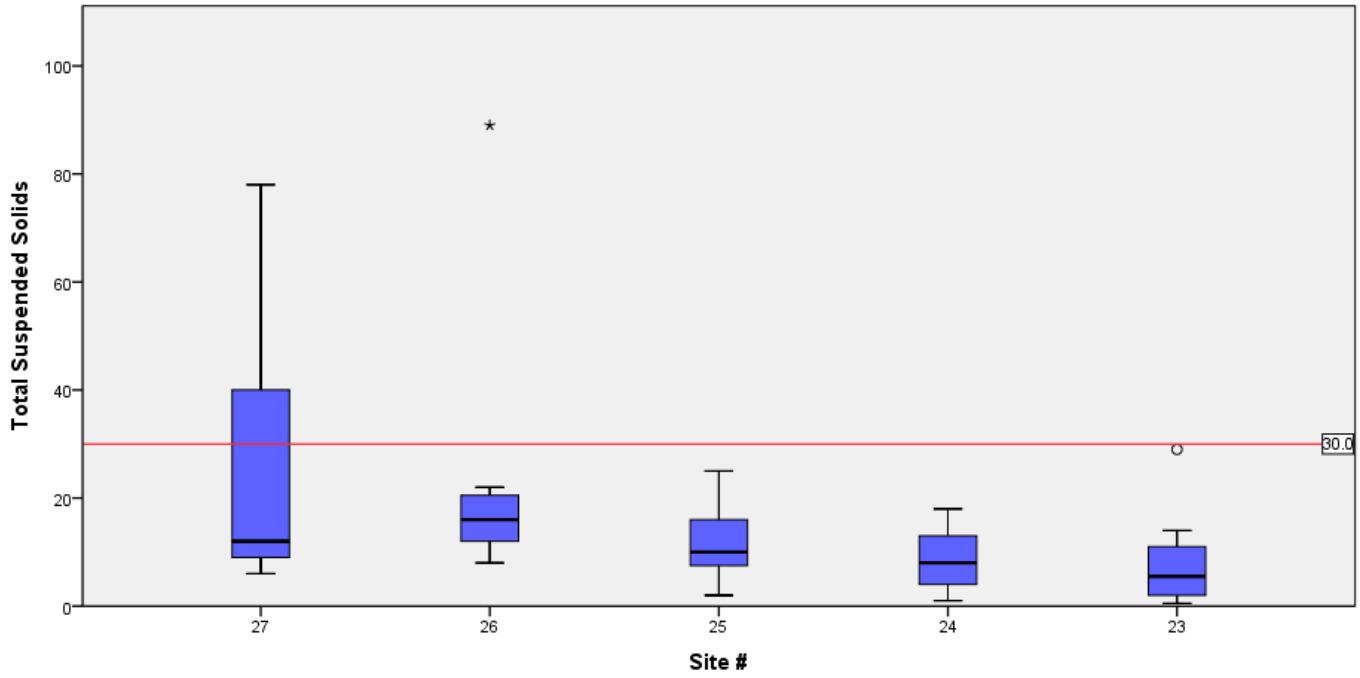

Figure 80 Box plot illustrating site total suspended solid concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 81 shows that Sites 25-27 had median concentrations exceeding the 10.4 NTU threshold recommended by the U.S. EPA. Nearly all the observations at Sites 26 and 27 eexceeded this threshold.

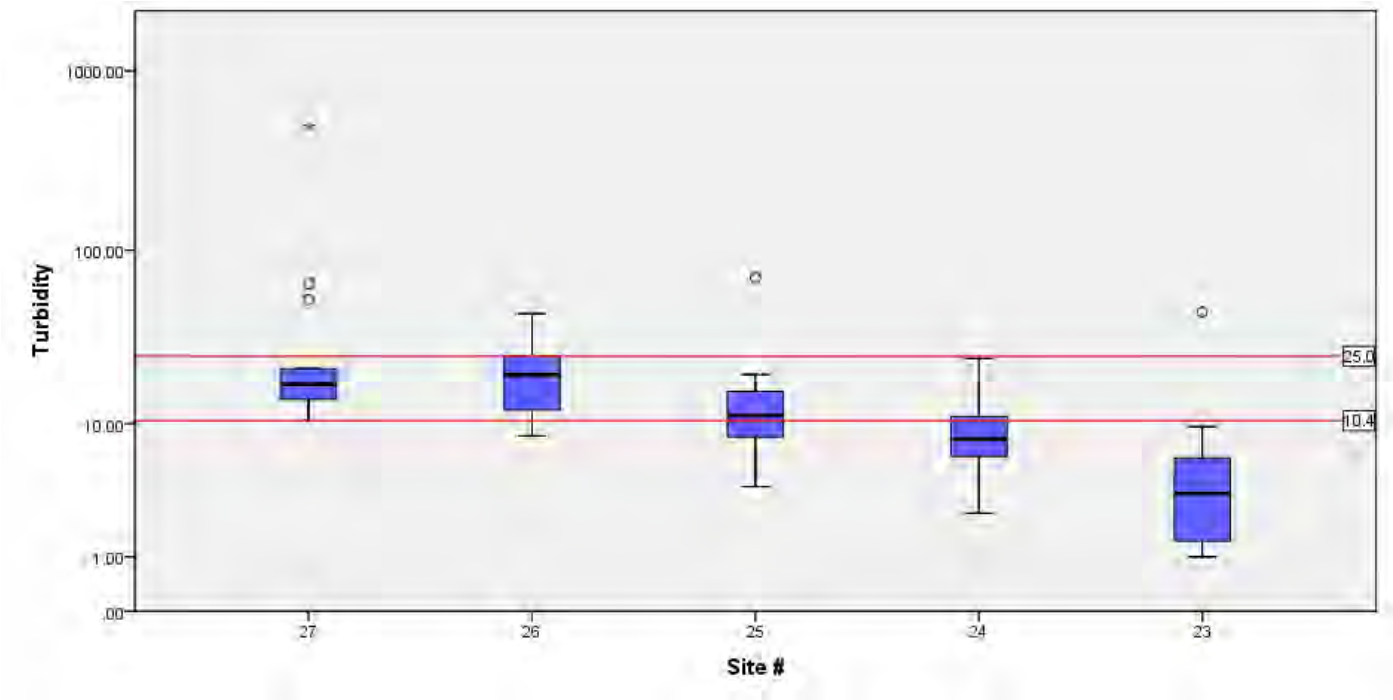

Figure 81 Box plot illustrating site turbidity levels within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.9 *Habitat*

The habitat evaluation performed by IDEM revealed that Sites 27-24 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Figure 82 shows that the major habitat limitations for Sites 27-24 include poor substrate, in-stream cover, channel morphology, and riffle/run quality. All sites had poor gradients. Stream substrates at Sites 27-24 were characterized by muck and silt, and had moderate to heavy siltation and extensive embeddedness. All sites had poor channel morphology characterized by no channel sinuosity, poor riffle/pool development, and moderate to low stability.

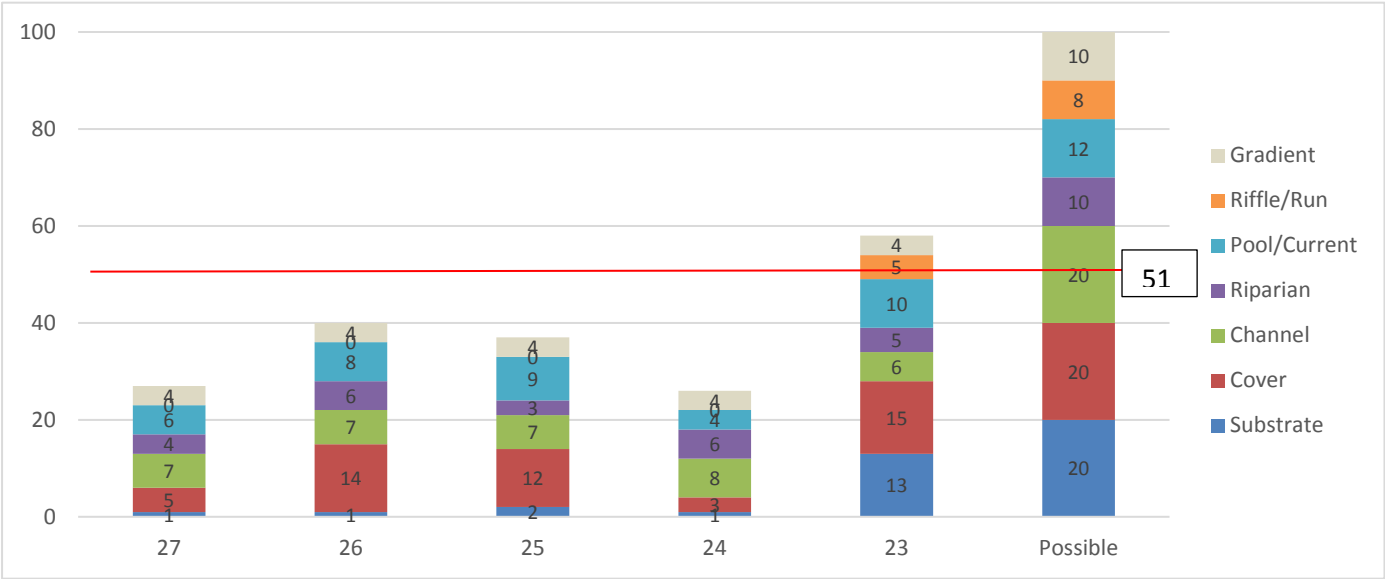

Figure 82 Site qualitative habitat evaluation index scoring within the Headwaters Main Beaver Dam Ditch Subwatershed

The poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed are located on reaches that are maintained as legal drains (Figure 84).

4.1.3 Land Cover & Land Use

Overall, the predominant land cover types within the subwatershed are developed (44%) and agricultural (26%) lands (Figure 83). Crown Point has the largest municipal footprint within the subwatershed and much of the development can be found here and the adjoining unicorporated areas. Further to the west, the subwatershed takes on a more rural agricultural setting. These unicorporated areas are mostly unsewered.

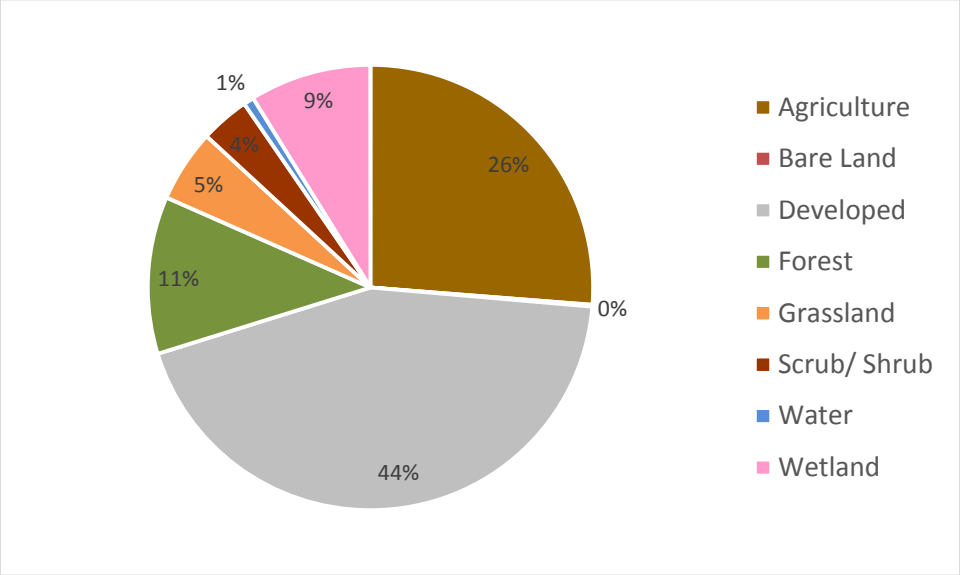

Figure 83 Percent land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

Land cover information for each site's drainage area is provided in Table 48. There is nearly an equal mix of developed and agriclultral land within Site 27's drainage area. The site is bordered by subdivisions and a wetland immediately upstream. A large wetland area surrounds Site 26. Further up in its drainage area land cover includes a mix of agricultural, forest, wetland and developed lands. Site 25 includes the drainage areas of Sites 27 and 26. Site 25's drainage area is primarily agricultural immediately upstream but is also bordered by wetland. Site 24 drains primarily developed land within the City of Crown Point.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
27	44.1	0.5	48.8	0.3	1.5	0.5	0.4	3.9
26	32.7	0.1	16.0	23.0	7.0	5.8	1.0	14.4
25	43.4	0.2	24.2	12.6	5.3	3.6	0.7	10.1
24	1.9	0.0	80.5	6.4	4.8	1.3	1.5	3.6
23	25.5	0.1	45.6	11.0	5.2	3.4	0.7	8.5

Table 48 Site percent land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 49. Agriculture and developed land are the dominant cover types within the riparian zone for Site's 27, 25, 24, and 23. Site 26 has slightly less agriculture and development within the riparian zone however they still account for nearly 30% of the cover. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
27	37.2	1.6	38.0	0.0	1.6	0.0	1.9	19.8

26	10.8	0.0	19.6	4.5	7.3	4.5	3.7	49.5
25	31.2	0.3	22.6	3.0	4.1	3.2	2.4	33.2
24	0.0	0.0	60.5	5.2	7.3	2.4	10.9	13.7
23	19.4	0.2	34.4	6.0	5.0	5.0	2.6	27.5

Table 49 Site percent riparian land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

There are two NPDES industrial facilities located in the subwatershed based on the TMDL. (See TMDL for facility locations map.) The TMDL does not reference any permit violations for either of these facilities over the five year period between 2010 and 2014. There are four CSO outfalls in the subwatershed. The one located upstream of Site 24 is listed as inactive. According to the TMDL there have been 60 CSO events between 2009 and 2013 from outfalls in the subwatershed. In addition to these point sources, there is a land fill and two dumps located in a wetland area of the subwatershed adjacent to Site 26 (Figure 84).

Five potential livestock facilities were identified in the subwatershed (Figure 84). One is located south of an intermittent tributary that flows in Main Beaver Dam Ditch downstream of Site 27. Three are located south of Lateral #11. The other is located south of Lateral #5.

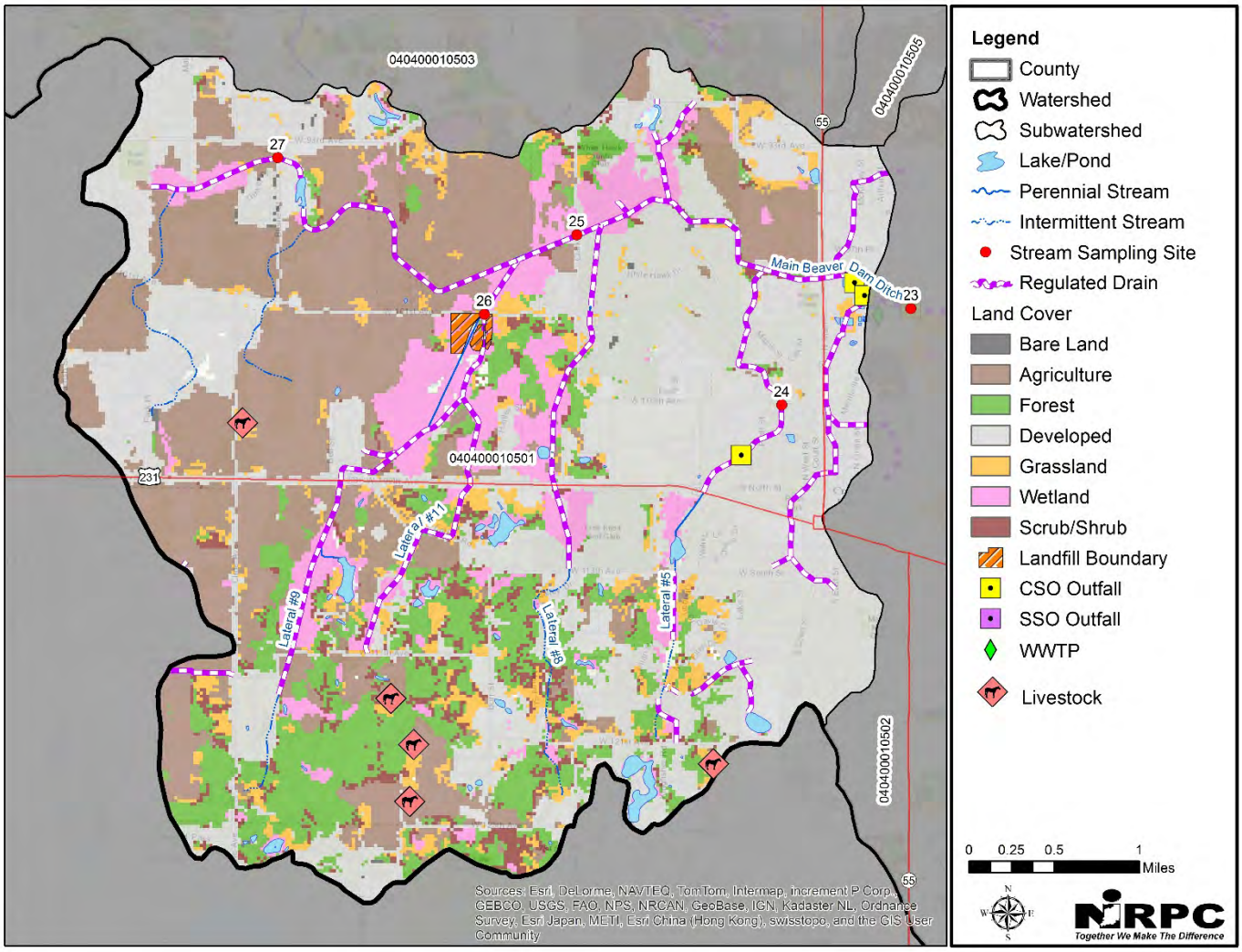

Figure 84 Land cover and land use in the Headwaters Main Beaver Dam Ditch subwatershed

4.1.4 Soils

Most of the soils immediately surrounding the tributaries within the subwatershed are rated as hydric indicating these areas would have historically been wetland (Figure 85). Highly erodible or potentially highly erodible soils appear equally distributed within the subwatershed. Soils with steep slopes bound lateral drain # 5, 8, 9, and 11. Soil surface textures adjacent to the tributaries are primarily classified as silty clay loam or muck (Figure 7). A majority of the soils in the subwatershed have poor infiltration rates and are prone to producing runoff (Figure 11). These soil characteristics in part help explain the poor substrate conditions observed at Sites 27-24 (Section 4.1.2.9).

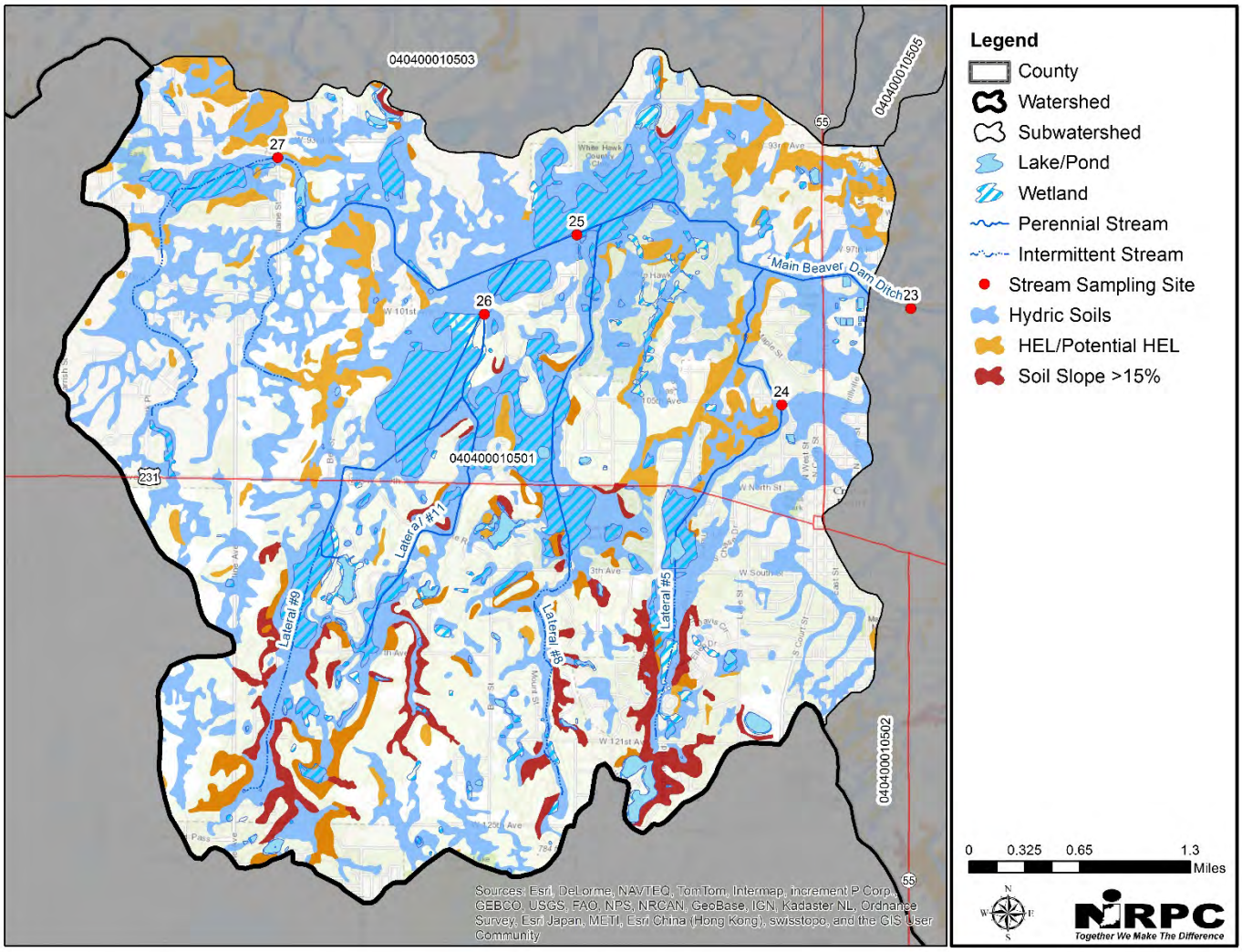

Figure 85 Hydric, highly erodible, & steep slope soils within the Headwaters Main Beaver Dam Ditch Subwatershed

4.2 Main Beaver Dam Ditch Subwatershed (HUC 040400010502)

4.2.1 Overview

The Main Beaver Dam Ditch subwatershed is located in the south-central portion of the watershed. It drains approximately 26.3 mi² of primarily agricultural (46%) and developed (35%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, and high nutrient and *E. coli* levels.

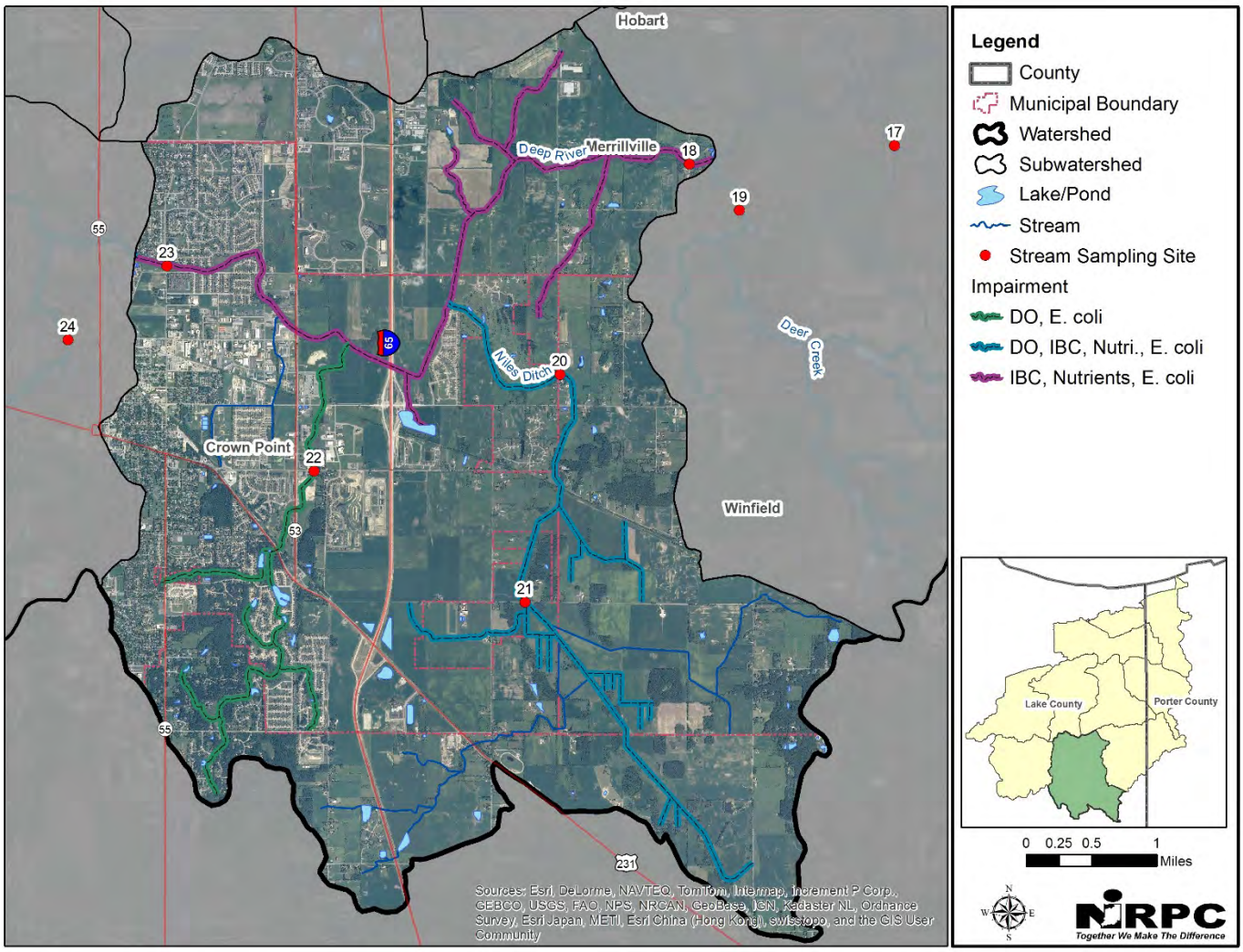

Figure 86 Stream impairments within the Main Beaver Dam Ditch Subwatershed

4.2.2 Water Quality

IDEM collected water quality data at five monitoring stations (Sites 18, 20-23) within the Main Beaver Dam Ditch subwatershed (Figure 86). Site 18 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.2.2.1 *Pathogens*

Figure 87 shows that any full body contact recreational use would be threatened by high pathogen levels as indicated by *E. coli*. Sites 18, 20 and 22 have median *E. coli* concentrations in excess of 235 CFU/100 mL. Over 75%

of the samples collected at Sites 18 and 22 exceeded 235 CFU/100 mL. Exceedances occurred across high flow and dry conditions indicating both nonpoint and point source contributions.

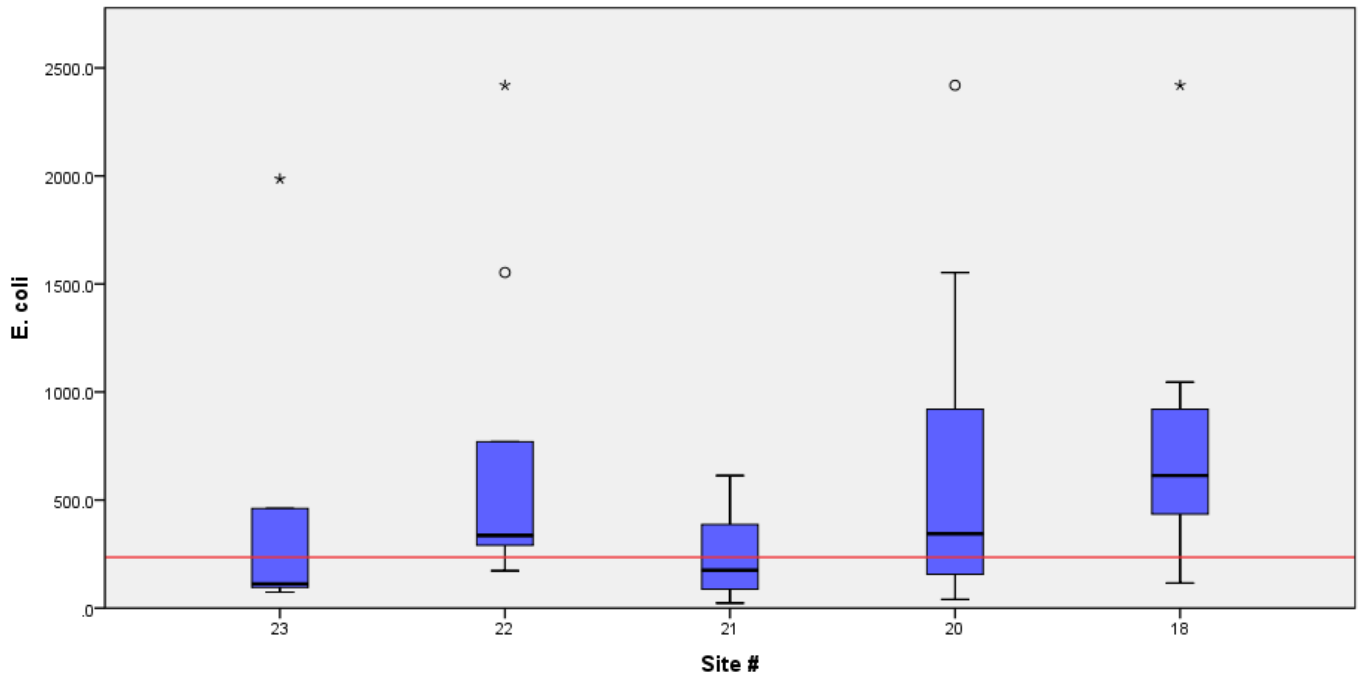

Figure 87 Box plot illustrating site E. coli concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.2 *Fish*

Site 21 was the only site found not to be fully supporting of Aquatic Life Use. Only one fish was collected from this site. Sites 23, 22, 20, and 18 were found to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent. Fish species that require clean gravel/cobble substrates to spawn were also generally lacking.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
22	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
21	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
20	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
18	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 50 Site fish index of biotic integrity scores within the Main Beaver Dam Ditch Subwatershed

4.2.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed Sites 21 and 22 were not supporting of Aquatic Life Use. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
22	24	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
21	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
20	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
18	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 51 Site macroinvertebrate index of biotic integrity scores within the Main Beaver Dam Ditch Subwatershed

4.2.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 19-22°C, (66-72°F). Figure 88 shows that Site 22 was generally warmer than the other sites within the subwatershed (highest max and temperatures skewed above the median). A review of aerial imagery shows a number of inline ponds associated with housing development within Site 22's drainage area. Site 22's drainage area is also predominately developed which can be a sources of warmer runoff due the large amounts of impervious surface cover which act as a heat sink.

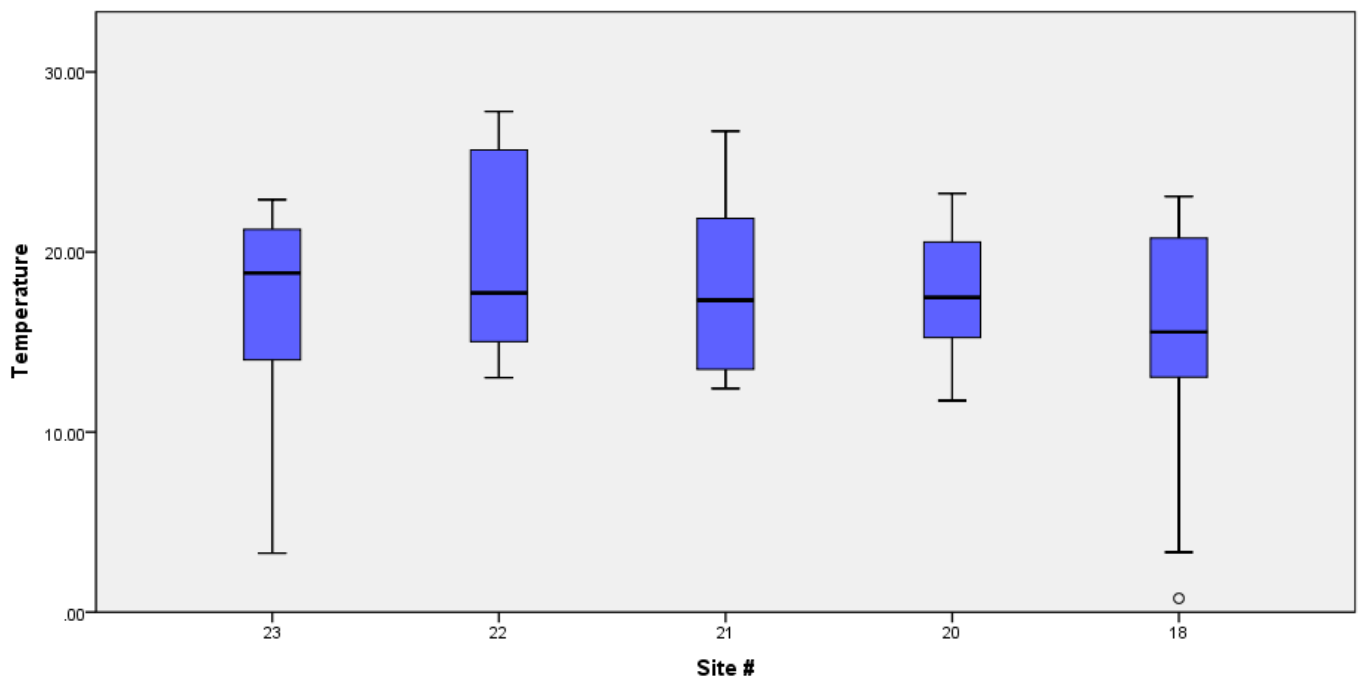

Figure 88 Box plot illustrating site water temperatures within the Main Beaver Dam Ditch Subwatershed

4.2.2.5 *Dissolved Oxygen*

Figure 89 shows that dissolved oxygen levels at Sites 21 and 20 are a problem, with median concentrations well below 4 mg/L. Sites 22 also occassionally failed to meet the minimum concentration of 4 mg/L. Violations typically occurred during the summer and fall when water temperatures are at their warmest.

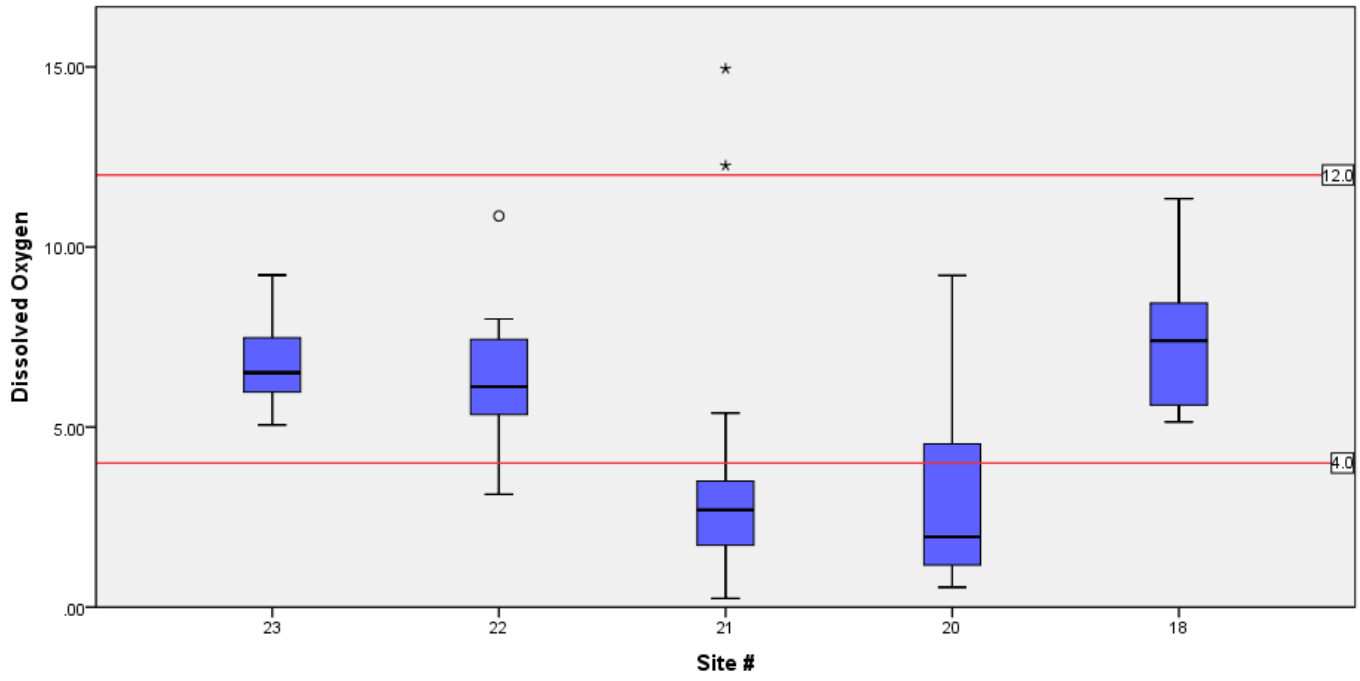

Figure 89 Box plot illustrating site dissolved oxygen concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.6 *Total Organic Carbon*

Figure 90 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Sites 20-22.

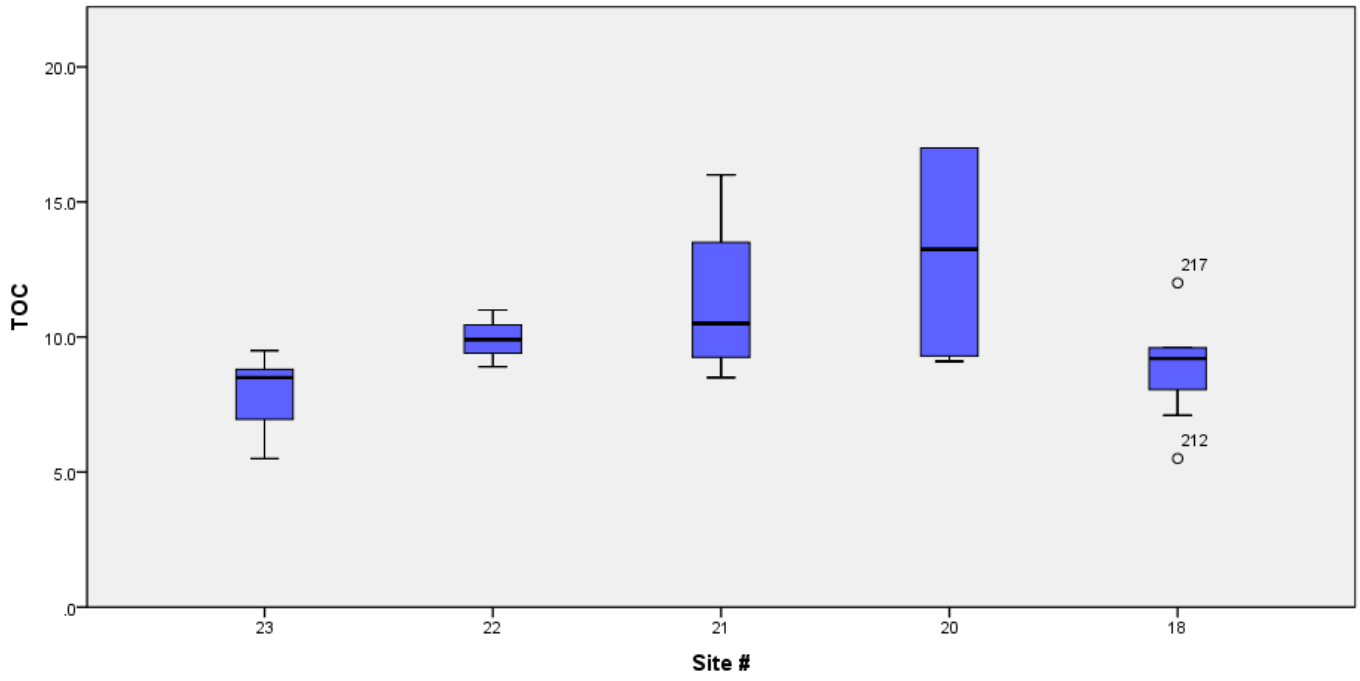

Figure 90 Box plot illustrating site TOC concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.7 *Nutrients*

Figure 91 shows that none of the site samples collected fell below the 0.07 mg/L total phosphorus threshold. Sites 18 and 23 had the highest median concentrations each being above the 0.3 mg/L threshold. Sites 21 and 20 exceeded the 0.3 mg/L threshold during the summer months with mean concentrations of 0.6 mg/L and 0.4 mg/L respectively. Site 18 exceeded the threshold during the summer, fall, and winter months. Site 23's exceedances occurred year round and were attributed to permit violations at the Crown Point Waste Water Treatment Plant. The distribution of total phosphorus concentrations was found to be significantly different across seasons.

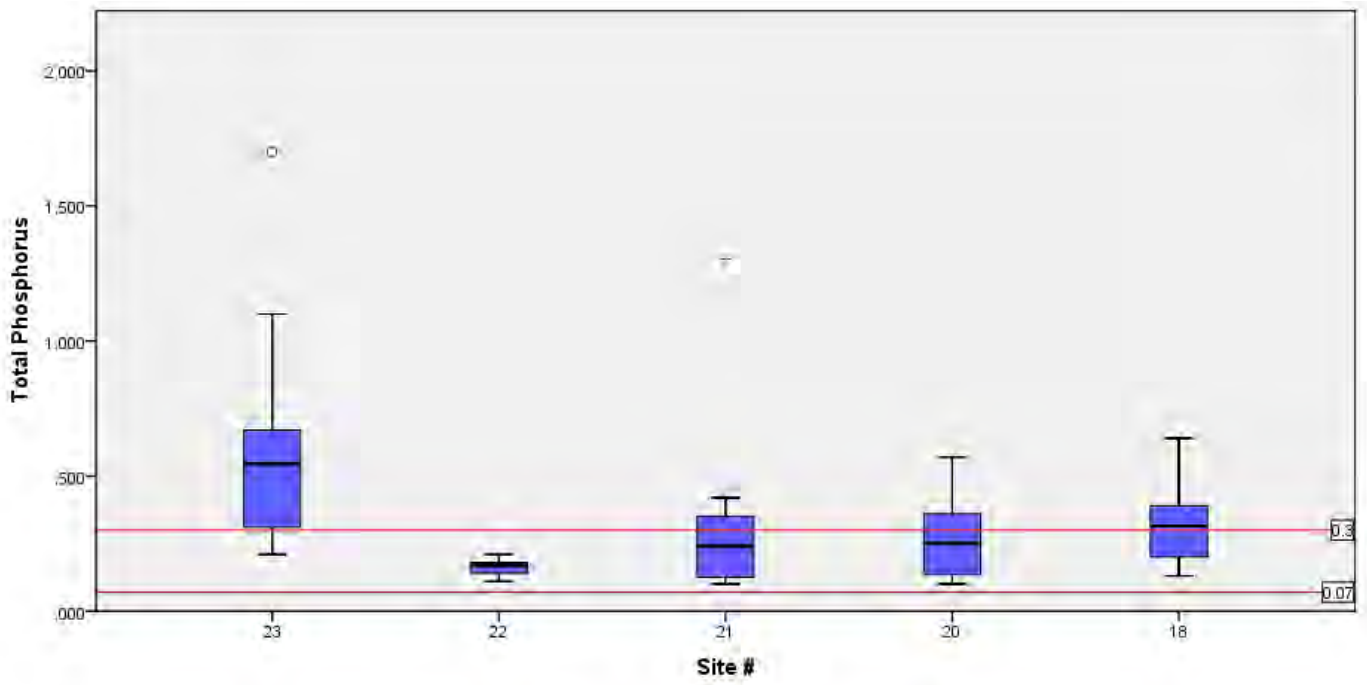

Figure 91 Box plot illustrating site total phosphorus concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 92 shows that 100% of the samples collected at Sites 18 and 23 exceeded the 1.09 mg/L nitrate threshold. Site 23 had a median nitrate concentration greater than the 10 mg/L threshold. Nitrate concentrations at Sites 20 and 21 typically (>75%) fell below 1.09 mg/L.

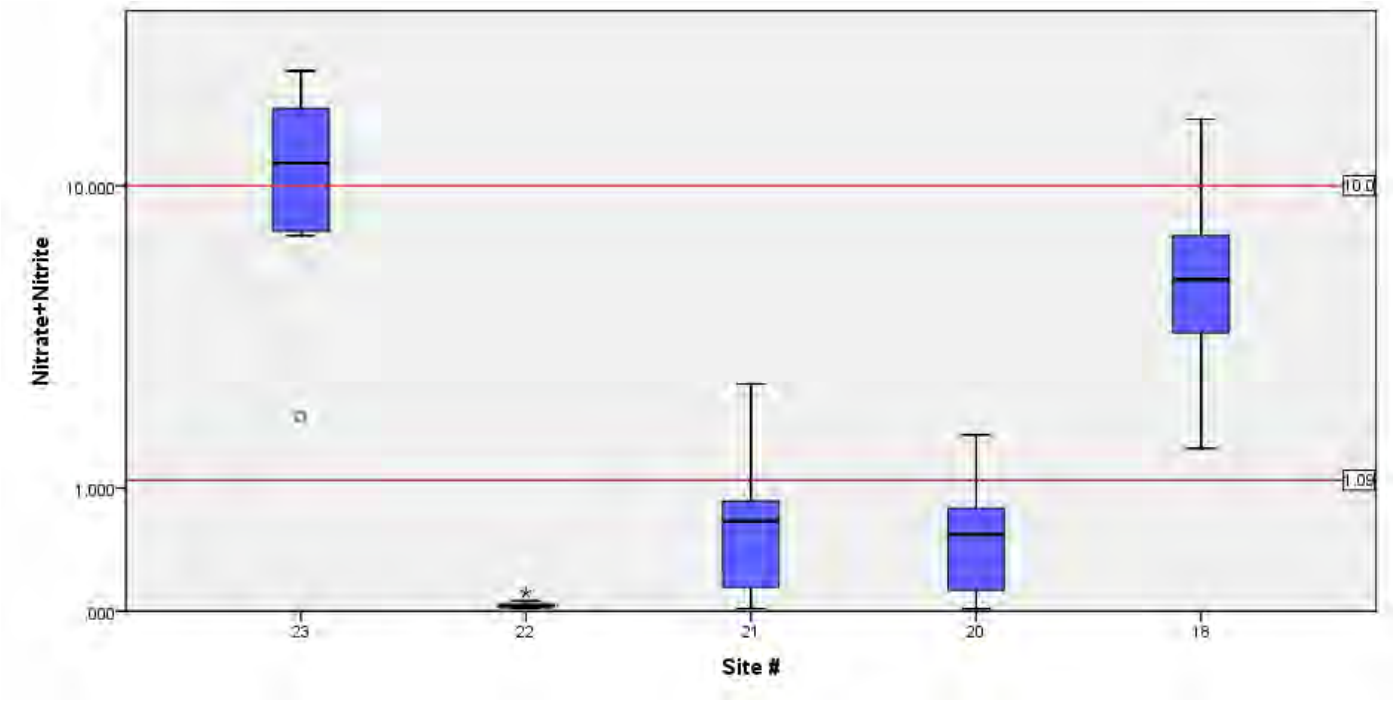

Figure 92 Box plot illustrating site nitrate concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 93 shows that all sites within the subwatershed had median total Kjeldahl nitrogen concentrations in excess of the 0.68 mg/L threshold. Sites 20, 21, and 23 had median concentrations in excess of 1.27 mg/L. Aside from the outlier observed at Site 21, Site 20 generally had the highest total Kjeldahl nitrogen concentrations.

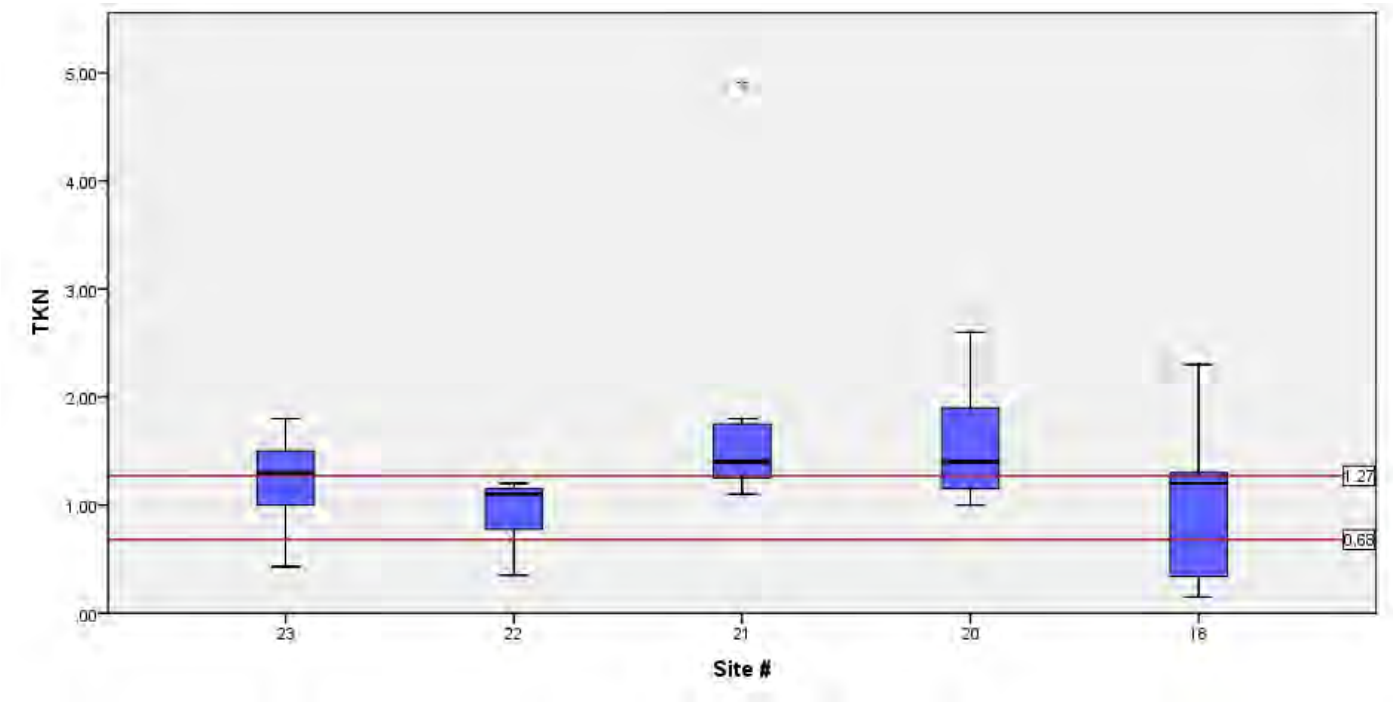

Figure 93 Box plot illustrating site total kjeldahl nitrogen concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 94 shows that median ammonia concentrations were above 0.03 mg/L at all sites. Median ammonia concentrations at Sites 21 and 20, were in excess of 0.21 mg/L. Ammonia concentrations show a slight overall

decrease moving downstream from Site 21 to Site 20. However, the median concentration actually increases indicating there may be an additional source between the sites.

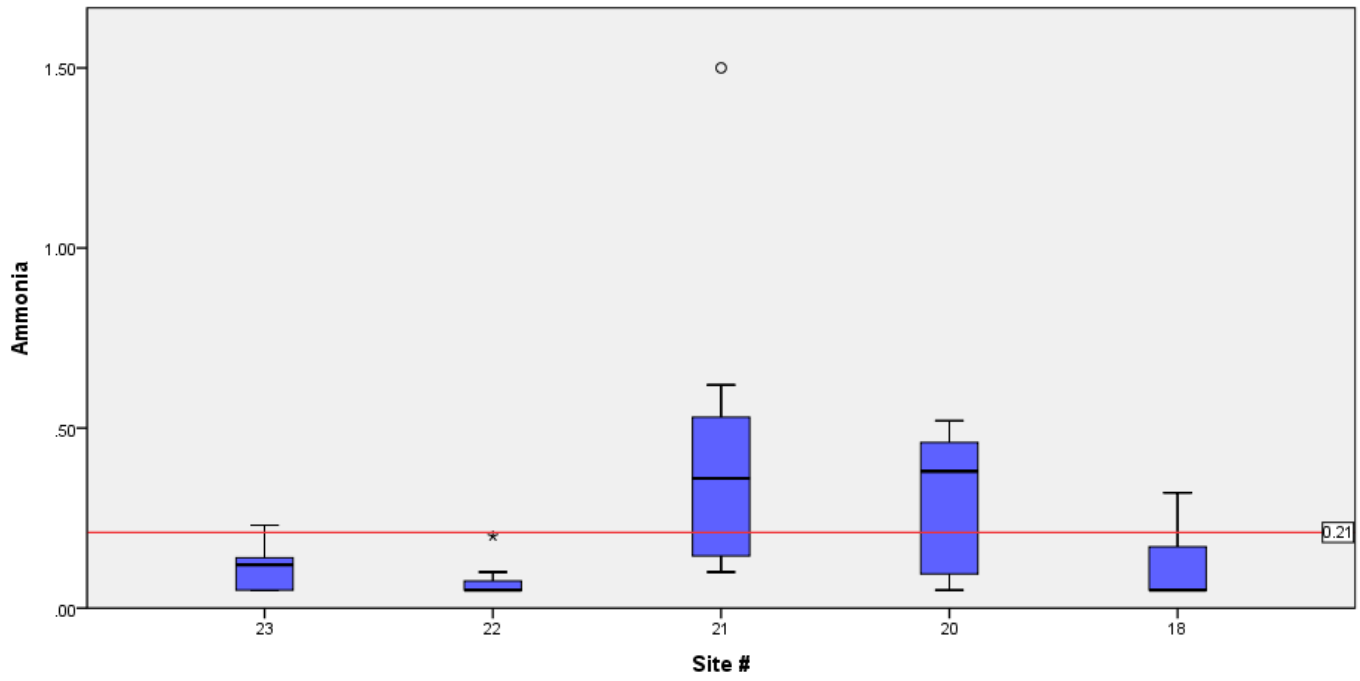

Figure 94 Box plot illustrating site ammonia concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.8 *Suspended Solids & Turbidity*

Figure 95 shows that Site 22 regularly exceeded (>75%) the 30 mg/L total suspended solids threshold value. Exceedances at this site occurred both during dry and wet weather conditions. There was an increasing trend in suspended solid median concentrations moving from Site 21 downstream to Site 20. Site 21 and 18 had one observation each exceeding the threshold. These exceedances corresponded to rain events a few days prior to sampling.

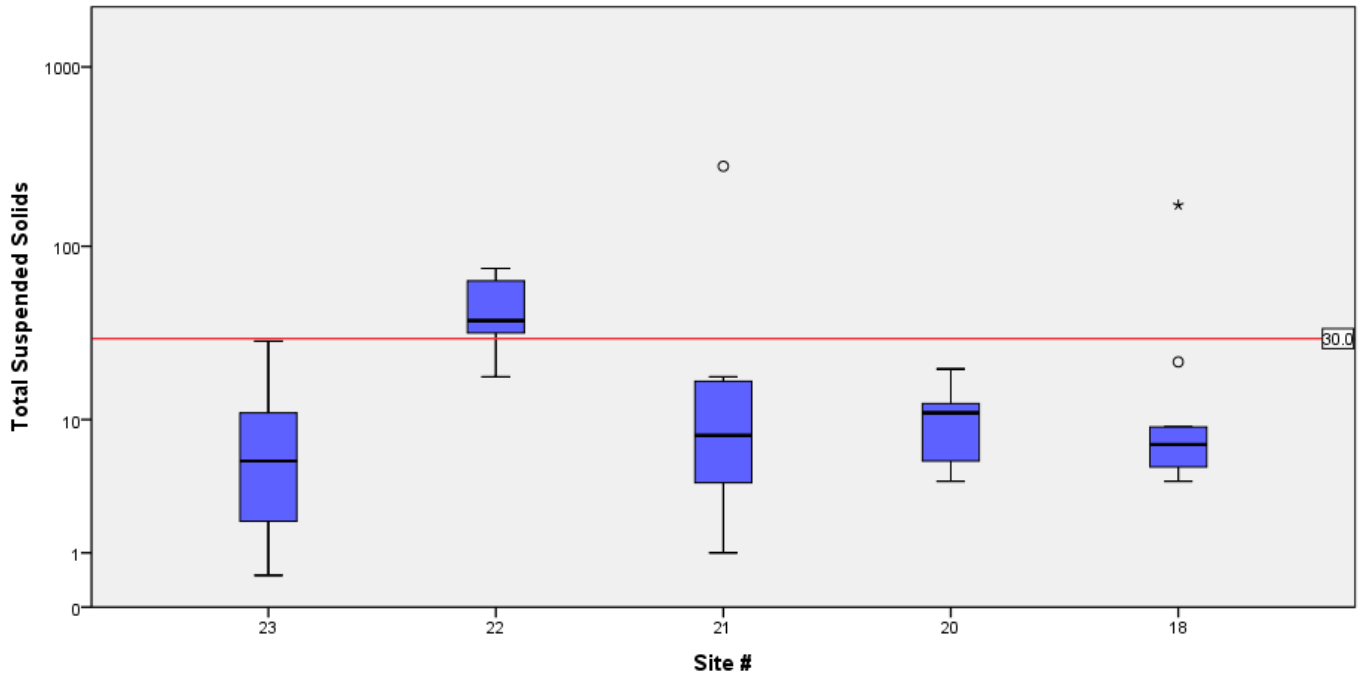

Figure 95 Box plot illustrating site total suspended solids concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 96 shows similar site patterns for turbidity as was observed for total suspended solids. Site 22 had the highest turbidity levels with more than 75% of the samples exceeding the 25 NTU threshold. Sites 18, 20, 21 and 23 had median turbidity concentration below the 10.4 NTU threshold. However, median concentrations at Sites 20 and 21 were very near 10.4 NTU and almost 50% of the samples exceeded this threshold.

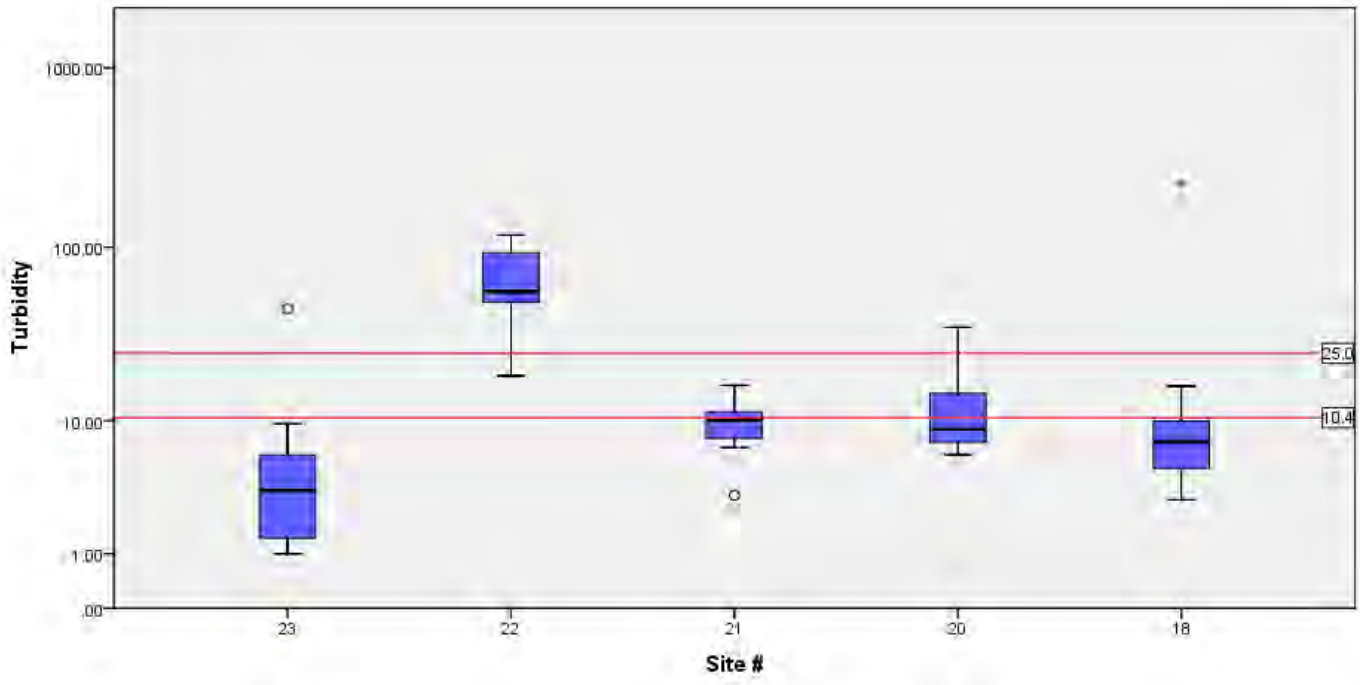

Figure 96 Box plot illustrating site turbidity levels within the Main Beaver Dam Ditch Subwatershed

4.2.2.9 *Habitat*

Figure 97 shows that Sites 22-20 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). The major habitat limitations for Sites 22-20 include poor substrate, in-stream cover, channel morphology, riparian and riffle quality. Stream substrates at Sites 22 and 21 were characterized by muck, heavy siltation and extensive embeddedness. Sites 23, 20, and 18 had sand bottoms. Sites 20 and 18 had moderate levels of siltation and embeddedness. Sites 23-20 had poor channel morphology characterized by low to no channel sinuosity, poor riffle/pool development, recent or recovering from channelization, and moderate stability.

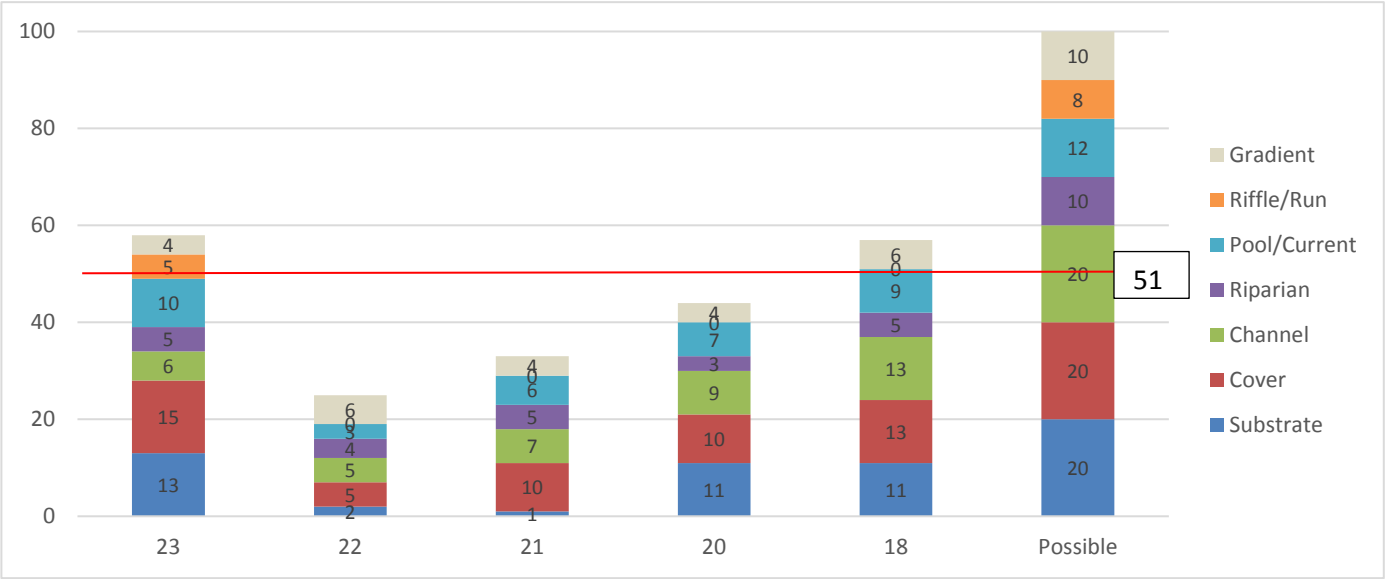

Figure 97 Site qualitative habitat evaluation index scores within the Main Beaver Dam Ditch Subwatershed

The poor to generally poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed are located on reaches that are maintained as legal drains (Figure 99).

4.2.3 Land Cover & Land Use

Agricultural and developed lands account for a majority of the land cover within the subwatershed (Figure 98). The greatest concentration of development is located west of Broadway (State Road 53) in Crown Point. Moving east the subwatershed begins to transisiton to a more rural landscape. Most of the homes and small developments located in the unicorporated areas are unsewered. Many areas in the Town of Winfield are also unsewered.

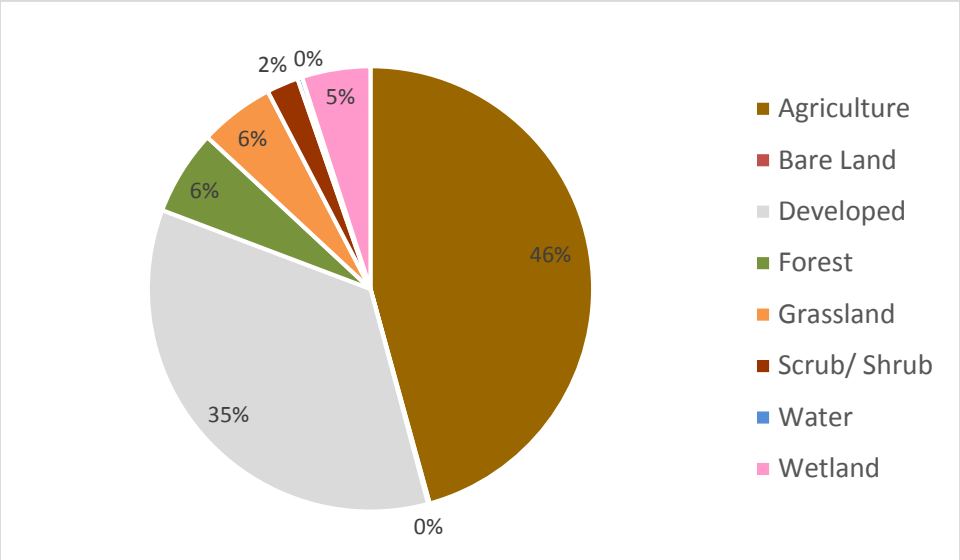

Figure 98 Percent land cover within the Main Beaver Dam Ditch Subwatershed

Table 52 includes land cover information for each site's drainage area. Sites 23 and 22 are predominately developed while Sites 21-20 are mostly agricultural. Site 18 has nearly an equal mix of developed and agriclultral land.

Site 23 and 22's surrounding land use is development within the City of Crown Point. Wetland and forest provide a small buffer from the adjacent developed areas upstream of Site 22 on Smith Ditch. A series of inchannel ponds have have also been excavated along Smith Ditch in this area as well. Site 21's immediated surrounding land use is agriculture. A dairy farm that was once classified as a CAFO is located immediately to the west of the site. Manure from the facility is land applied to the neighboring fields. Upstream of Site 21, Niles Ditch drains contiguous wetland areas surrounded by row crop. Site 20's immediate surrounding land uses low density residential development and agriculture. A majority of the Niles Ditch drainage area is unsewered.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
23	25.5	0.1	45.6	11.0	5.2	3.4	0.7	8.5
22	4.7	0.3	66.7	14.1	4.1	2.2	0.4	7.5
21	67.3	0.0	7.5	9.0	4.8	2.8	0.4	8.2
20	67.3	0.0	7.5	9.0	5.6	3.3	0.3	7.2
18	37.7	0.1	38.6	8.3	5.3	2.8	0.5	6.6

Table 52 Site percent land cover within the Main Beaver Dam Ditch Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 53. Agriculture and/or developed land make up a fairly large percentage of the riparian zone for each site's drainage. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
23	19.4	0.2	34.4	6.0	5.0	5.0	2.6	27.5
22	2.4	0.0	45.6	8.6	6.1	2.5	2.1	32.8
21	59.0	0.0	4.5	2.6	5.7	5.1	0.6	22.4
20	61.4	0.0	4.0	3.5	5.8	5.4	0.5	19.4
18	32.5	0.1	27.4	5.9	5.4	5.5	1.6	21.6

Table 53 Site percent riparian land cover within the Main Beaver Dam Ditch Subwatershed

The TMDL reports six NPDES permitted industrial facilities located in subwatershed. (See TMDL for facility locations map). The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. The Crown Point WWTP and a CSO outfall are located on Main Beaver Dam Ditch near Site 23 (Figure 99). The TMDL includes this CSO with the other CSO points in the Headwaters Main Beaver Dam Ditch subwatershed in reporting the number of CSO events, which was 60 between 2009 and 2013. The TMDL documents 19 permit violations for TSS, copper, and ammonia between 2010 and 2013 for the Crown Point WWTP. The baseline assessment conducted as part of the TMDL also documented violations for phosphorus between June 2013 and July 2014 for the Crown Point WWTP.

Twelve potential livestock facilities were identified in the subwatershed (Figure 99). Most of the facilities are located east of I-65 with the greatest number occurring in the Niles Ditch drainage area. The facility located east of Site 21 was formerly regulated as a CFO operation (Section 2.6.3.2).

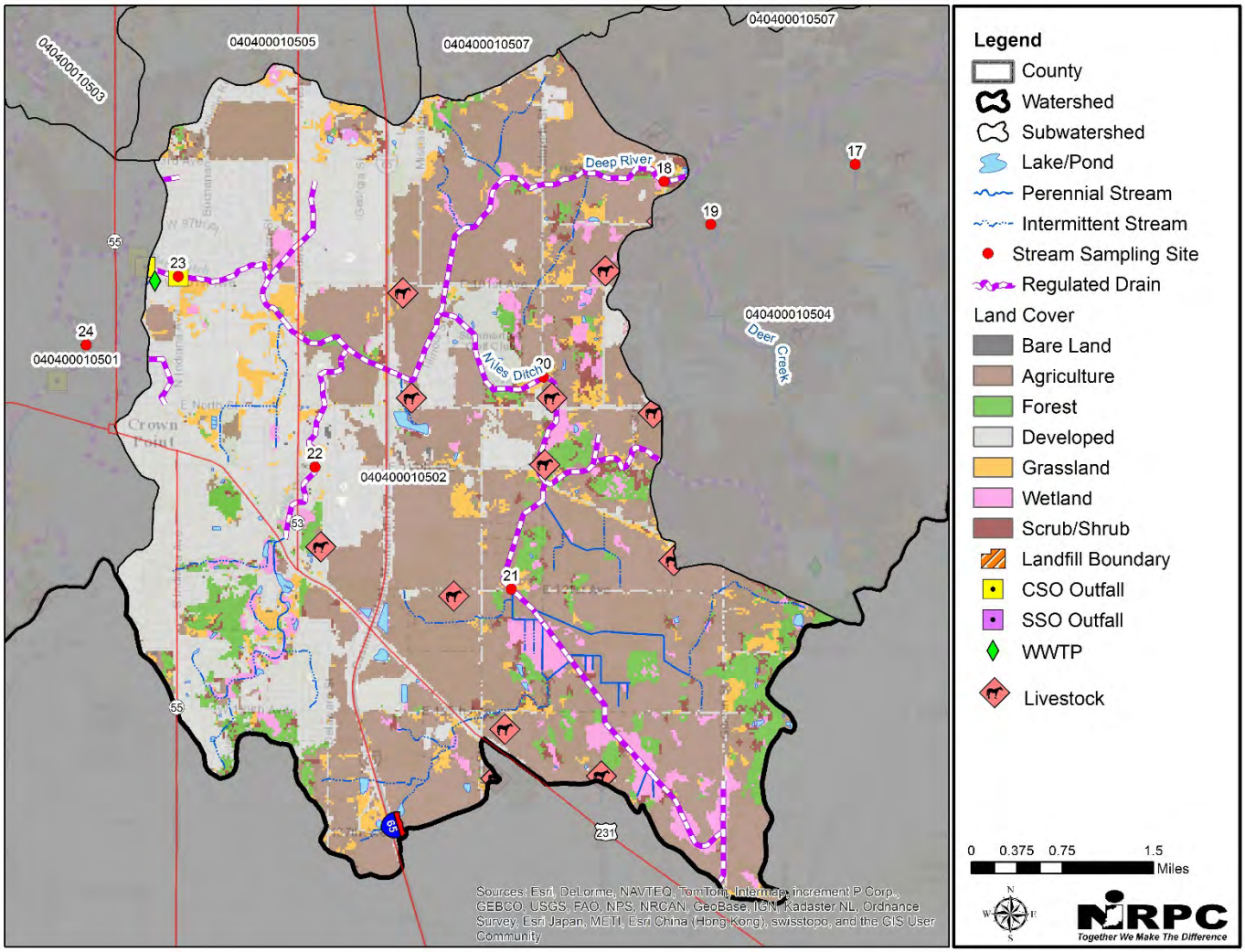

Figure 99 Land cover and land use within the Main Beaver Dam Ditch Subwatershed

4.2.4 Soils

Many of the soils immediately surrounding the tributaries within the subwatershed are rated as hydric indicating these areas would have historically been wetland (Figure 100). Highly erodible or potentially highly erodible soils appear to be most widely distributed west of Niles Ditch. These soils border or are located in close proximity to a number of tributaries in this area. There are only a few locations where soil slopes are greater than 15%. The most relevant location is upstream of Site 22, adjacent to an intermittent stream south of US Hwy 231. Soil surface textures adjacent to the tributaries are primarily classified as silty clay loam or muck (Figure 7). A majority of the soils in the subwatershed have poor infiltration rates and are prone to producing runoff (Figure 11). These soil characteristics in part help explain the poor substrate conditions observed at Sites 22 and 21 (Section 4.2.2.9).

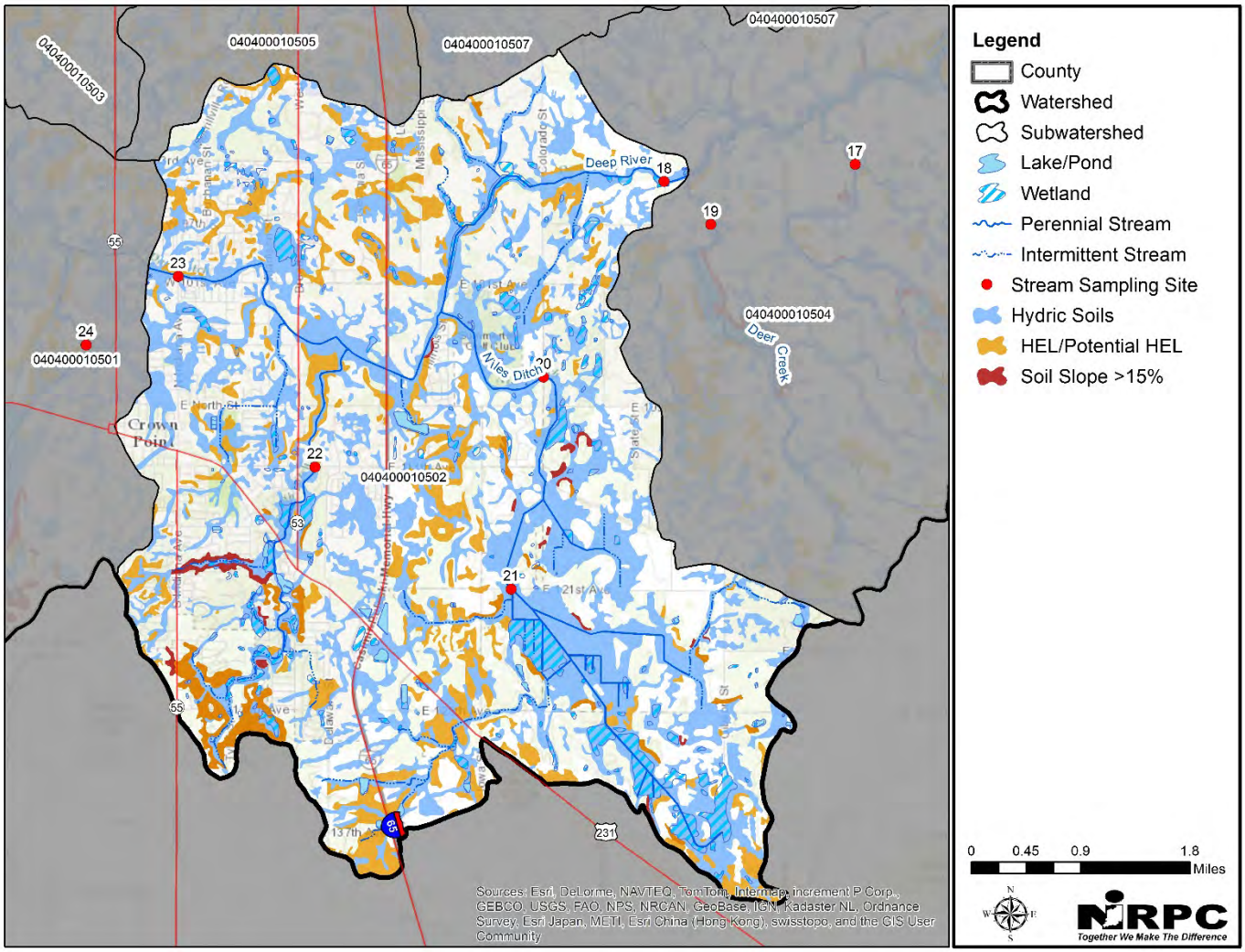

Figure 100 Hydric, highly erodible and steep slope soils within the Main Beaver Dam Ditch Subwatershed

4.3 Headwaters Turkey Creek Subwatershed (HUC 0404000103)

4.3.1 Overview

The Headwaters Turkey Creek subwatershed is located in the west central portion of the watershed. It drains approximately 21.2 mi² of primarily developed (55%) land. Based on the monitoring completed by IDEM, five stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high *E. coli* and nutrient levels.

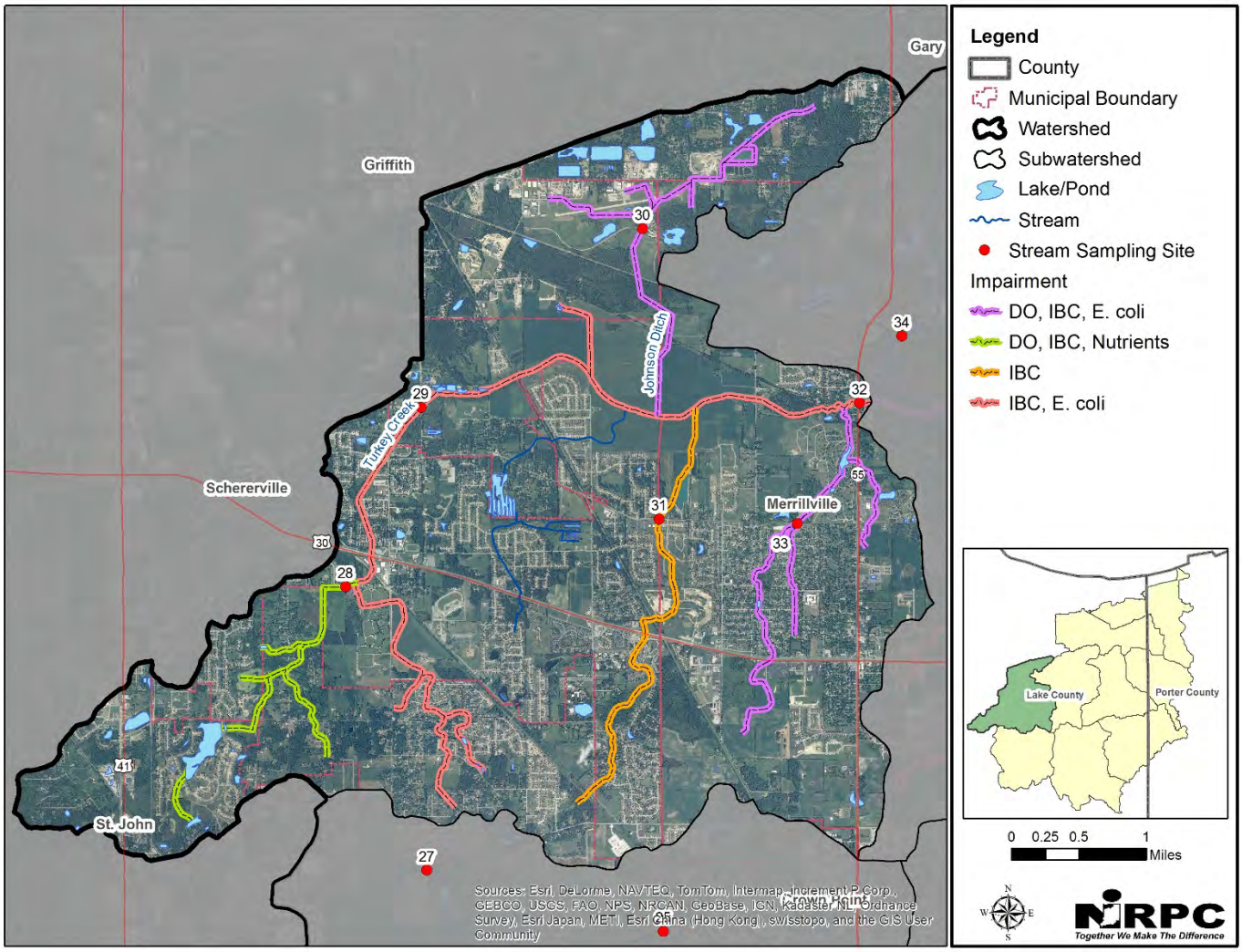

Figure 101 Impaired streams within the Headwaters Turkey Creek Subwatershed

4.3.2 Water Quality

IDEM collected water quality data at six monitoring stations (Sites 28-33) within the Headwaters Turkey Creek subwatershed (Figure 101). Site 32 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.3.2.1 *Pathogens*

Figure 102 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 29, 31, and 33 regularly exceed the single sample *E. coli* water quality standard with median concentrations

above 235 CFU/100 mL. Exceedances occurred across dry to high flow stream flow conditions indicating input from point and nonpoint sources. 75% or less of the observations at Sites 28, 30 and 32 were above 235 CFU/100 mL.

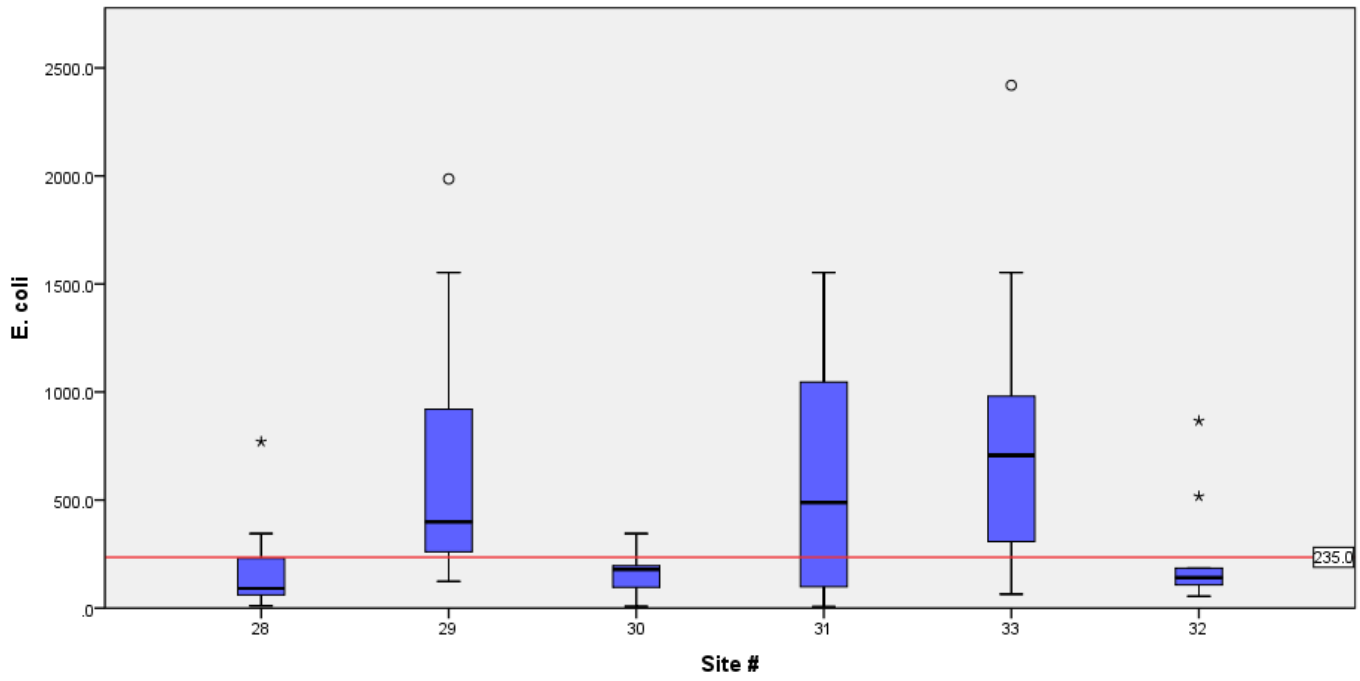

Figure 102 Box plot illustrating site E. coli concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 28, 30, 31 and 33 are not supporting of their Aquatic Life Use designation. Sites 29 and 32 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
28	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
29	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
30	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
31	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
33	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
32	44	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 54 Site fish index of biotic integrity scores within the Headwaters Turkey Creek Subwatershed

4.3.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of them meet their Aquatic Life Use designation. No sample was taken at Site 28 due to the stream being choked with vegetation which

prevented the use of the dip net. The individual metrics used to evaluate the macroinvertebrate communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
28	No Sample	NA	NA	NA
29	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
30	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
31	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
33	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
32	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 55 Site macronvertebrate index of biotic integrity scores within the Headwaters Turkey Creek Subwatershed

4.3.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 20-22°C, (68-72°F) with Sites 28 and 30 being the warmest.

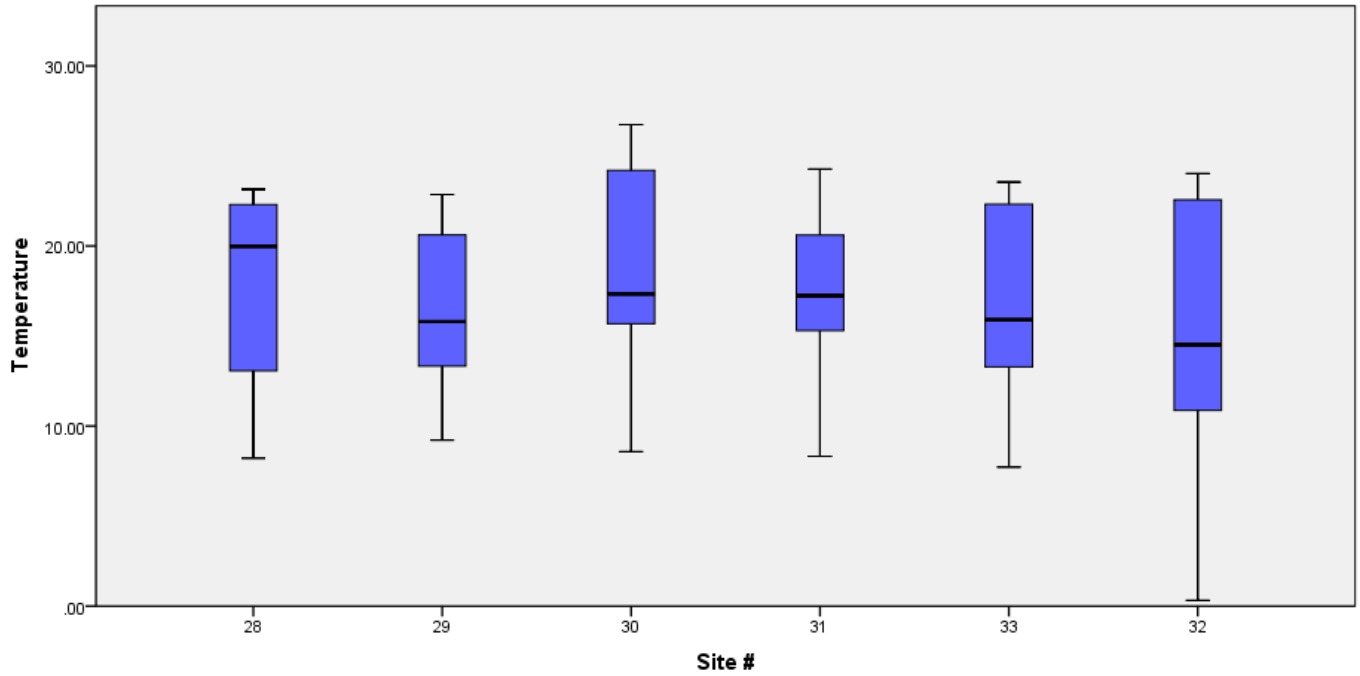

Figure 103 Box plot illustrating site temperatures within the Headwaters Turkey Creek Subwatershed

4.3.2.5 *Dissolved Oxygen*

Figure 104 shows that low dissolved oxygen levels are primarily an issue at Sites 28 and 33. Site 28 has a median dissolved oxygen concentration below the 4 mg/L water quality standard. Site 33's median concentration was much higher, but more than 25% of the observations fell below 4 mg/L. Site 30 had two samples that were slightly less

than 4 mg/L. Site 32's exceedance of 12 mg/L occurred in December so is not likely a concern given the dissolved oxygen concentrations observed at the site during other times of the year.

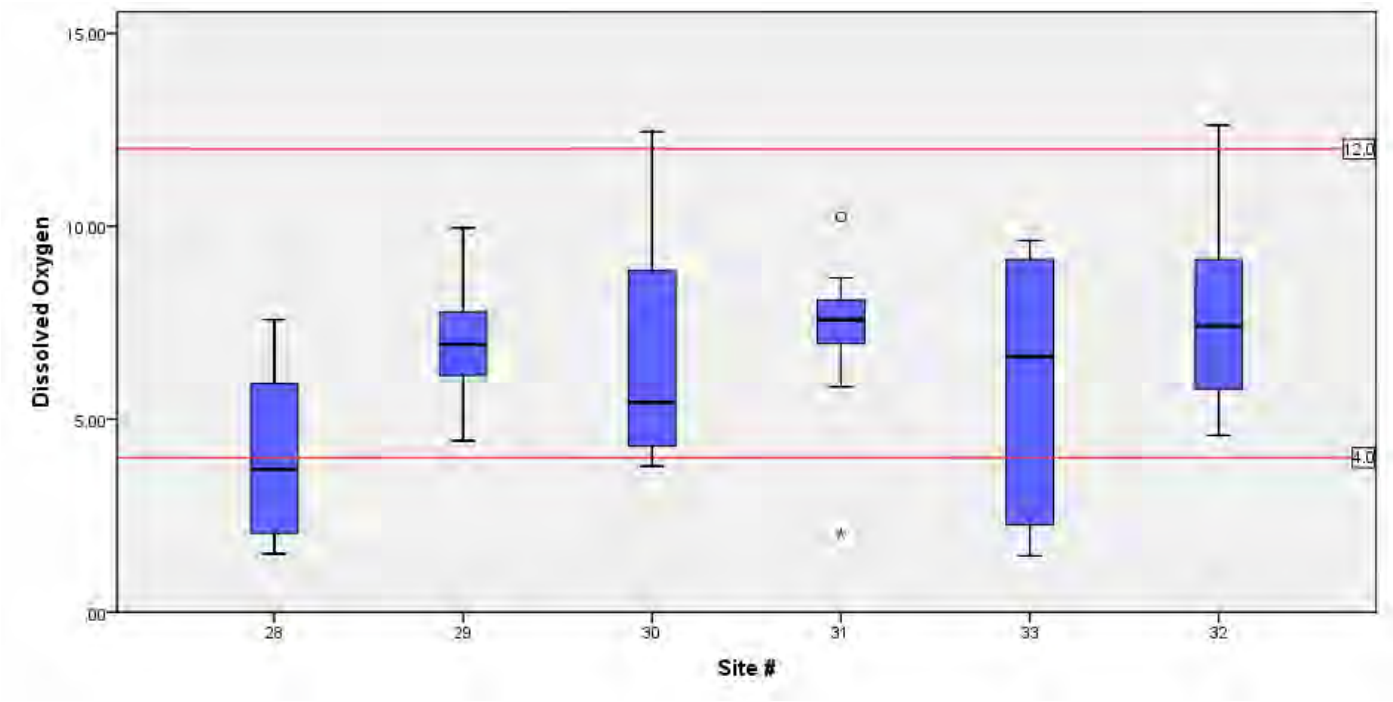

Figure 104 Box plot illustrating site dissolved oxygen concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.6 *Total Organic Carbon*

Figure 105 shows organic material loading and decomposition is at least partially driving the dissolved oxygen issues observed at Site 28. Organic material doesn't appear to be a factor in the low oxygen levels observed at Site 33.

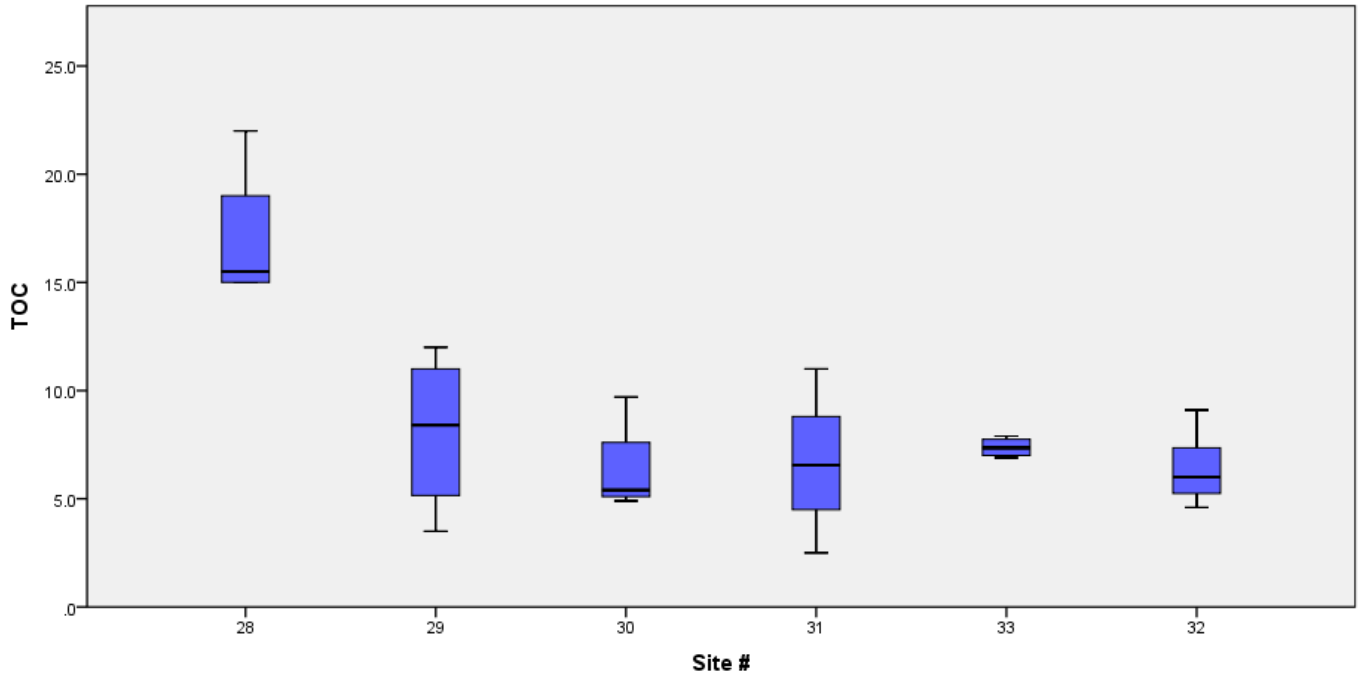

Figure 105 Box plot illustrating site TOC concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.7 *Nutrients*

Figure 106 shows that Site 28, 29, 31, and 33 had median total phosphorus concentrations above 0.07 mg/L. Aside from the outlier data point observed at Site 28, Site 31 generally had the highest total phosphorus concentrations. Site 28's exceedance of the 0.3 mg/L threshold occurred during dry stream flow conditions in the summer indicating a possible point source contribution.

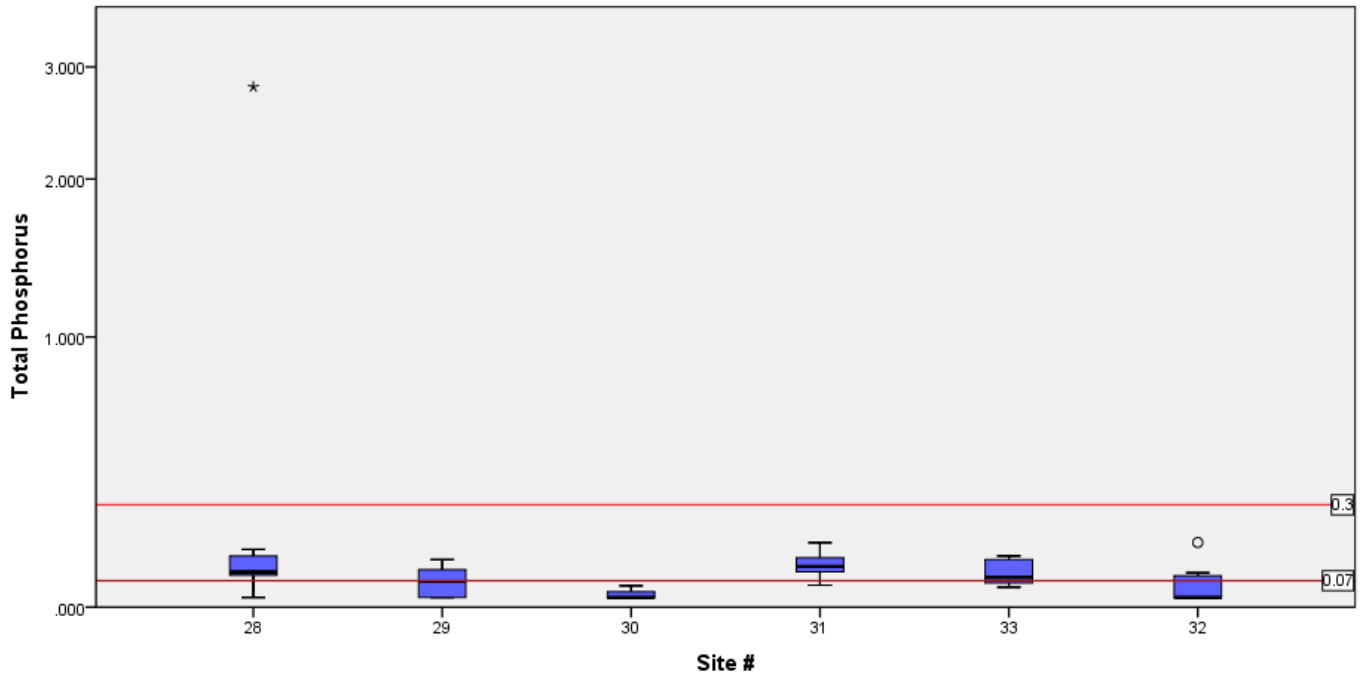

Figure 106 Box plot illustrating site total phosphorus concentrations within the Headwaters Turkey Creek Subwatershed

Figure 107 shows that none of the sites had nitrate concentrations that exceeded the 1.09 mg/L threshold.

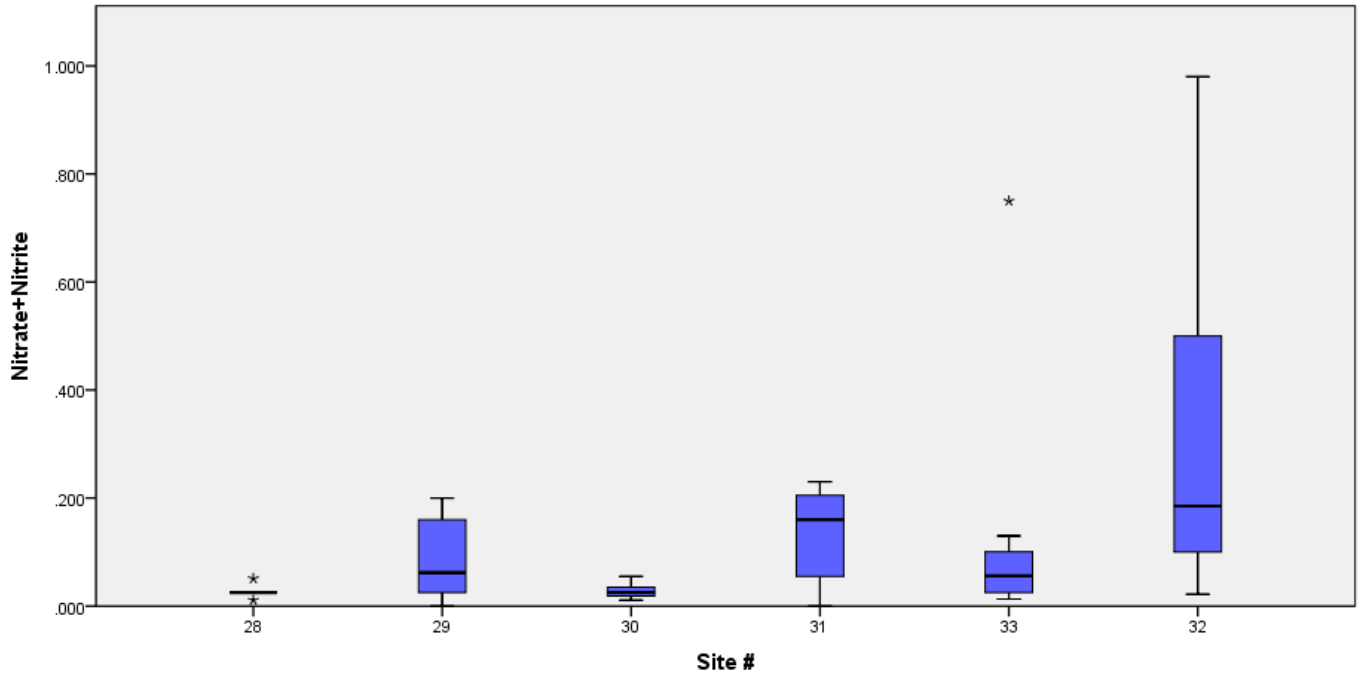

Figure 107 Box plot illustrating site nitrate concentrations within the Headwaters Turkey Creek Subwatershed

Figure 108 shows that Sites 28, 29 and 33 have median total Kjeldahl nitrogen concentrations above 0.68 mg/L. Sites 28 and 23 generally had the highest concentrations with approximately 90% of the observations above 0.68 mg/L. The sample in which the total Kjeldahl nitrogen outlier was observed at Site 28 also resulted in the total phosphorus outlier.

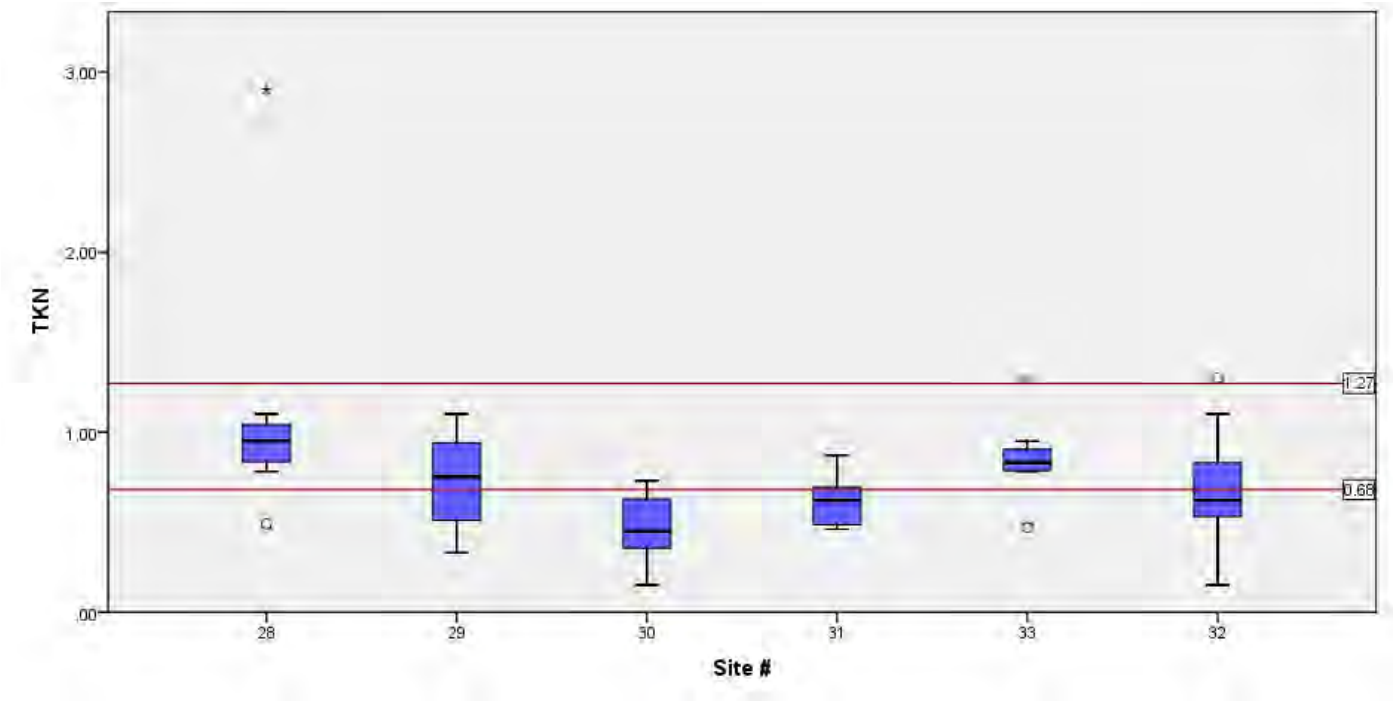

Figure 108 Box plot illustrating site total kjeldahl nitrogen concentrations within the Headwaters Turkey Creek Subwatershed

Figure 109 shows Sites 28, 29, and 32 had median ammonia concentrations above 0.03 mg/L. Sites 30, 31, and 33 typically had ammonia concentrations that fell below the lab detection limit (0.05 mg/L). Sites 28, 30, and 33 each had single observations above the 0.21 mg/L threshold and were considered outliers in this dataset. The outlier observed at Site 28 corresponds with those seen for total phosphorus and total Kjeldahl nitrogen. As levels near 2.0 mg/L, even ammonia-tolerant fish like carp begin to die.

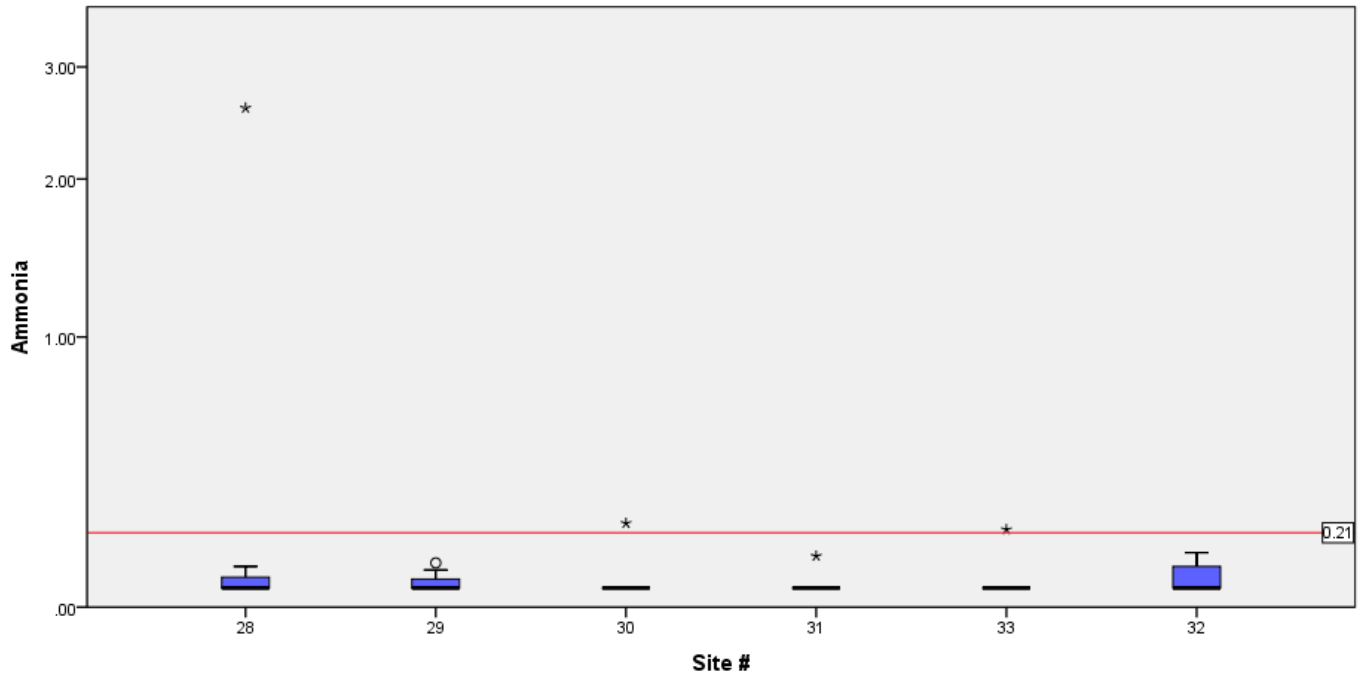

Figure 109 Box plot illustrating site ammonia concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.8 *Suspended Solids & Turbidity*

Figure 110 shows that total suspended solid concentration almost always fell below the 30 mg/L threshold and anything above was considered an outlier in the dataset. The exceedance occurring at Site 28 corresponds to the exceedances observed above for nutrients. Site 32's exceedance occurred during high stream flows and is indicative of runoff and streambank erosion. Site 33's exceedance occurred during low stream flow conditions in March.

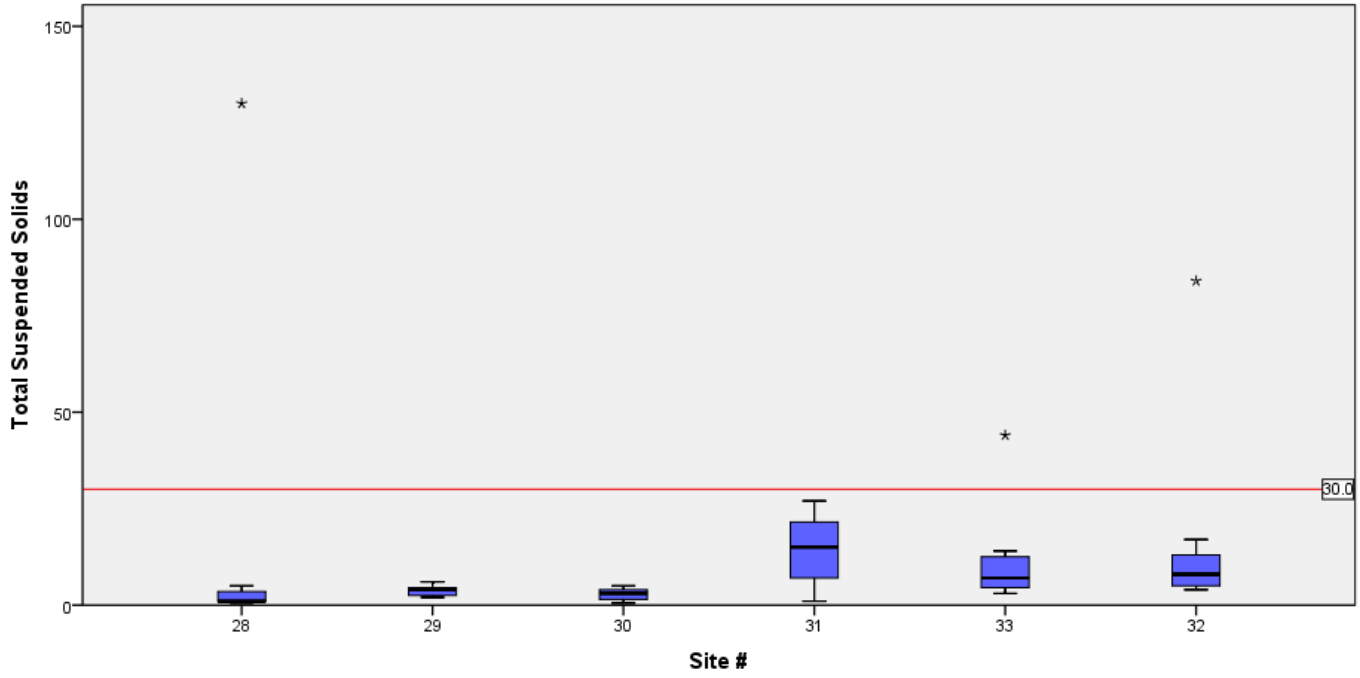

Figure 110 Box plot illustrating site total suspended solids concentrations within the Headwaters Turkey Creek Subwatershed

Figure 111 shows similar site patterns for turbidity as those observed for total suspended solids. Turbidity levels for Sites 28-30 were low, typically falling below the 10.4 NTU threshold. Site 31 and 33 had median turbidity levels greater than 10.4 NTU. Site 31 had the highest median level and more than 25% of its samples were above the 25 NTU threshold.

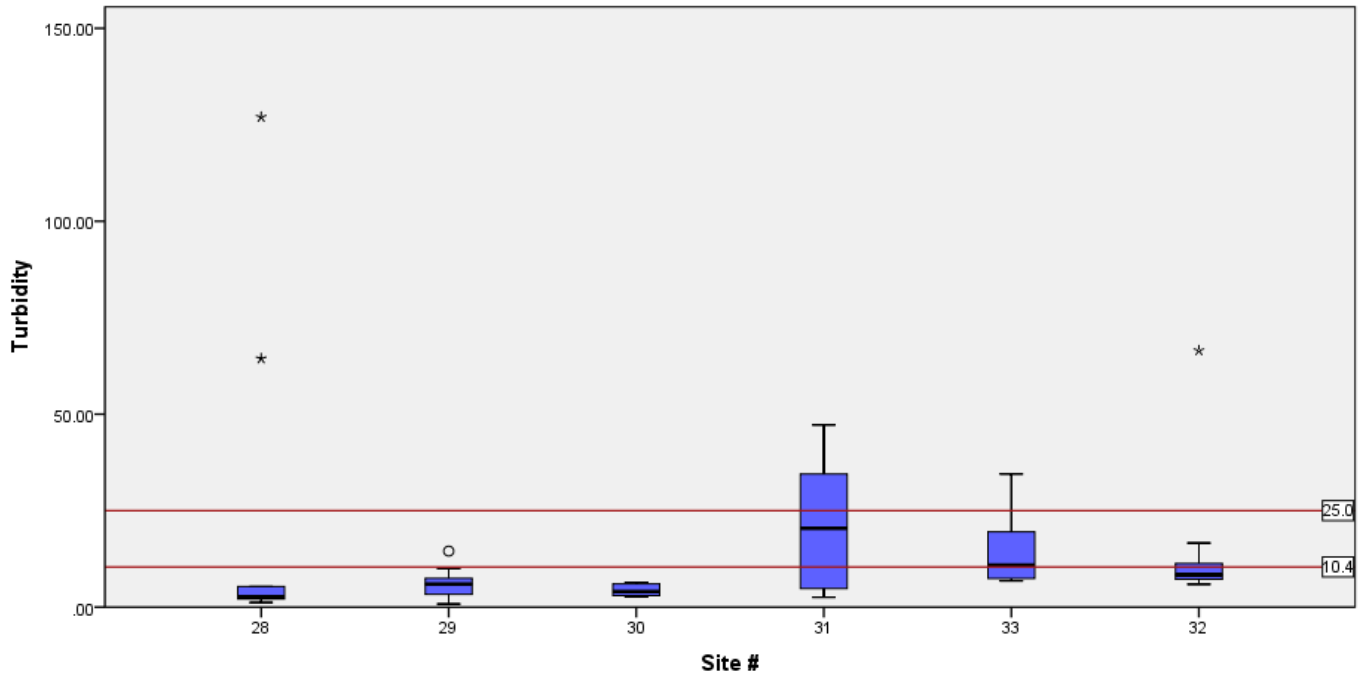

Figure 111 Box plot illustrating site turbidity levels within the Headwaters Turkey Creek Subwatershed

4.3.2.9 *Habitat*

Figure 112 shows that none of the sites generally possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51) with the exception of Site 32 which only had a QHEI score 51. Site 29 received a QHEI score of 49. The major habitat limitations included poor substrate, in-stream cover, and riparian quality and poor channel morphology. None of the sites had riffle/run habitat. Stream substrates at Sites 28, 30, 31, and 33 were characterized by muck, and moderate to heavy siltation and moderate to extensive embeddedness. Stream substrates at Sites 29 and 32 were characterized as sandy with moderate siltation and embeddedness. Sites 28-30 and 33 had poor channel morphology characterized by low to no channel sinuosity, poor to fair riffle/pool development, showed recent sign of channelization or recovery, and had low to moderate stability.

The poor habitat quality at many of these sites is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed, except Site 31, are located on reaches that are maintained as county legal drains (Figure 114). Aerial imagery however shows that at least portions of this tributary to Turkey Creek were modified at some point to improve drainage.

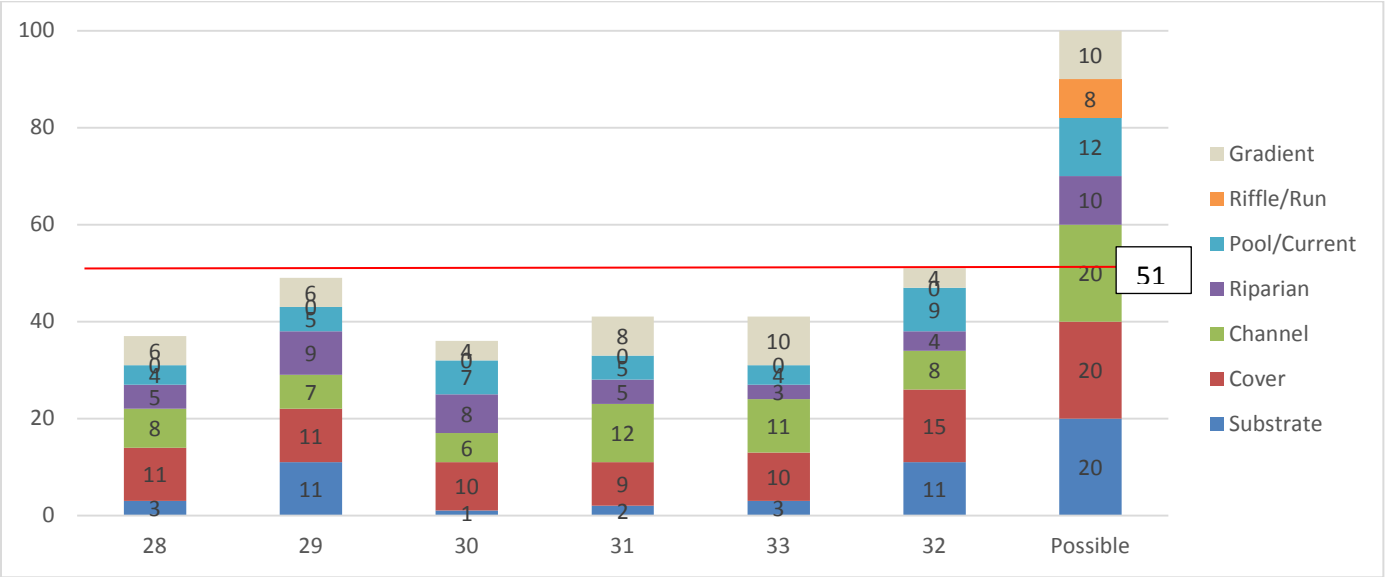

Figure 112 Site qualitative habitat evaluation index scores within the Headwaters Turkey Creek Subwatershed

4.3.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed land (55%) followed distantly by agriculture (16%) lands (Figure 113). Portions of Griffith, St. John, Schererville, and Merrillville fall within the boundaries of the subwatershed. The unincorporated areas are mostly unsewered.

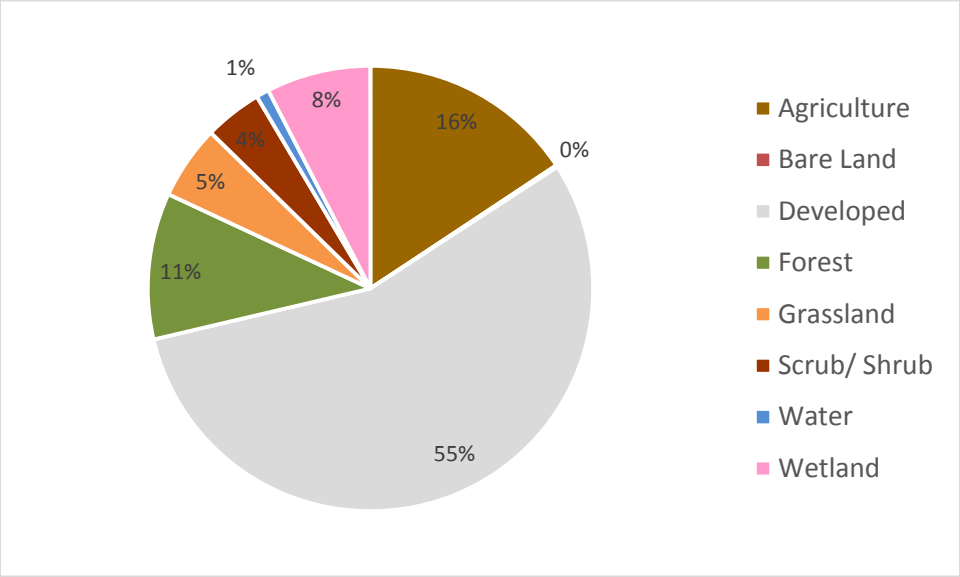

Figure 113 Percent land cover within the Headwaters Turkey Creek Subwatershed

Table 56 includes land cover information for each site's drainage area. Every site's drainage area includes a large percentage of developed land. Site's 28 and 30 have the largest percentage of natural land cover within their drainage areas. The riparian area upstream of Site 28 includes patches of wetland, forest and scrub/shrub habitat that provide a buffer to adjacent development and the small amount of agricultural lands. Site 30 is primarily surrounded by grasslands within Oak Ridge County Park. The area surrounding Site 29 is primarily wetland habitat along Turkey Creek. However most of the land draining to the sites is development. The stream segments draining to Sites 31 and 33 are bordered by development for almost their entire length. Small patches of forest and scrub/shrub habitat are located near their headwaters. The largest agricultural area within the subwatershed borders Turkey Creek between Sites 29 and 32. There appears to be a limited amount of stream buffer along this stretch.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
28	3.6	0.0	61.3	15.6	5.2	5.2	1.4	7.5
29	7.9	0.0	60.3	13.2	6.8	5.4	0.8	5.6
30	0.8	0.0	46.5	22.3	6.7	4.6	4.1	15.0
31	13.3	0.2	65.6	8.5	4.2	3.7	0.7	3.9
33	24.9	0.1	61.6	5.7	3.4	2.5	0.3	1.6
32	15.7	0.1	55.4	10.7	5.4	4.2	0.9	7.6

Table 56 Site percent land cover within the Headwaters Turkey Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 57. Developed land is the most prevalent land cover type within each drainage's riparian zone. In many instances, when agriculture is factored in, human uses comprise over 60% of the riparian zone. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed for a number of sites in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
28	7.0	0.0	32.7	18.5	1.6	11.2	5.1	23.8
29	11.4	0.0	49.3	11.2	4.3	8.0	2.6	13.2
30	0.8	0.0	59.0	12.9	10.8	6.7	4.6	5.1
31	6.9	0.0	69.1	13.5	1.3	3.9	1.3	3.9
33	12.5	0.0	80.4	2.2	0.0	2.2	2.2	0.6
32	17.0	0.0	48.3	9.5	4.1	5.5	1.9	13.8

Table 57 Site percent riparian land cover within the Headwaters Turkey Creek Subwatershed

The TMDL reports seven NPDES permitted industrial facilities located in subwatershed. (See TMDL for NPDES industrial facility location map.) The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. There is one sanitary sewer overflow outfall located in the subwatershed upstream of Site 33 on Kaiser Ditch (Figure 114).

Three potential livestock facilities were identified in the subwatershed. All three are located in the upstream area around Site 28, south of U.S. Hwy 30 (Figure 114). At least one of these, potentially two, drain to the tributary that joins Turkey Creek north of Site 28.

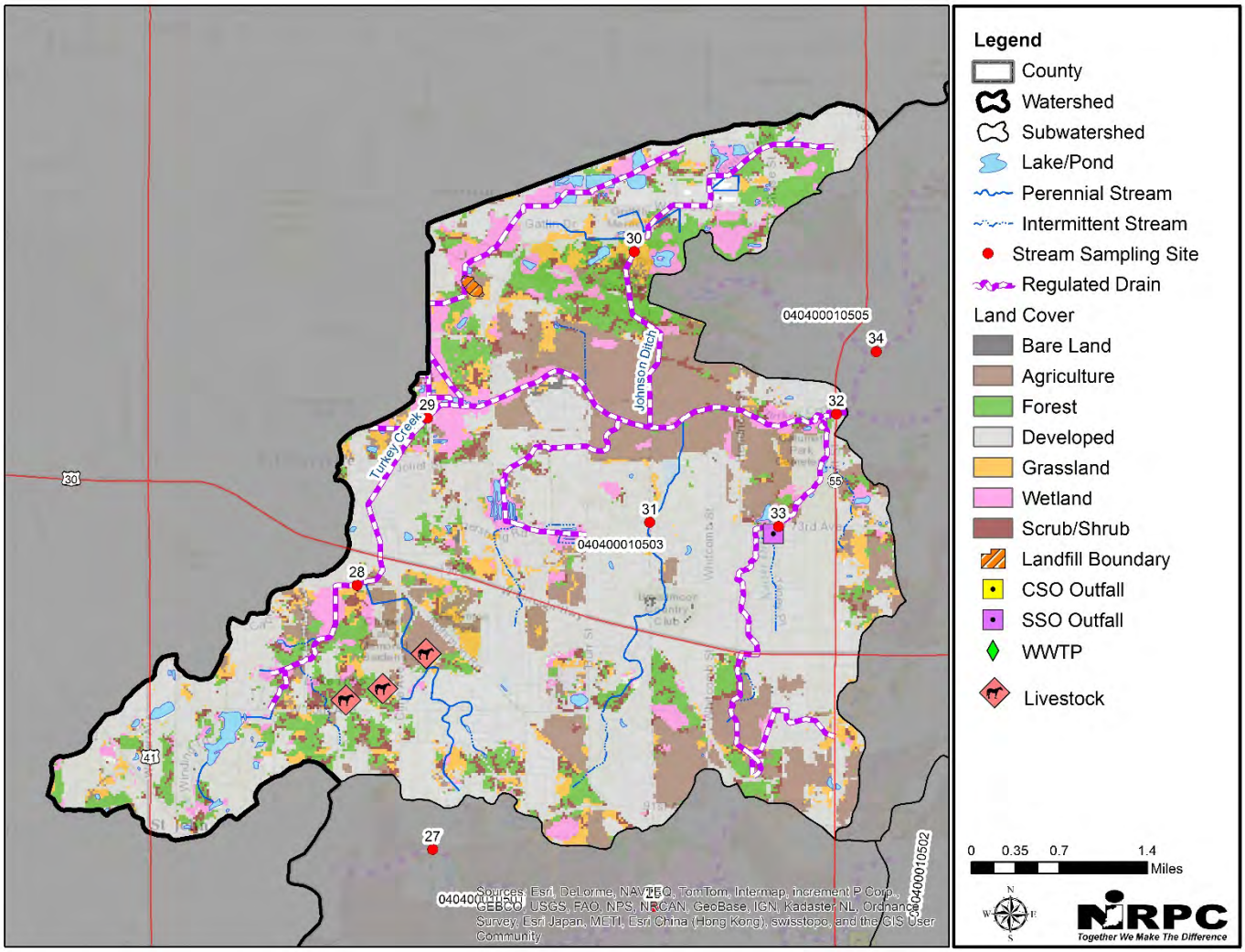

Figure 114 Land cover and land use within the Headwaters Turkey Creek Subwatershed

4.3.4 Soils

Generally the soils located south of Turkey Creek are prone to producing runoff. Many of the streams in this southern half of the subwatershed are bordered by silty clay loam and silt loam which in part explains the poor streambed substrate quality documented in Section 4.3.2.9. The Headwaters Turkey Creek subwatershed has the highest percentage of hydric soils in the entire watershed (Table 9). Much of the area surrounding Turkey Creek and its tributaries were formally wetland. Many of these areas were originally drained for agricultural production but have since been converted to development. A majority of the highly or potentially highly erodible soils in the subwatershed are located in areas with natural land cover or have been developed. Some of these soils are still in agriculture production within the drainage areas of Site 31 and 33. There is one area with steep slopes upstream of Site 30 adjacent to Johnson Ditch (Figure 115).

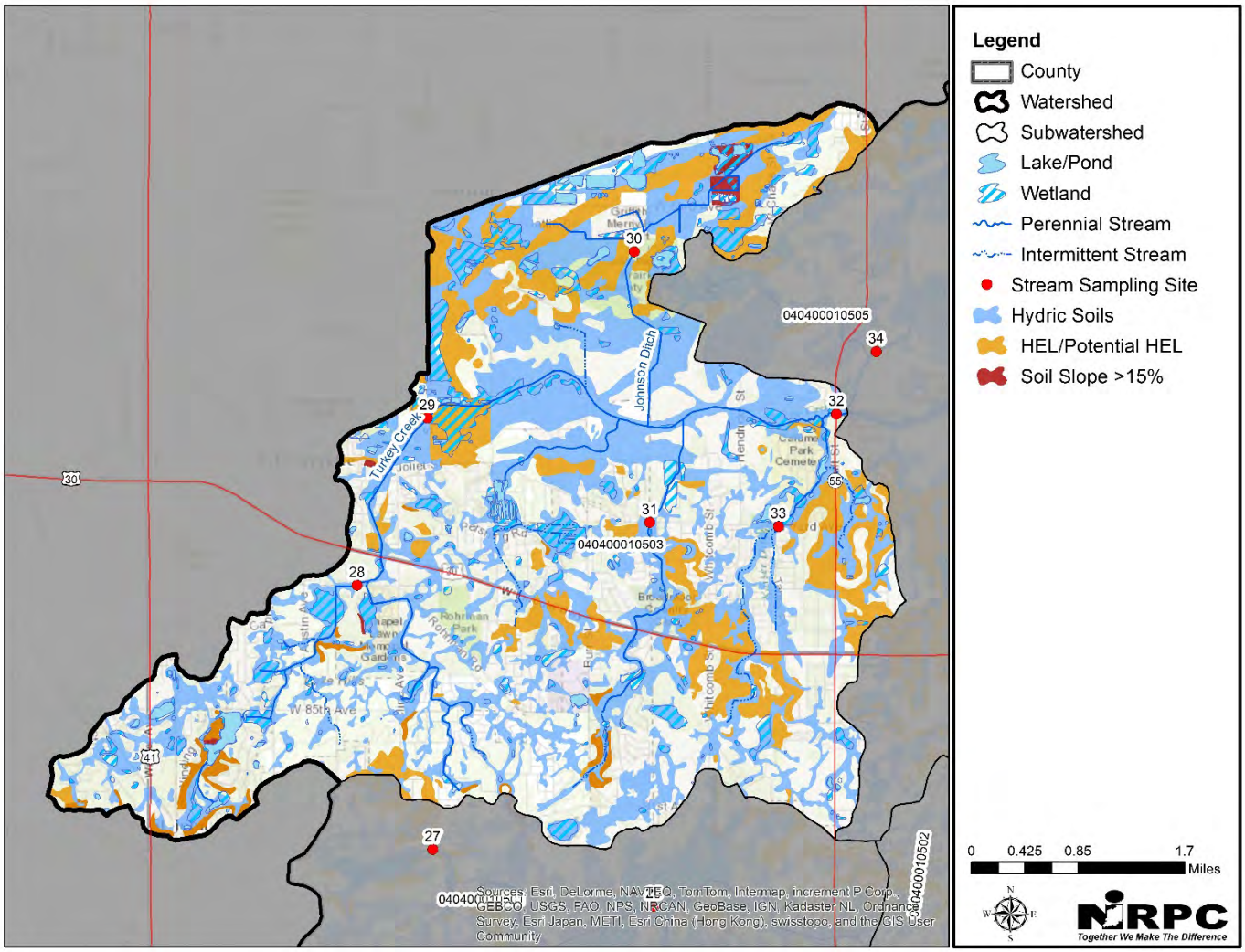

Figure 115 Soils within the Headwaters Turkey Creek Subwatershed

4.4 Deer Creek Subwatershed (HUC 0404000104)

4.4.1 Overview

The Deer Creek subwatershed is located in the south-western portion of the watershed. It drains approximately 26.3 mi² of primarily agricultural (44%), developed (19%), and forested (14%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, siltation, and high nutrient and E. coli levels.

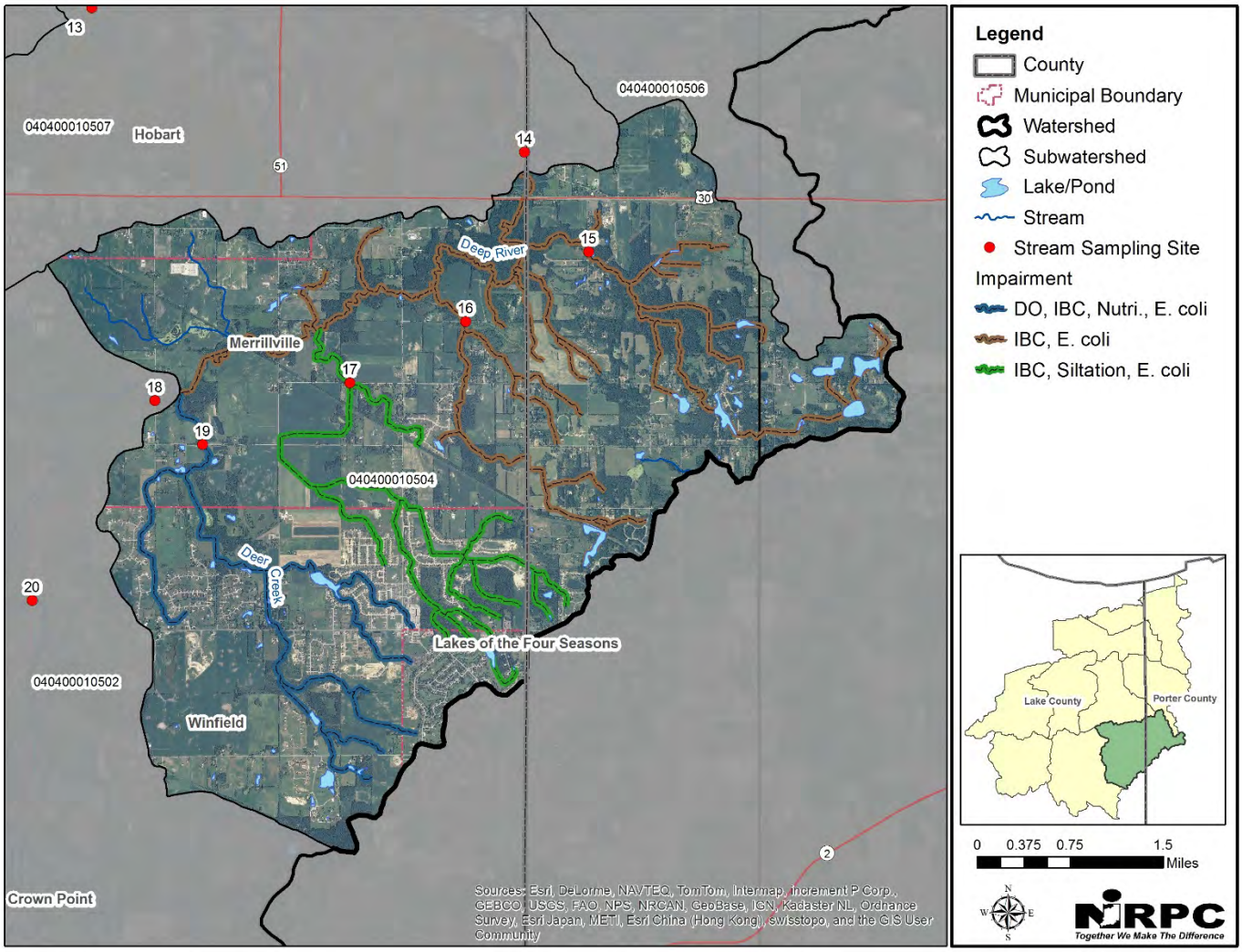

Figure 116 Stream impairements within the Deer Creek Subwatershed

4.4.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 15-17 and 19) within the Deer Creek subwatershed (Figure 116). Site 14, which provided the safest road access point, was used to represent the subwatershed and to assess its contribution to the overall Deer River- Portage Burns Waterway watershed.

4.4.2.1 *Pathogens*

Figure 117 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 15-17 and 19 had median *E. coli* concentration in excess of the 235 CFU/100 mL water quality standard. Site 14

was the only site within the subwatershed in which the median concentration fell below this threshold. The exceedances occurred across high flow and dry conditions indicating both nonpoint and point source contributions.

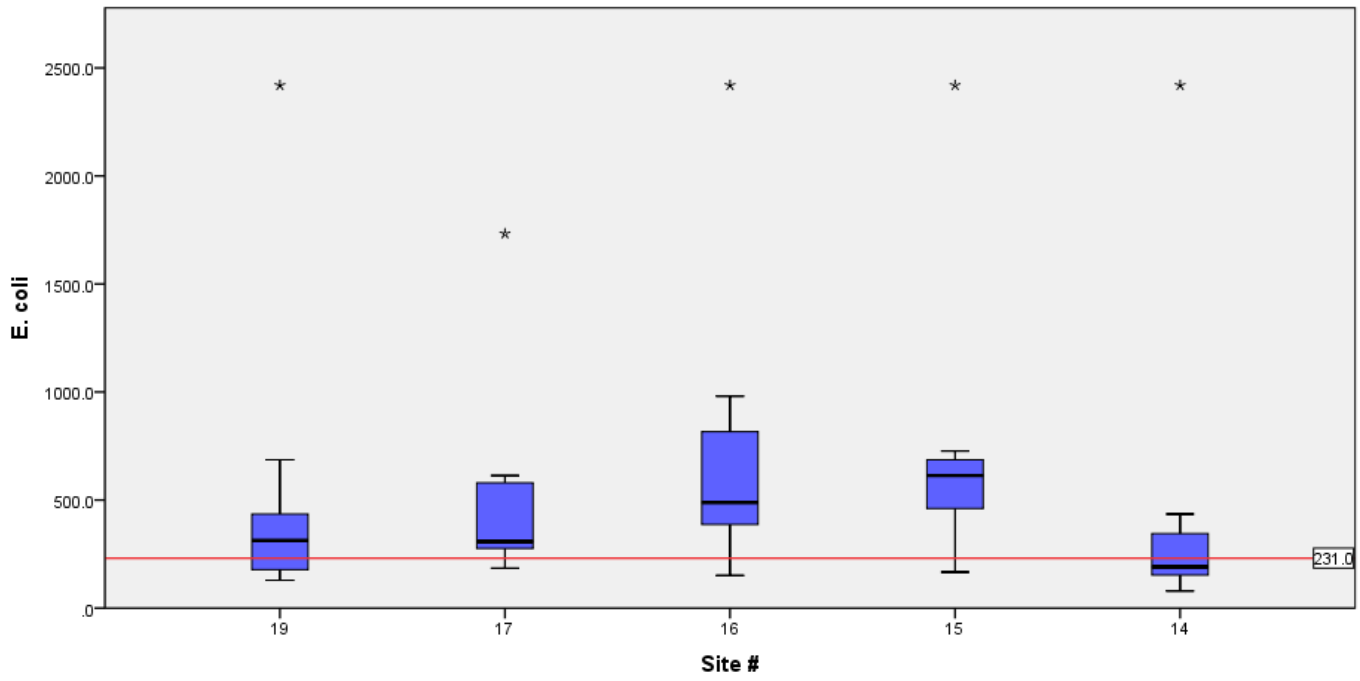

Figure 117 Box plot illustrating site E. coli concentrations within the Deer Creek Subwatershed

4.4.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 15, 17 and 19 are not supporting of their Aquatic Life Use designation. Sites 14 and 16 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent. Fish species that require clean gravel/cobble substrates to spawn were absent/nearly absent at sites 16, 17, and 19.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
19	32	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
17	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
16	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
15	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
14	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 58 Site fish index of biotic integrity scores within the Deer Creek Subwatershed

4.4.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Site 15, 16 and 19 are not supporting of their Aquatic Life Use designation. All sites were dominated by macroinvertebrates that are tolerant of pollution

and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
19	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
17	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
16	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
15	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
14	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 59 Site macroinvertebrate index of biotic integrity scores within the Deer Creek Subwatershed

4.4.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-21°C, (63-70°F) with Sites 19 and 14 being the warmest.

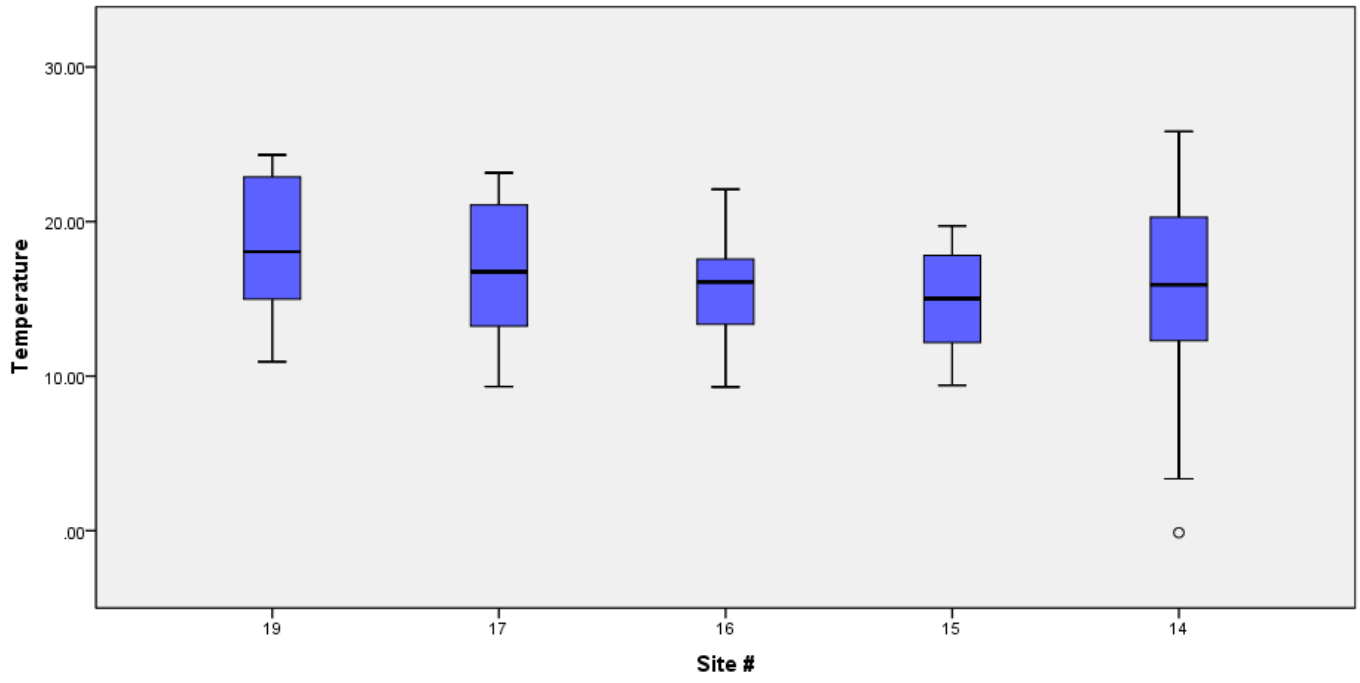

Figure 118 Box plot illustrating site temperatures within the Deer Creek Subwatershed

4.4.2.5 *Dissolved Oxygen*

Figure 119 shows that all sites typically met the dissolved oxygen water quality standard of 4-12mg/L. Site 19 had the lowest median dissolved oxygen concentration and was the only site to have an observation below 4 mg/L. Dissolved oxygen concentrations at Site 19 dropped fairly more rapidly once water temperatures began to warm during late spring. Site 14's exceedance is not likely an issue since this location has extensive riffle habitat and the observation occurred during the winter.

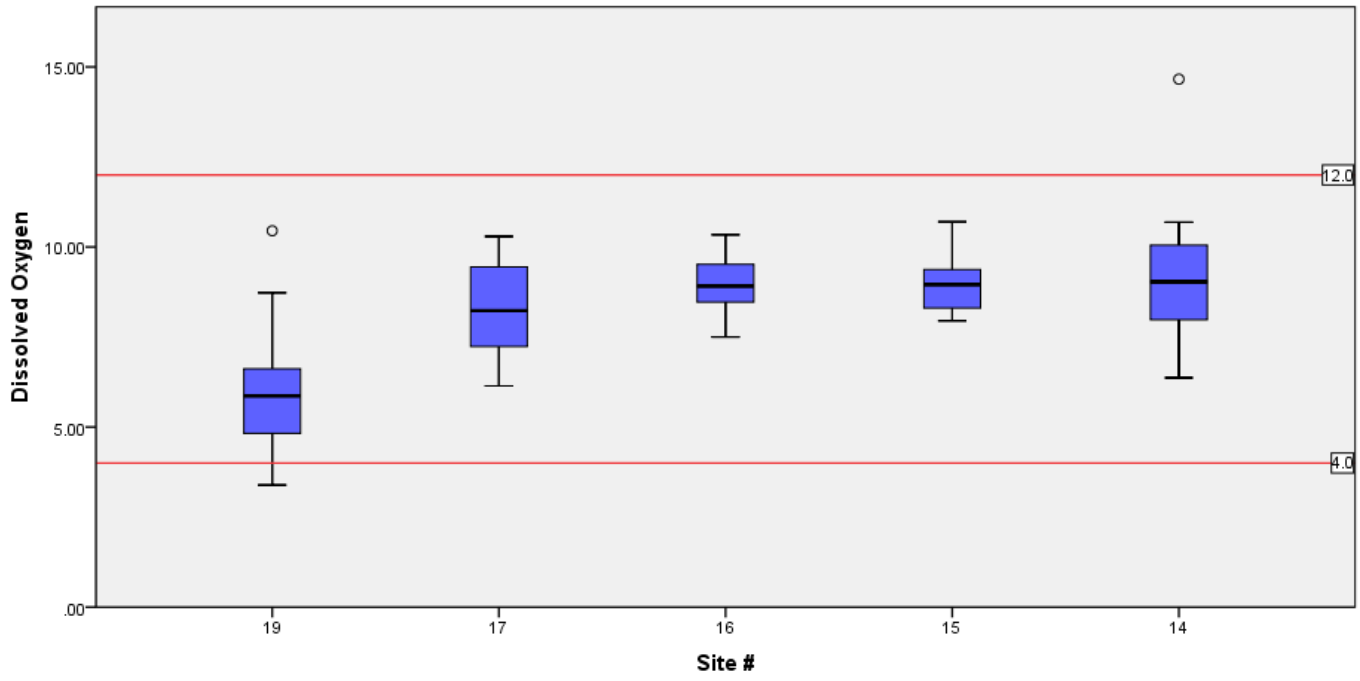

Figure 119 Box plot illustrating site dissolved oxygen concentrations within the Deer Creek Subwatershed

4.4.2.6 *Total Organic Carbon*

Figure 120 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the occasional dissolved oxygen issues observed at Site 19.

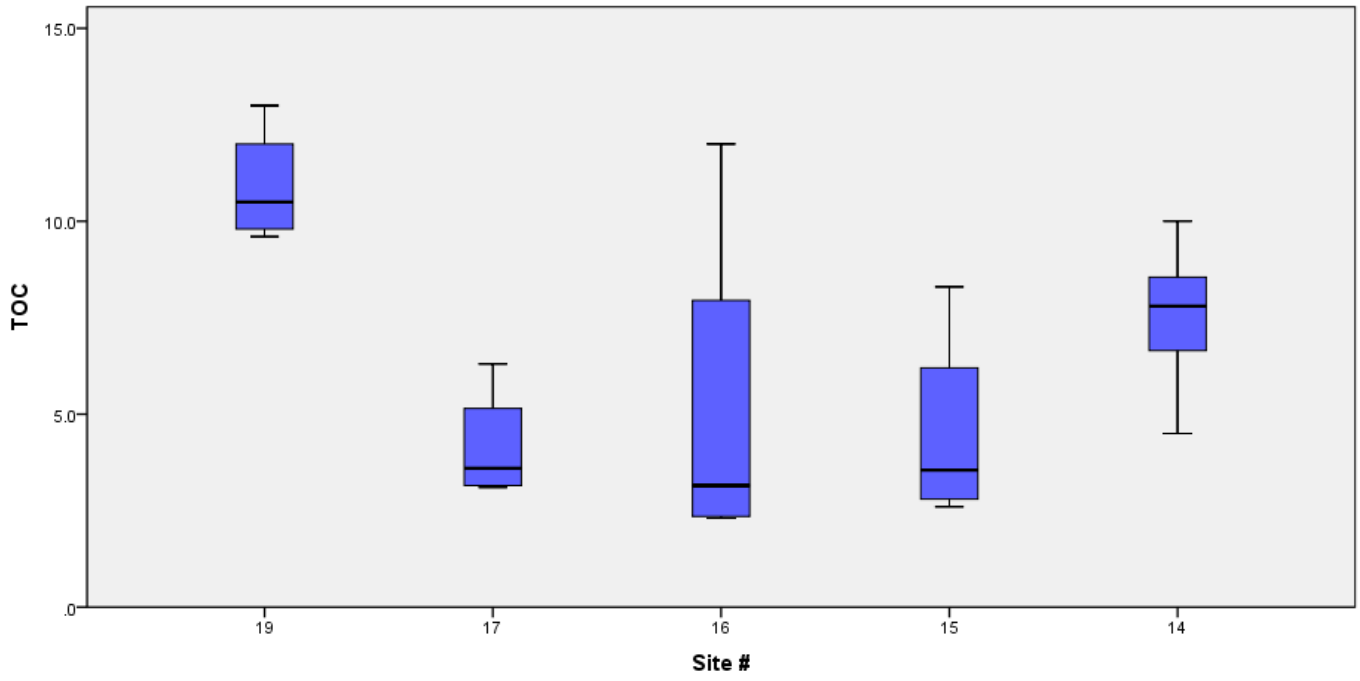

Figure 120 Box plot illustrating site TOC concentrations within the Deer Creek Subwatershed

4.4.2.7 *Nutrients*

Figure 121 shows that the median total phosphorus concentration for Sites 14, 16, and 19 exceed the 0.07 mg/L threshold. Sites 14 and 19 occasionally had observations exceed 0.3 mg/L. Seasonally, mean total phosphorus concentrations were highest during the summer for Sites 19 (0.36 mg/L), 17 (0.06 mg/L), 16 (0.14 mg/L) and 15 (0.05 mg/L) and winter for Site 14 (0.34 mg/L). However, the distribution of total phosphorus concentrations was not found to be statistically different across seasons.

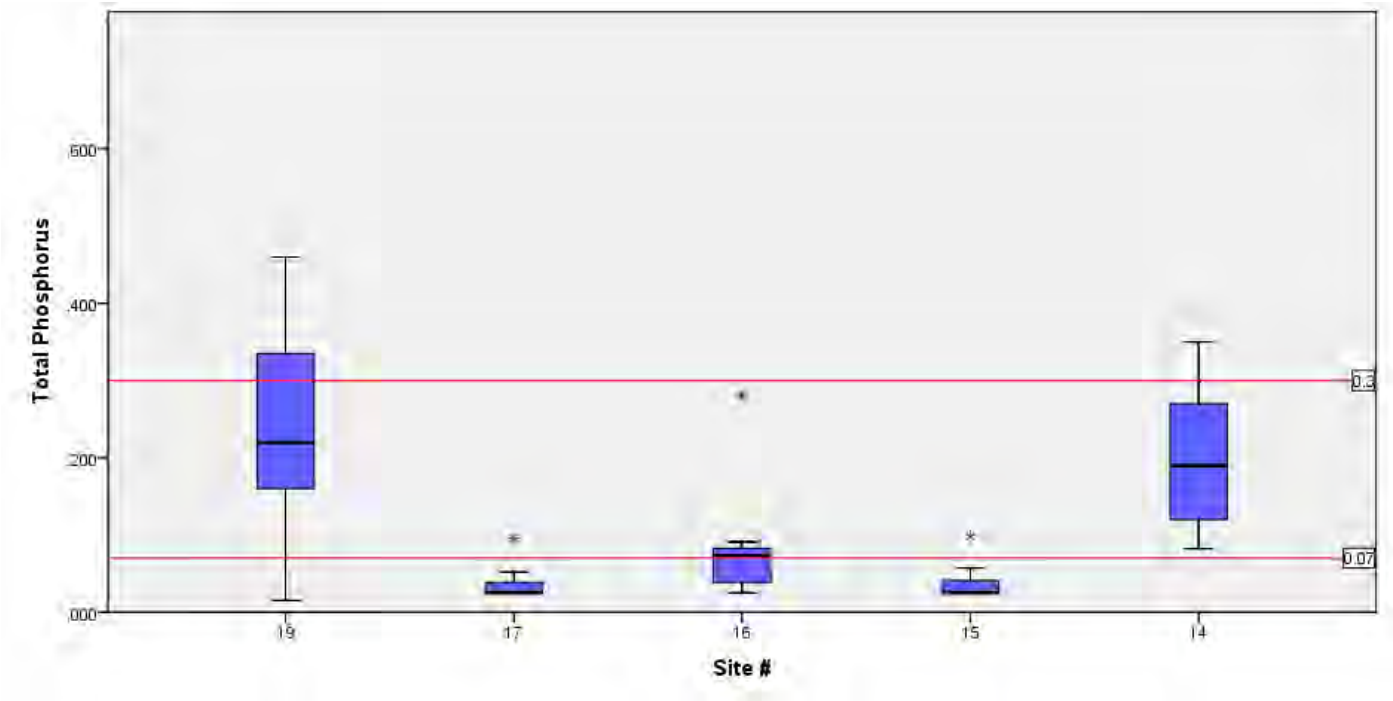

Figure 121 Box plot illustrating site total phosphorus concentrations within the Deer Creek Subwatershed

Figure 122 shows that Site 14 was the only site within the subwatershed to have nitrate concentrations exceed the 1.09 mg/L threshold. All of the nitrate samples collected from Site 14 exceeded this threshold. The maximum concentration observed was 6.9 mg/L.

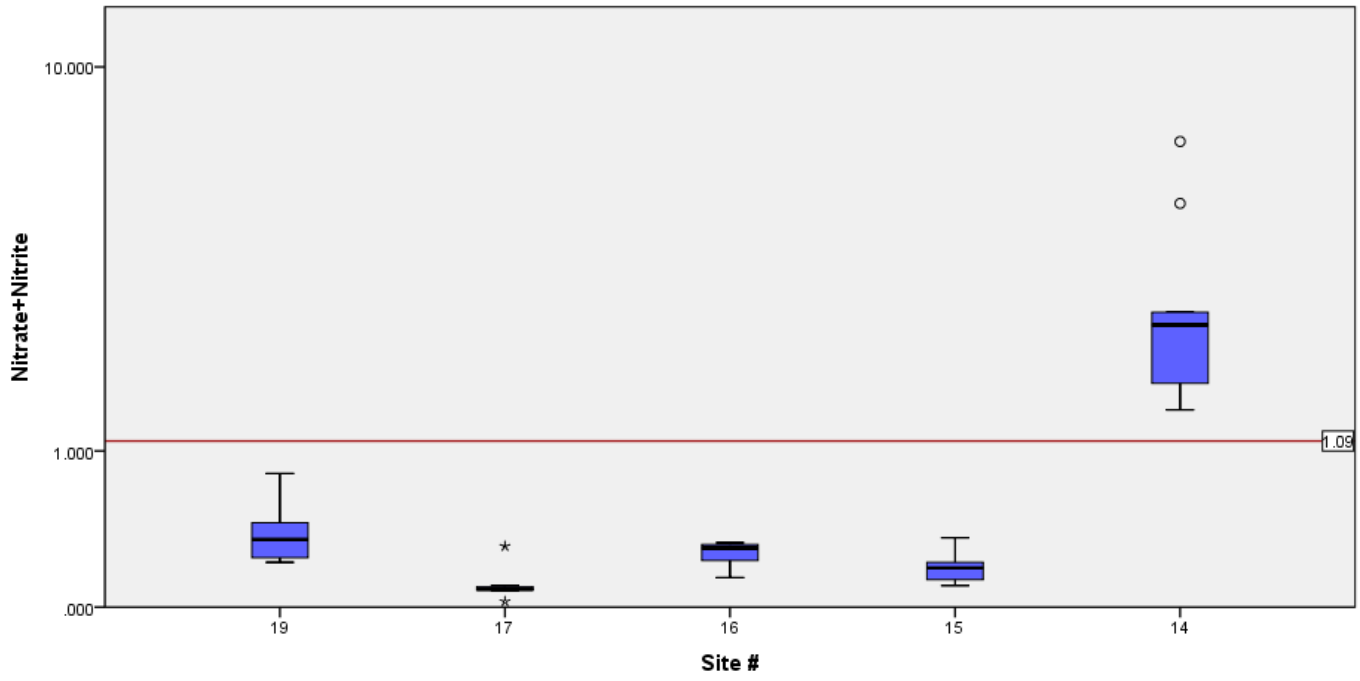

Figure 122 Box plot illustrating site nitrate concentrations within the Deer Creek Subwatershed

Figure 123 shows that Site 19 generally had the highest total Kjeldahl nitrogen concentrations with a median concentration greater than 1.27 mg/L. Approximately 75% of the samples from Site 14 exceeded the 0.68 mg/L threshold. Almost all the samples collected (>90%) from Sites 15-17 fell below 0.68 mg/L threshold.

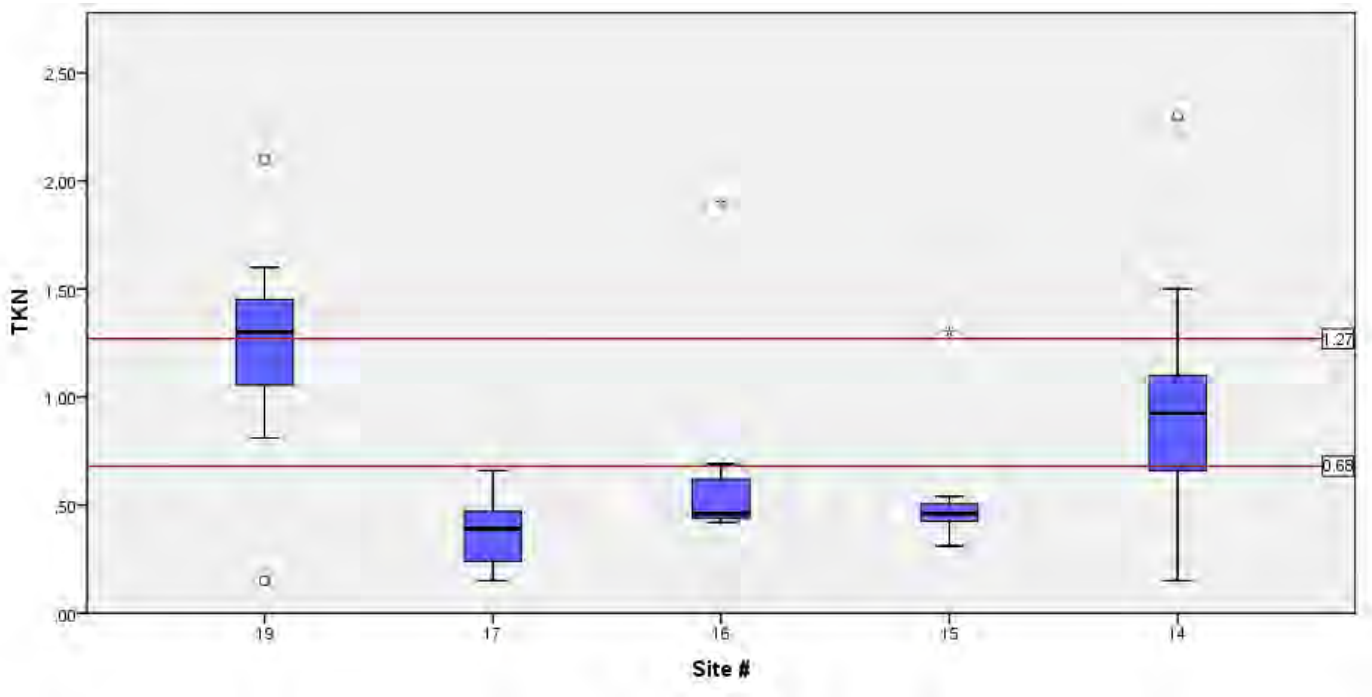

Figure 123 Box plot illustrating site total Kjehdahl nitrogen concentrations within the Deer Creek Subwatershed

Figure 124 shows that ammonia concentrations at Site 19 often exceeding the 0.21 mg/L threshold. The two highest concentrations observed 0.38 and 0.4 mg/L occurred during the summer. Ammonia concentration at the other sites were below the lab detection limit with one exception being Site 14 during the winter.

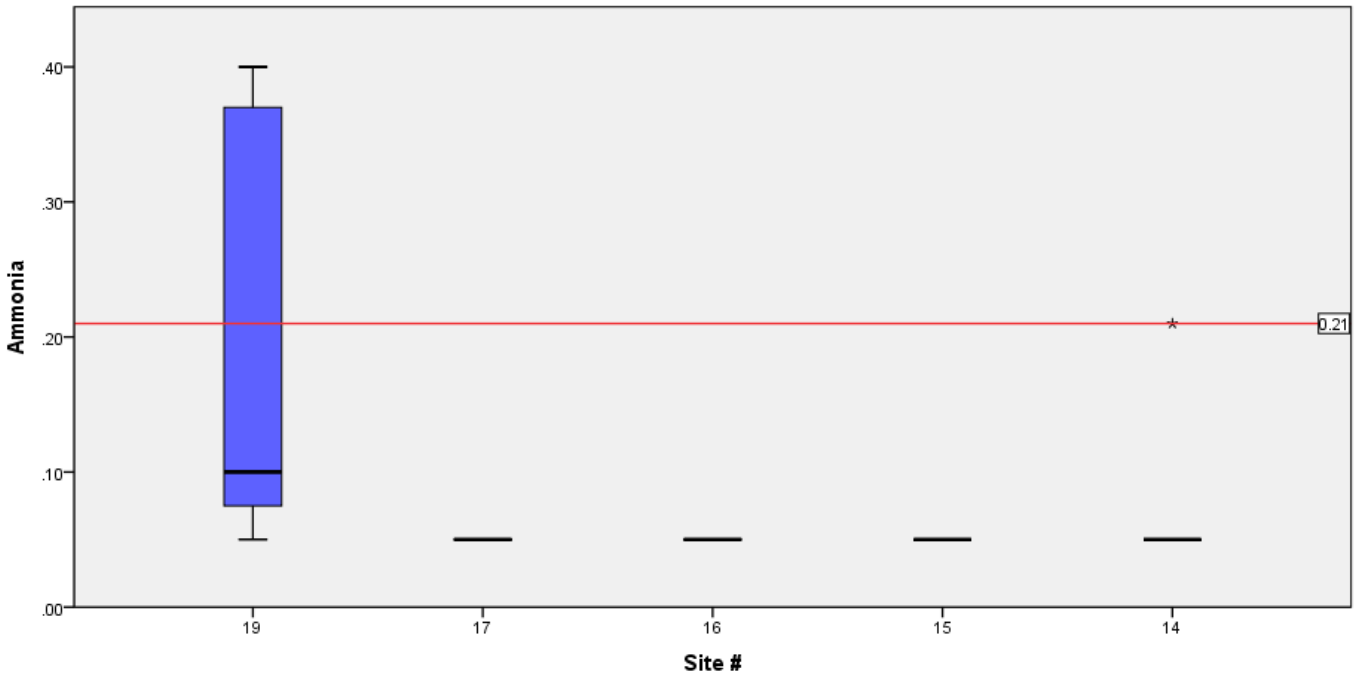

Figure 124 Box plot illustrating site ammonia concentrations within the Deer Creek Subwatershed

4.4.2.8 *Suspended Solids and Turbidity*

Figure 125 shows that total suspended solids median concentrations for all the subwatershed sights fell below the 30 mg/L threshold. Sites 14, 16 and 19 had occasional exceedances which corresponded to precipitation events and higher stream flows.

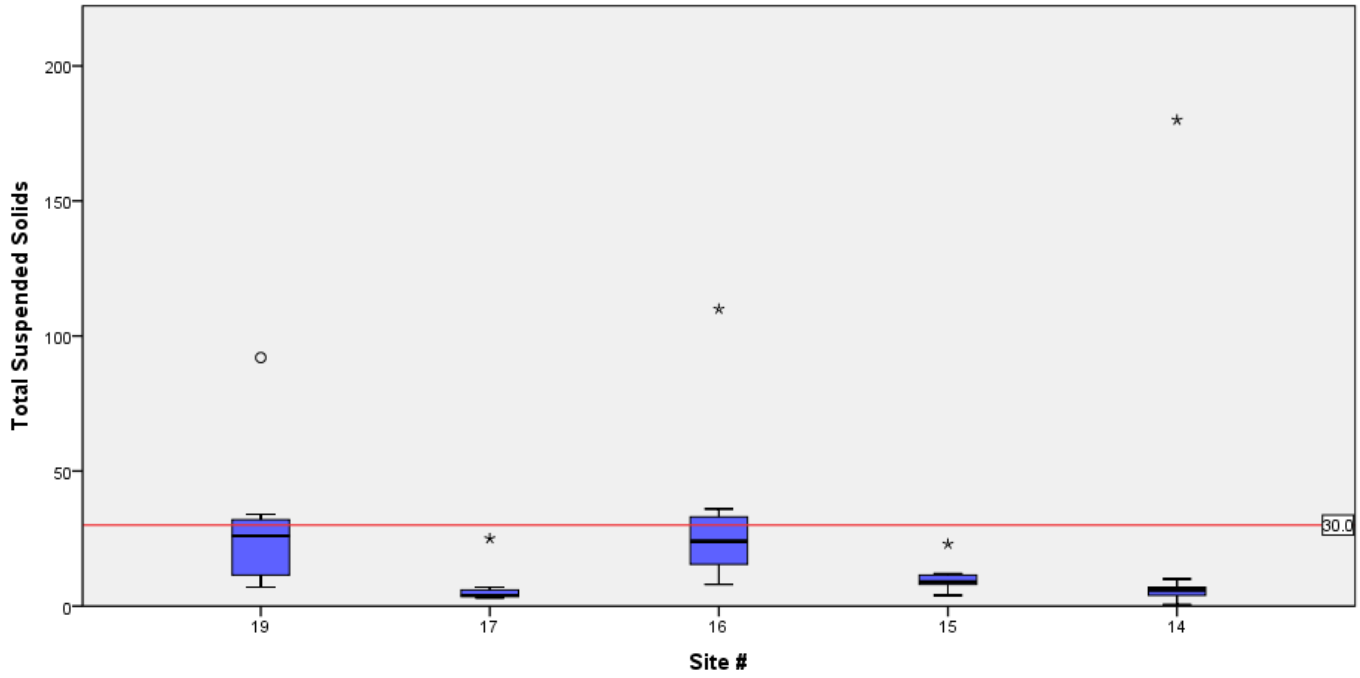

Figure 125 Box plot illustrating site total suspended solids concentrations within the Deer Creek Subwatershed

Figure 126 shows similar site patterns to those seen for total suspended solids. Sites 15, 16, and 19 frequently (40-75%) had turbidity levels higher than 10.4 NTU.

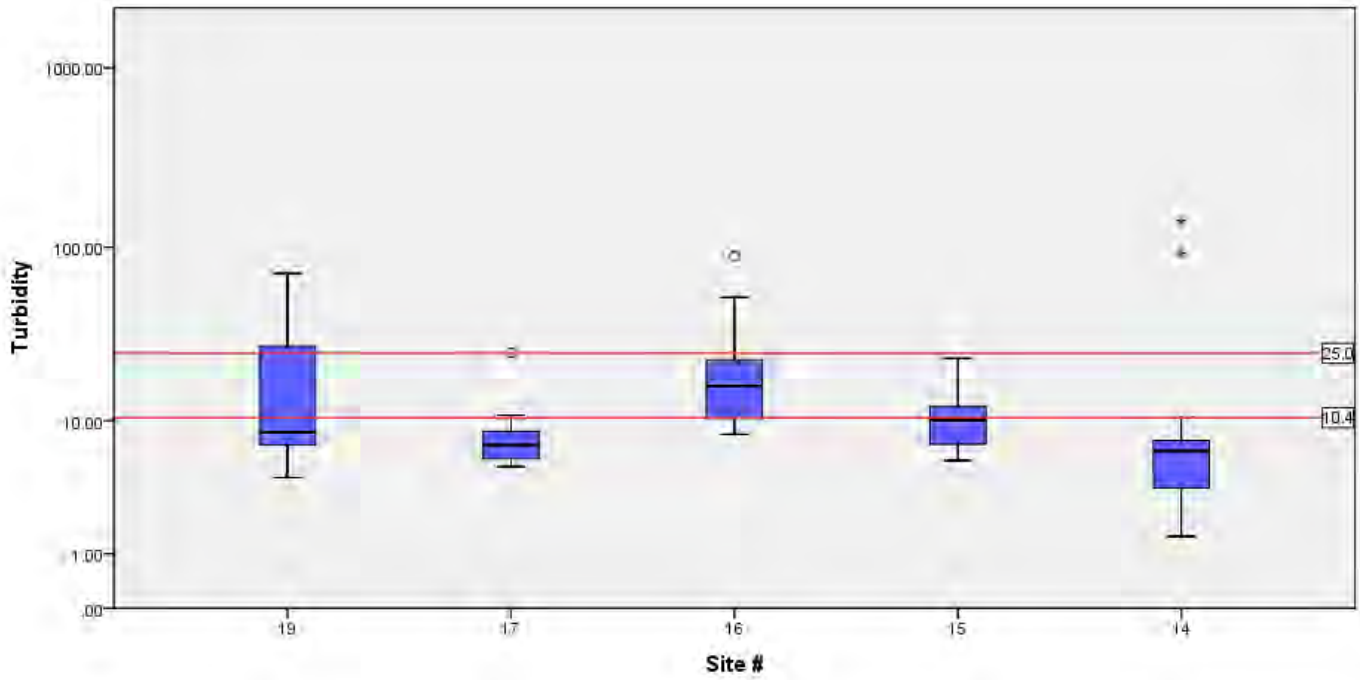

Figure 126 Box plot illustrating turbidity levels within the Deer Creek Subwatershed

4.4.2.9 *Habitat*

Figure 127 shows that Site 19 does not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Each habitat metric evaluated for this site scored very poorly. Habitat quality at Sites 16 and 17 is marginal in its ability to support a healthy fishery receiving QHEI scores of 52 and 51 respectively. Based on the individual metric scores, substrate quality stands out as a major habitat limitation for sites 16, 17, and 19. Substrates at Sites 16 and 19 are characterized by muck with moderate to heavy siltation and moderate embeddedness. These two sites are located in wetland areas. The substrate at Site 17 is characterized by hardpan (clay) with moderate siltation and embeddedness. The lower channel morphology scores at Sites 17 and 19 can be attributed to past channelization. Both sites had moderately low channel sinuosity with fair pool –riffle development. Site 17 was listed by IDEM as having recovered from channelization but Site 19 was still recovering. Only a small portion of Main Beaver Dam Ditch near the western boundary of the subwatershed is maintained as a county legal drain (Figure 129).

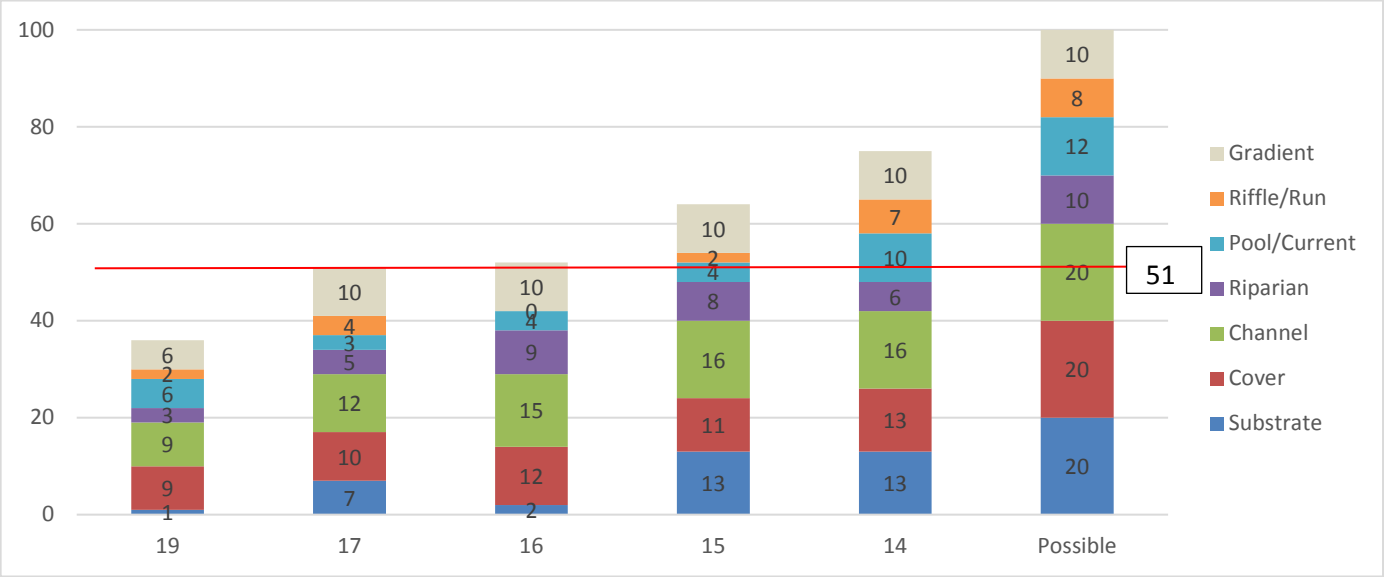

Figure 127 Site qualitative habitat evaluation index scores within the Deer Creek Subwatershed

4.4.3 Land Cover & Land Use

Overall, agriculture is the dominant land cover type within the subwatershed (Figure 128). Compared to the other watersheds, Deer Creek still retains a fair amount of natural land cover. The density of development in the subwatershed is sparse enough that almost all the developed areas, with the exception of Lakes of the Four Seasons, are unsewered and therefore rely on septic systems to treat waste water.

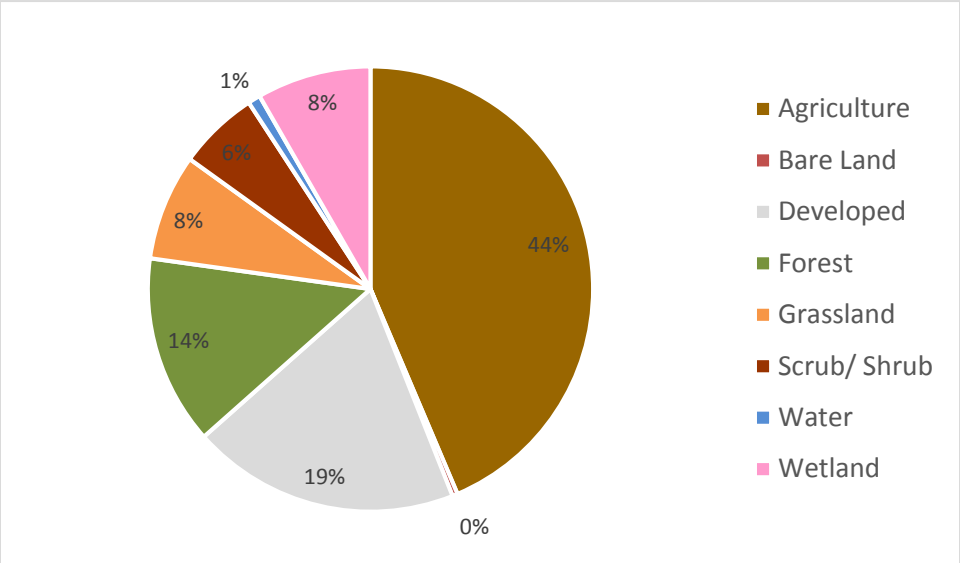

Figure 128 Percent land cover within the Deer Creek Subwatershed

Table 60 includes land cover information for each site's drainage area. Sites 17 and 19 have the highest percentage of developed land in the subwatershed, including portions of Winfield, Lakes of the Four Seasons, and Merrillville. Upstream of Site 19, wetland and forestland buffer stretches Deer Creek's mainstem from adjacent human land uses. Less natural land cover is appearent along the tributaries that drain to Site 17. Sites 16 and 15 have the highest percentage of natural land cover and least amount of development in the subwatershed (Figure 129). Site 14 is generally representative of the entire subwatershed. It's immediate surrounding land cover is forest and wetland. Site 14 is located within Deep River County Park.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
19	45.3	0.1	30.5	7.7	6.2	2.9	0.8	6.6
17	33.8	0.8	39.8	9.4	6.6	6.3	1.9	1.4
16	33.5	1.2	14.9	19.8	12.7	8.1	0.7	9.0
15	32.9	0.0	2.9	32.4	9.5	7.2	1.9	13.3
14	39.7	0.2	32.2	10.1	6.2	3.8	0.6	7.1

Table 60 Site percent land cover within the Deer Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 61. Agricultural and developed land cover makes up a fairly large percentage of many of the riparian zones. Site 15 and 16's riparian zones have one of the highest percentages of natural land cover in the entire watershed.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
19	21.8	0.0	27.9	6.8	8.9	2.9	2.9	28.6
17	20.2	0.9	38.6	13.4	5.9	11.5	7.2	2.2
16	19.1	0.8	13.6	20.4	10.6	7.1	2.3	26.2
15	24.3	0.0	1.2	26.5	1.3	5.7	5.7	35.4
14	28.5	0.2	22.1	9.8	5.3	6.4	2.5	25.3

Table 61 Site percent riparian land cover within the Deer Creek Subwatershed

There are no NPDES permitted industrial facilities documented in the subwatershed. The TMDL identified four waste water treatment plants (Figure 129). The Winfield WWTP (IN0058343) had one 1 TSS violation in 2011 and inspections found violations in February 2010 and January 2012. The Deep River Water Park WWTP (IN0058378) had 11 violations between 2009 and 2014 primarily for ammonia but also for *E. coli* and chlorine. No inspections were shown to occur for Chicagoland Christian Village (IN0054470) or the Falling Waters Conservancy District (IN0062090) over this time period.

Nine potential livestock facilities were identified in the subwatershed (Figure 129). One facility is located in the drainage area of an intermittent tributary that enters Deep River from the north. At least two facilities are located in the Deer Creek drainage area. Two other facilities are very close to this area and may at least in part fall within the Deer Creek drainage. Another two facilities are located between the unnamed tributaries Sites 16 and 17 are located on. An additional facility is upstream of Site 16 near an intermittent, headwater tributary. Two facilities are located near an intermittent, headwater tributary upstream of Site 15. Another facility is located south of U.S. Hwy 30 in the eastern portion of the subwatershed.

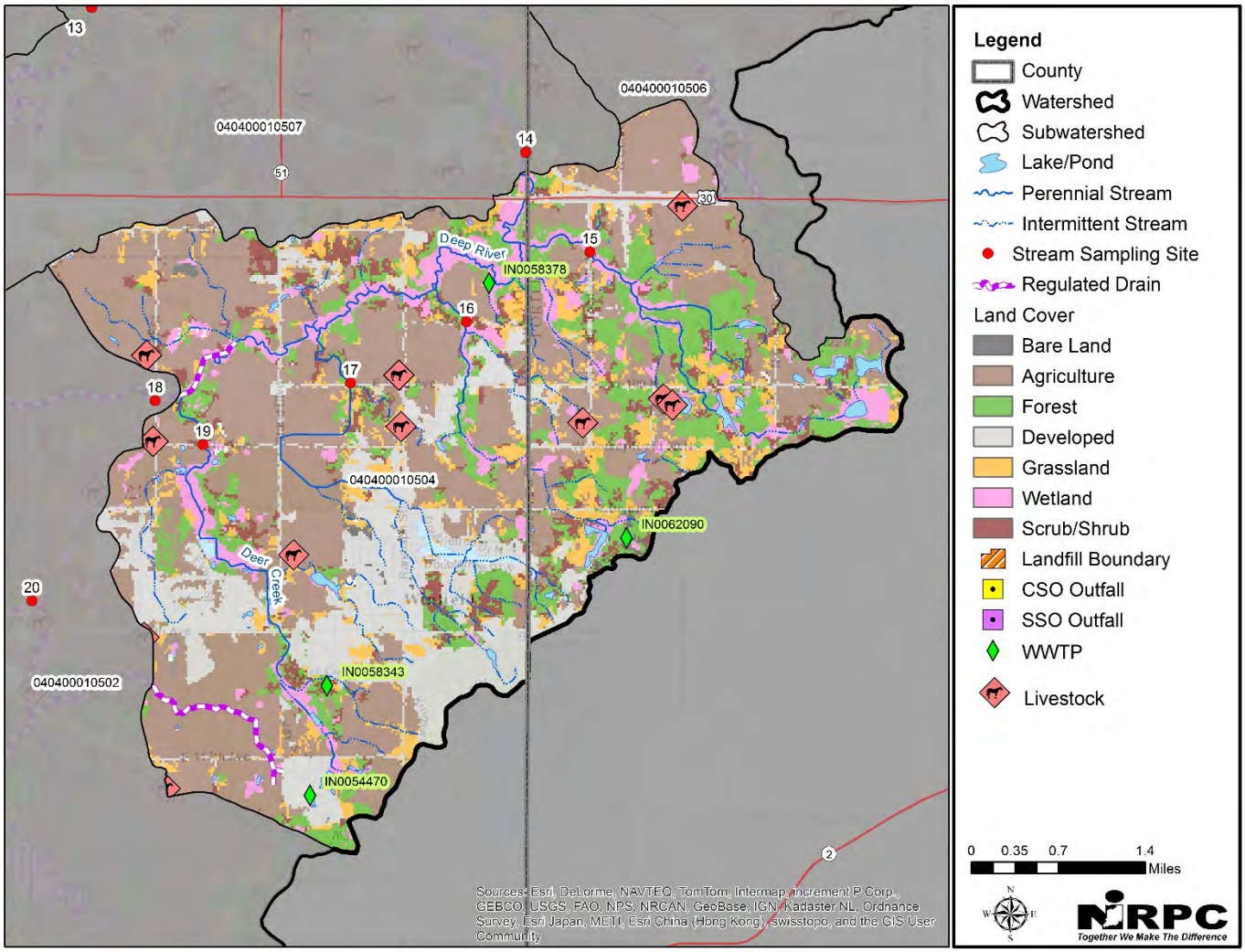

Figure 129 Land cover and land use within the Deer Creek Subwatershed

4.4.4 Soils

Like numerous other areas in the watershed, many of the soils that border the streams in the subwatershed are primarily rated as hydric. Many of these soils have been drained for agricultural production or development (Figure 56). The subwatershed has the third highest percentage of highly or potentially highly erodible soils in the watershed (Section 2.4.2). The largest concentration of these soils is located in the western and southern portion of the subwatershed (Figure 130). Steep slopes can be found adjacent to many of the tributaries entering Deep River from the south (Figure 130). The most prominent areas are located upstream of Sites 15 and 19.

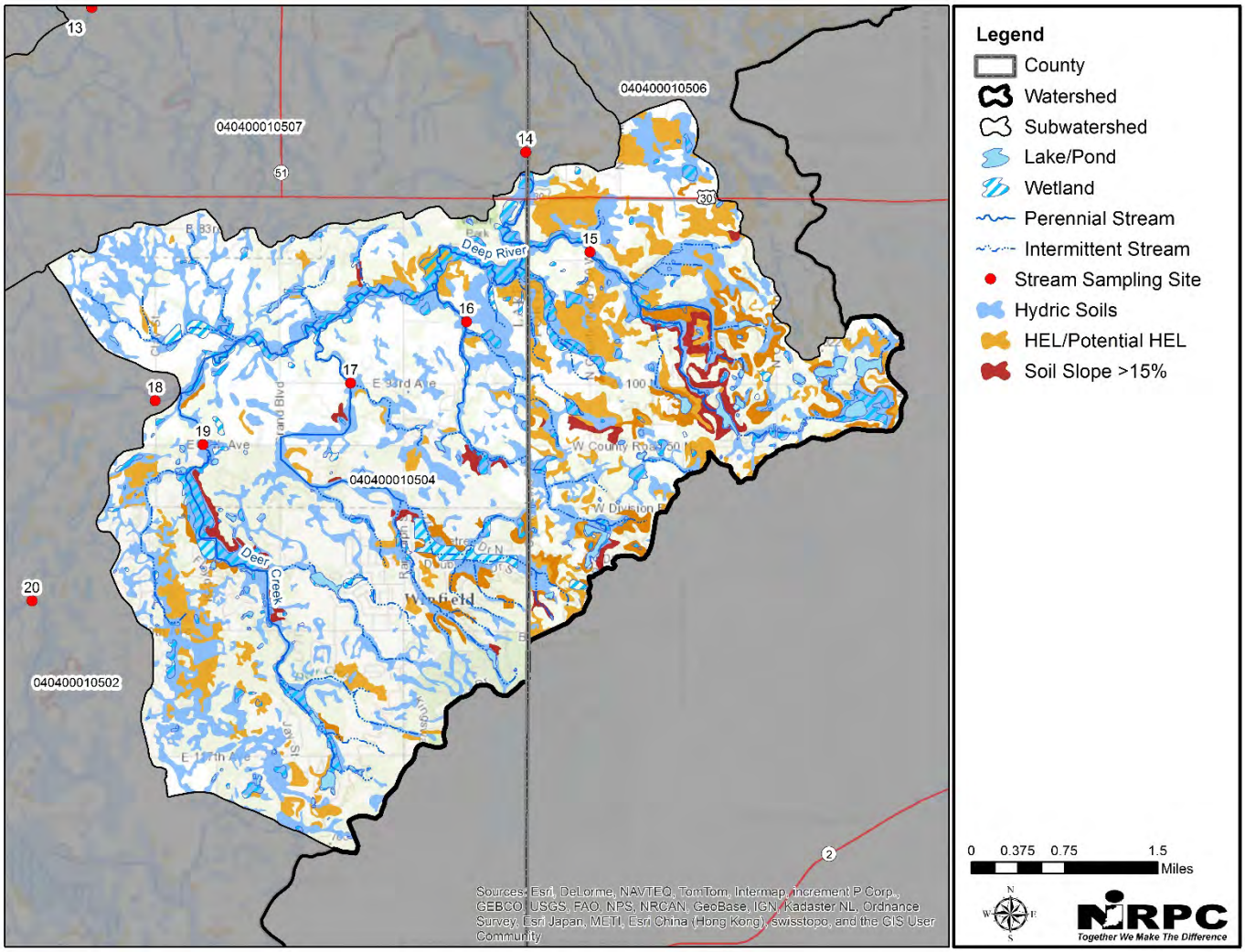

Figure 130 Soils within the Deer Creek Subwatershed

4.5 City of Merrillville Subwatershed (HUC 040400010505)

4.5.1 Overview

The City of Merrillville subwatershed is located in the central portion of the watershed. It drains approximately 19.5 mi² of primarily developed (63%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high E. coli and nutrient levels.

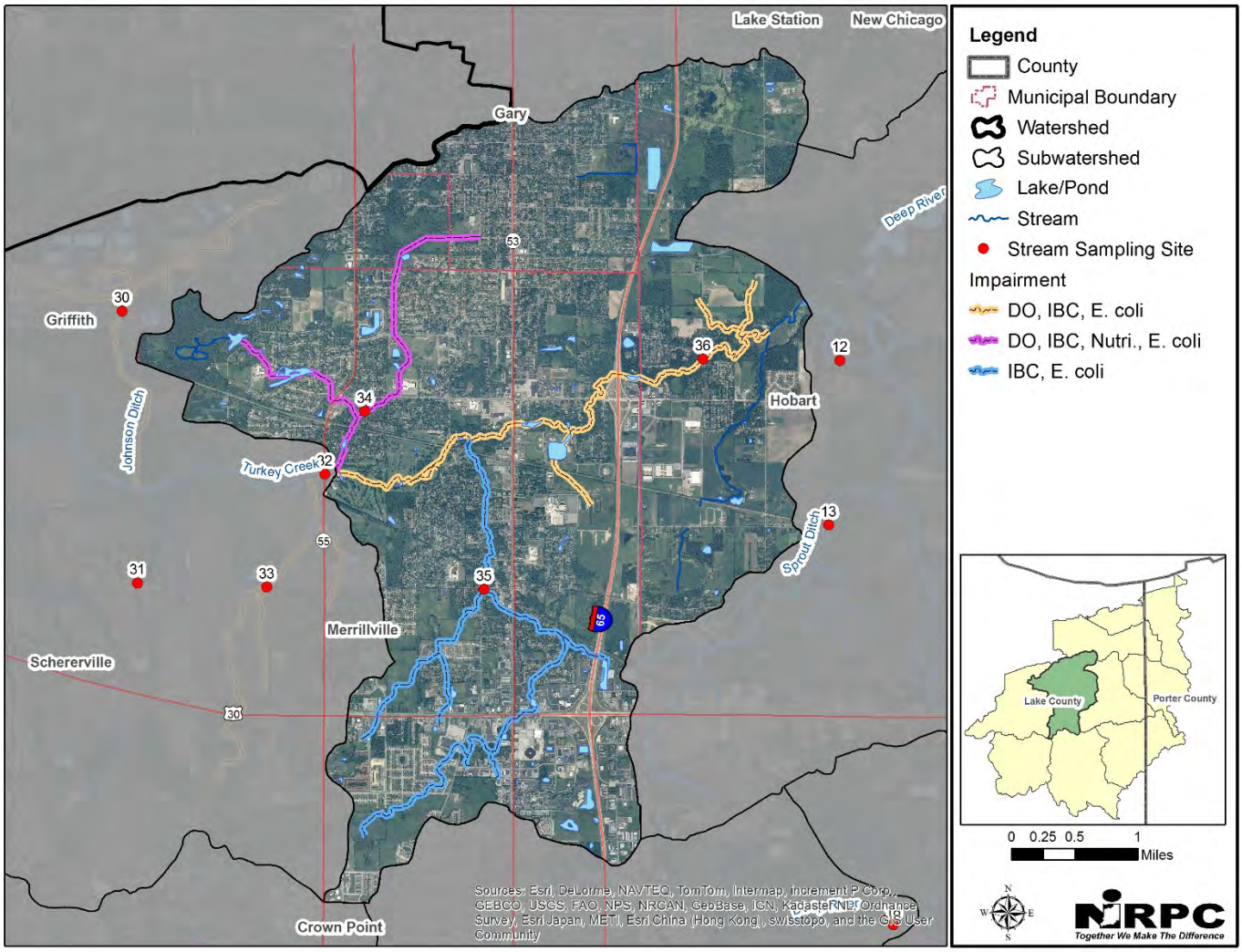

Figure 131 Impaired streams within the City of Merrillville Subwatershed

4.5.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 34-36) within the Deer Creek subwatershed (Figure 131). Site 36 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.5.2.1 *Pathogens*

Figure 132 shows that full body contact recreational use would be threatened by elevated pathogen levels. Samples taken at Sites 35 and 36 always exceeded the single sample *E. coli* water quality standard of 235 CFU/100 mL. Site

34 also frequently exceeded the *E. coli* water quality standard. Exceedances occurred across dry to high flow stream flow conditions indicating input from point and nonpoint sources.

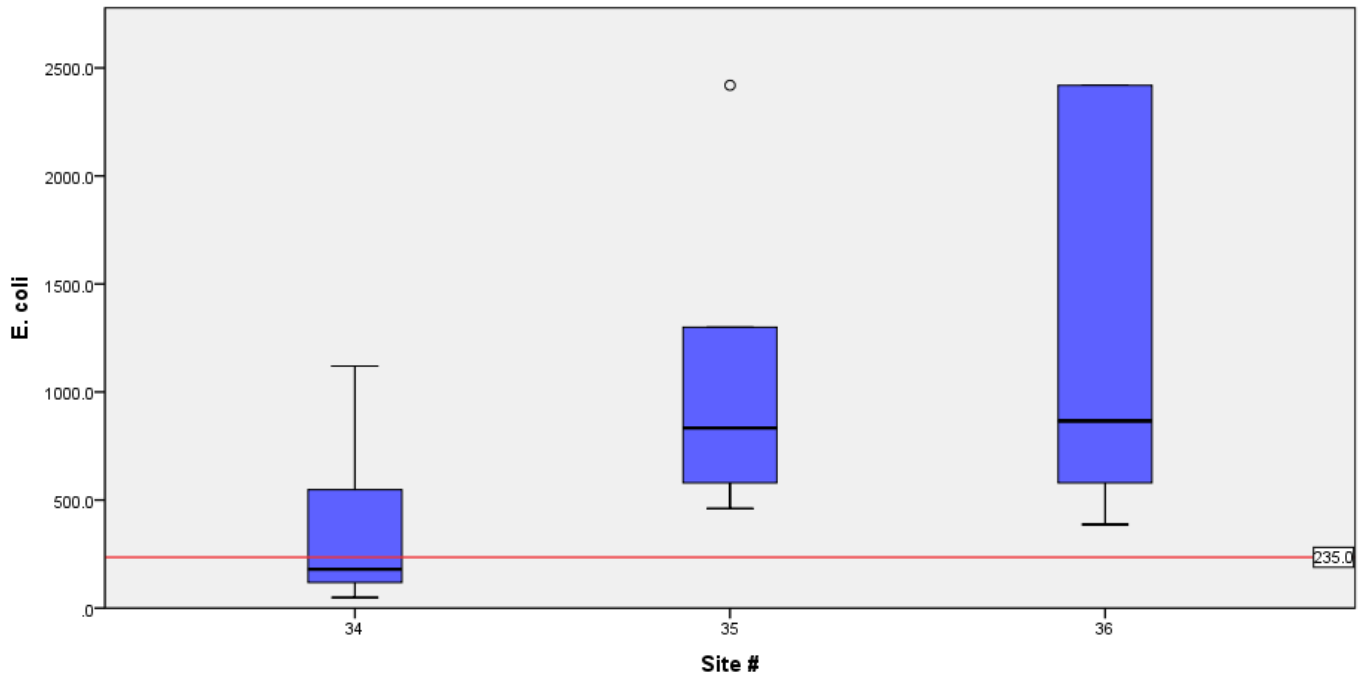

Figure 132 Box plot illustrating site E. coli concentrations within the City of Merrillville Subwatershed

4.5.2.2 *Fish*

An evaluation of each site's fish community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "very poor" integrity class rating. Only seven fish, representing two species, were collected form Site 34. Site 36 faired only slightly better with 25 fish collected, representing three species. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
34	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
35	20	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
36	16	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Table 62 Site fish index of biotic integrity scores within the City of Merrillville Subwatershed

4.5.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "poor" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
34	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
35	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
36	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 63 Site macroinvertebrate index of biotic integrity scores within the City of Merrillville Subwatershed

4.5.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, was 21°C, (70°F) for all sites.

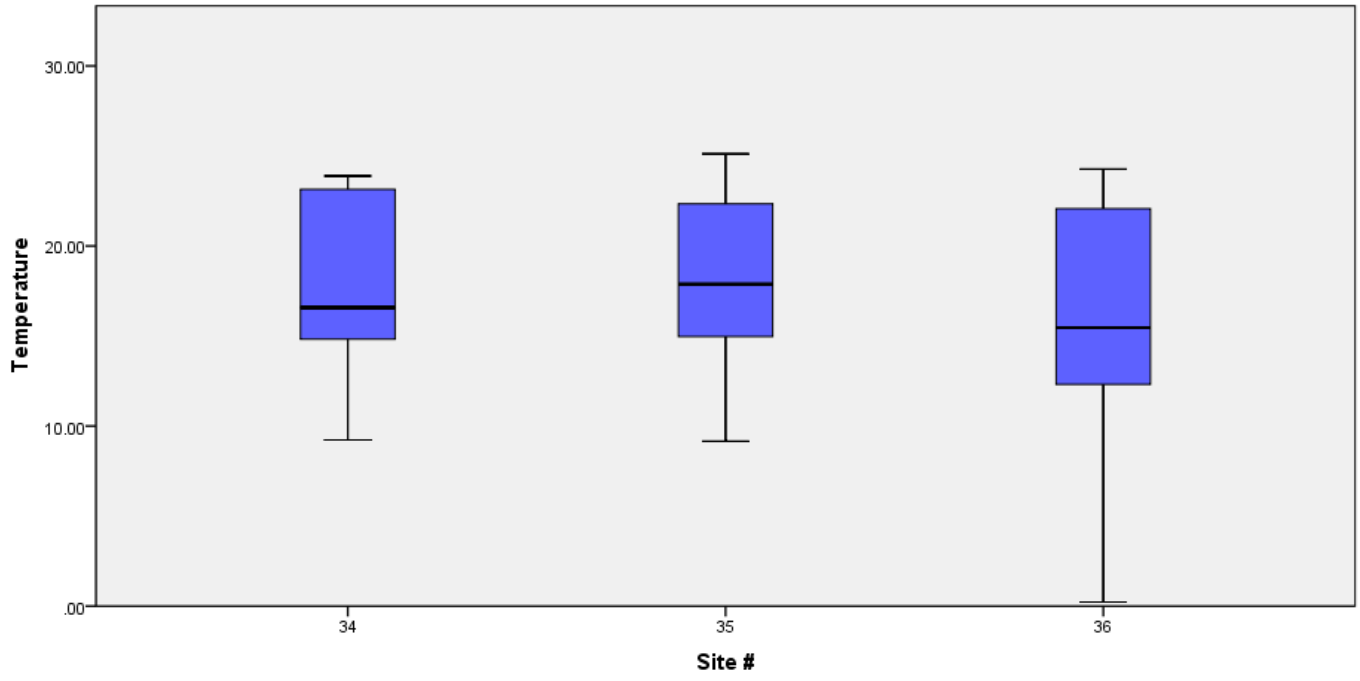

Figure 133 Box plot illustrating site water temparutre within the City of Merrillville Subwatershed

4.5.2.5 *Dissolved Oxygen*

Figure 134 shows severely depleted dissolved oxygen concentrations at Site 34. Over 75% of the observations fell below the 4 mg/L dissolved oxygen water quality standard.

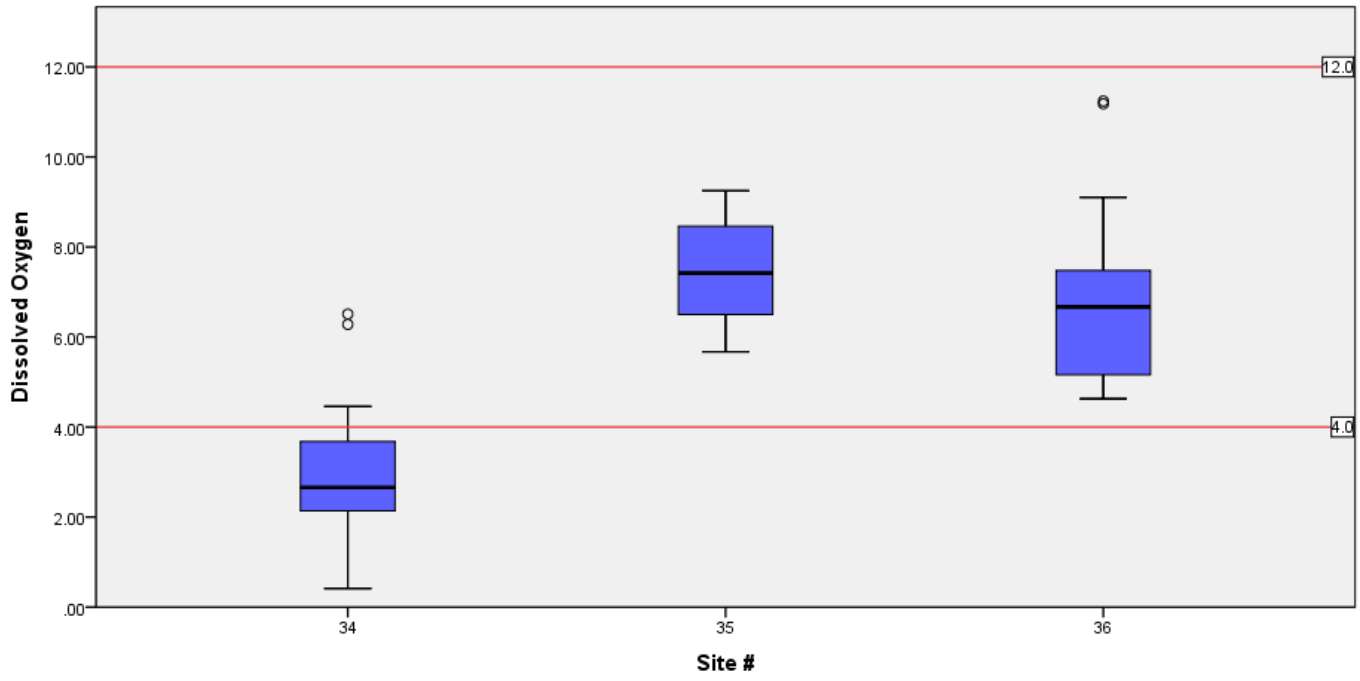

Figure 134 Box plot illustrating site dissolved oxygen concentrations within the City of Merrillville Subwatershed

4.5.2.6 *Total Organic Carbon*

Figure 135 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 34.

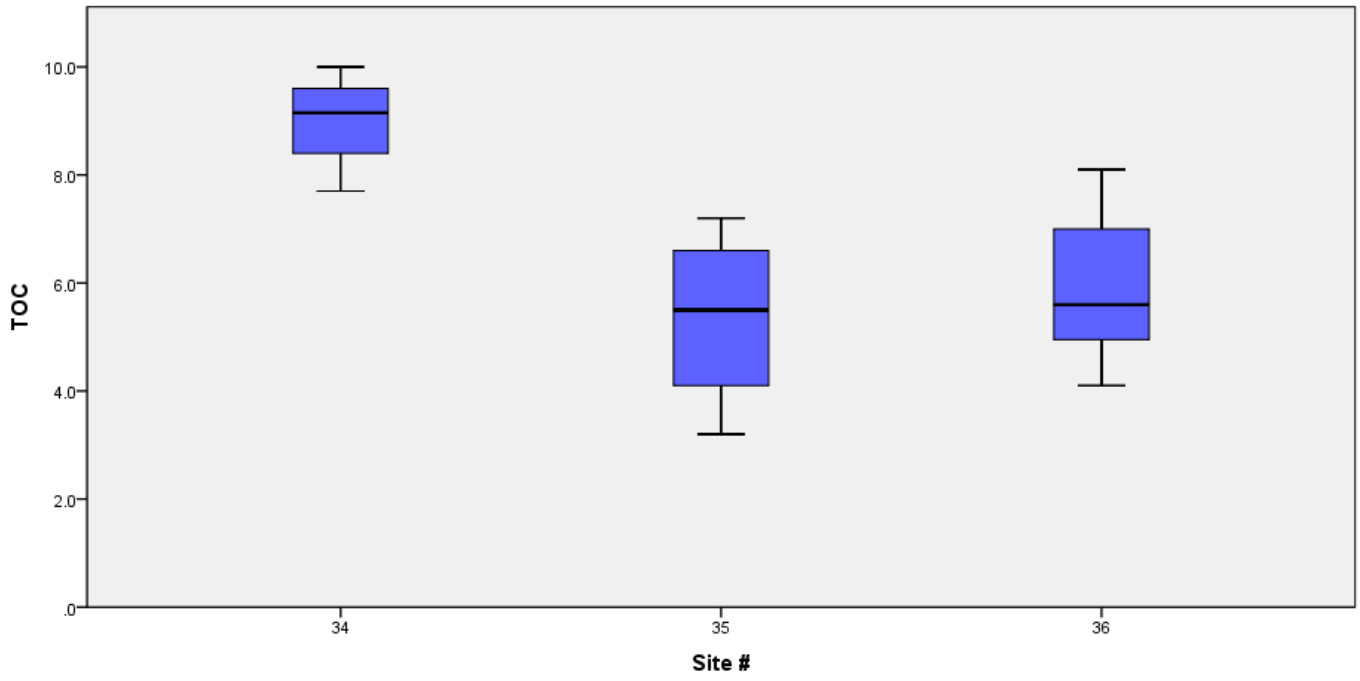

Figure 135 Box plot illustrating site TOC concentrations within the City of Merrillville Subwatershed

4.5.2.7 *Nutrients*

Figure 136 shows the highest total phosphorus levels occur at Site 34 with a median concentration in excess of the 0.07 mg/L threshold. Sites 35 and 36 had similar median concentrations, however nearly 50% of the samples from Site 36 exceeded 0.07 mg/L.

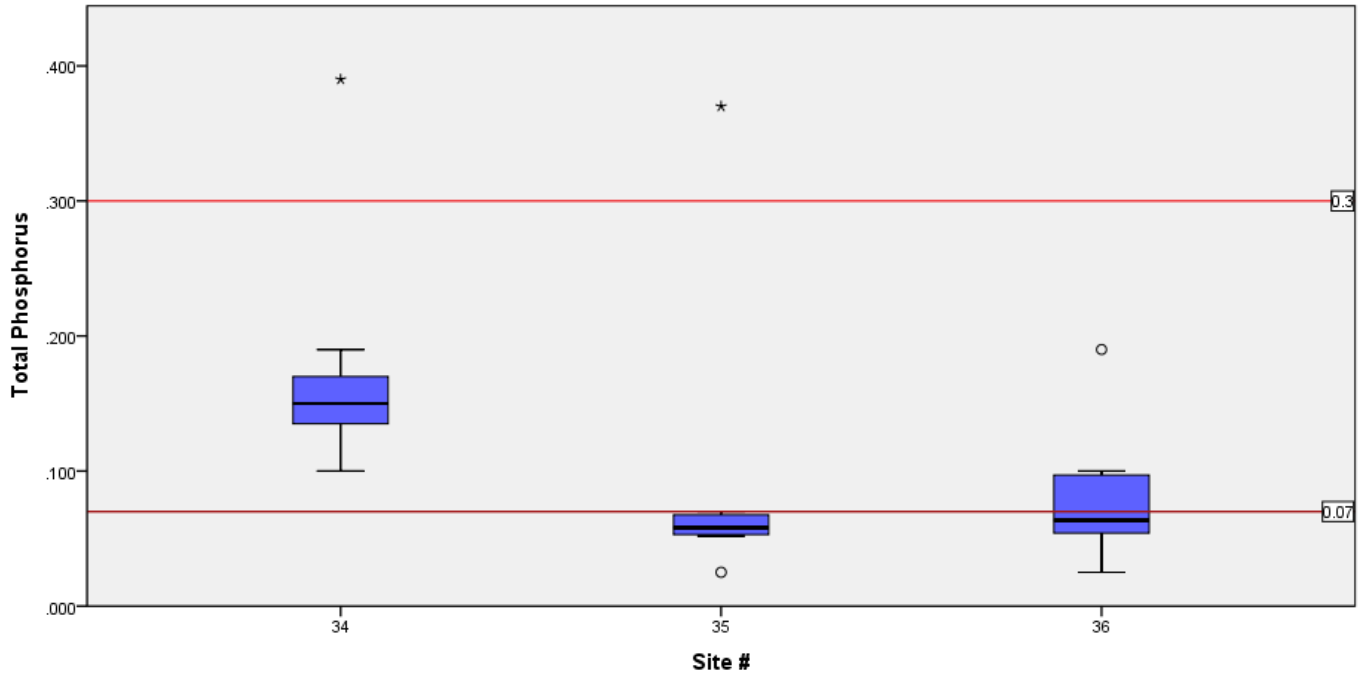

Figure 136 Box plot illustrating site total phosphorus concentrations within the City of Merrillville Subwatershed

Figure 137 shows that none of the sites had nitrate concentrations exceed the 1.09 mg/L threshold.

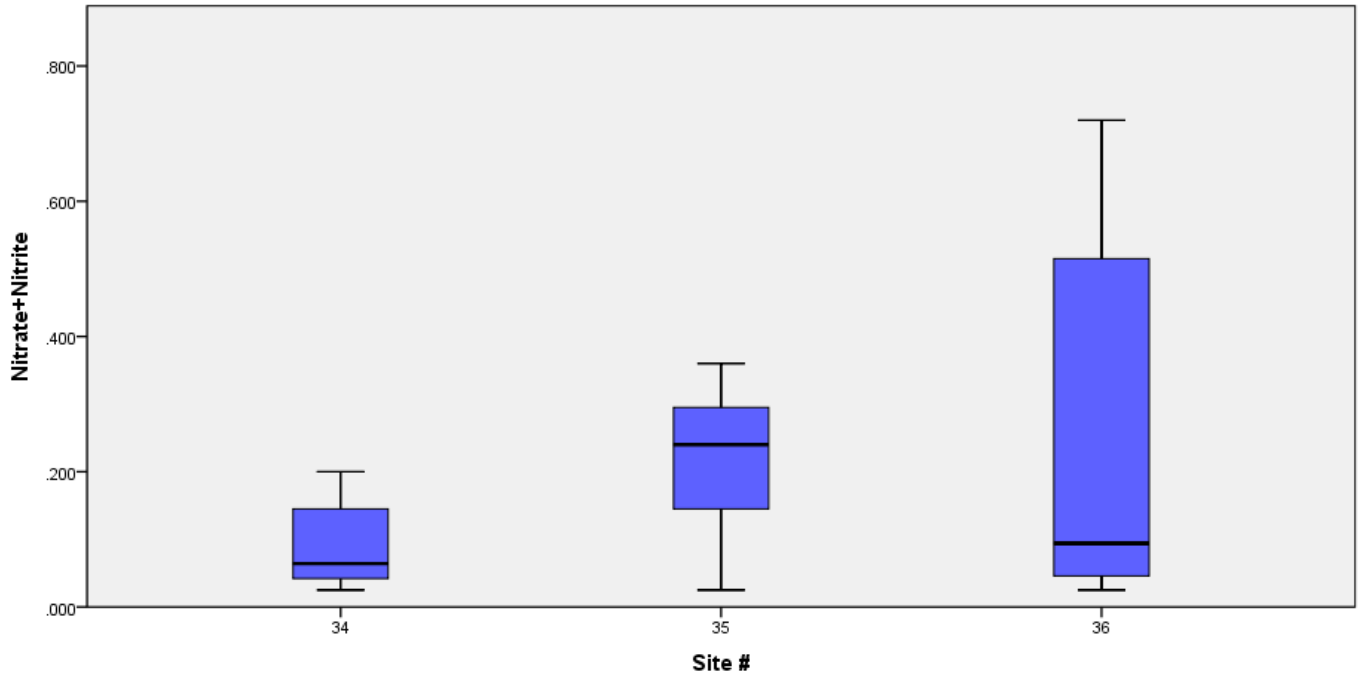

Figure 137 Box plot illustrating site nitrate concentrations within the City of Merrillville Subwatershed

Figure 138 shows that all sites had median total Kjeldahl nitrogen concentrations at or above the 0.68 mg/L threshold. Site 34 had the highest median and maximum concentration observed.

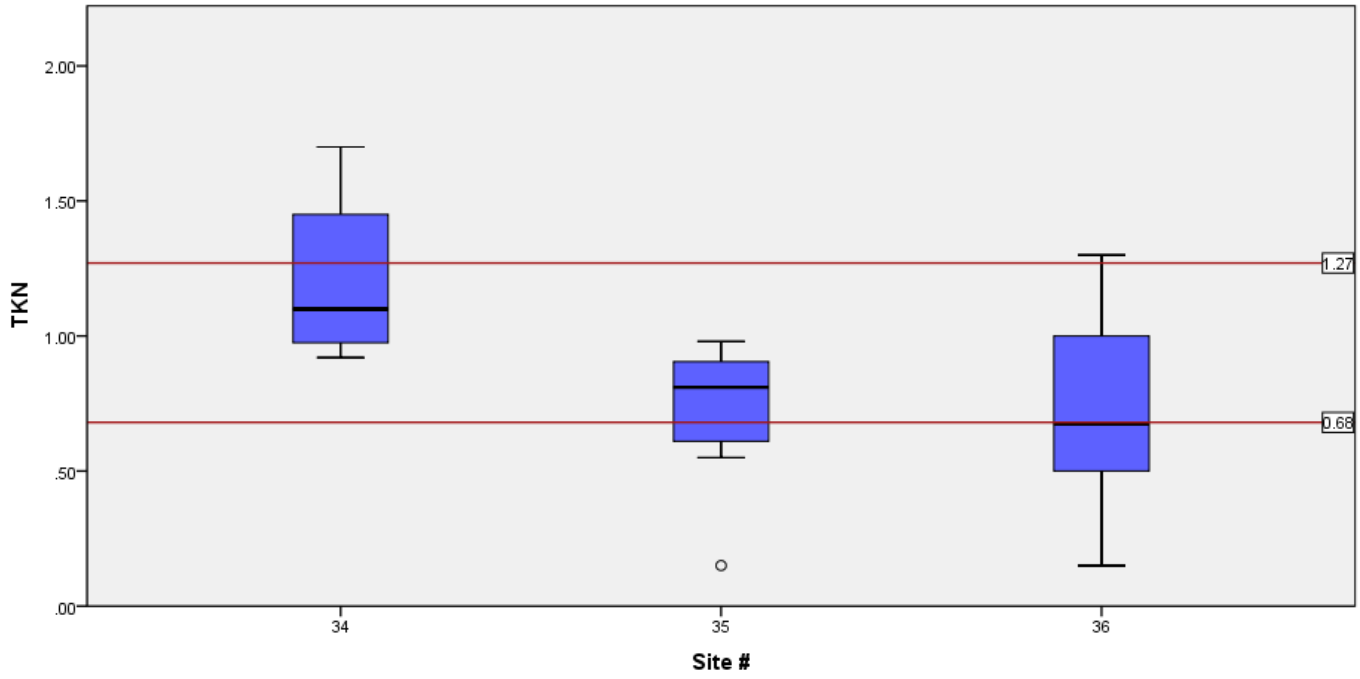

Figure 138 Box plot illustrating site total Kjeldahl nitrogen concentrations within the City of Merrillville Subwatershed

Figure 139 shows high ammonia levels at Site 34 with a median concentration near 0.21 mg/L and a maximum concentration of 0.59 mg/L. Sites 35 and 36 have median ammonia concentrations above 0.03 mg/L with maximum concentrations of 0.15 mg/L and 0.14 mg/L respectively.

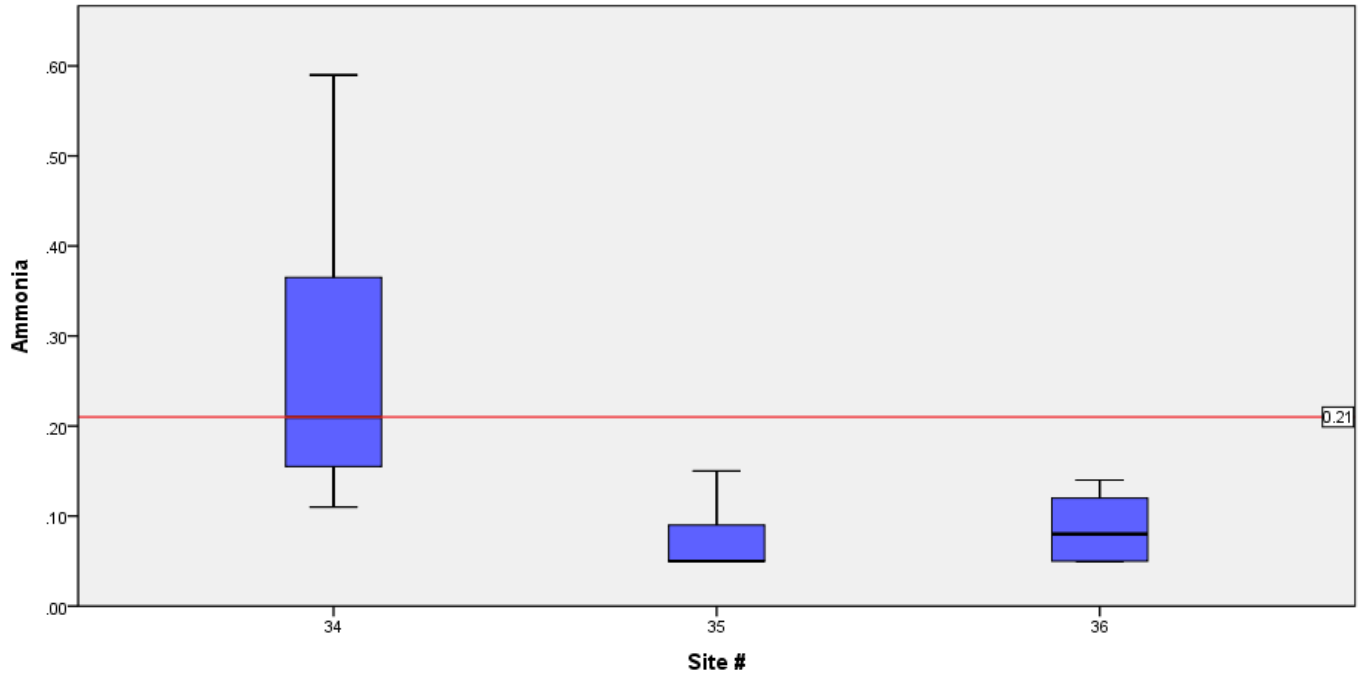

Figure 139 Box plot illustrating site ammonia concentrations within the City of Merrillville Subwatershed

4.5.2.8 *Suspended Solids & Turbidity*

Figure 140 shows that total suspended solid concentrations almost always fell below the 30 mg/L threshold and anything above this value was considered an outlier in the dataset. The exceedances at Sites 34 and 35 occurred during low stream flow conditions indicating a potential point source contribution. Site 36's exceedance occurred during high stream flows and is indicative of runoff and/or streambank erosion.

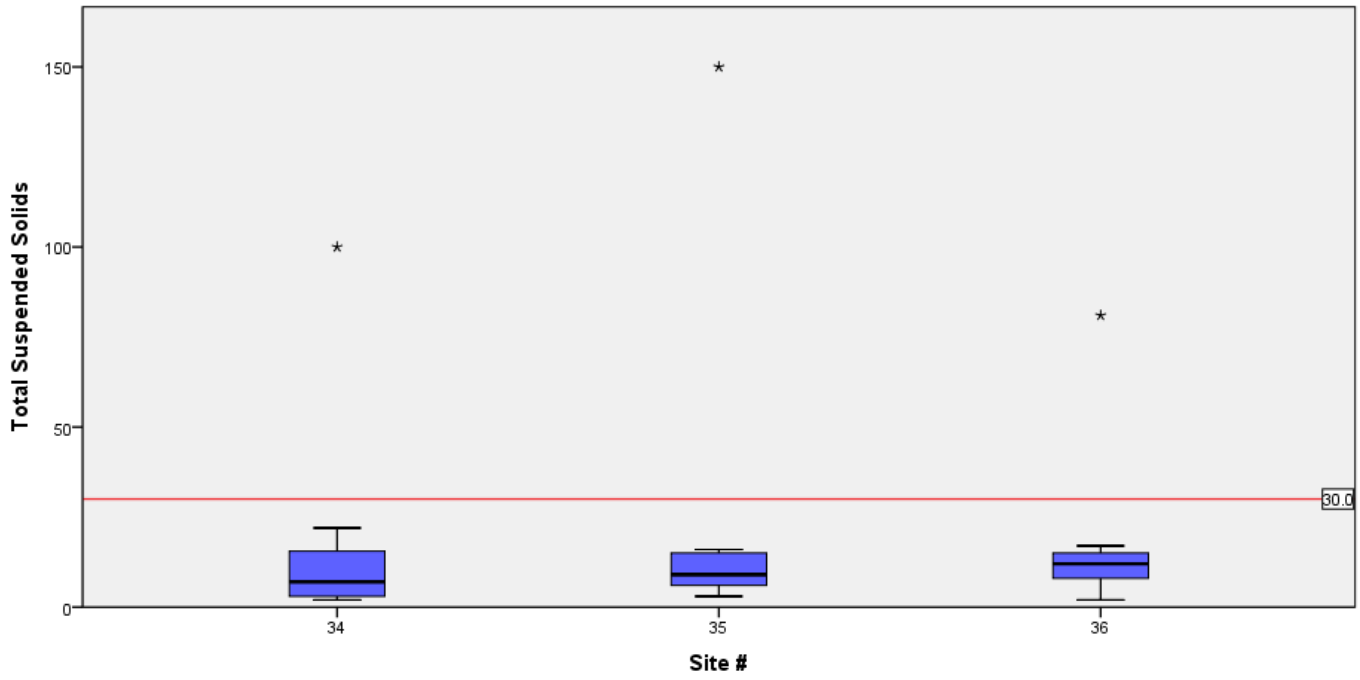

Figure 140 Box plot illustrating site total suspended solids concentrations within the City of Merrillville Subwatershed

While total suspended solid concentrations were relatively similar between sites, Figure 141 shows that Site 34 had much higher turbidity levels with a median level over 25 NTU. The discrepancy may be due to higher colored dissolved organic matter which would not be picked up by total suspended solids testing. Sites 35 and 36 also had median turbidity levels over the 10.4 NTU threshold.

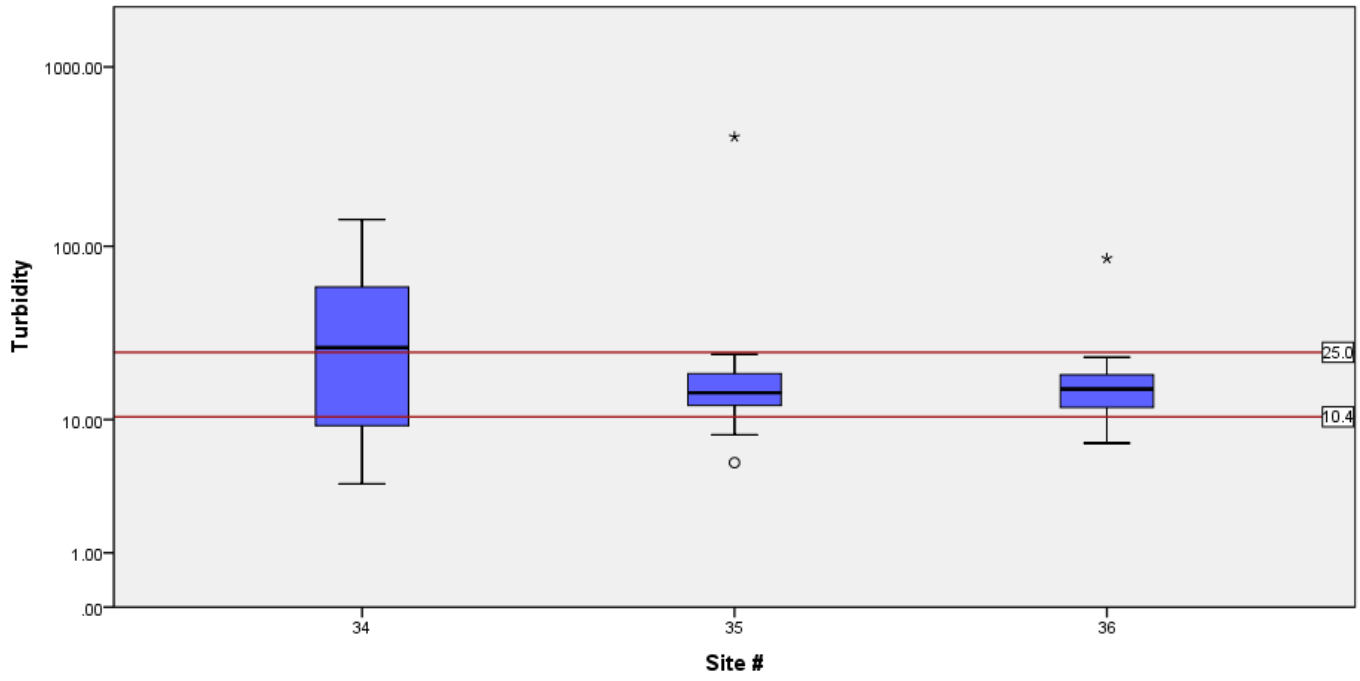

Figure 141 Box plot illustrating site turbidity levels within the City of Merrillville Subwatershed

4.5.2.9 *Habitat*

Figure 142 shows that none of the sites possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51). Poor substrate quality was a limiting factor at all sites. Substrates at Sites 34 and 36 were characterized by muck, heavy siltation and extensive embeddedness. Site 35's substrate was primarily characterized as artificial (riprap and concrete) with normal levels of siltation and embeddedness. Each site had low to no channel sinuosity, poor to fair riffle/pool development, and low to moderate channel stability.

Sites 34 and 35 are located on channels that are in essence urban drains. The channels have relatively trapezoidal cross-sections with minimal or no active floodplain and very narrow to no riparian buffers. In some areas, the stream channel has been piped and buried. Examples include the tributary of Turkey Creek adjacent to Merrillville Intermediate School on 61st Avenue, upstream of Site 34 and the tributary of Turkey Creek adjacent to what used to be Old Mill Pizza on 73rd Avenue and Madison Street at Site 35. Site 36 is located on a low gradient, sluggish flow reach of Turkey Creek surrounded by floodplain wetland.

The poor habitat quality at Sites 34 and 35 is symptomatic of the waterways being excavated into existence or modified to improve drainage. Each of sites in the subwatershed, except Site 35, are located on reaches that are maintained as county legal drains (Figure 144). Aerial imagery however shows that at least portions of this tributary to Turkey Creek were modified at some point to improve drainage.

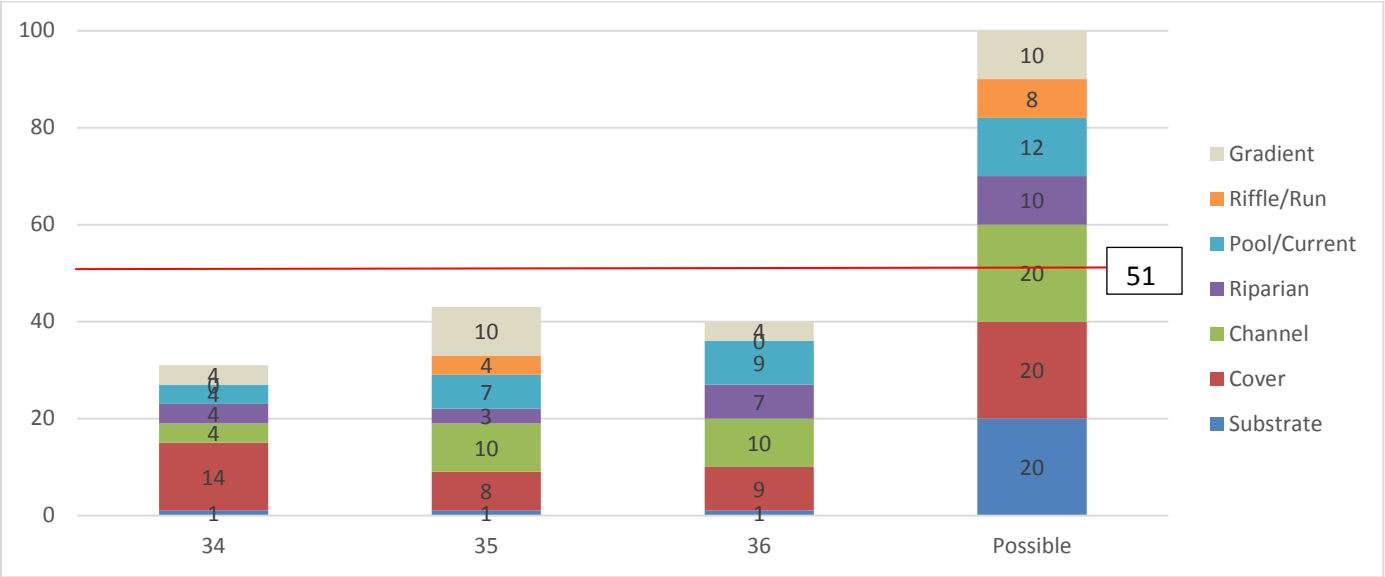

Figure 142 Site Qualitative Habitat Evaluation Index scores within the City of Merrillville Subwatershed

4.5.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed lands (63%) lands (Figure 143). Agriculture is a relatively minor land use within the watershed only accounting for approximately 12% of the land area. Merrillville has the largest municipal footprint within the subwatershed but it also includes portions of Gary and Hobart. These unincorporated areas are mostly unsewered.

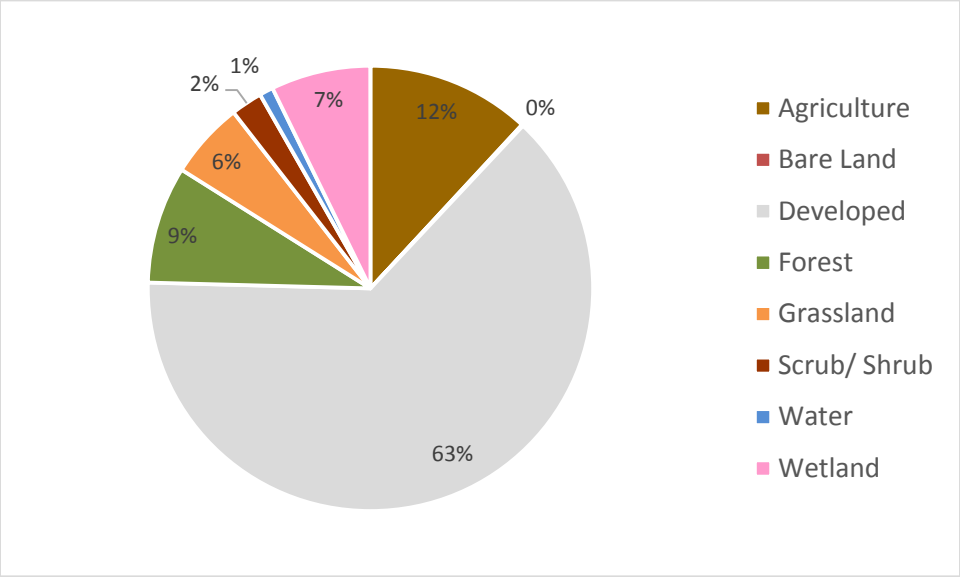

Figure 143 Percent land cover within the City of Merrillville Subwatershed

Table 64 includes land cover information for each site's drainage area. All sites have a high percentage of developed land within their drainage areas (62-73%). A majority of the natural land cover within the subwatershed is located within the city limits of Hobart and Oak Ridge Prairie County Park.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
34	4.2	0.0	72.5	7.3	3.7	2.2	1.0	9.1
35	13.6	0.2	72.6	3.2	6.6	1.9	0.3	1.5
36	12.5	0.1	61.9	9.2	5.0	3.3	0.8	7.1

Table 64 Site percent land cover within the City of Merrillville Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 65. Agricultural and developed land cover makes up the greatest percentage of the riparian zones in the subwatershed.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
34	0.6	0.0	67.6	5.5	3.7	4.0	0.0	18.7
35	11.1	0.0	74.3	5.5	1.0	2.8	0.1	5.1
36	12.3	0.0	55.2	7.6	2.9	4.3	1.7	16.0

Table 65 Site percent riparian land cover within the City of Merrillville Subwatershed

The TMDL reports two NPDES permitted industrial facilities located in subwatershed. (See TMDL for NPDES industrial facility location map.) The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. There is one sanitary sewer overflow outfall located in the subwatershed upstream of Site 36 on Turkey Creek (Figure 144).

Four potential livestock facilities were identified in the subwatershed. All four are located east of I-65 in the drainage area of an intermittent stream that joins Turkey Creek downstream of Site 36(Figure 144).

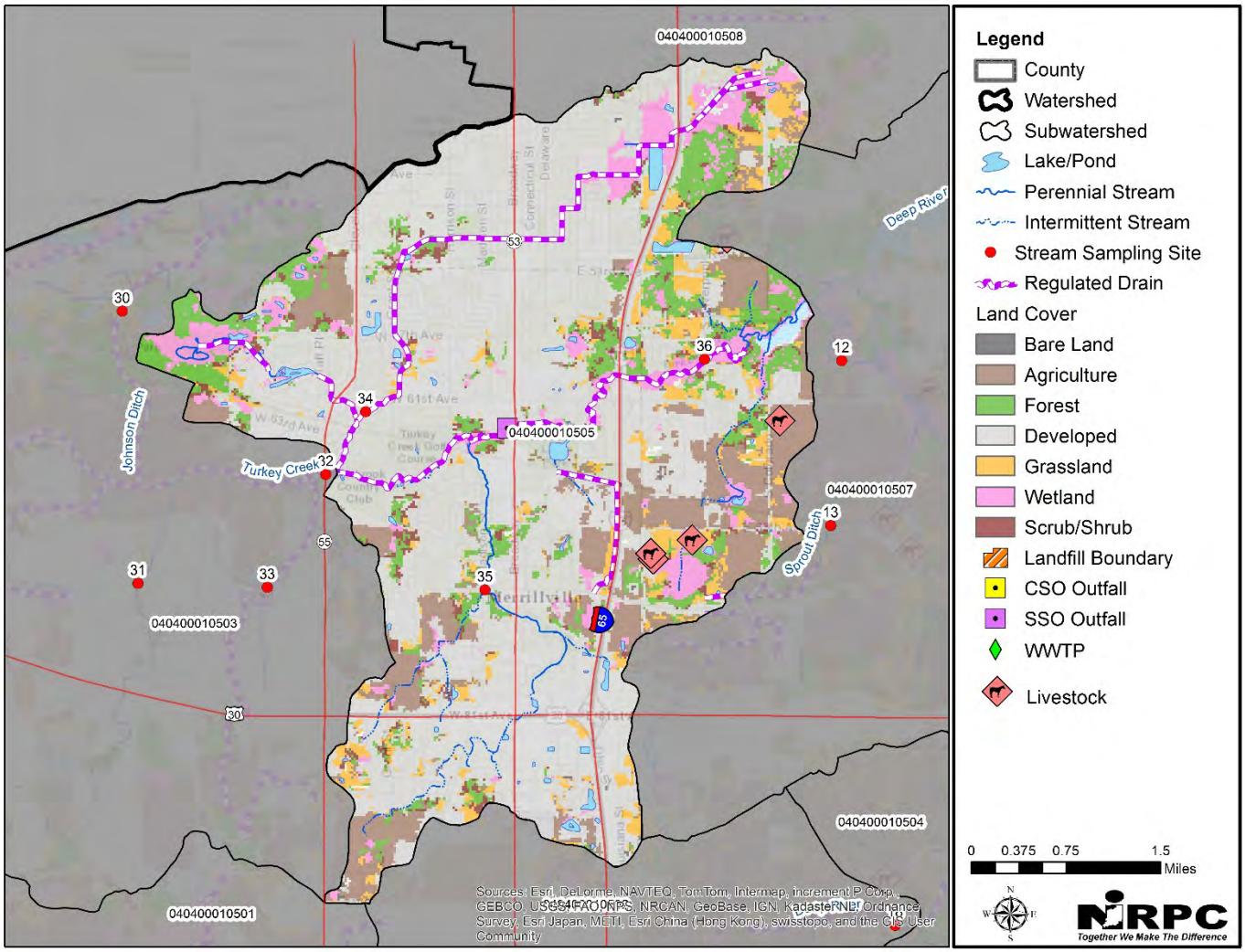

Figure 144 Land cover and land use within the City of Merrillville Subwatershed

4.5.4 Soils

A majority of the soils that border the streams in the subwatershed are classified as hydric. In most cases these areas were drained or filled for agricultural or development purposes. A very high concentration of highly erodible/ potentially highly erodible soils is located in the southern extent of the subwatershed within and surrounding Site 35's drainage area. A number of these areas remain in agricultural production. Soil surface texture in these areas are comprised of silt loam and silty clay loams especially surrounding the tributaries. This in part may help explain the poor substrate quality noted in the stream habitat assessments. There are small inclusions of steeply sloped soils along the unnamed tributary to Turkey Creek west of I-65.

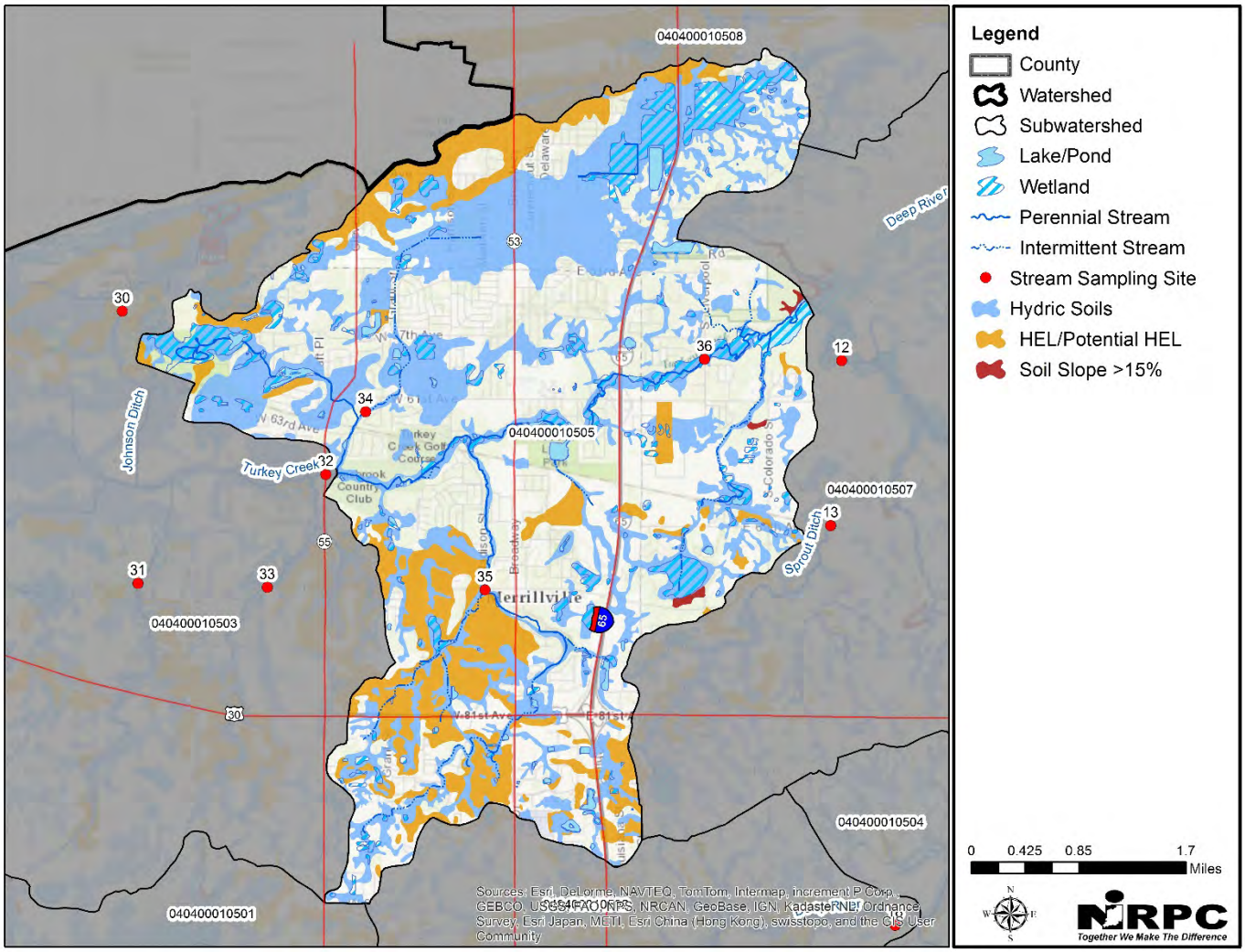

Figure 145 Soils within the City of Merrillville Subwatershed

4.6 Duck Creek Subwatershed (HUC 0404000106)

4.6.1 Overview

The Duck subwatershed is located in the east central portion of the watershed. It drains approximately 15.8 mi² of primarily agricultural (51%) and developed (23%) land. Based on the monitoring completed by IDEM, two stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high *E. coli* and nutrient levels.

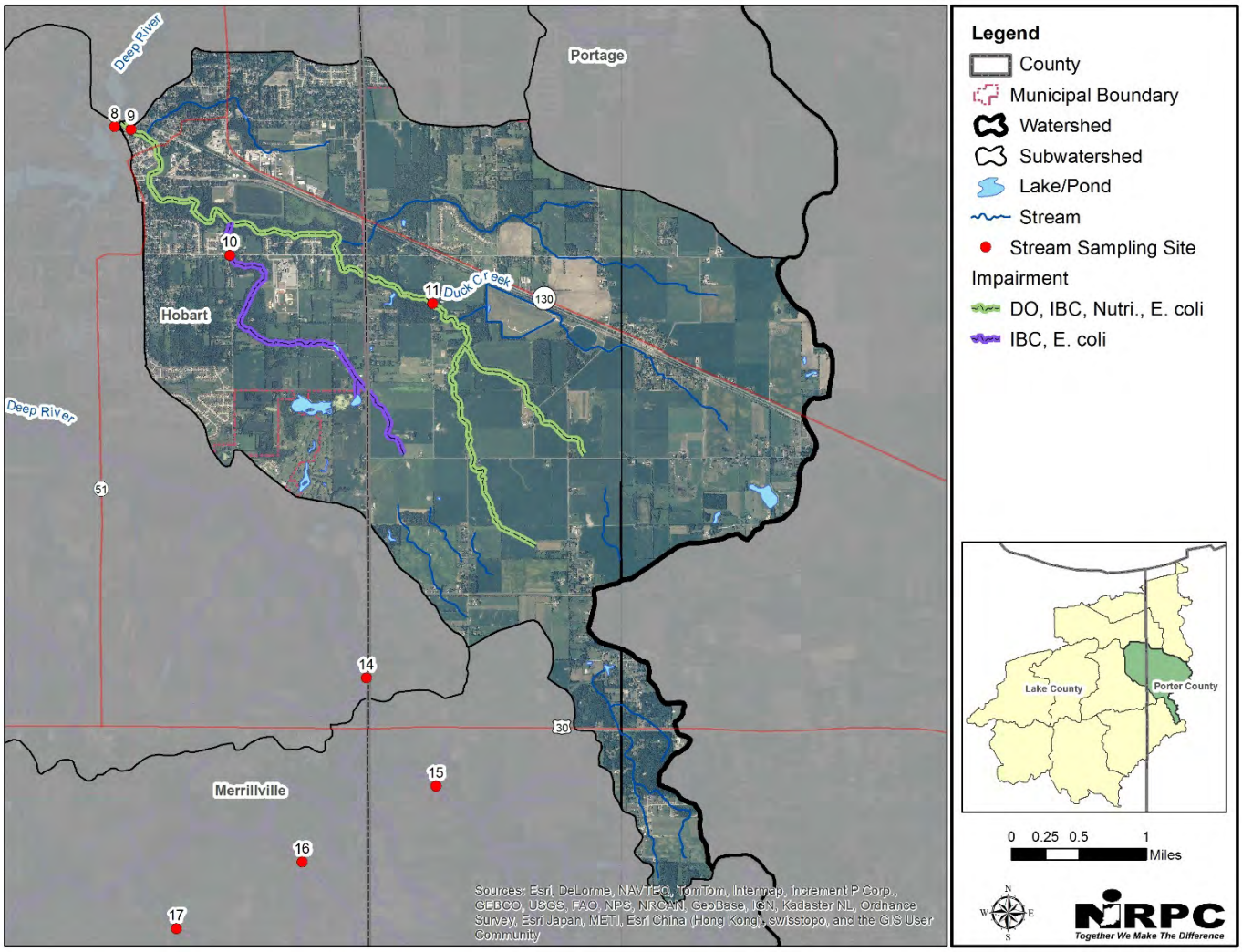

Figure 146 Impaired streams within the Duck Creek Subwatershed

4.6.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 9-11) within the subwatershed (Figure 146). Site 9 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.6.2.1 *Pathogens*

Figure 147 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 11 and 10 consistently exceed the single sample *E. coli* water quality standard with median concentrations above 235 CFU/100 mL. Exceedances for Sites 10 and 11 occurred across dry to higher stream flow conditions

indicating input from point and nonpoint sources. Site 9's exceedance were mostly limited to higher stream flows indicating a majority of the exceedances were attributed to nonpoint source inputs.

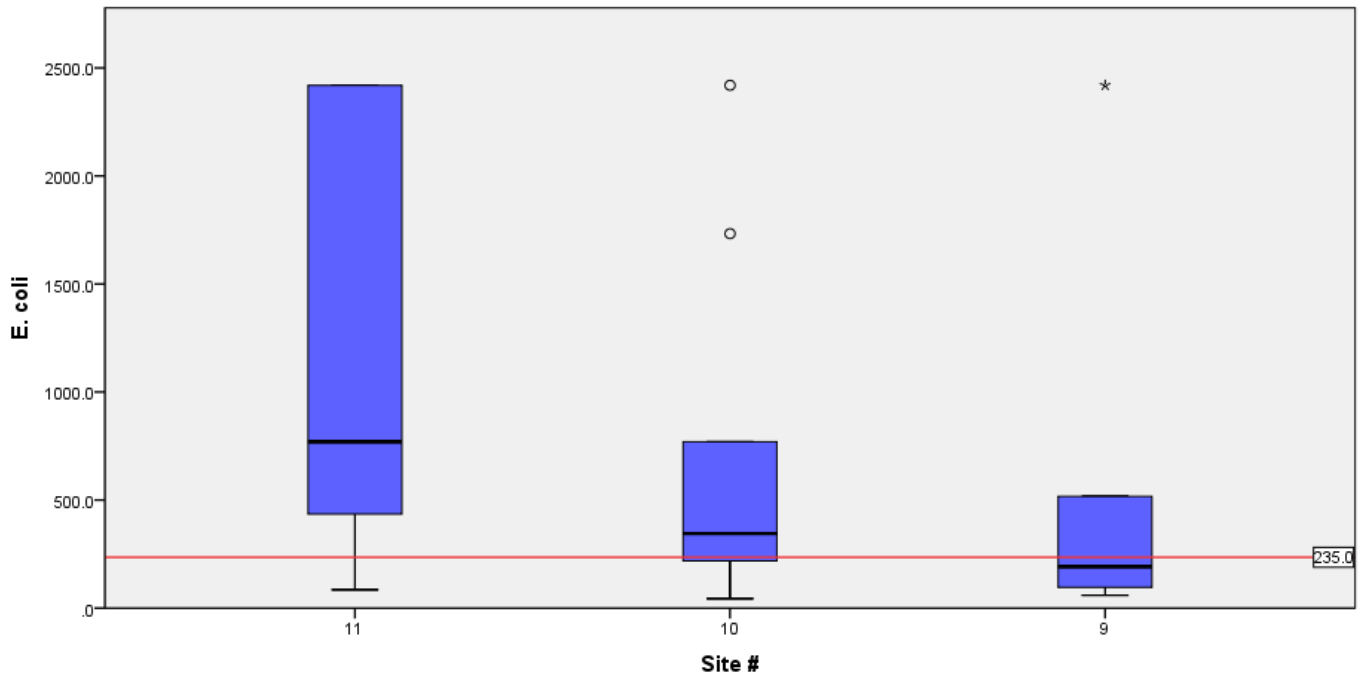

Figure 147 Box plot illustrating site E. coli concentrations within the Duck Creek Subwatershed

4.6.2.2 *Fish*

An evaluation of each site's fish community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, either receiving a "very poor" or "poor" integrity class rating. Only one fish was collected from Site 10. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
11	24	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
10	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
9	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 66 Site fish index of biotic integrity scores within the Duck Creek Subwatershed

4.6.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "poor" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes

11	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
10	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
9	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 67 Site macroinvertebrate index of biotic integrity scores within the Duck Creek Subwatershed

4.6.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, ranged from 18-21°C, (64-70°F) with Site 11 being the coolest.

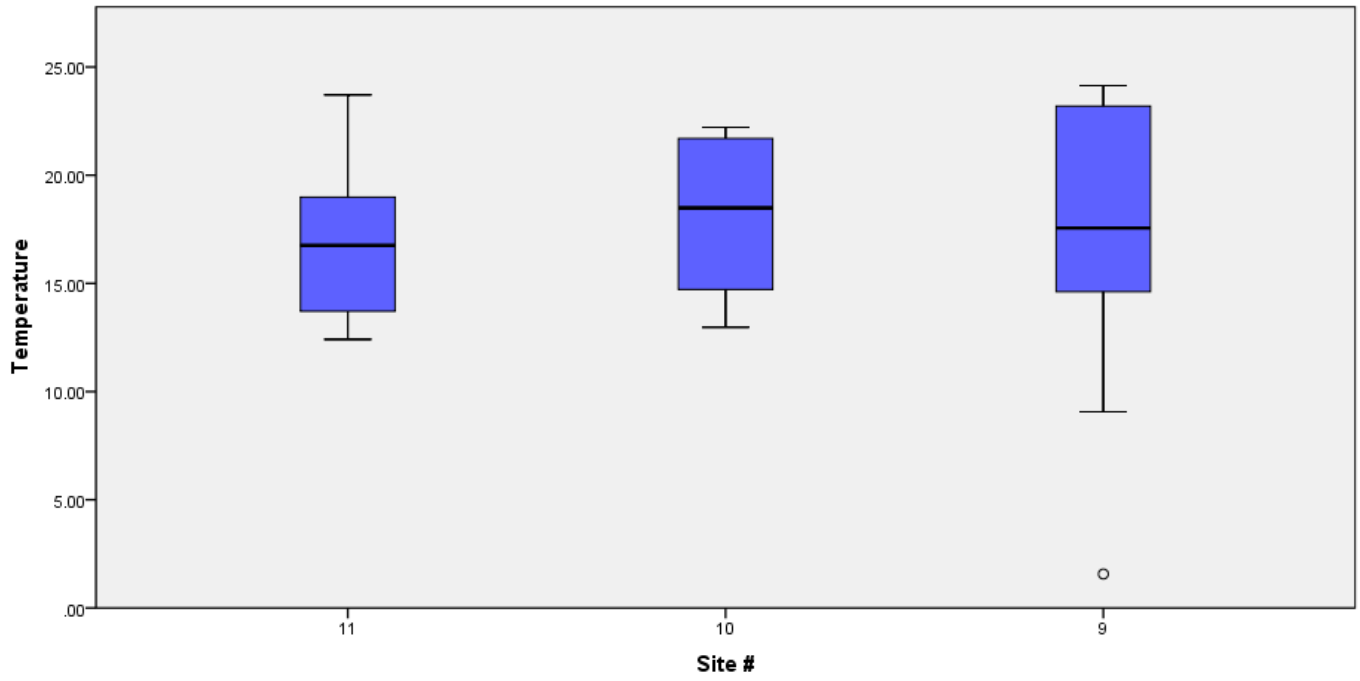

Figure 148 Box plot illustrating site water temperatures within the Duck Creek Subwatershed

4.6.2.5 *Dissolved Oxygen*

Figure 149 shows that all sites have median dissolved oxygen concentrations between 4-12 mg/L, however Site 11 frequently had dissolved oxygen concentrations that fell below the 4 mg/L water quality standard. The lowest concentration observed was less than 1 mg/L. These observations typically occurred during the summer when water temperatures were at their warmest. Dissolved oxygen concentrations higher than the 12 mg/L threshold all occurred in spring when water temperatures were still relatively cool.

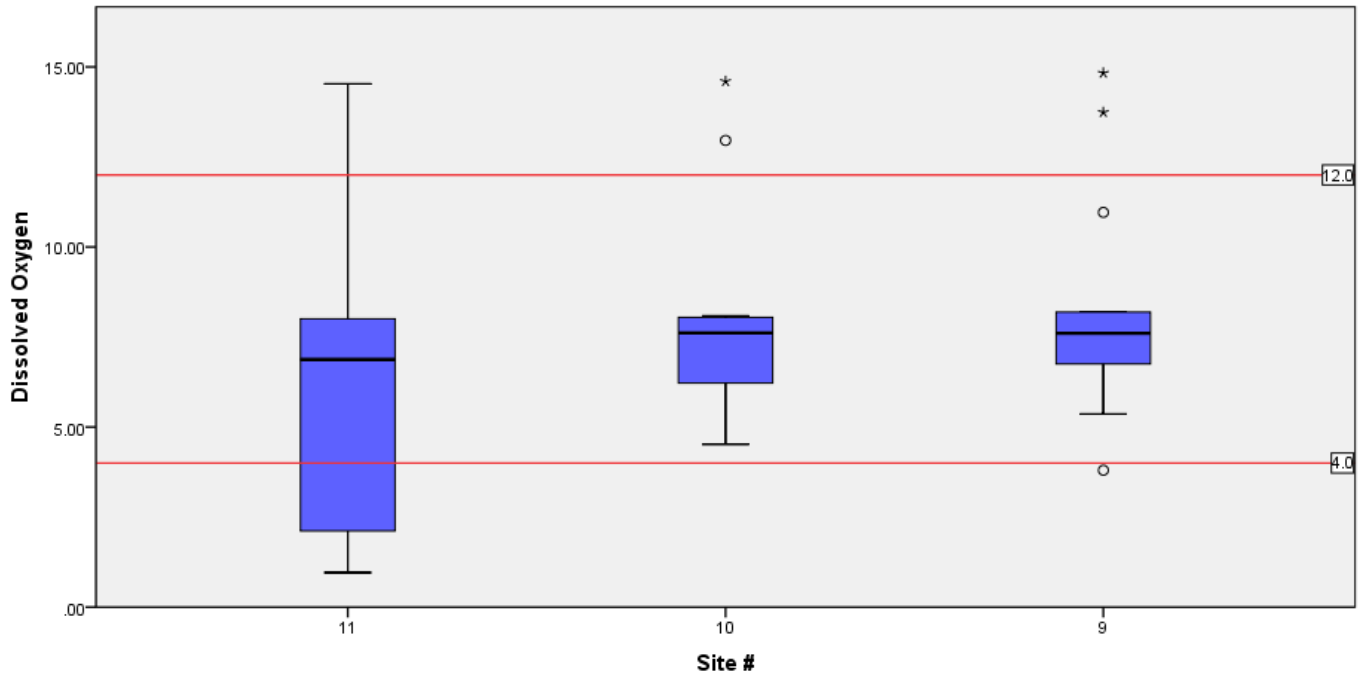

Figure 149 Box plot illustrating site dissolved oxygen concentrations within the Duck Creek Subwatershed

4.6.2.6 *Total Organic Carbon*

Figure 150 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 11.

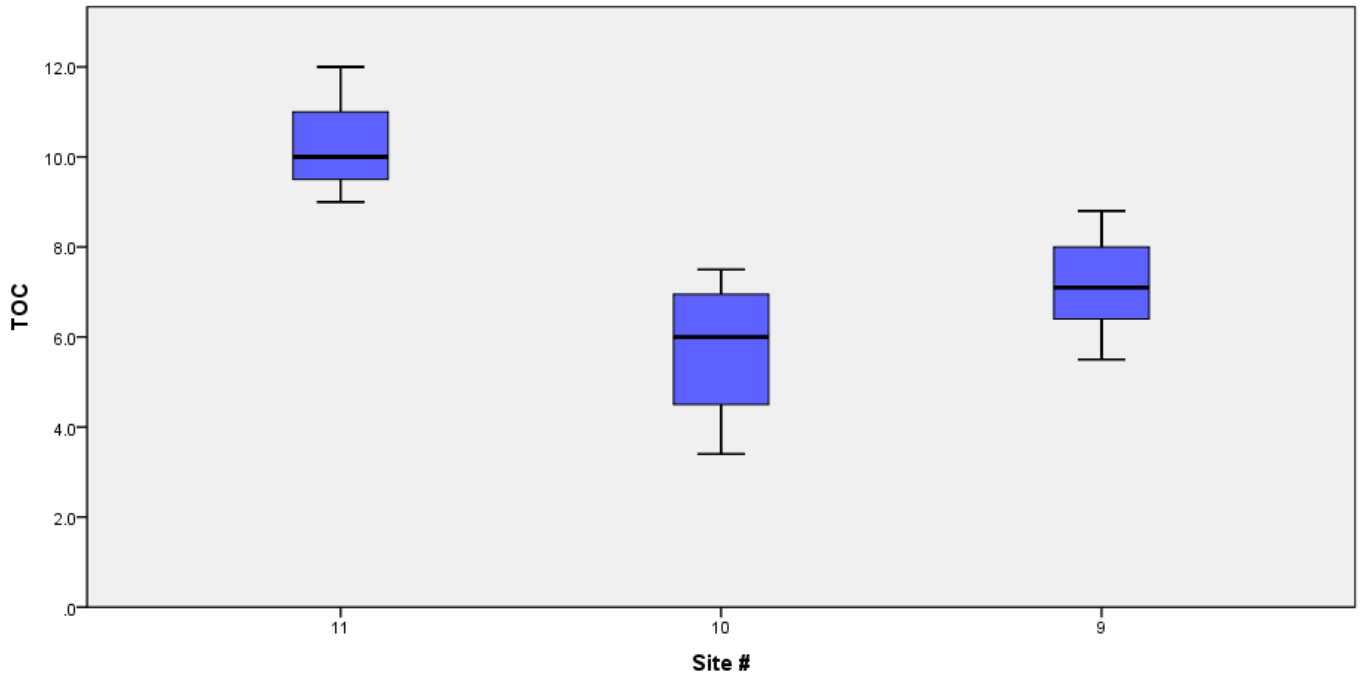

Figure 150 Box plot illustrating site TOC concentrations within the Duck Creek Subwatershed

4.6.2.7 *Nutrients*

Figure 151 shows that median total phosphorus concentrations fell between the 0.3 mg/L and 0.07 mg/L thresholds. Site 11 had the highest median and maximum total phosphorus concentration.

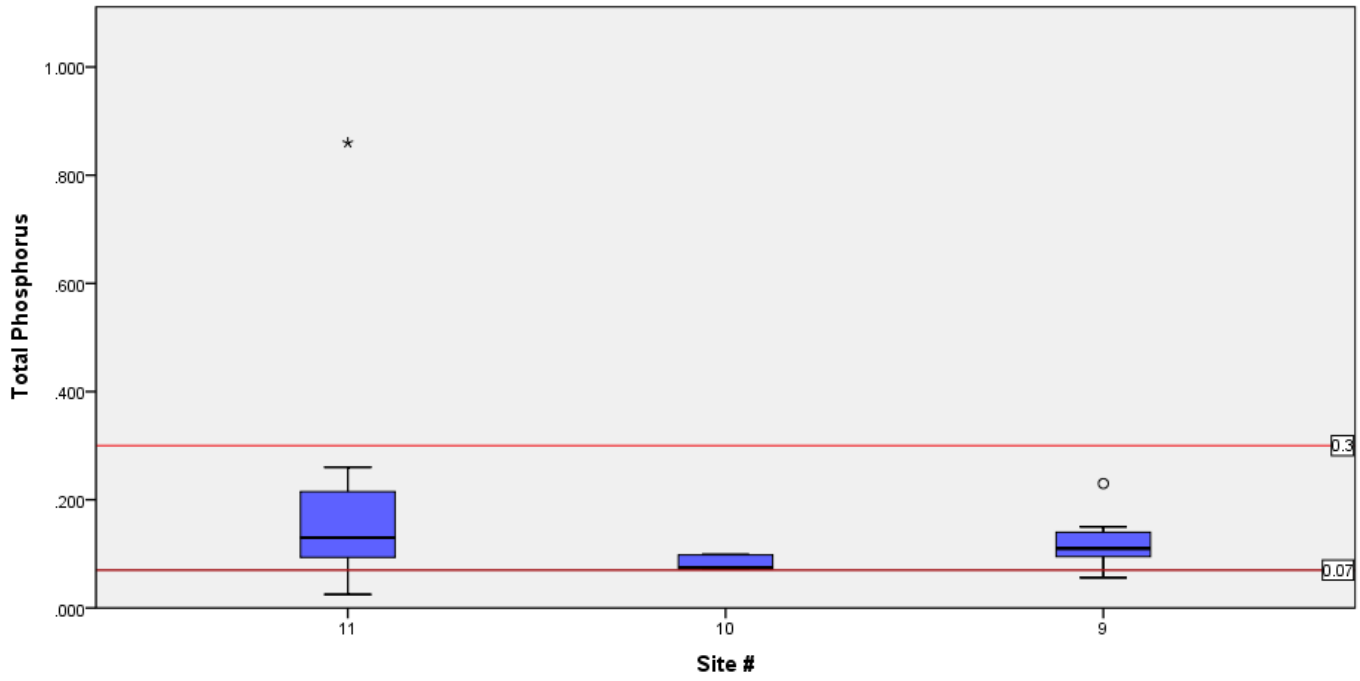

Figure 151 Box plot illustrating site total phosphorus concentrations within the Duck Creek Subwatershed

Figure 152 shows that none of the sites exceeded the 10 mg/L threshold. Site 11 was the only site to have a median nitrate concentration above the 1.09 mg/L threshold.

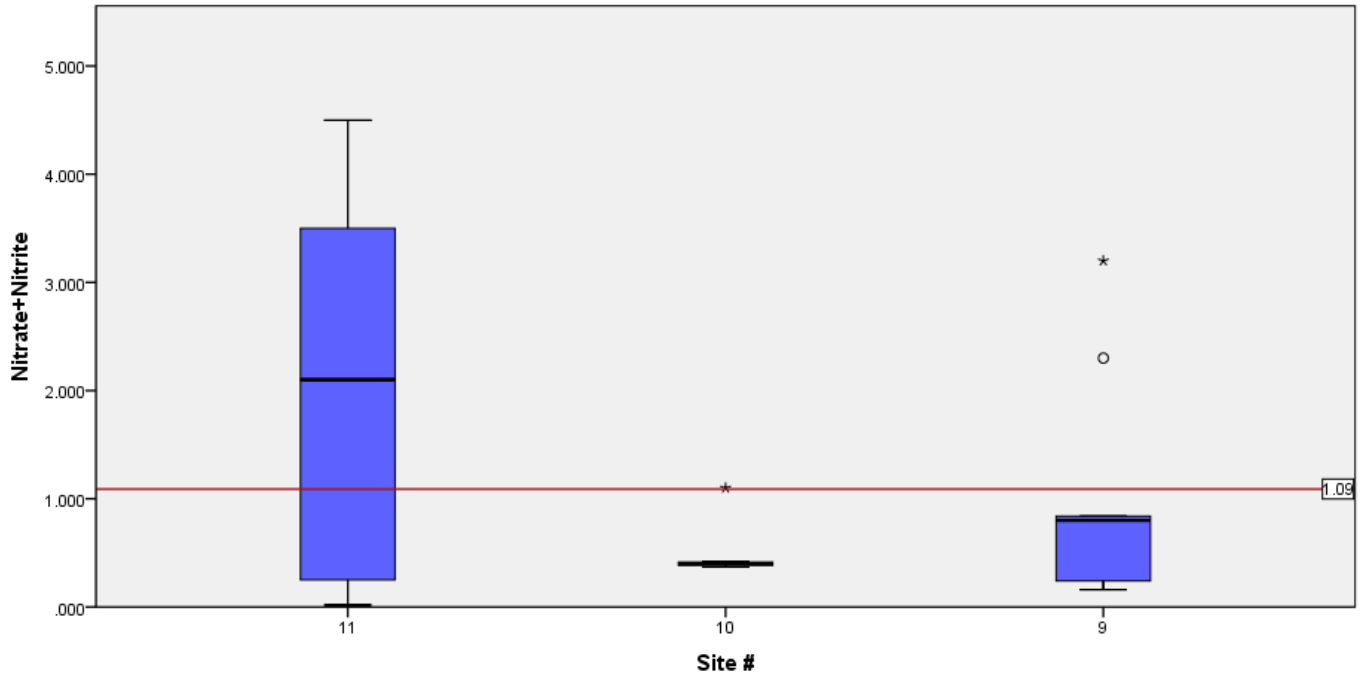

Figure 152 Box plot illustrating site nitrate concentrations within the Duck Creek Subwatershed

Figure 153 shows that Sites 9 and 11 have median total Kjeldahl nitrogen concentrations that fall between the 0.68 mg/L and 1.27 mg/L thresholds. The outlier at Site 11 occurred during the summer and coincides with other peaks.

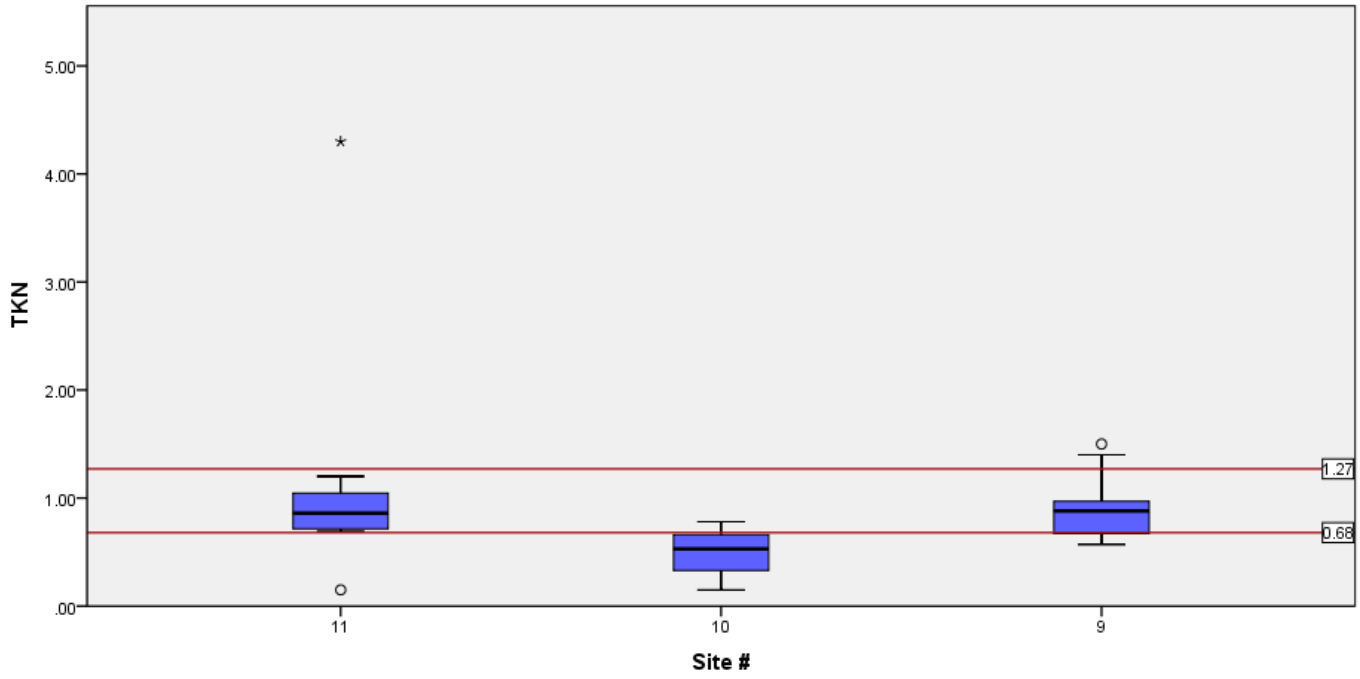

Figure 153 Box plot illustrating site total Kjeldahl nitrogen concentrations within the Duck Creek Subwatershed

Figure 154 shows that ammonia concentrations most typically fell below the lab detection limit except for a few outlier events observed at Sites 9 and 11. The maximum concentration observed at Site 9 was 0.21 mg/L during the spring and 2.6 mg/L at Site 11 during the summer.

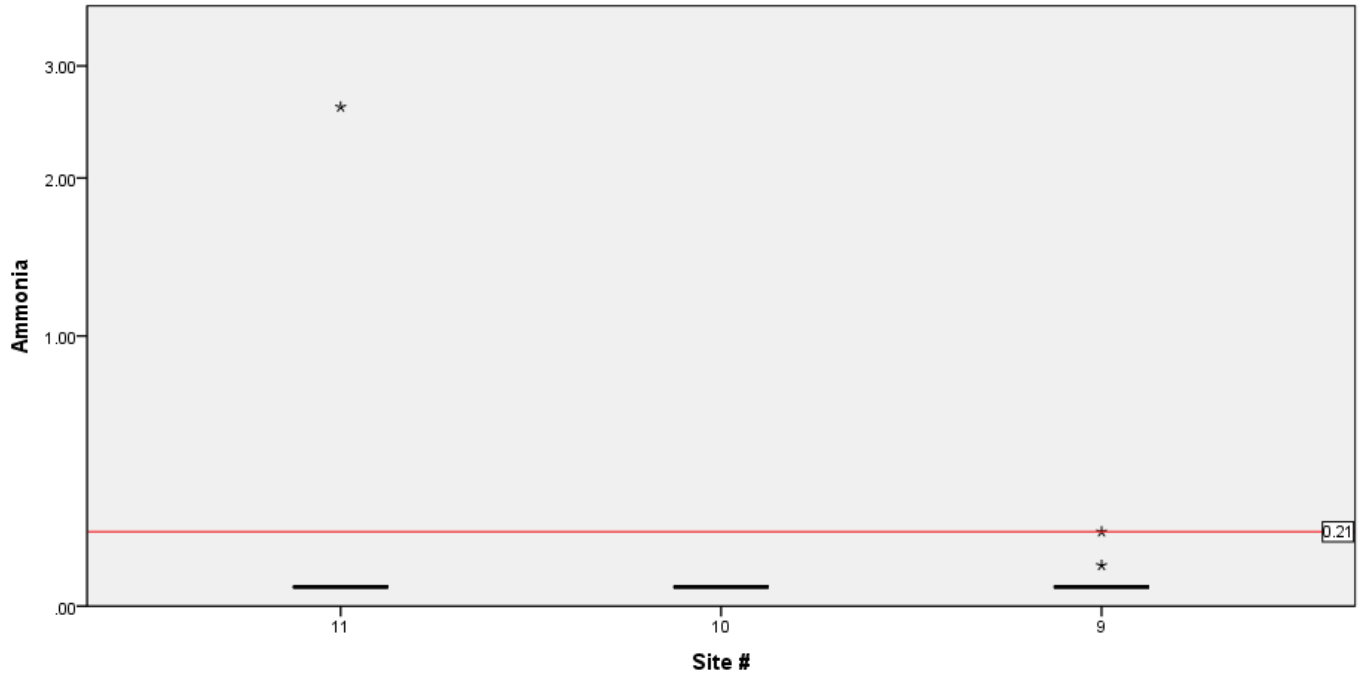

Figure 154 Box plot illustrating site ammonia concentrations within the Duck Creek Subwatershed

4.6.2.8 *Suspended Solids & Turbidity*

Figure 155 shows that all sites typically had maximum total suspended solids concentrations below the 30 mg/L threshold except for on occasion at Site 11. The exceedance at occurred during mid-range stream flow conditions indicating a likely nonpoint source contribution.

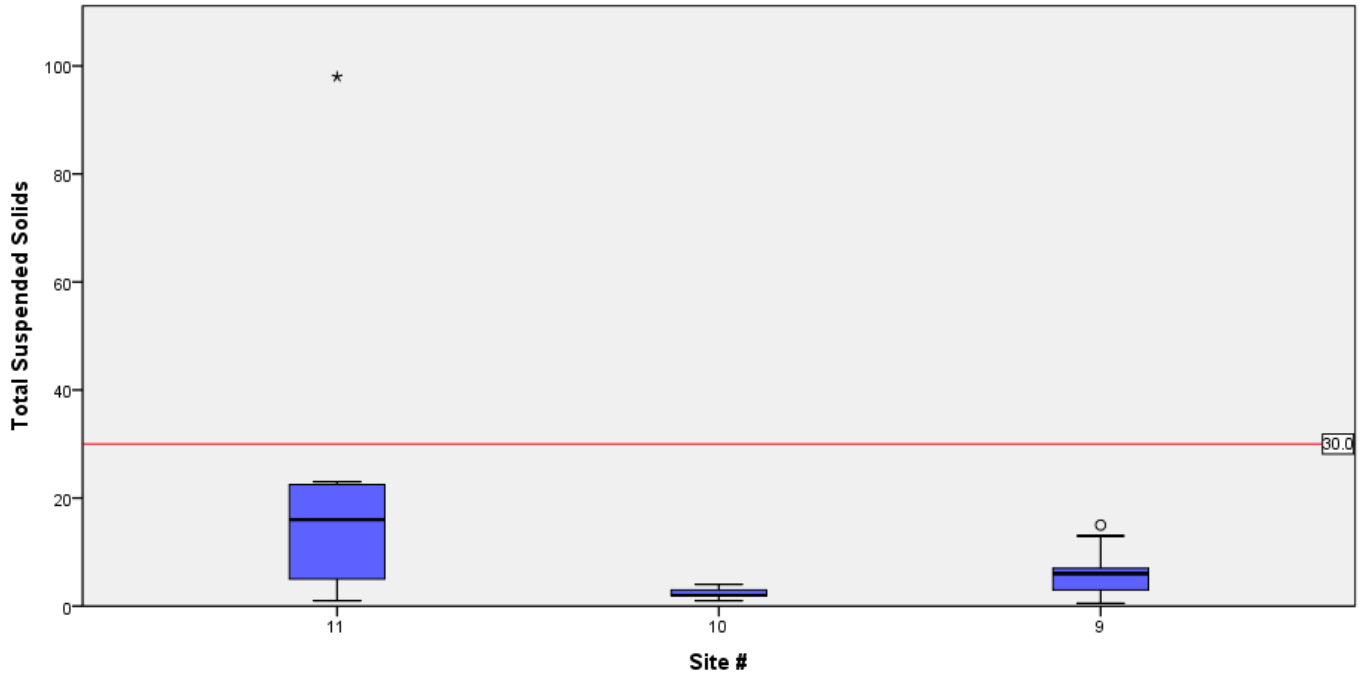

Figure 155 Box plot illustrating site total suspended solids concentrations within the Duck Creek Subwatershed

Figure 156 shows that Site 11 had a median turbidity level greater than 10.4 NTU. Turbidity levels at Sites 9 and 10 typically fell below 10.4 NTU.

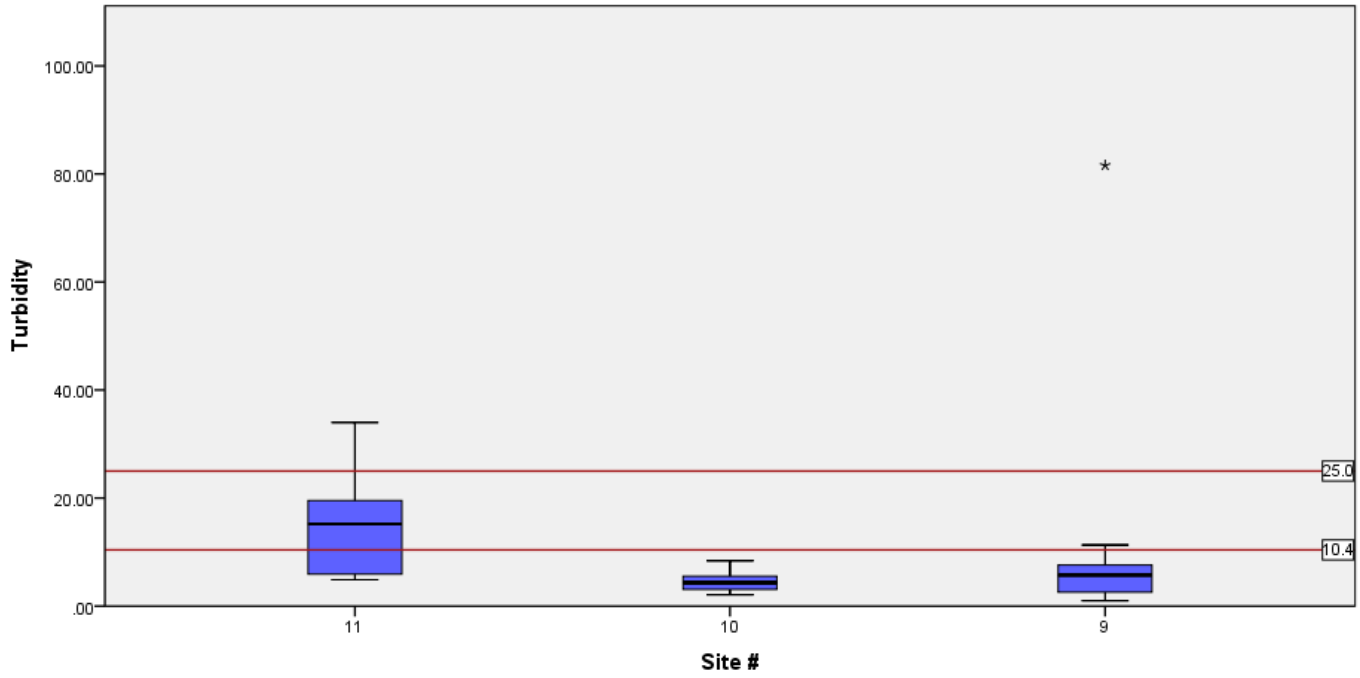

Figure 156 Box plot illustrating site turbidity levels within the Duck Creek Subwatershed

4.6.2.9 *Habitat*

Figure 157 shows that Sites 10 and 11 generally do not possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51). The QHEI for Site 9, just met this threshold with a score of 52.

The major habitat limitations for Site 10 are poor substrate quality and channel morphology. Substrates at Site 10 were characterized as predominately muck with moderate silt cover and embeddedness. The channel reach had low sinuosity, poor riffle/pool development, showed recent or no recovery from stream channelization and had low channel stability. Aerial imagery shows this small stream meandering within its floodplain upstream and downstream of the site on East 10th Street. Land cover data shows much of the streams length to be bordered by wetland, forest and grassland. The poor channel morphology at the site appears to be attributed to placement of fill in the floodplain to construct the roadway and clearing to maintain flow through the two large culverts that the stream passes through under the road.

The major habitat limitation at Site 11 is substrate quality and instream cover. Substrates at Site 11 were characterized as predominately muck with moderate silt cover and embeddedness. The channel reach had moderate sinuosity, good riffle/pool development, but showed signs of having recovered from past channelization. Instream habitat cover was documented as being sparse.

The primary habitat limitations at Site 9 include substrate quality, channel morphology and instream cover. Substrates were characterized as predominately sand with inclusions of gravel and muck. Silt cover was categorized as moderate and embeddedness was extensive. This stretch of Duck Creek has a low channel gradient and it meanders through a forested floodplain wetland which could explain the substrate quality. The stream channel sinuosity was categorized as low however there was no indication of past channelization. Channel stability was categorized as low. Once again this might be because of the fine substrates in addition to a moving bedload.

None of the sites in the subwatershed are located on reaches that are maintained as county regulated drains. However there are segments located upstream of Site 11 (Figure 159).

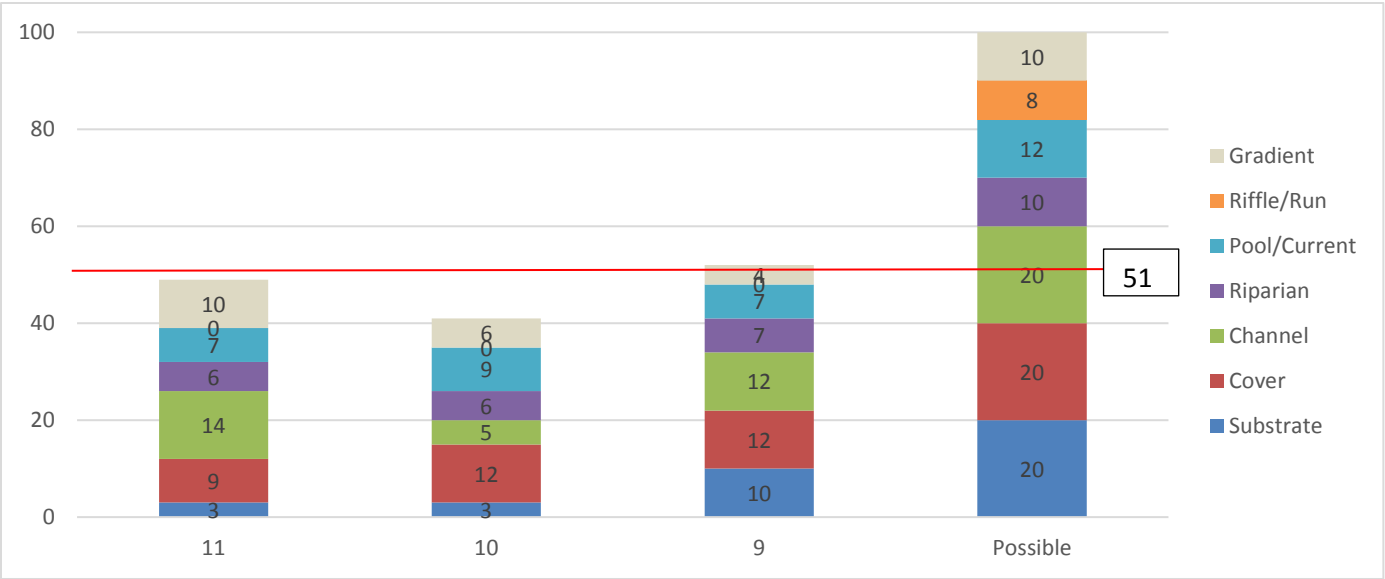

Figure 157 Site qualitative habitat evaluation index scores within the Duck Creek Subwatershed

4.6.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is agricultural lands (51%) Figure 158). Most of the development occurring within the subwatershed is located within the boundaries of Hobart in Lake County. The Porter County portion of the subwatershed is almost entirely unincorporated except for a very small area to the north that fall within Portage. A majority of the subwatershed is unsewered except for some areas within Hobart (Figure 61).

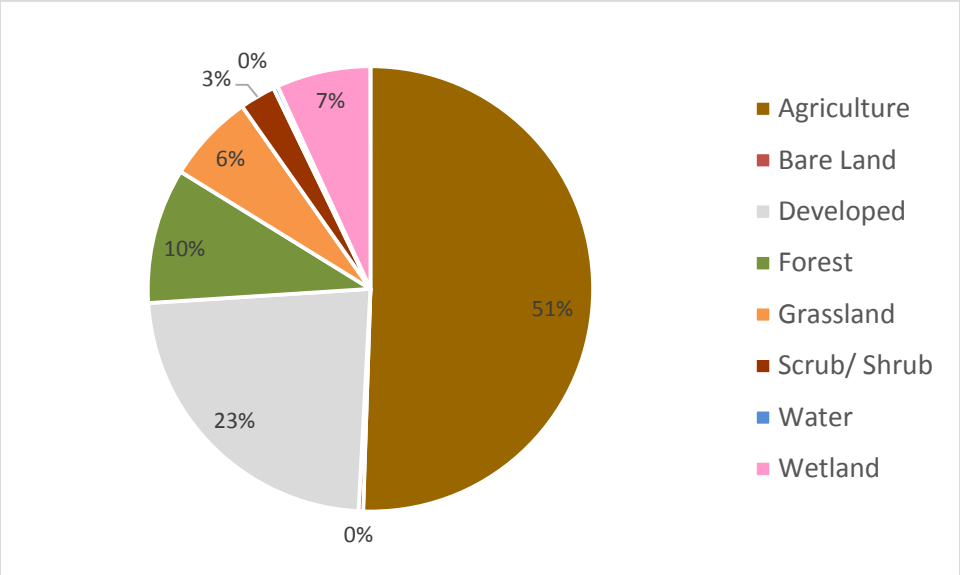

Figure 158 Percent land cover within the Duck Creek Subwatershed

Table 68 includes land cover information for each site's drainage area. Each sites drainage area is dominated by agricultural land uses. Sites 9 and 10 have the highest percentage of developed land, with portions of their drainage area falling near downtown Hobart. Long reaches of Duck Creek and its tributaries are buffered by floodplain wetlands and upland forest except within the headwater areas.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
11	69.0	0.3	9.5	7.5	6.2	2.2	0.5	4.8
10	56.4	0.1	19.3	8.1	5.5	1.8	0.5	8.2
9	50.4	0.3	23.2	9.8	6.4	2.6	0.3	6.8

Table 68 Site percent land cover within the Duck Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 69. Overall, natural land cover makes up the largest percentage of cover in the riparian zone. However, human uses are still a significant component of the subwatershed's riparian zone. Agriculture is the most prevalent human land cover type especially within Site 10's drainage area.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
11	36.6	0.0	6.9	13.6	14.8	5.5	1.1	21.5
10	54.1	0.0	3.8	4.0	1.7	0.6	1.0	34.7
9	33.2	0.0	10.4	10.0	7.8	3.3	0.7	34.6

Table 69 Site percent riparian land cover within the Duck Creek Subwatershed

No NPDES permitted facilities were identified by the TMDL in the subwatershed. However, there is one landfill (Wheeler Landfill) located along State Highway 130. A tributary of Duck Creek runs adjacent to the landfill (Figure 159). This reach was recently cleaned to improve drainage and reduce flooding impacts observed upstream. This maintenance activity resulted in a deep channel profile with steep slopes. Erosion is already evident.

Ten potential livestock facilities were identified in the subwatershed. Three facilities are located in the drainage area of the unnamed tributary to Duck Creek that Site 10 is located on. The other facilities are located upstream of Site 11 on the Porter County portion of the subwatershed (Figure 159).

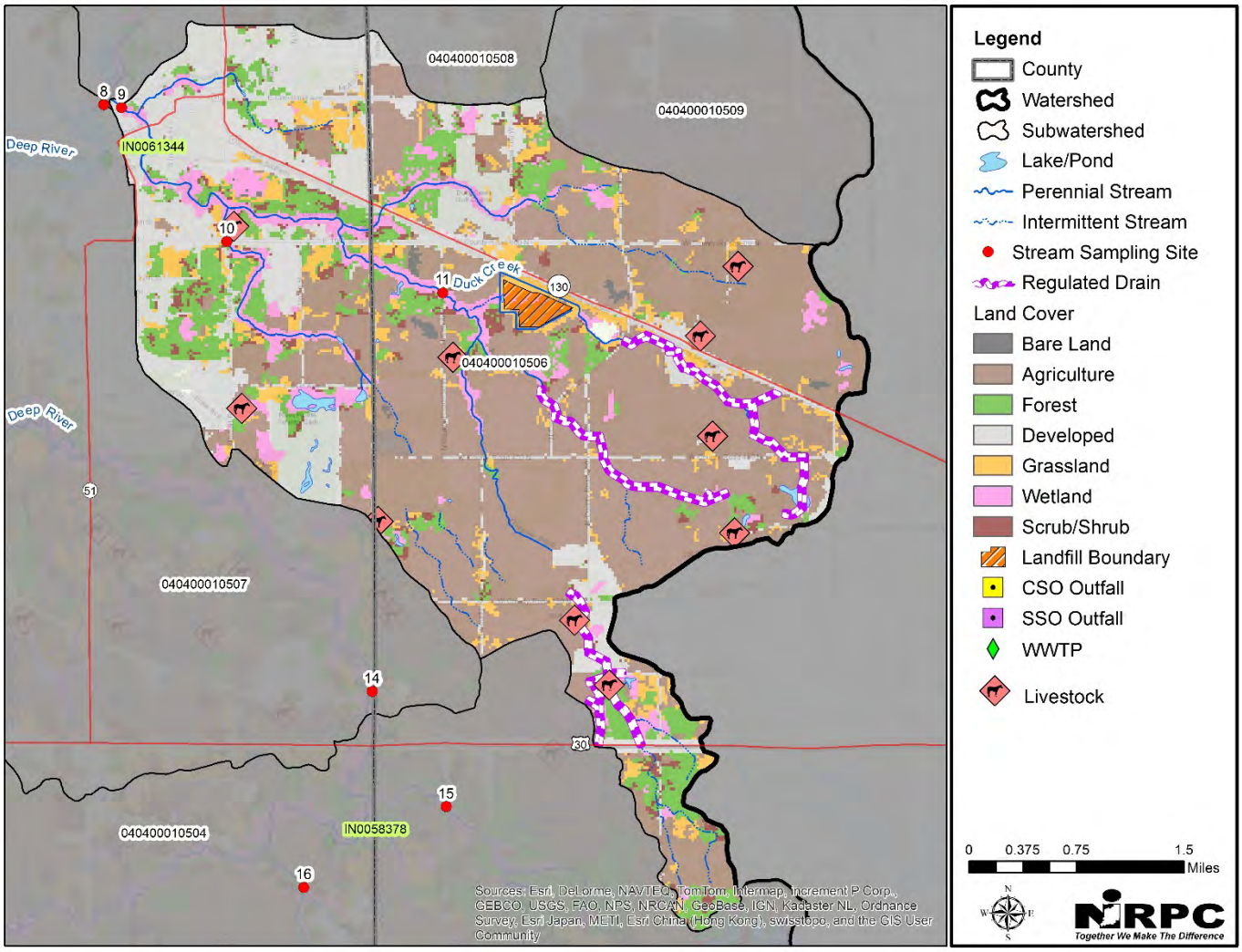

Figure 159 Land use and land cover within the Duck Creek Subwatershed

4.6.4 Soils

A majority of the soils that border the streams in the subwatershed are classified as hydric. The subwatershed is somewhat unique in that relatively long reaches of Duck Creek and its tributaries retain portions of their riparian wetlands (Figure 159). Despite this, the subwatershed has the second highest loss of wetland habitat (Table 35). Many areas of highly or potentially highly erodible soils are located adjacent or in proximity to Duck Creek and its tributaries, especially in the agricultural areas within Porter County. A high percentage of the soils in the subwatershed have moderate to high runoff potential. Soil surface texture in these areas are largely comprised of silt loam and silty clay loams. This in part may help explain the poor substrate quality noted in the stream habitat assessments. There is one small area around the landfill in which soil slope exceeds 15%.

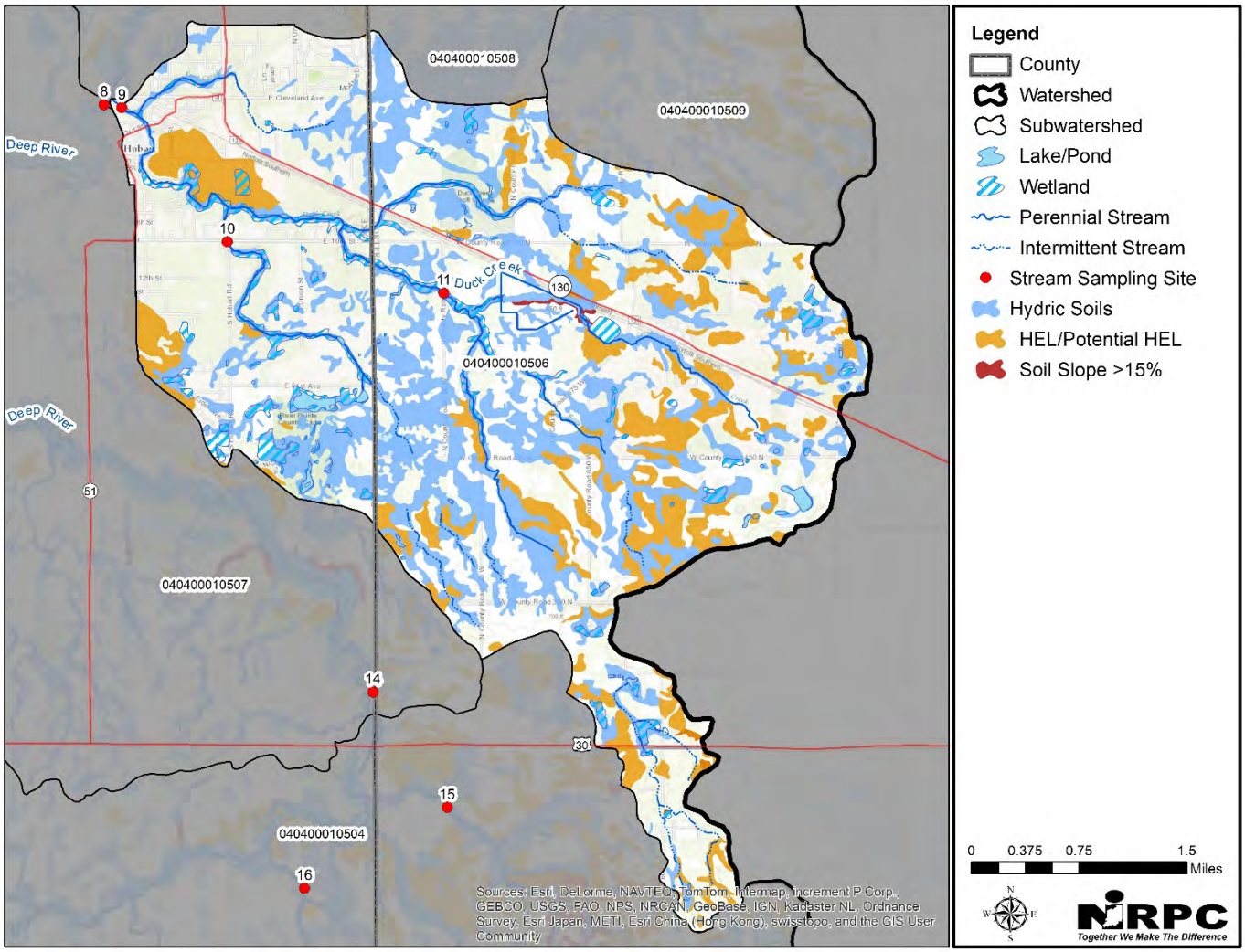

Figure 160 Soils within the Duck Creek Subwatershed

4.7 Lake George Subwatershed (HUC 0404000107)

4.7.1 Overview

The Lake George subwatershed is located in the central portion of the watershed. It drains approximately 17.3 mi² of primarily developed (35%) and agricultural (29%) land. Based on the monitoring completed by IDEM, two stream segments have been identified as impaired. Known water quality problems include impaired biotic communities and high *E. coli* levels.

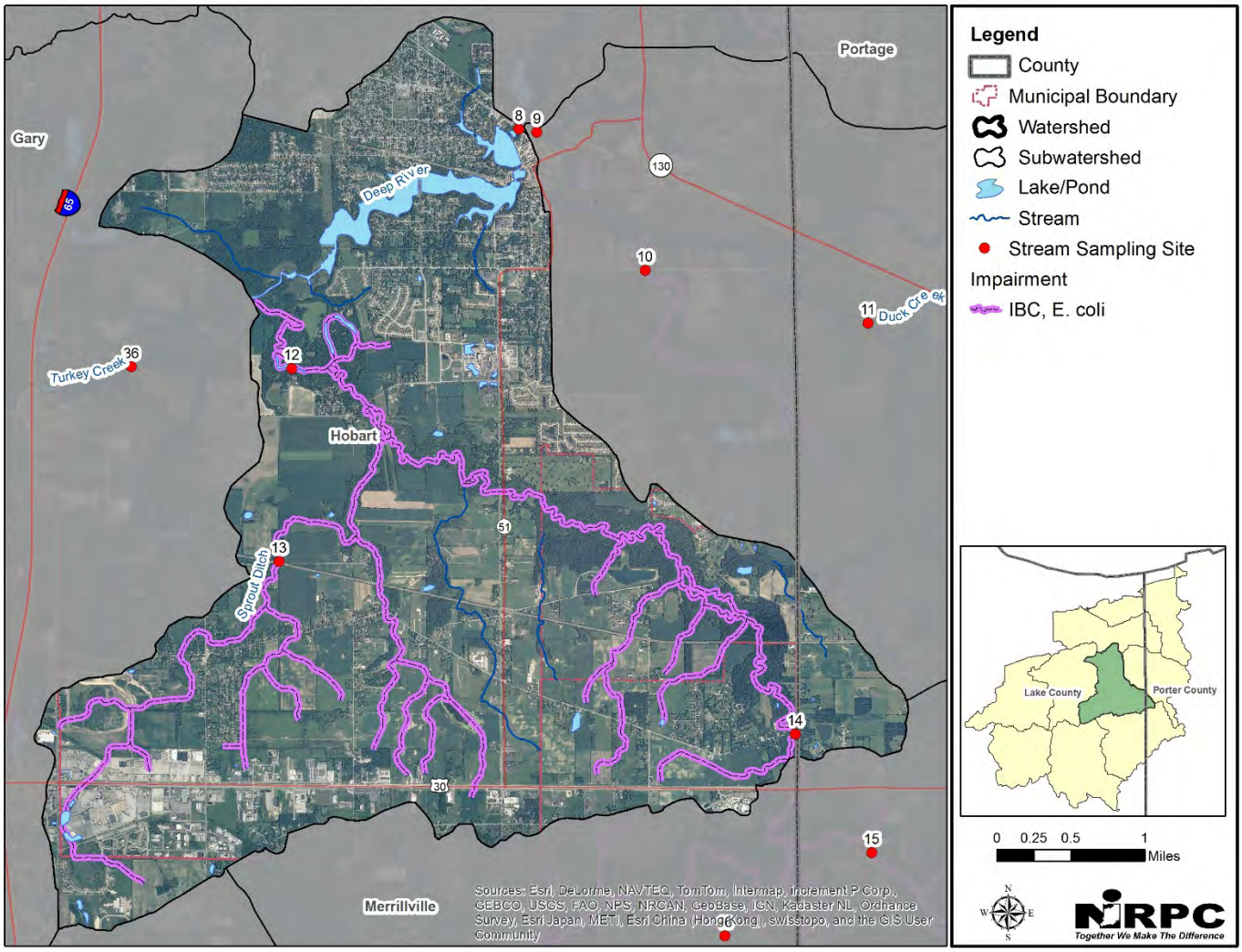

Figure 161 Impaired streams within the Lake George Subwatershed

4.7.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 8, 12-14) within the Lake George subwatershed (Figure 161). Site 8 was used to represent the subwatershed and to assess its contribution to the overall Deep River-Portage Burns Waterway watershed.

4.7.2.1 *Pathogens*

Figure 162 shows that full body contact recreational use is threatened by elevated pathogen levels. Sites 8, 12, and 13 had median *E. coli* concentrations above the 235 CFU/100 mL single sample water quality standard. There is an increase in *E. coli* concentrations between Site 14 (downstream) and Site 12 (upstream) on Deep River. Site 13,

located on Sprout Ditch, generally had the highest concentrations observed and may be contributing to the higher *E. coli* levels downstream at Site 12. There was a slight decrease in median *E. coli* concentrations between Sites 8 and 12 on Deep River. This decrease in part may be attributed to Lake George.

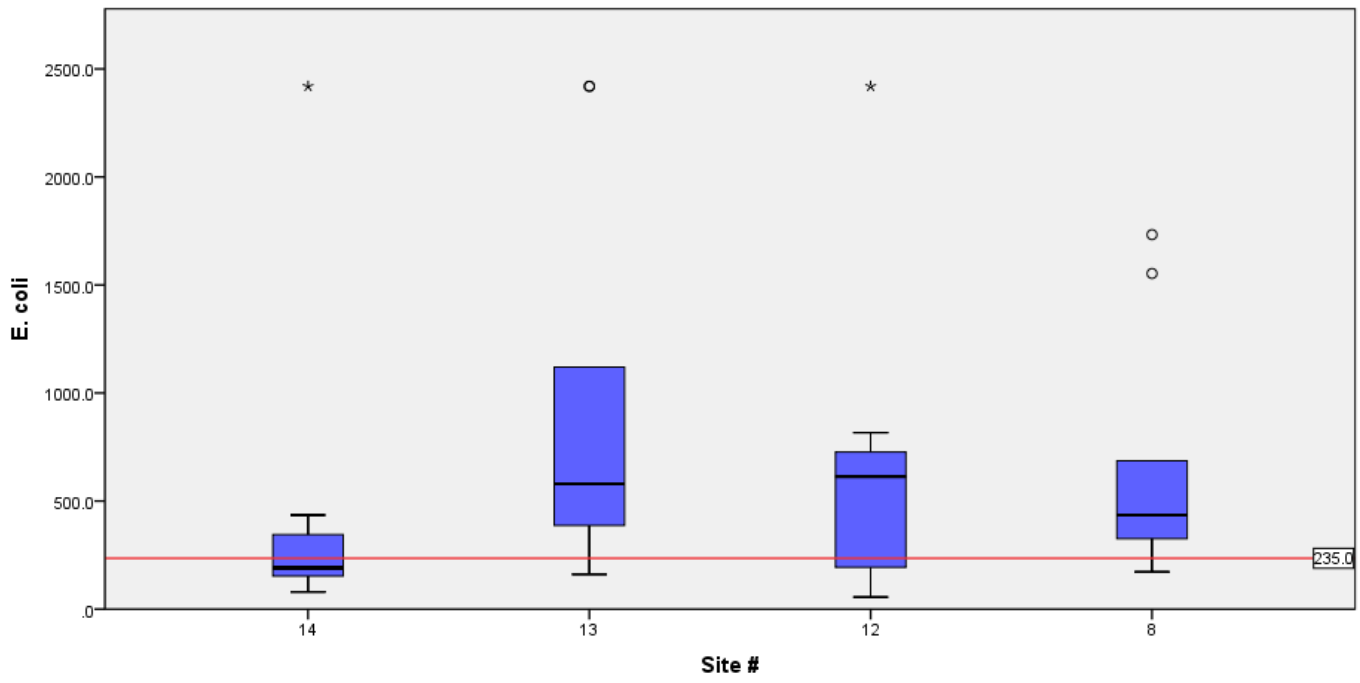

Figure 162 Box plot illustrating site E. coli concentrations within the Lake George Subwatershed

4.7.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 8 and 13 are not supporting of their Aquatic Life Use designation. Sites 12 and 14 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
14	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
13	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
12	42	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
8	32	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 70 Site fish index of biotic integrity scores within the Lake George Subwatershed

4.7.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that Sites 8 and 12 are not supporting of their Aquatic Life Use designation. Sites 13 and 14 are considered to be fully supporting however, they only received a "fair" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
14	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
13	42	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
12	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
8	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 71 Site macroinvertebrate index of biotic integrity scores within the Lake George Subwatershed

4.7.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 19-21°C, (66-70°F).

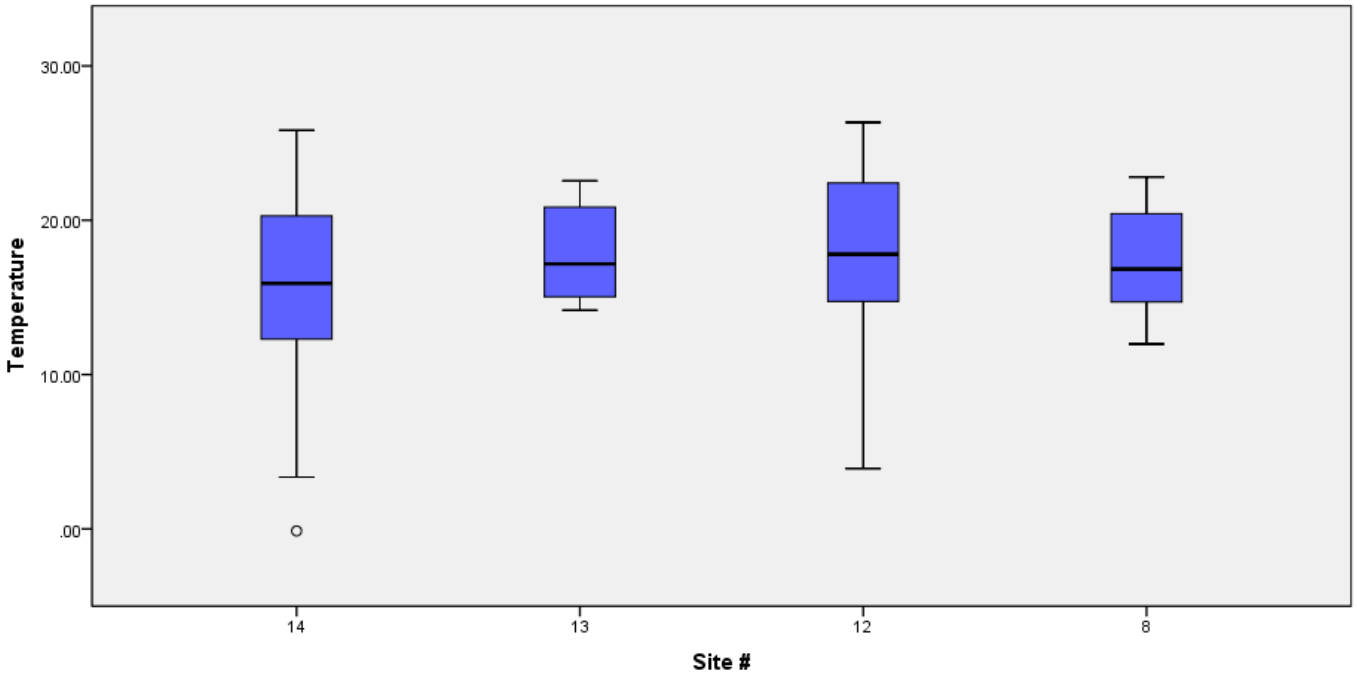

Figure 163 Box plot illustrating site water temperature within the Lake George Subwatershed

4.7.2.5 *Dissolved Oxygen*

Figure 164 shows that all sites typically met the dissolved oxygen water quality standard of 4-12mg/L. There were two occasions during the summer in which Site 8, located below the Lake George dam, had dissolved oxygen concentrations less than 4 mg/L. Sites 12-14 had dissolved oxygen concentrations that occasionally exceeded the 12 mg/L target. The exceedances at Sites 12 and 13 occurred during the spring while Site 14's exceedance occurred during the summer.

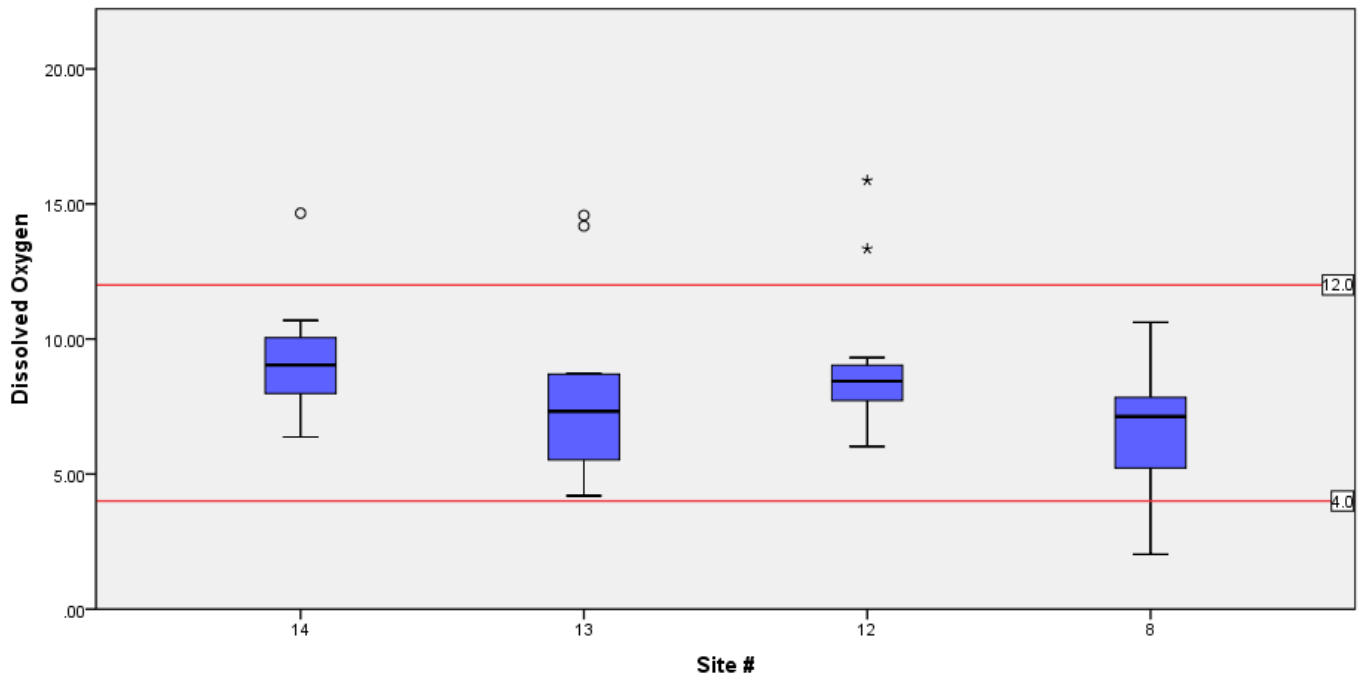

Figure 164 Box plot illustrating site dissolved oxygen concentrations within the Lake George Subwatershed

4.7.2.6 *Total Organic Carbon*

Organic material loading and decomposition doesn't appear to be the primary driver for the occasional dissolved oxygen problems observed at Site 8. Figure 165 shows a fairly sizable drop in total organic concentrations between Sites 12 and 8 indicating that organic materials carried by Deep River are settling out in Lake George.

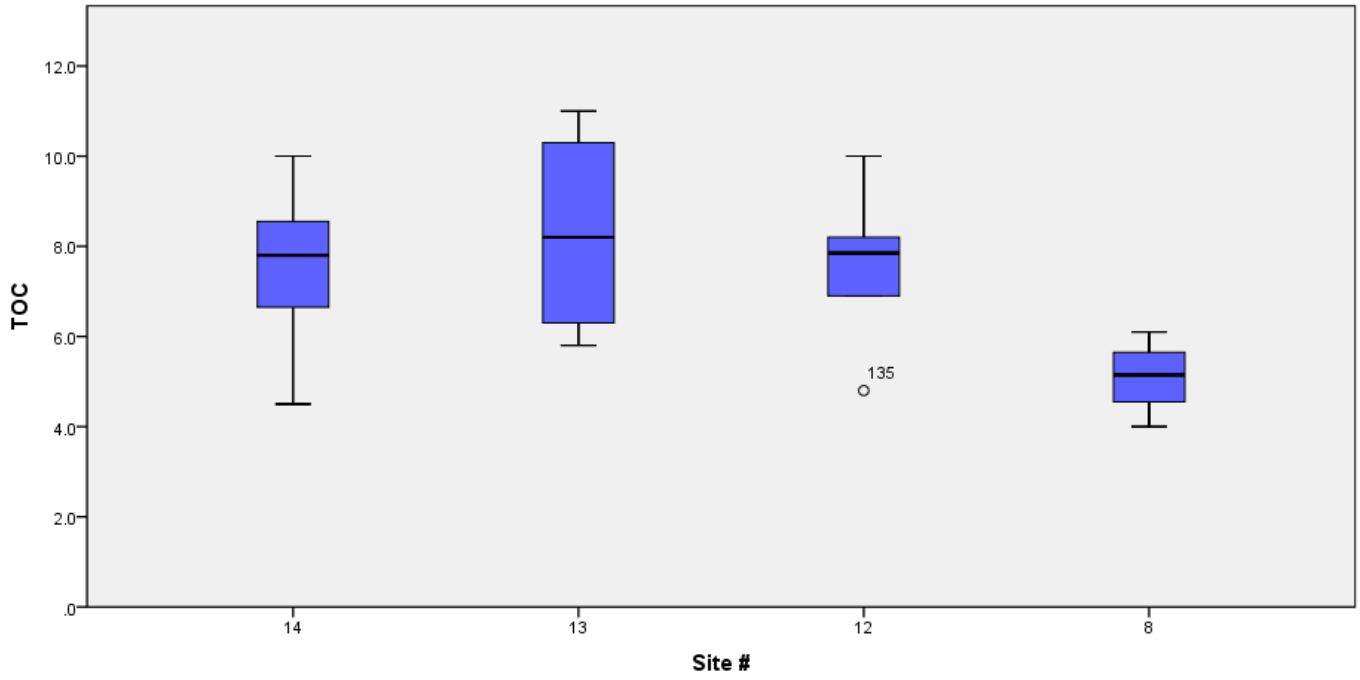

Figure 165 Box plot illustrating site TOC concentrations within the Lake George Subwatershed

4.7.2.7 *Nutrients*

Figure 166 shows that all sites had median total phosphorus concentrations between the 0.07 mg/L and 0.3 mg/L thresholds. Generally Site 14 had the highest observed concentrations but we can see a decreasing as we move from upstream to downstream along Deep River. Additionally the figure shows that median concentrations drop below the Lake George dam indicating the lake is acting a phosphorus sink within the system.

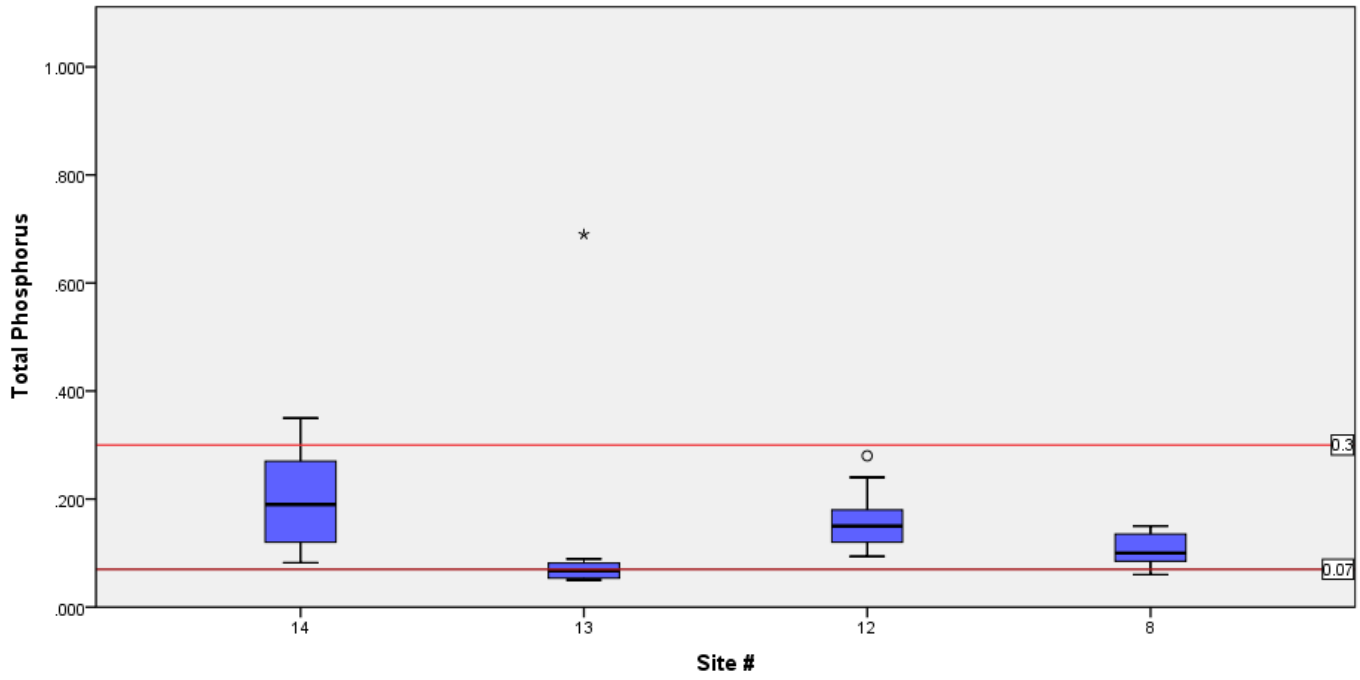

Figure 166 Box plot illustrating site total phosphorus concentrations within the Lake George Subwatershed

Figure 167 shows similar site patterns for nitrate concentrations as was observed for total phosphorus. Median nitrate concentrations decrease moving from upstream to downstream along Deep River. Nitrate concentrations show a large drop between Sites 12 and 8 indicating denitrification is occurring within Lake George. No sites exceeded the 10 mg/L threshold but Sites 12 and 14 have median nitrate concentrations above the 1.09 mg/L threshold.

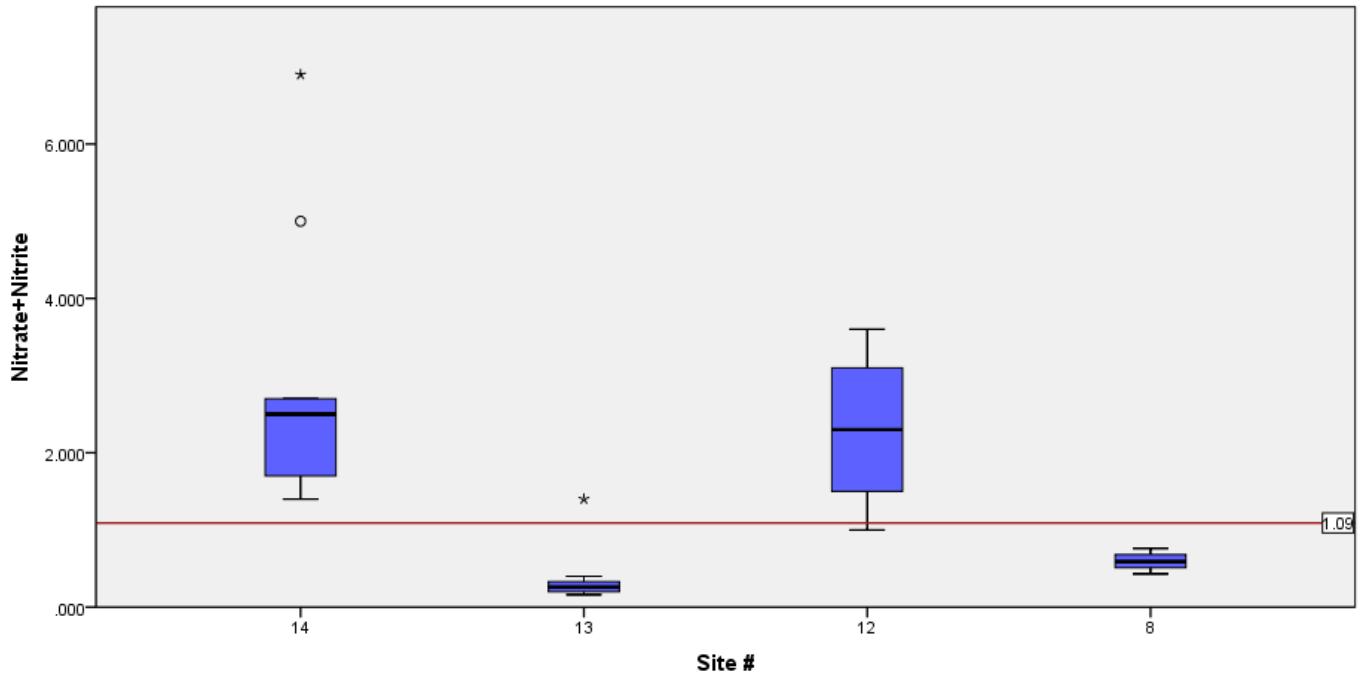

Figure 167 Box plot illustrating site nitrate concentrations within the Lake George Subwatershed

Figure 168 shows a decreasing trend in total Kjeldahl nitrogen levels from upstream to downstream on Deep River. Sites 14 and 12 have median concentrations between the 0.68 mg/L and 1.27 mg/L thresholds.

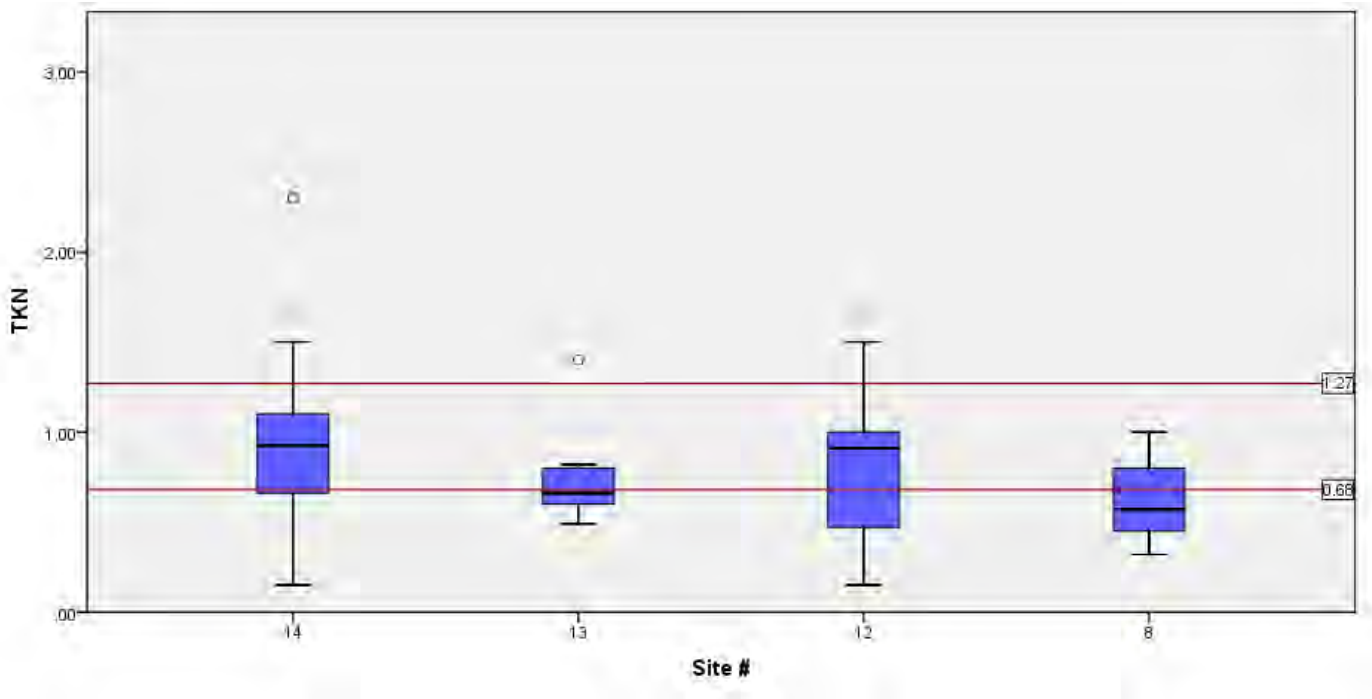

Figure 168 Box plot illustrating site total kjeldahl nitrogen concentrations within the Lake George Subwatershed

Figure 169 shows that ammonia concentrations at Sites 12-14 frequently fell below the laboratory detection limit. The highest maximum ammonia concentration was observed at Site 14 during the winter. Site 8 had the highest frequency of concentrations above 0.03 mg/L indicating excess organic material deposition in Lake George.

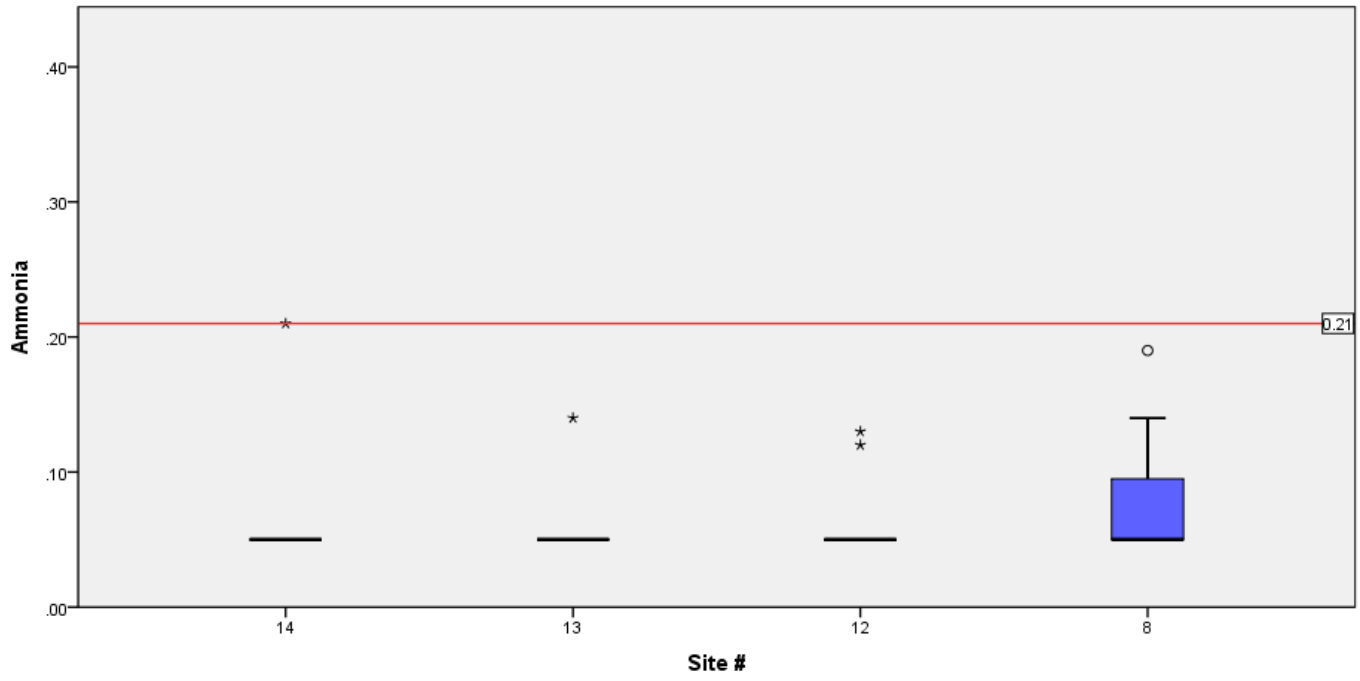

Figure 169 Box plot illustrating site ammonia concentrations within the Lake George Subwatershed

4.7.2.8 *Suspended Solids & Turbidity*

Figure 170 shows that very rarely did any site exceed the 30 mg/L total suspended solids threshold. There is an increasing trend in median total suspended solids concentrations from Site 14 downstream to Site 12. However, total suspended solid concentrations generally decline at Site 8 below the Lake George dam, indicating solids are falling out of suspension in the lake.

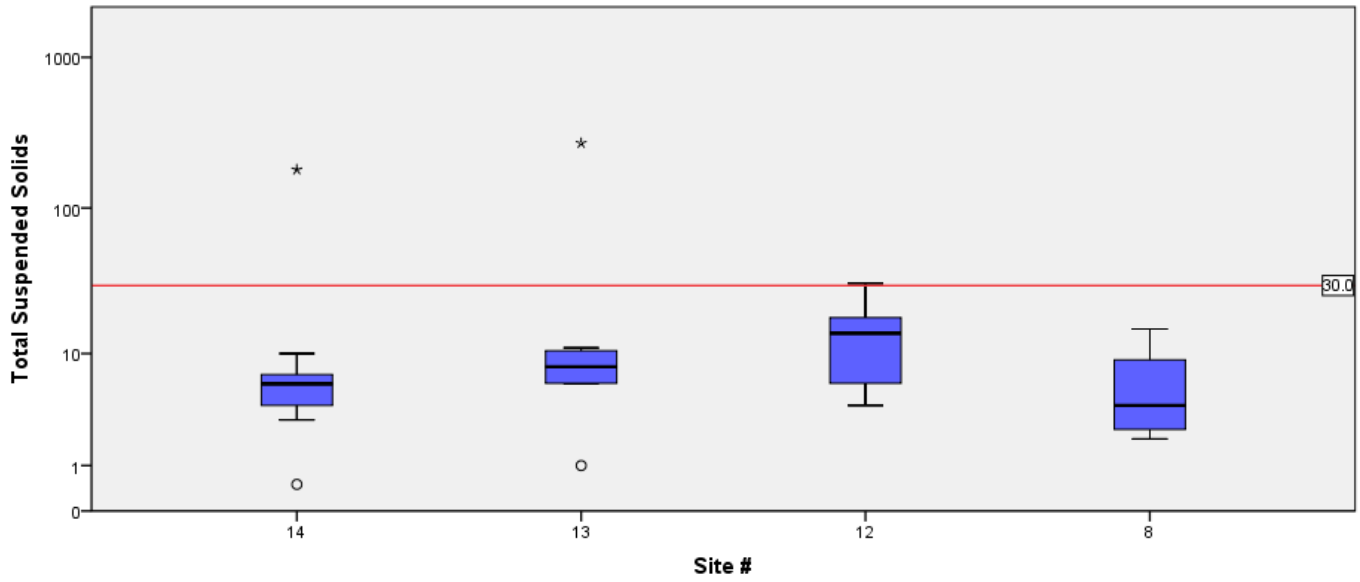

Figure 170 Box plot illustrating site total suspended solids concentrations within the Lake George Subwatershed

Figure 171 shows similar site patterns to those seen above for total suspended solids. Sites 12 and 13 had median turbidity levels slightly higher than the 10.4 NTU threshold. There is an increase in median turbidity concentrations

moving from Site 14 downstream to Site 12. Turbidity concentrations fall at Site 8 indicating that suspended materials are settling out in Lake George.

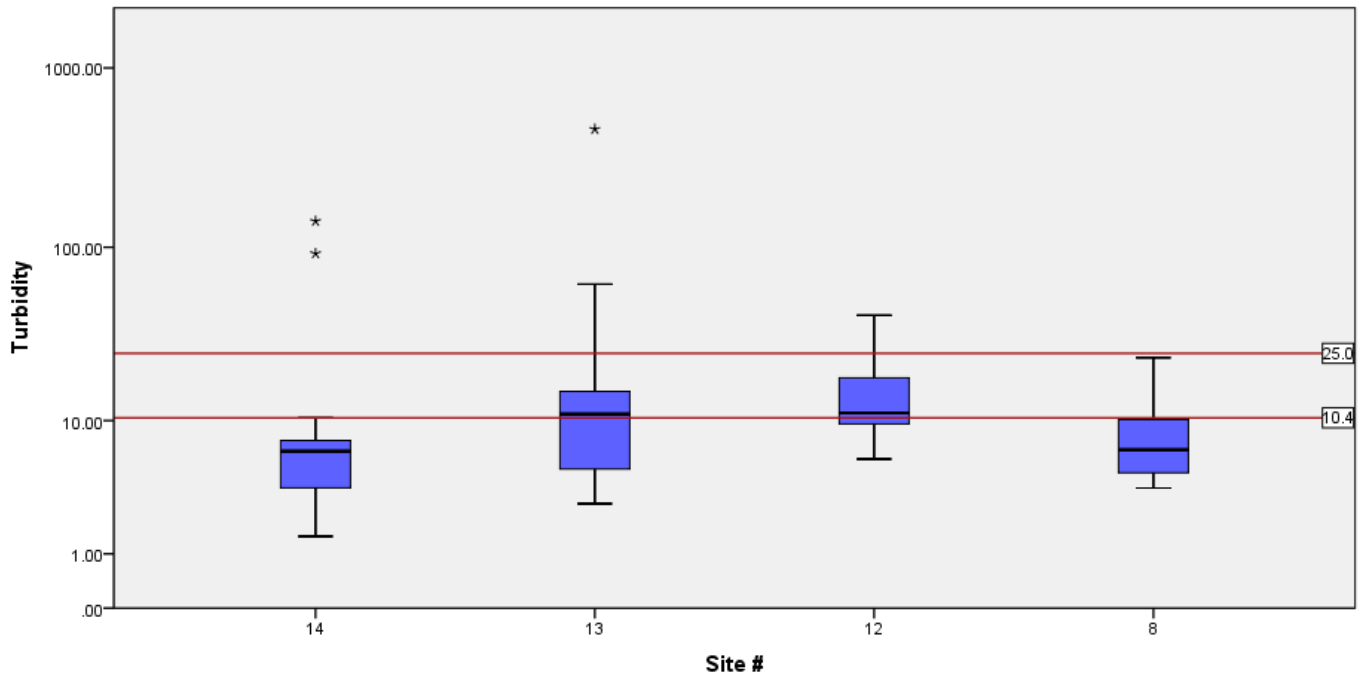

Figure 171 Box plot illustrating site turbidity levels within the Lake George Subwatershed

4.7.2.9 *Habitat*

Figure 172 shows habitat quality is generally conducive to supporting at healthy warmwater fishery at each of survey sites in the subwatershed (QHEI >51). A decline in habitat quality was observed moving downstream from Site 14 to Site 12 on Deep River. The decline appears to be primarily attributed to a decline in substrate quality and absence of riffle/run habitat. Site 12's substrate was characterized as primarily hardpan (clay) with inclusions of sand, detritus, muck and silt. Silt cover and embeddedness were classified as moderate. Site 14's substrate was characterized as primarily sand with inclusions of cobble, gravel, muck and artificial substrate (riprap). Siltation and embeddedness was classified as normal. The difference in substrate quality and riffle habitat may be partly explained by stream gradient between sites. Stream gradient and current velocity greater at Site 14 compared to Site 12.

Habitat quality at Site 8, located below the Lake George dam in Hobart, rebounded to a level similar to that observed at Site 14. Deep River widens out in this area below the dam into a bowl shaped basin. Substrates at Site 8 are characterized as primarily sand with moderate silt cover and embeddedness.

Site 13 is located on Sprout Ditch, a tributary to Deep River. Channel morphology was slightly poorer than the other sites in the subwatershed. Channel sinuosity as low and the reach was recovering from channelization. A portion of Sprout Ditch upstream of Site 13 is maintained as a county legal drain (Figure 174).

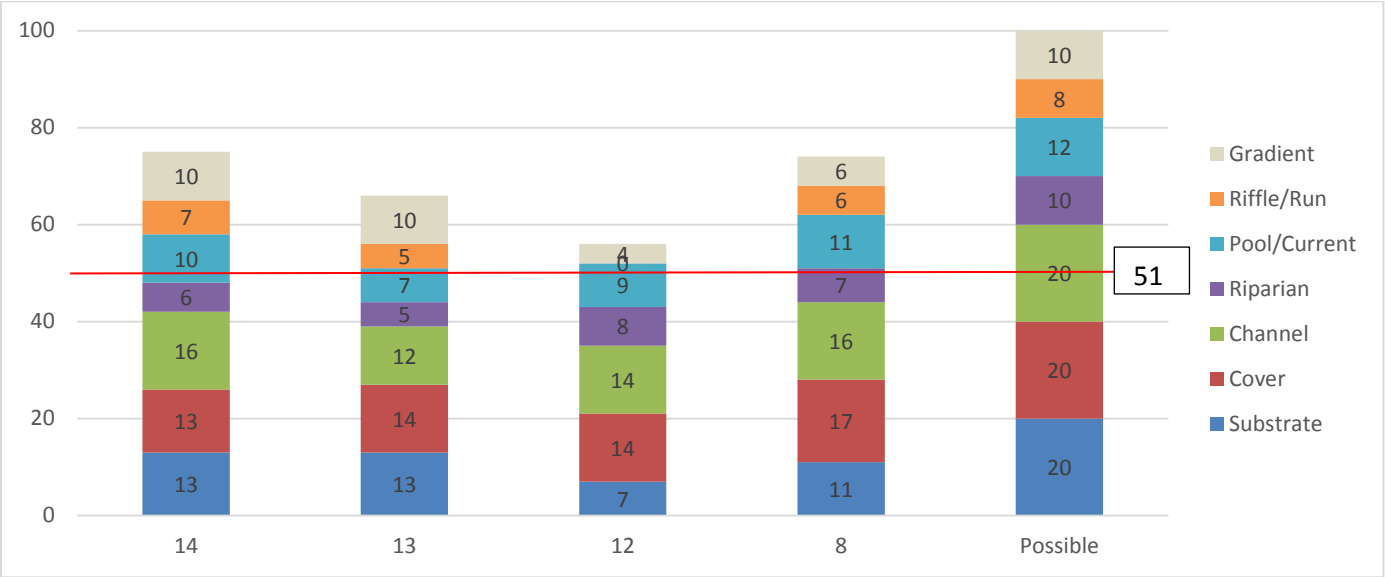

Figure 172 Site qualitative habitat evaluation idex scores within the Lake George Subwatershed

4.7.3 Land Cover & Land Use

Overall, the predominant land cover types within the subwatershed are developed (35%) and agricultural (29%) lands (Figure 173). The highest concentration of development is located in Hobart around Lake George and along the US 30 corridor. Most of the subwatershed's agricultural lands exist between these two higher density developed areas. Much of the low intesity development in this area is unsewered.

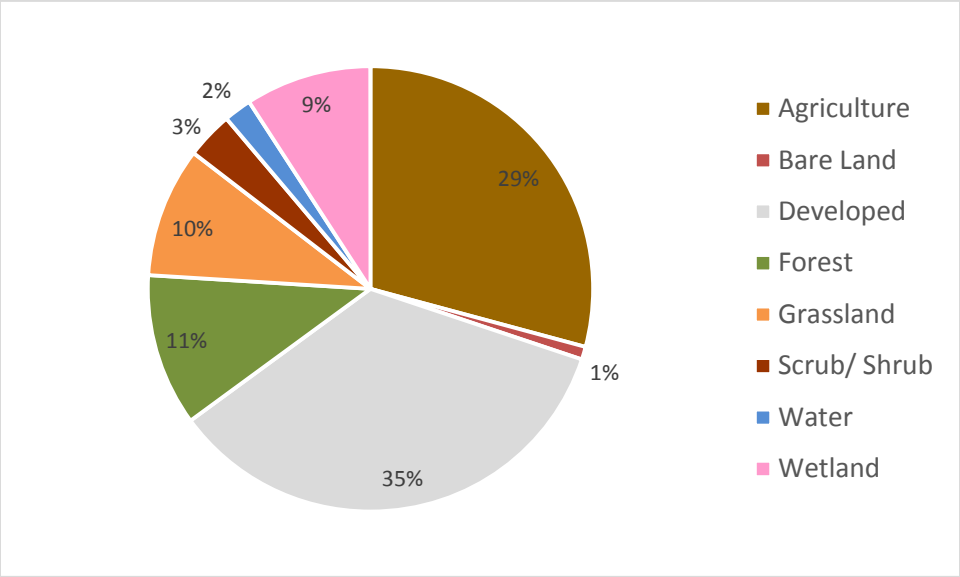

Figure 173 Percent land cover within the Lake George Subwatershed

Table 72 includes land cover information for each site's drainage area. Site 14 is located on Deep River adjacent to Deep River County Park. It's drainage area is primarily agricultural and developed land but the site itself is surrounded by wetland and forest. Site 13, located on Sprout Ditch, has the highest percentage of developed land within its drainage which includes a large portion of the retail business area along the US 30 corridor. Furhter downstream Sprout Ditch passes through primarily agricultural land. Site 12 shares a similar composition of land cover to that of Site 14 and is also bordered by wetland and forest that buffer Deep River from adjacent human land uses. Site 8 is located below the tailwaters of the Lake George dam on Deep River. The immediate surrounding land use is development near downtown Hobart.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland

14	39.7	0.2	32.2	10.1	6.2	3.8	0.6	7.1
13	29.8	0.3	46.1	6.3	9.9	3.8	0.7	3.1
12	39.1	0.4	31.4	10.0	6.9	3.8	0.6	7.6
8	29.7	0.3	41.6	10.1	6.4	3.6	0.9	7.5

Table 72 Site percent land cover within the Lake George Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 73. There's a relatively equal contribution of human and natural land cover types within the subwatershed's riparian zones. Generally, the mainstem of Deep River is buffered from adjacent human uses by forested floodplain wetland which is edged by upland forest along the river valley. Human uses are most prevalent along the tributaries flowing into Deep River (Figure 174).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
14	28.5	0.2	22.1	9.8	5.3	6.4	2.5	25.3
13	31.8	0.0	25.9	9.5	14.2	7.3	3.0	8.2
12	28.1	0.4	19.5	10.1	5.8	6.3	2.2	27.6
8	22.9	0.3	27.9	9.9	5.0	5.6	3.4	25.2

Table 73 Site percent riparian land cover within the Lake George Subwatershed

There are no NPDES permitted industrial facilities documented in the subwatershed. However, the TMDL identified one waste water treatment plant (Figure 174). The Hobart WWTP (IN0061344) had three inspection violations reported between 2010 and 2011. They were referred to enforcement in June 2011.

There are 13 potential livestock facilities located within the subwatershed (Figure 174). All but one of the facilities fall within Site 12's drainage area. A majority of these are located in the rural area south of Deep River and north of U.S. Highway 30. This area is drained by a number of intermittent tributaries.

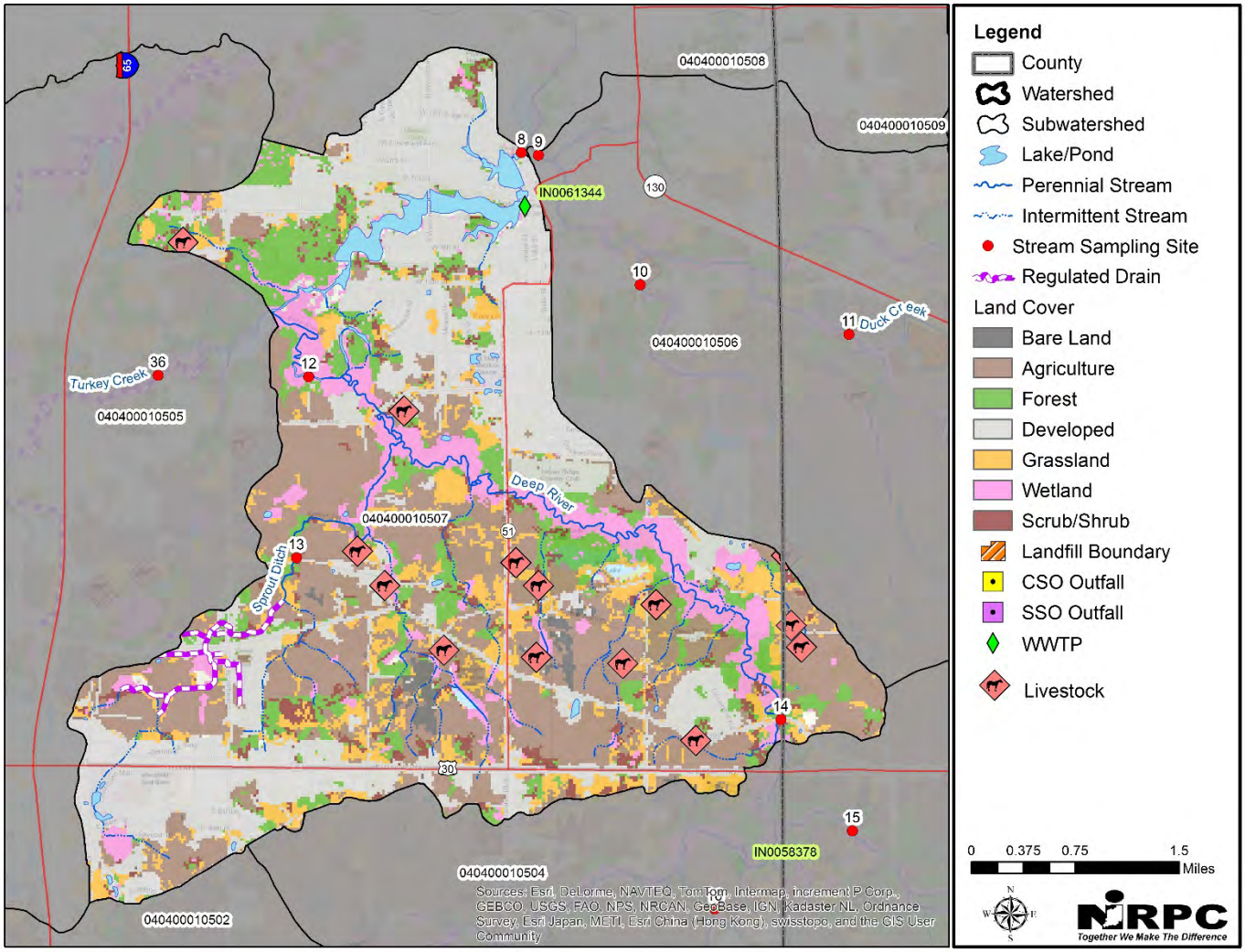

Figure 174 Land cover and land use within the Lake George Subwatershed

4.7.4 Soils

Deep River and many of its tributaries are bordered by hydric soils within the subwatershed. Most of the wetlands in which these soils developed have been drained for agricultural production and development except along Deep River (Figure 175). Areas of highly or potentially highly erodible soils are located within the Sprout Ditch drainage area and bordering Deep River to the east. There are a few locations in which soils with slopes greater than 15% occur within the subwatershed. A number of these locations are located directly adjacent to Deep River floodplain valley or intermittent tributaries.

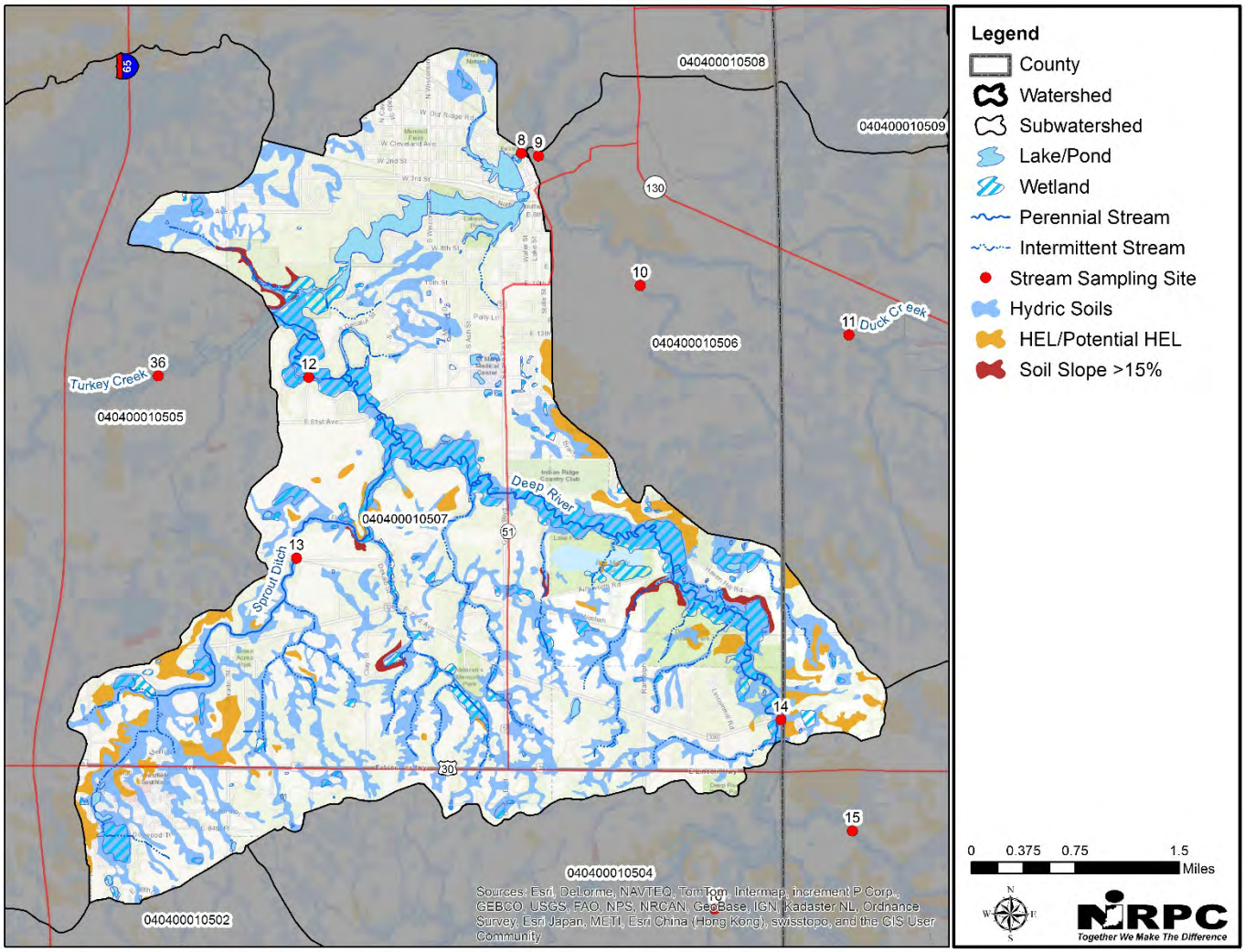

Figure 175 Soils within the Lake George Subwatershed

4.8 Little Calumet River-Deep River Subwatershed (HUC 040400010508)

4.8.1 Overview

The Little Calumet River-Deep River subwatershed is located in the northern tier of the watershed. It drains approximately 19 mi² of primarily developed land (71%). Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include impaired biotic communities and high *E. coli* levels.

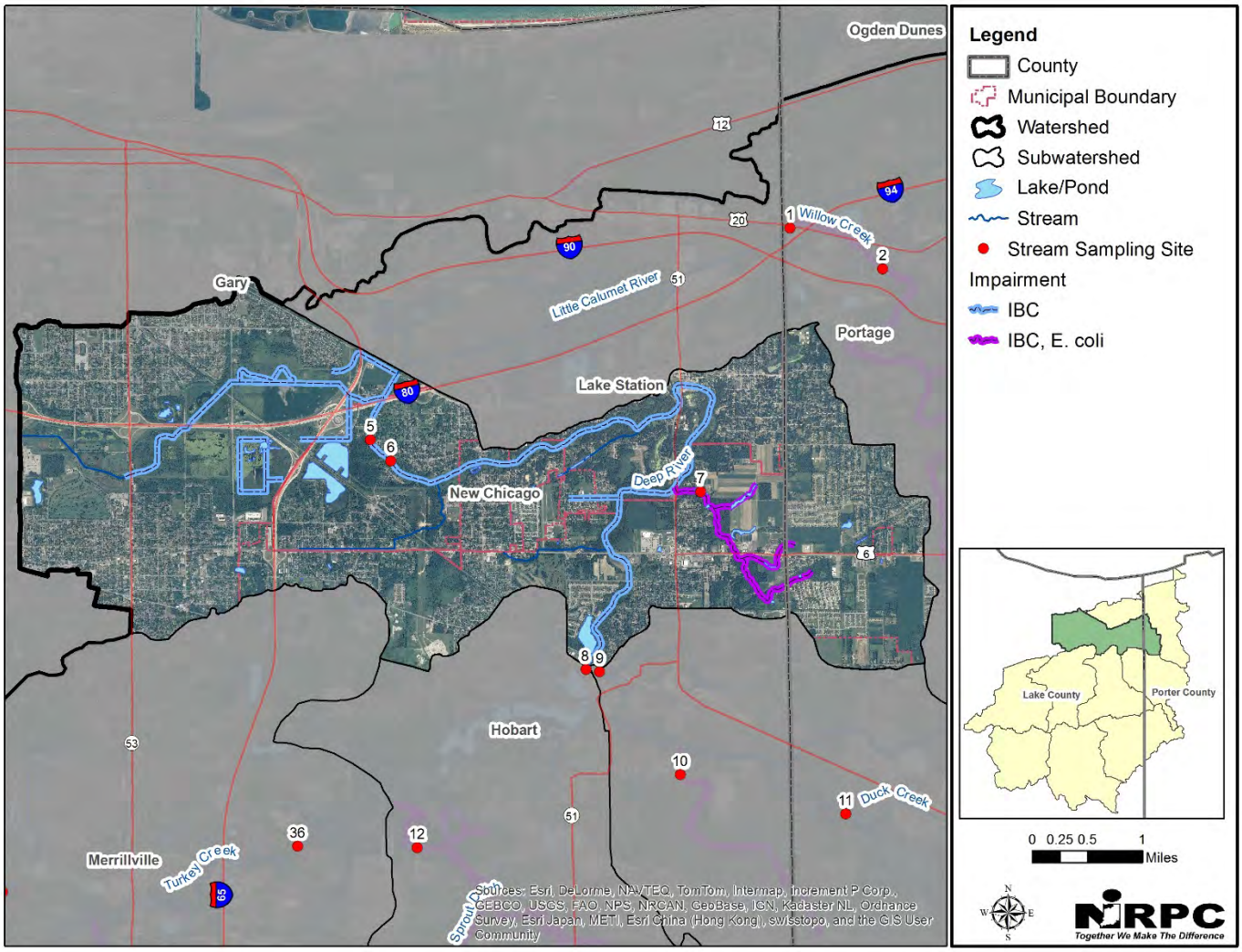

Figure 176 Impaired streams within the Little Calumet River Subwatershed

4.8.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 5-7) within the subwatershed (Figure 176). Site 6 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed. It is also important to note that Sites 5 and 6 bracket a dam located on Deep River in Lake Station (See Section 2.5.4.3 for additional details about this dam). Site 5 was added as a targeted monitoring point during the baseline assessment to help evaluate the potential impacts associated with the dam.

4.8.2.1 *Pathogens*

Figure 177 shows that Site 7's median *E. coli* concentration is greater than the single sample water quality standard of 235 CFU/100mL indicating that full body contact recreational use is threatened by elevated pathogen levels. Exceedances at Site 7 occurred across low to moderately high flow conditions indicating inputs from point and nonpoint sources. Site 5 had two observations over 235 CFU/100mL while Site 6 only had a single observation. These exceedances occurred during mid-range to moderately high flow conditions indicating nonpoint source inputs.

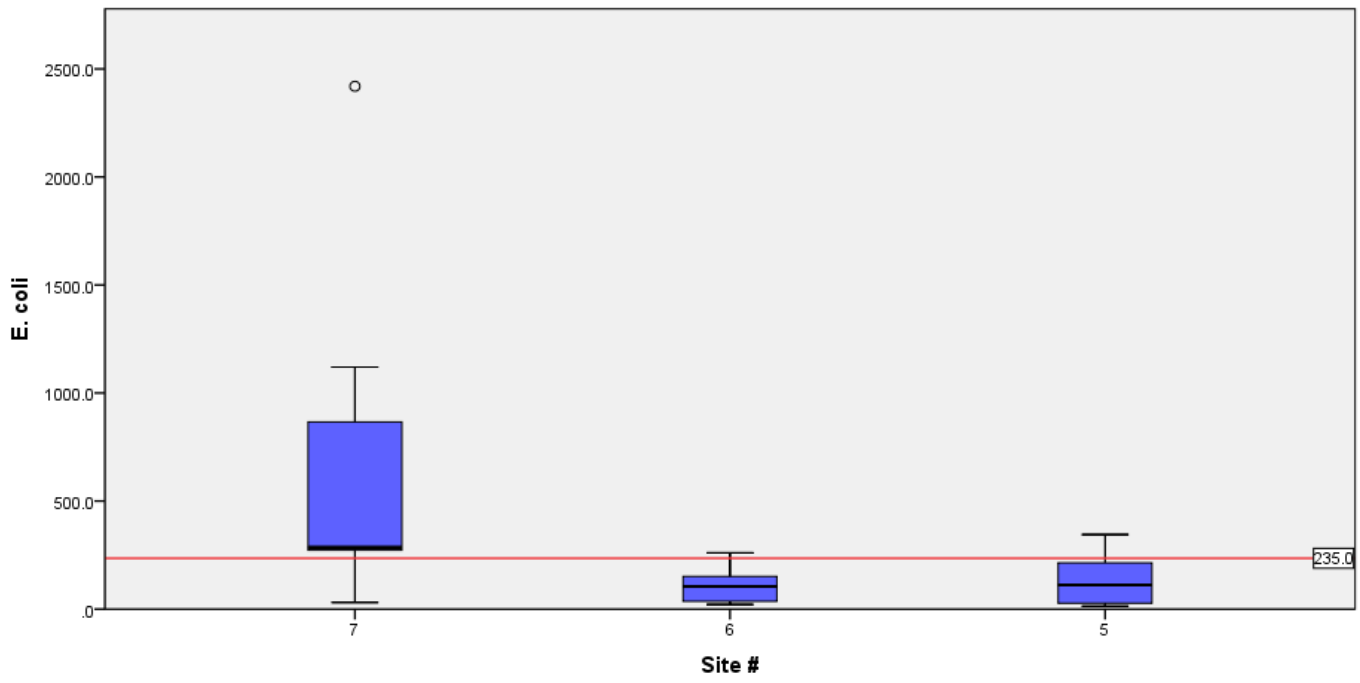

Figure 177 Box plot illustrating site E. coli concentrations within the Little Calumet River Subwatershed

4.8.2.2 *Fish*

An assessment of fish community structure showed that Sites 7 and 5 are not supporting of their Aquatic Life Use designation. While Site 6 was found to be fully supporting, it only received an integrity classification of "fair". The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking. Only five fish were collected at Site 7. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated environmental degradation at Site 7 and to some degree at Site 5. Fish species that require clean gravel/cobble substrates to spawn were lacking from all sites.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
7	18	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
6	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
5	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 74 Site fish index of biotic integriry scores within the Little Calumet River Subwatershed

4.8.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Site 7 was not supporting of its Aquatic Life Use designation. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
7	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
6	30	Fully Supporting	Poor	Many expected species absent or rare, tolerant species dominant
5	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 75 Site macroinvertebrate index of biotic integriry scores within the Little Calumet River Subwatershed

4.8.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, was 24°C, (75°F).

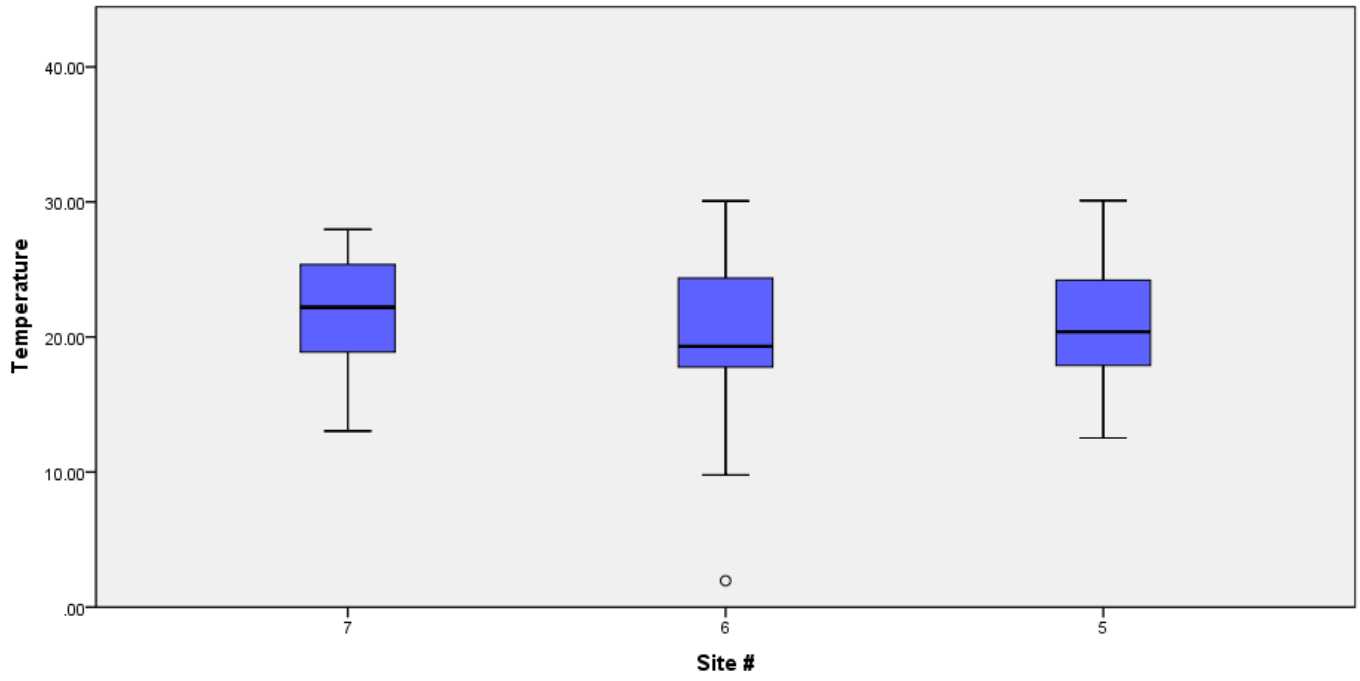

Figure 178 Box plot illustrating site water temperatures within the Little Calumet River Subwatershed

4.8.2.5 *Dissolved Oxygen*

Figure 179 shows that site median dissolved oxygen concentrations fell between 4-12 mg/L. Sites 5 and 7 each had one observation during the summer in which they failed to meet the water quality standard with dissolved oxygen concentrations of 3.3 mg/L and 3.9 mg/L respectively. Observations above 12 mg/L at Sites 6 and 7 occurred during the spring. The Deep River dam is located between Sites 6 (upstream) and 5 (downstream). The figure shows the influence of the dam as dissolved oxygen levels increase as water spills over and through the structure.

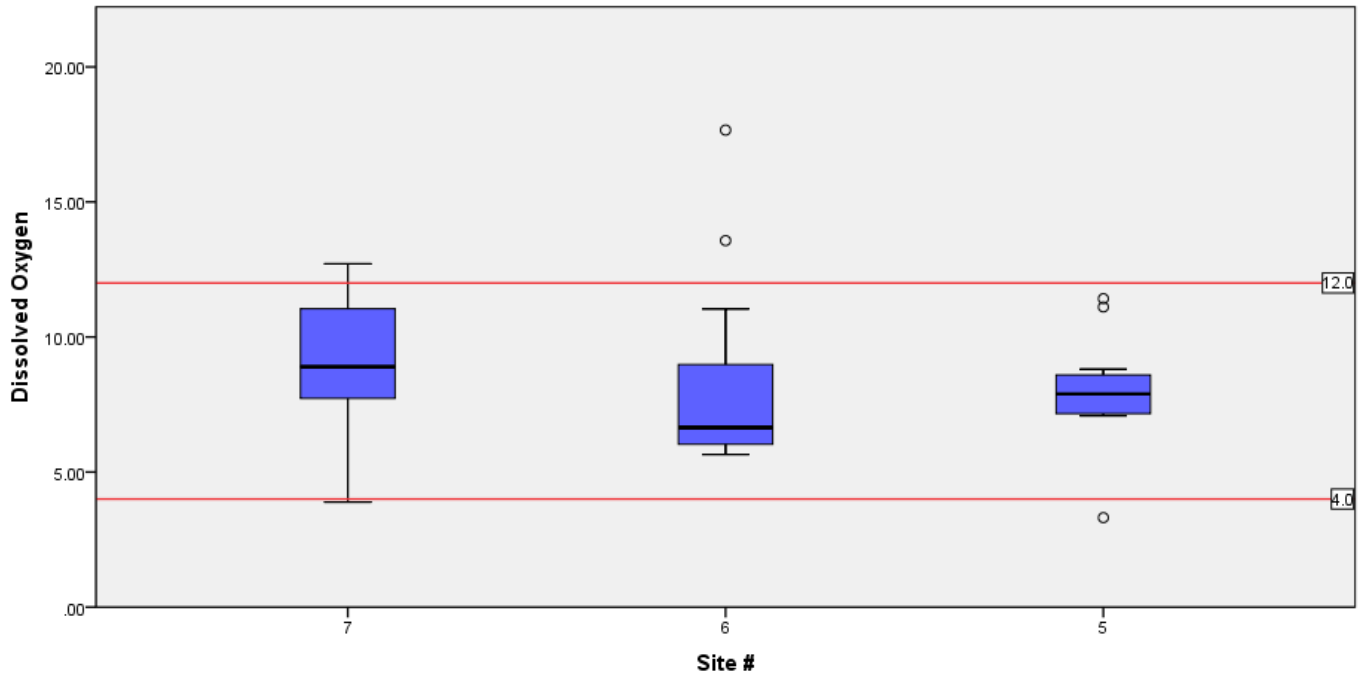

Figure 179 Box plot illustrating site dissolved oxygen concentrations within the Little Calumet River Subwatershed

4.8.2.6 *Total Organic Carbon*

Figure 180 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This indicates that organic material loading is influencing dissolved oxygen concentrations.

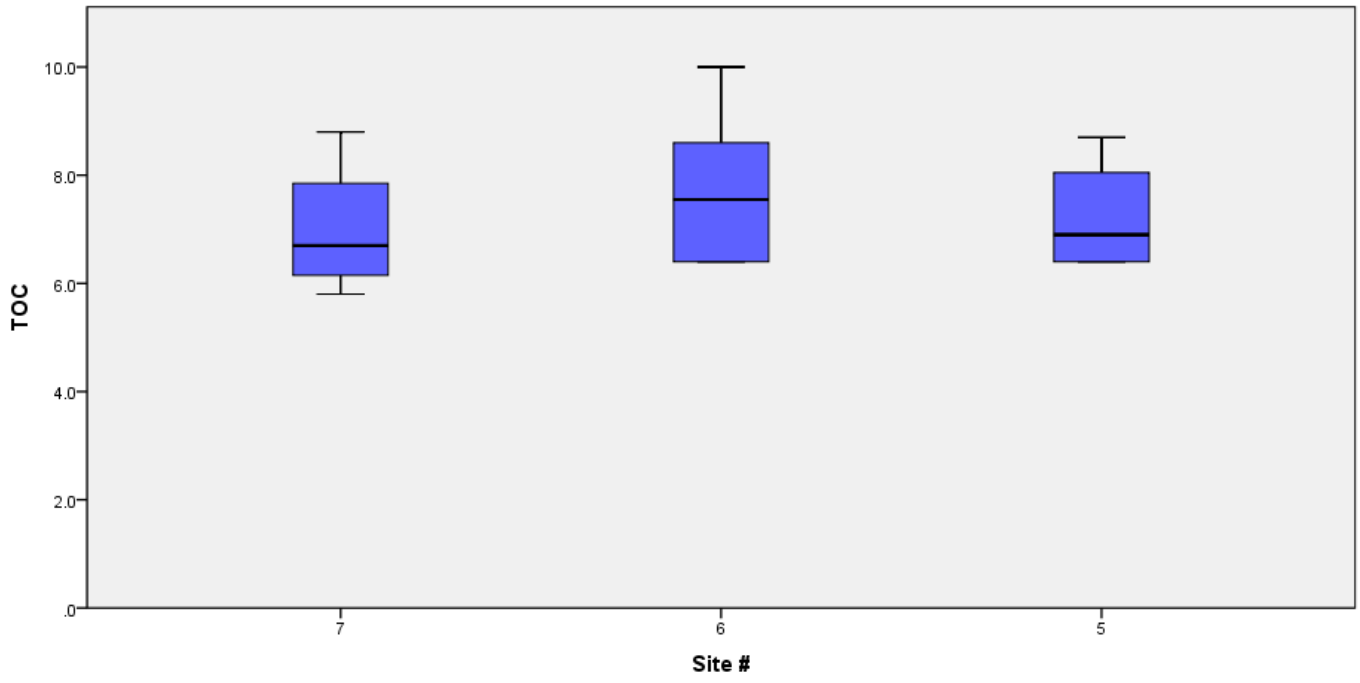

Figure 180 Box plot illustrating site TOC concentrations within the Little Calumet River Subwatershed

4.8.2.7 *Nutrients*

Figure 181 shows that none of the sites exceeded the 0.3mg/L total phosphorus threshold however, all sites had median concentrations exceeding the 0.07 mg/L threshold.

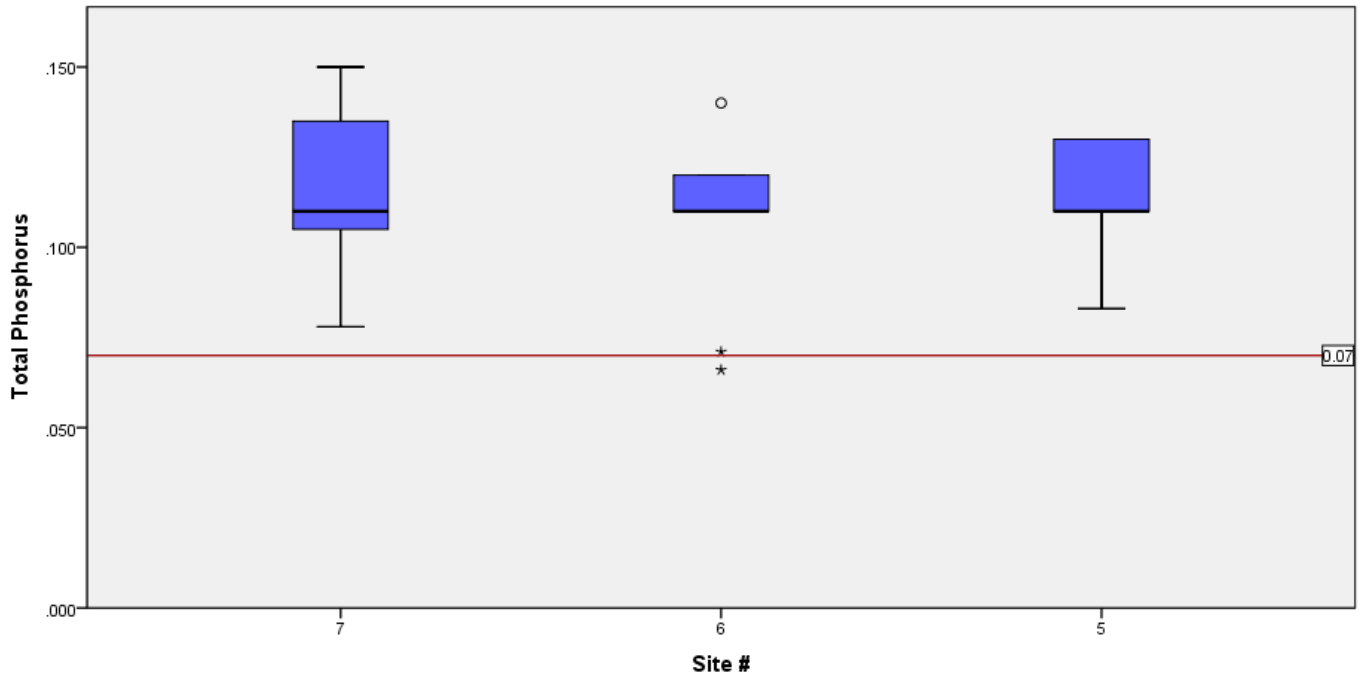

Figure 181 Box plot illustrating site total phosphorus concentrations within the Little Calumet River Subwatershed

Figure 182 shows that none of the sites exceeded the 10 mg/L nitrate threshold. Median nitrate concentrations fell below the 1.09 mg/L threshold for all sites.

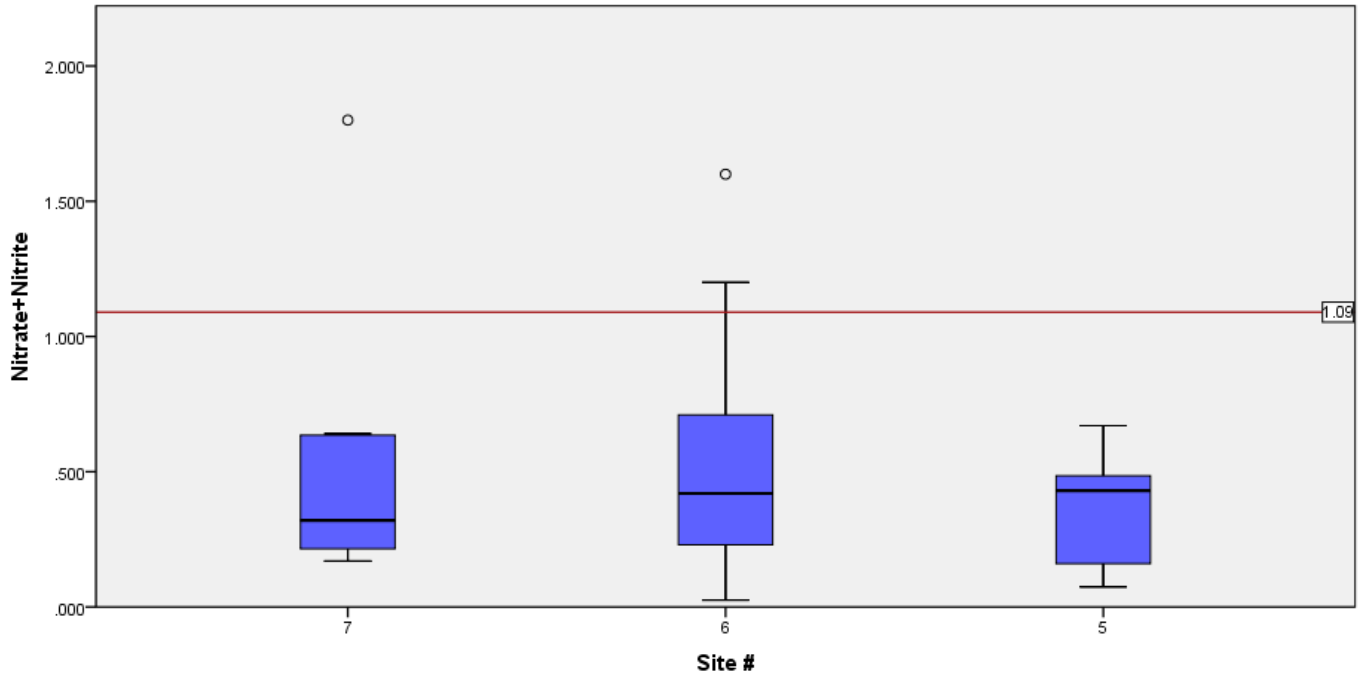

Figure 182 Box plot illustrating site nitrate concentrations within the Little Calumet River Subwatershed

Figure 183 shows that site median total Kjeldahl nitrogen concentrations fell between the 1.27 mg/L and 0.68 mg/L threshold. Since total Kjeldahl nitrogen is a measure of organic nitrogen and ammonia, looking at Figure 183 and Figure 184 we can see that Site 6, located upstream of the dam, has a higher organic nitrogen load.

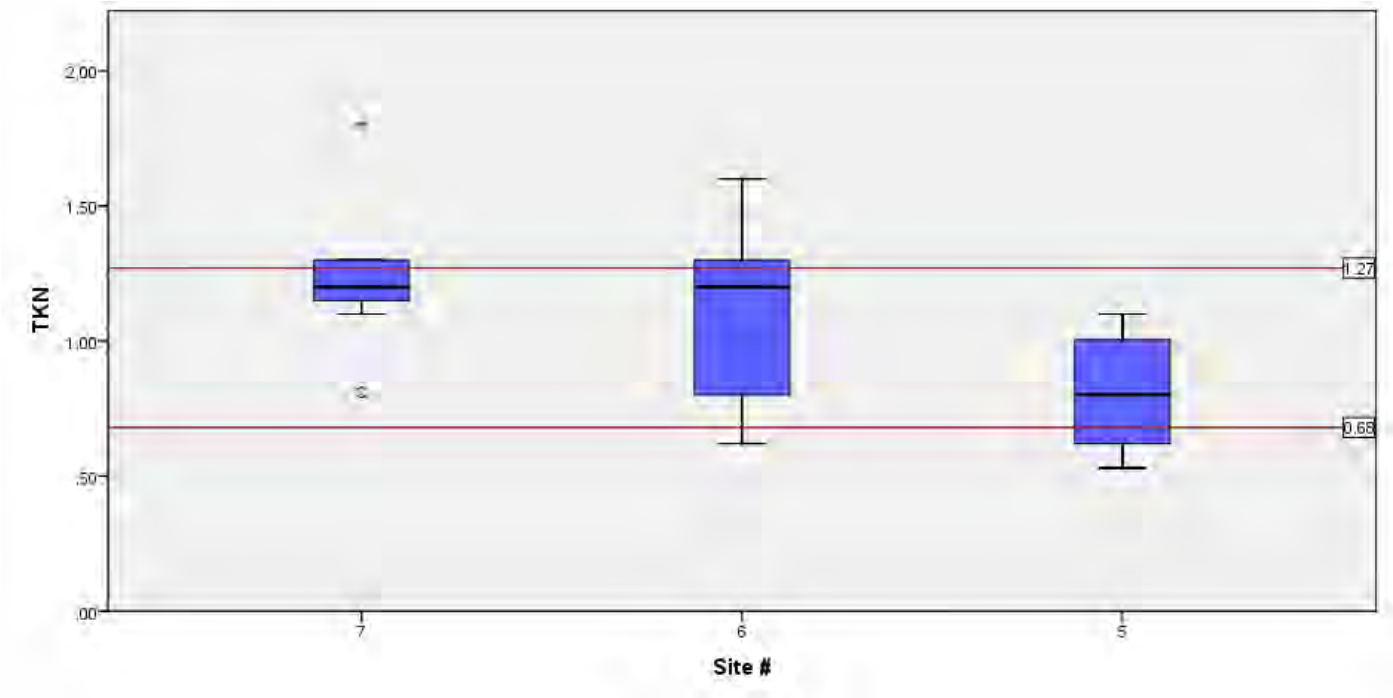

Figure 183 Box plot illustrating site total Kjeldahl nitrogen concentrations within the Little Calumet River Subwatershed

Figure 184 shows that ammonia concentrations typically fell below the lab detection limit for all sites. Each site had one or two outlier observations above 0.10 mg/L.

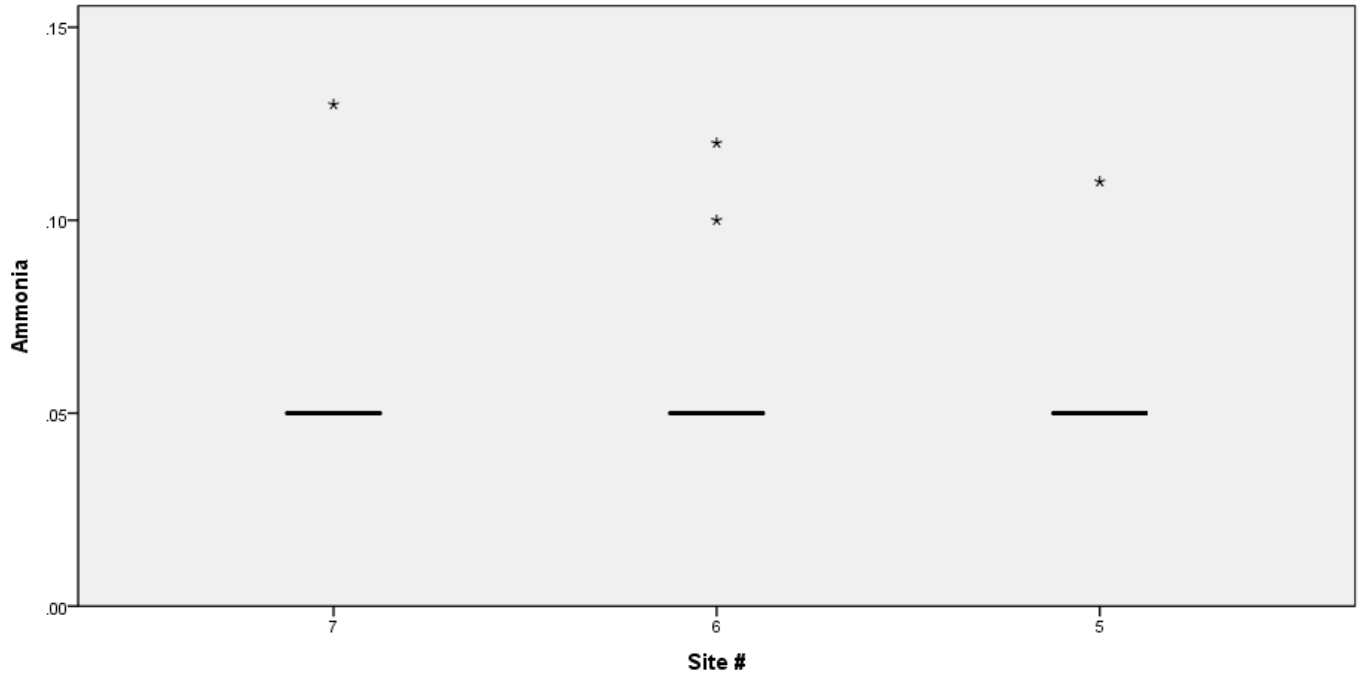

Figure 184 Box plot illustrating site ammonia concentrations within the Little Calumet River Subwatershed

4.8.2.8 *Suspended Sediment & Turbidity*

Figure 185 shows that all the sites had median total suspended solid concentration below the 30 mg/L threshold. We can see that median total suspended solids concentrations were lower on Deep River compared to the tributary represented by Site 7. An increase in median concentrations is apparent below the dam between Sites 6 and 7. This is likely due to the erosive energy of the water going over and through the dam structure.

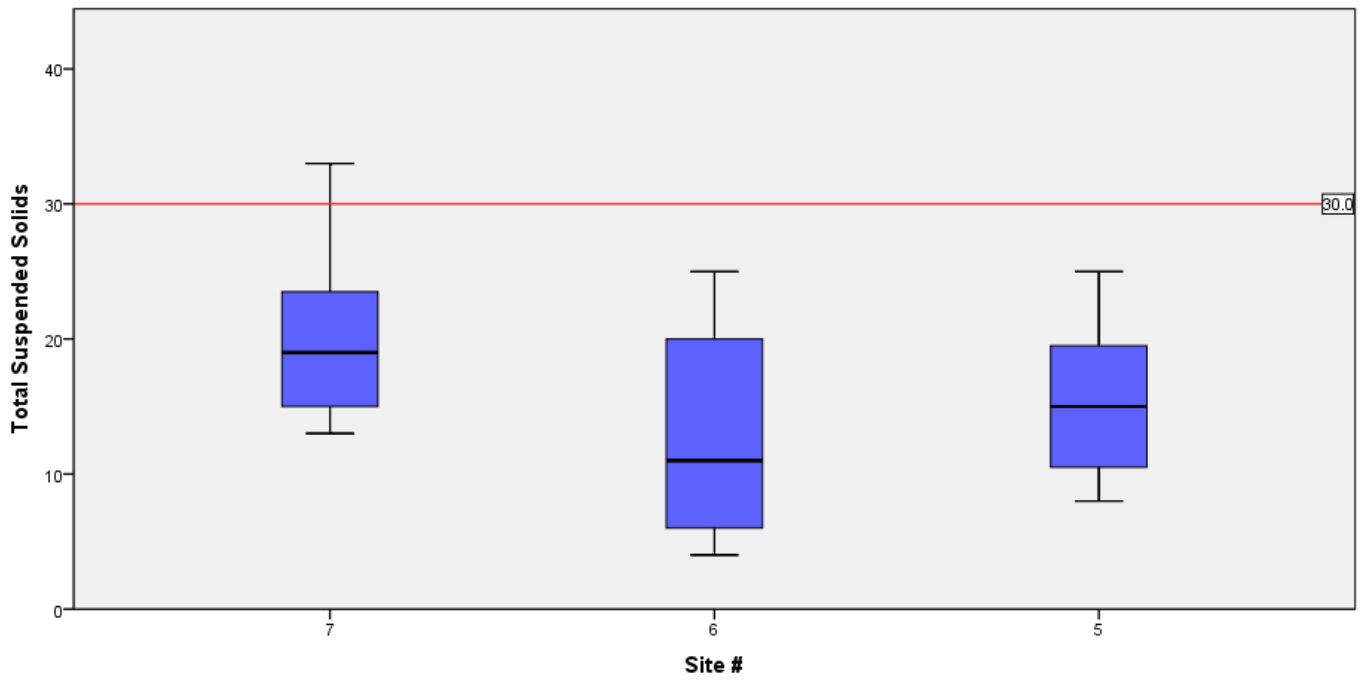

Figure 185 Box plot illustrating site total suspended solids concentrations within the Little Calumet River Subwatershed

Figure 186 shows similar site patterns as those observed above for total suspended solids. Sites 5 and 7 had median turbidity levels between 10.4 NTU and 25 NTU.

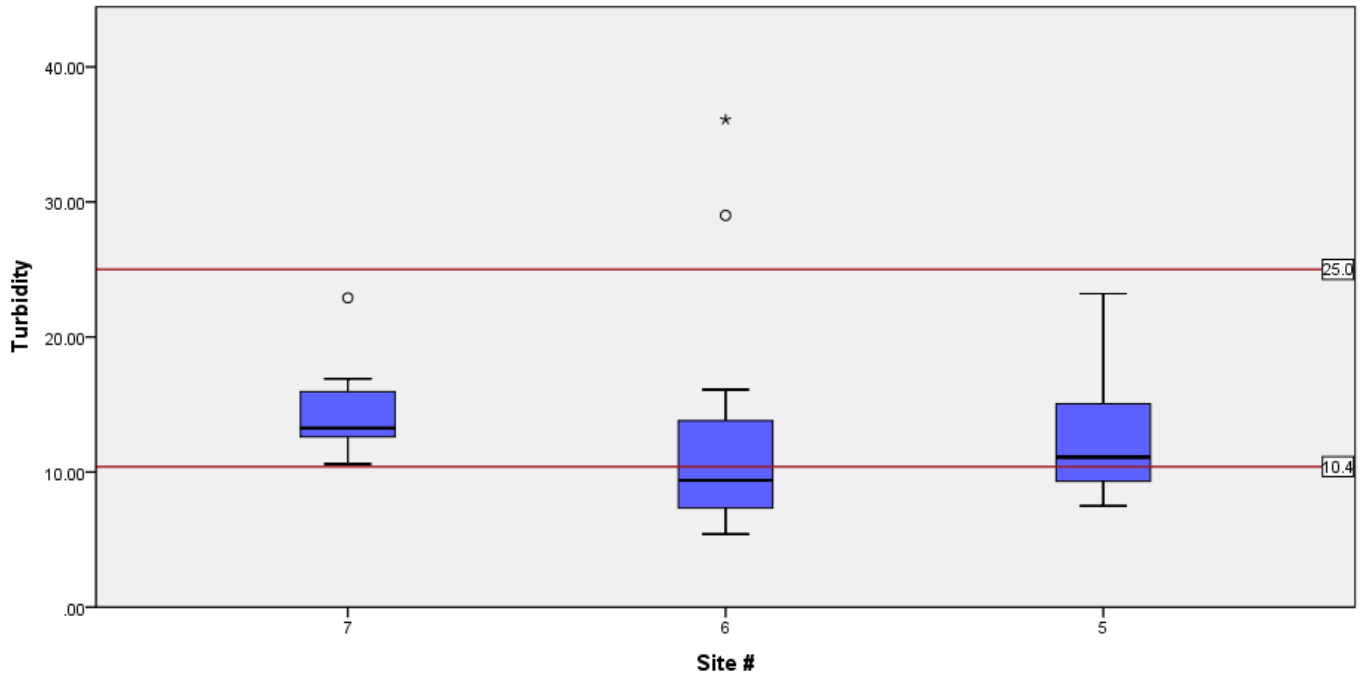

Figure 186 Box plot illustrating site turbidity levels within the Little Calumet River Subwatershed

4.8.2.9 *Habitat*

Habitat evaluations performed by IDEM revealed that Sites 5 and 7 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Site 6 was found to have habitat quality that was marginally capable of supporting a health warm water fishery with a QHEI score of 52.

Site 5 is located immediately downstream of the Deep River dam in Lake Station. Site 6 is located upstream of the dam. Site 6's reach on Deep River has a more lake-like appearance and function because of the dam. The river is nearly twice as wide upstream of the dam than downstream. Both sites had relatively poor substrate quality and channel morphology and instream cover. Muck and silt comprise a larger percentage of the substrate at Site 6 compared to downstream and aquatic macrophytes (plants) are the dominate instream cover.

The major habitat limitation at Site 7 was primarily substrate quality. Substrates at the site were characterized as muck with heavy silt cover and moderate embeddedness. Channel morphology and instream cover were also relatively poor. Channel sinuosity was moderate, pool/riffle development was poor and channel stability was low. There was no sign of past channelization.

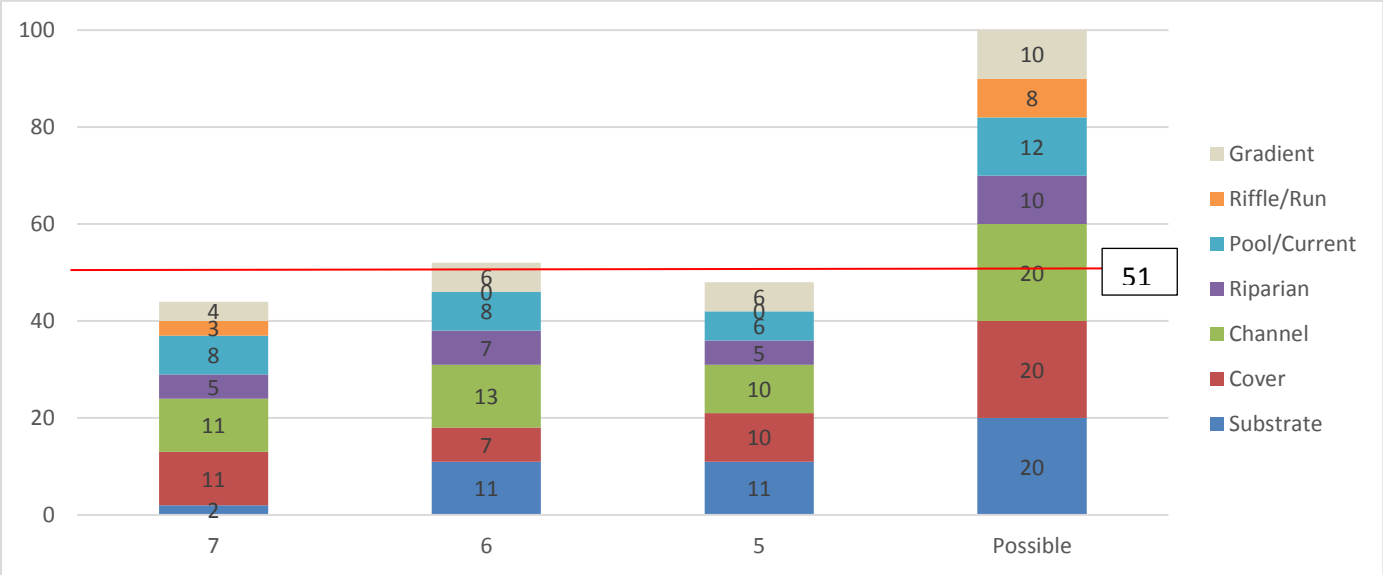

Figure 187 Site qualitative habitat evaluation index scores within the Little Calumet River Subwatershed

4.8.3 Land Cover & Land Use

Overall, the predominant land cover type within the subwatershed is developed lands (71%) (Figure 188). The subwatershed includes portions of Gary, Hobart, Lake Station, New Chicago, and Portage. There are three combined sewer overflows located on the West Branch of the Little Calumet River, west of Interstate 65, in Gary. Based on

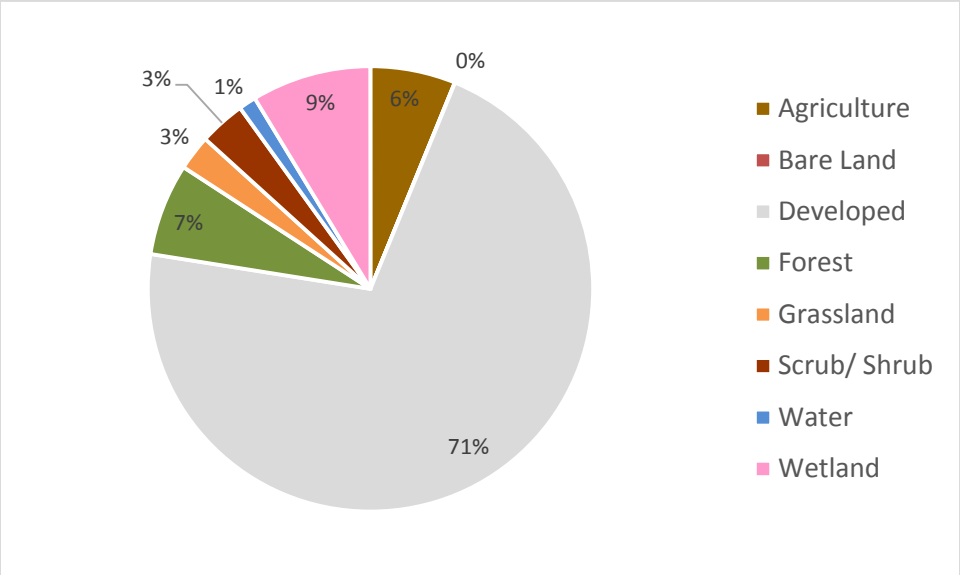

Figure 188 Percent land cover within the Little Calumet River Subwatershed

Table 76 includes information on the percentage of land types within each site's drainage area. Site 5 & 6 have identical percentages of land cover types within their respective drainage areas since they are located within 1/2 –mile of each other on Deep River. A majority of their drainage area is developed land. Most of the agricultural land that drains to these sites is located within Site 7's drainage area. Site 7 has the highest percentage of developed land in its drainage area including portions of Hobart and Portage. There are also several fields near the site where produce such as vegetables and blueberries are grown. Floodplain wetland and patches of upland forest border stretches of Deep River between US Highway 6 and Site 5. An extensive area of wetland is located in the western portion of the subwatershed south of Interstate 80/94.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
7	16.7	0.0	63.0	8.6	5.3	3.9	0.0	2.5
6	30.4	0.3	41.3	10.1	6.2	3.5	0.9	7.4
5	30.4	0.3	41.3	10.1	6.2	3.5	0.9	7.4

Table 76 Site percent land cover within the Little Calumet River Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 77. There's a relatively equal contribution of human and natural land cover types within the Site 5 and 6's riparian zones. Natural land cover is slightly more prevalent, at 60%, in Site 7's drainage area. Developed land accounts for a majority of the land cover. Generally, the large reaches of Deep River is buffered from adjacent human uses by floodplain wetland which is edged by upland forest in some areas along the river valley (Figure 174).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
7	2.2	0.0	38.1	14.7	1.3	10.6	0.3	32.8
6	22.7	0.2	26.8	10.0	5.1	5.5	3.2	26.6
5	22.6	0.2	26.8	10.0	5.1	5.5	3.2	26.6

Table 77 Site percent riparian land cover within the Little Calumet River Subwatershed

There are no NPDES permitted industrial facilities or waste water treatment plants documented in the subwatershed. The TMDL identified five Gary Sanitary District waste water treatment plant combined sewer overflows in the subwatershed (Figure 189). Between 2009 and 2013 there were 260 combined sewer overflow events.

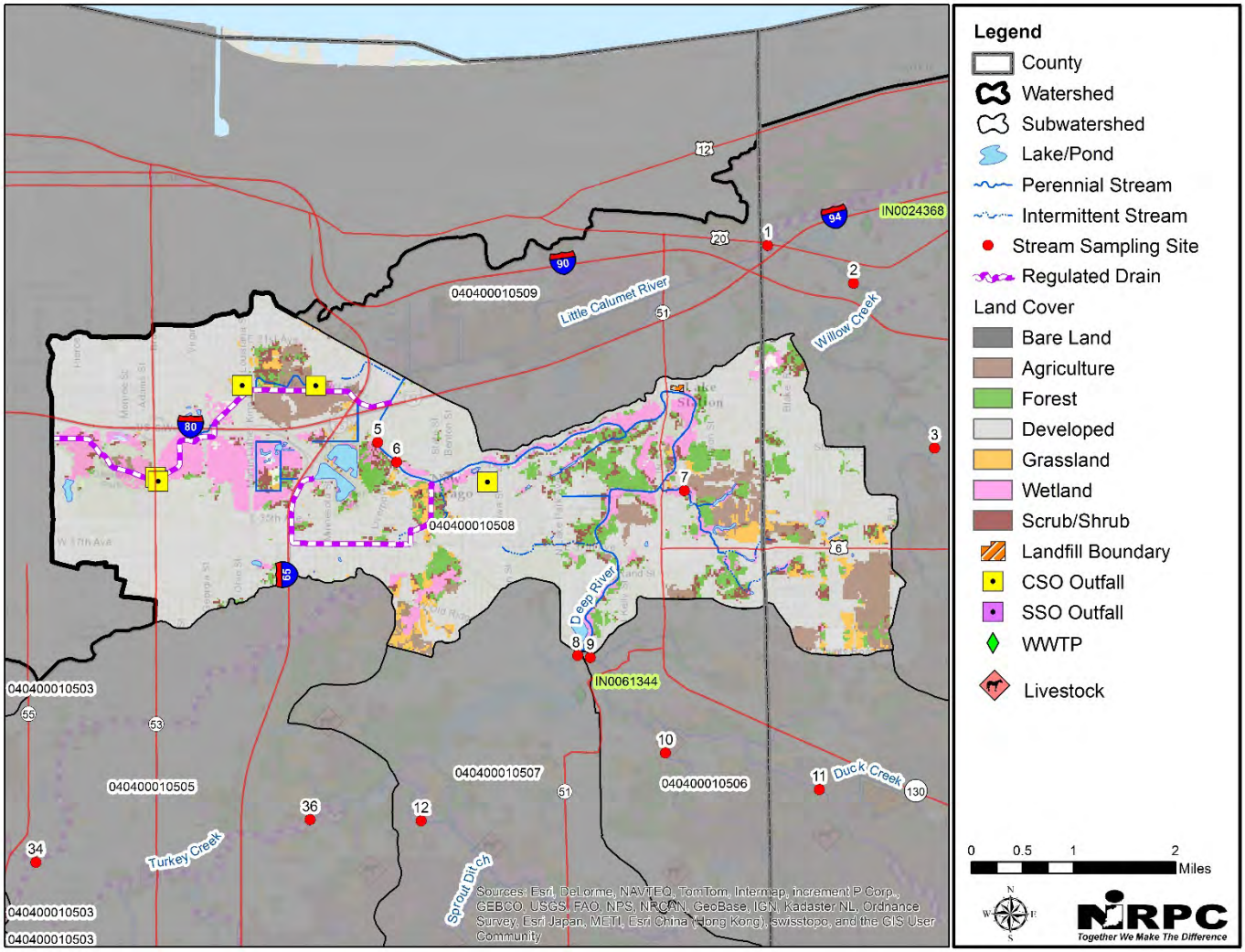

Figure 189 Land cover and land use within the Little Calumet River Subwatershed

4.8.4 Soils

Figure 190 shows an extensive amount of both hydric and highly/ potentially highly erodible soils within the subwatershed. Many of the hydric soils along the West Branch of the Little Calumet River were drained when the river was channelized sometime around the 1920's. Two wide bands of highly erodible/ potentially highly erodible soils run through the subwatershed. Many of these areas have been developed except for the agricultural land around Site 7. This could explain in part the poor substrate quality observed at the site.

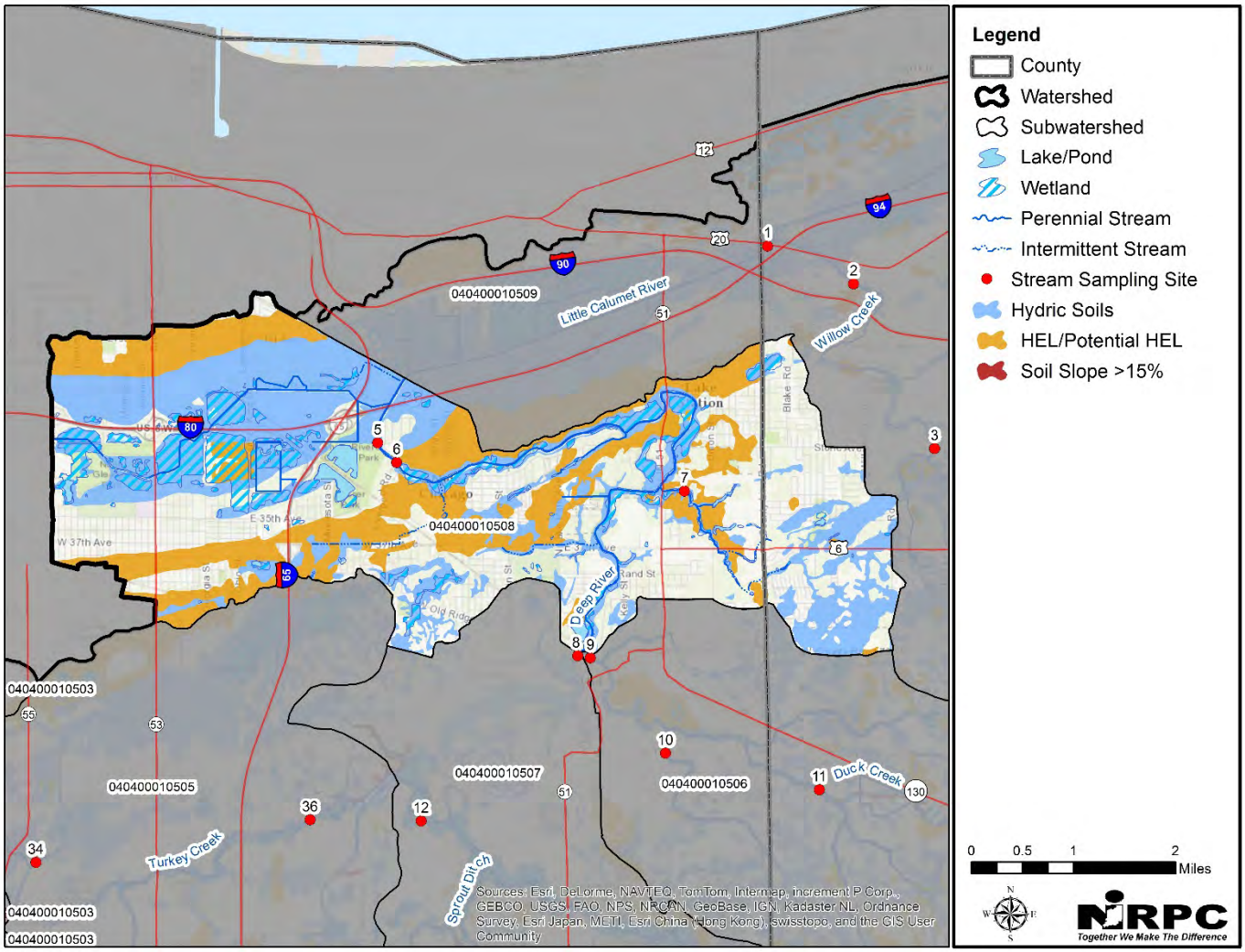

Figure 190 Soils within the Little Calumet River Subwatershed

4.9 Willow Creek-Burns Ditch Subwatershed (HUC 040400010509)

4.9.1 Overview

The Willow Creek-Burns Ditch subwatershed is located in the northern tier of the watershed. It drains approximately 20.9 mi² of primarily developed (56%) and agricultural land (20%). Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, high E. coli levels.

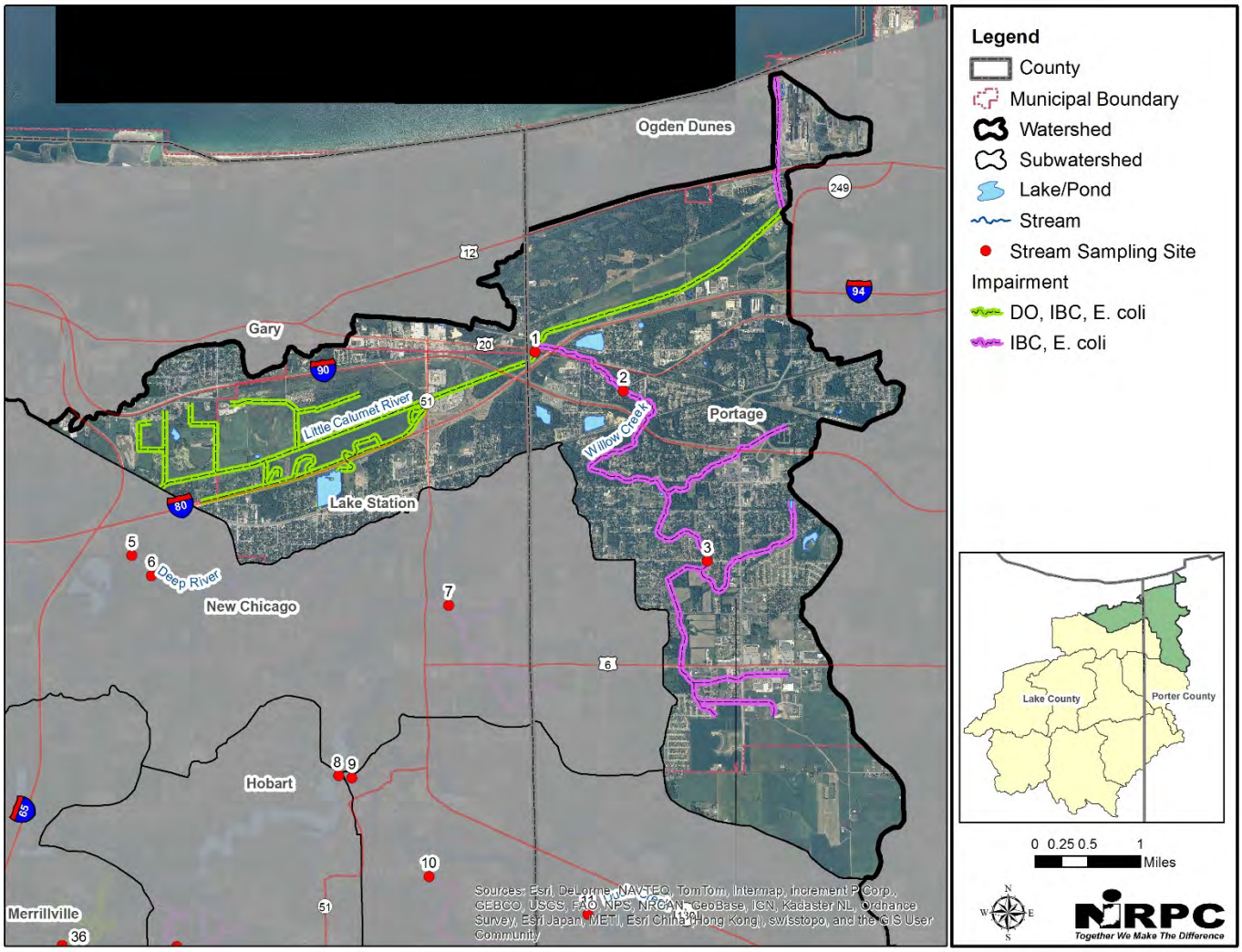

Figure 191 Impaired streams withing the Willow Creek Subwatershed

4.9.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 1-3) within the subwatershed (Figure 191). Site 1 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.9.2.1 *Pathogens*

Figure 192 shows that recreational use of the subwatershed's streams is threatened by elevated pathogen levels. All sites regularly violate the *E. coli* single sample water quality standard with median concentrations exceeding 235 CFU/100 mL. Sites 2 and 3, located on Willow Creek, had much higher *E. coli* levels than observed at Site 1 on the

Little Calumet River. There is a slight decrease in *E. coli* concentrations moving downstream from Site 3 to Site 2. Exceedances occurred across dry to high flow stream conditions indicating inputs from point and nonpoint sources.

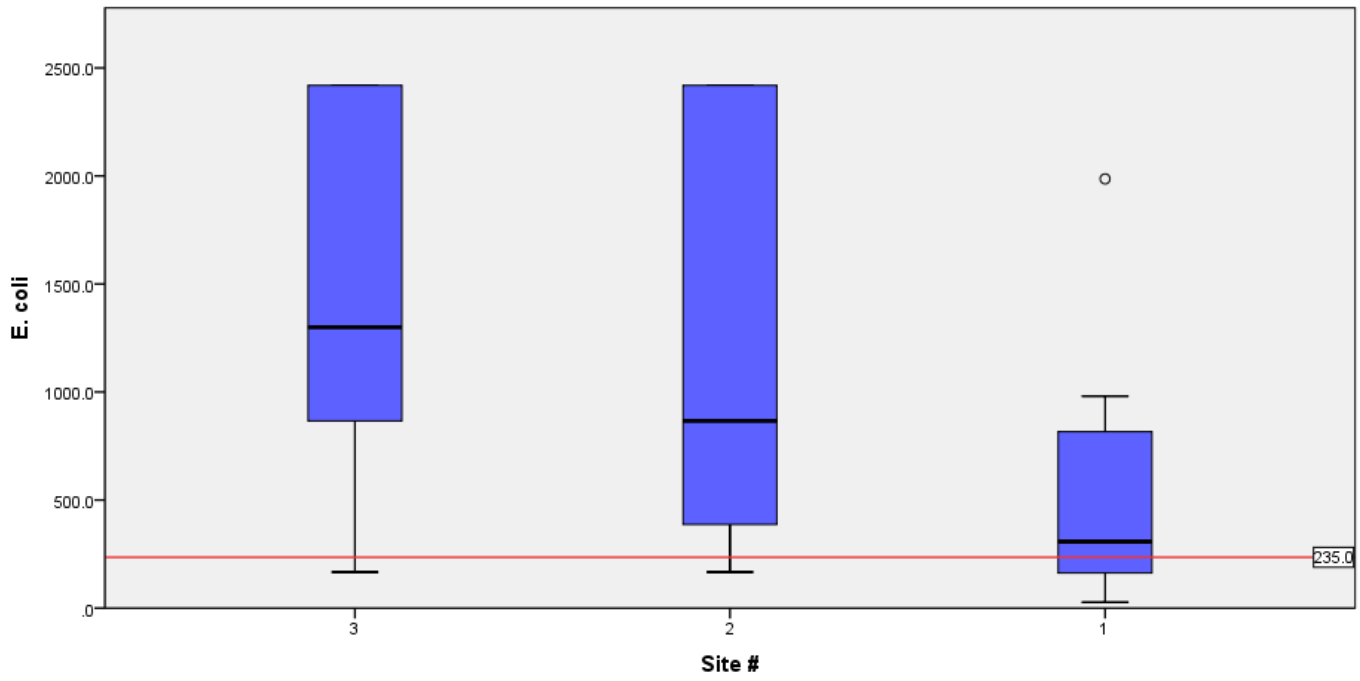

Figure 192 Box plot illustrating E. coli concentrations within the Willow Creek Subwatershed

4.9.2.2 *Fish*

An assessment of fish community structure shows that Sites 1-3 are not supporting of their Aquatic Life Use designation. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated environmental degradation at Sites 1- 2 and to some degree at Site 3.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
3	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
2	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
1	16	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Table 78 Site fish index of biotic integrity scores within the Willow Creek Subwatershed

4.9.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Sites 2-3 are not supporting of their Aquatic Life Use designation. While Site 1 was found to be fully supporting, it only received a “fair” integrity class rating. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes

3	26	Not Supporting	Poor	Intolerant and sensitive species absent, skewed trophic structure
2	22	Not Supporting	Poor	Intolerant and sensitive species absent, skewed trophic structure
1	36	Fully Supporting	Fair	Many expected species absent or rare, tolerant species dominant

Table 79 Site macroivertebrate index of biotic integrity scores within the Willow Creek Subwatershed

4.9.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-23°C, (63-73°F). Water temperatures on Willow Creek tended to be cooler downstream at Site 2 compared to Site 3 during much of the year.

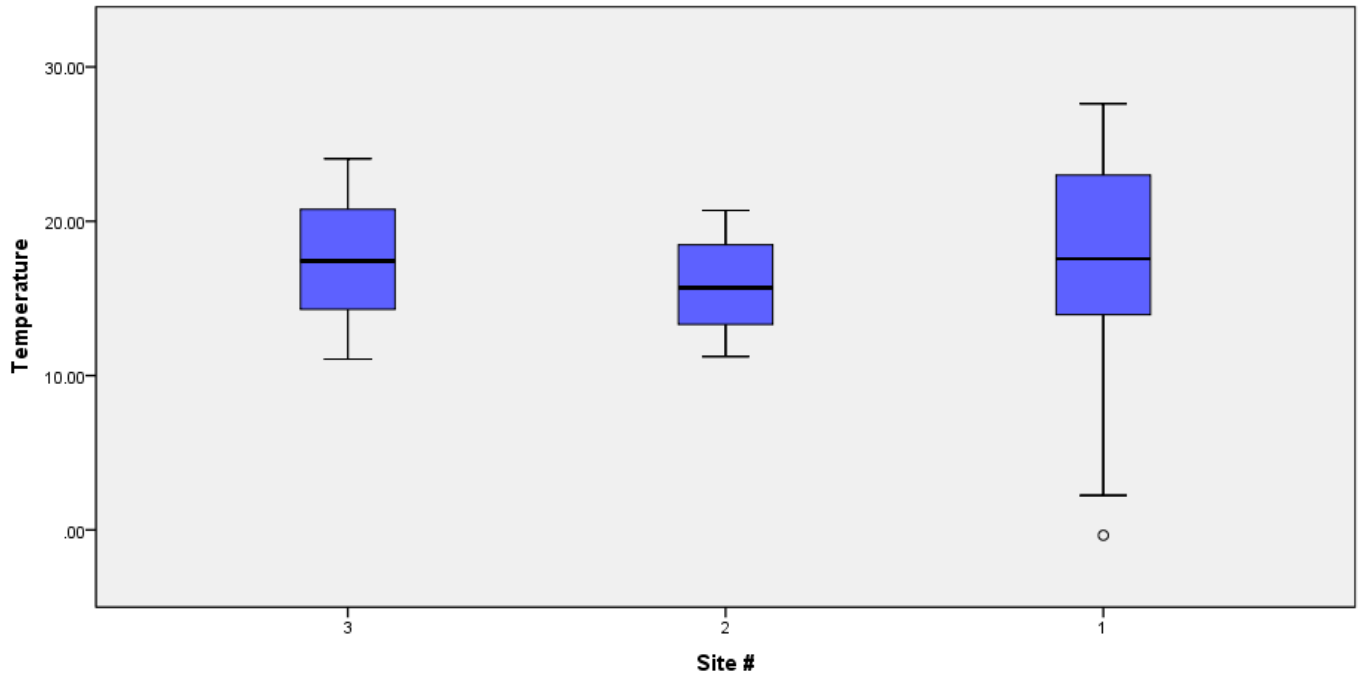

Figure 193 Box plot illustrating water temperatures within the Willow Creek Subwatershed

4.9.2.5 *Dissolved Oxygen*

Figure 194 shows that site dissolved oxygen concentrations typically met the state water quality standard with median values between 4 to 12 mg/L. Concentrations above 12 mg/L at Sites 1 and 2 occurred during late fall and early spring when water temperatures were cool. Site 1 had a single observation below 4 mg/L during the summer.

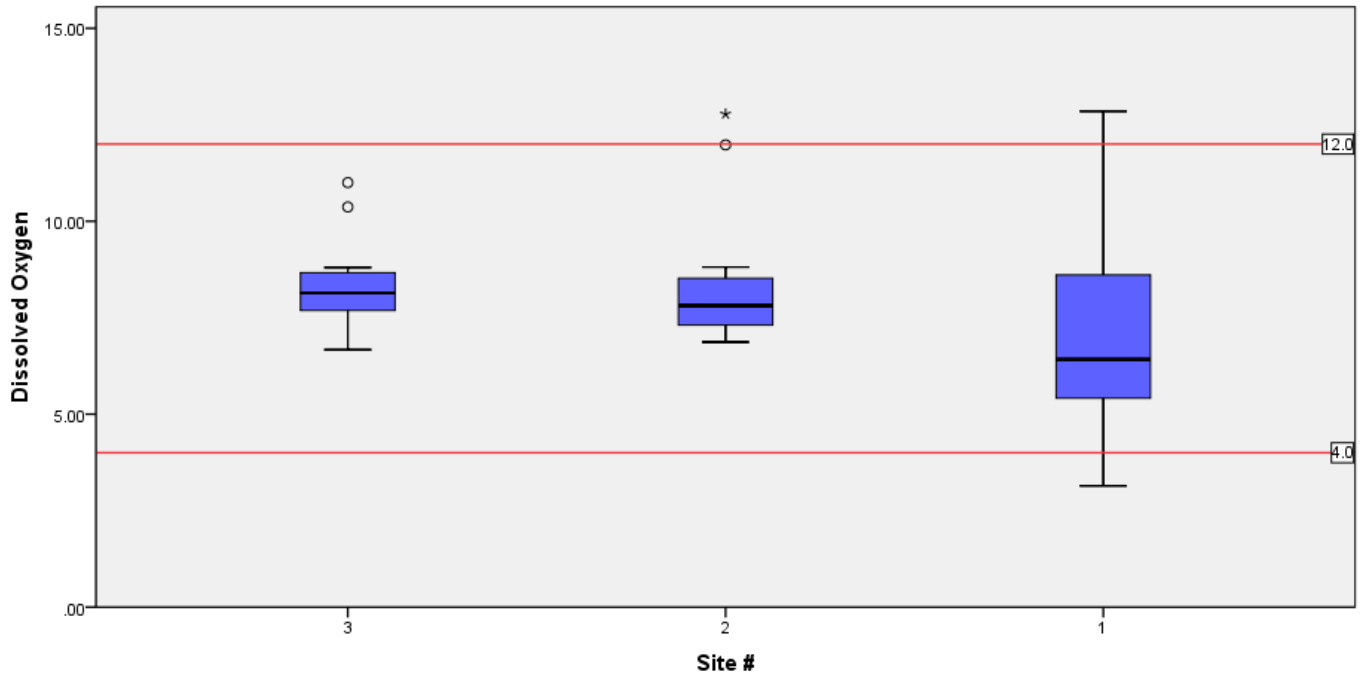

Figure 194 Box plot illustrating dissolved oxygen concentrations within the Willow Creek Subwatershed

4.9.2.6 *Total Organic Carbon*

Figure 195 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 1.

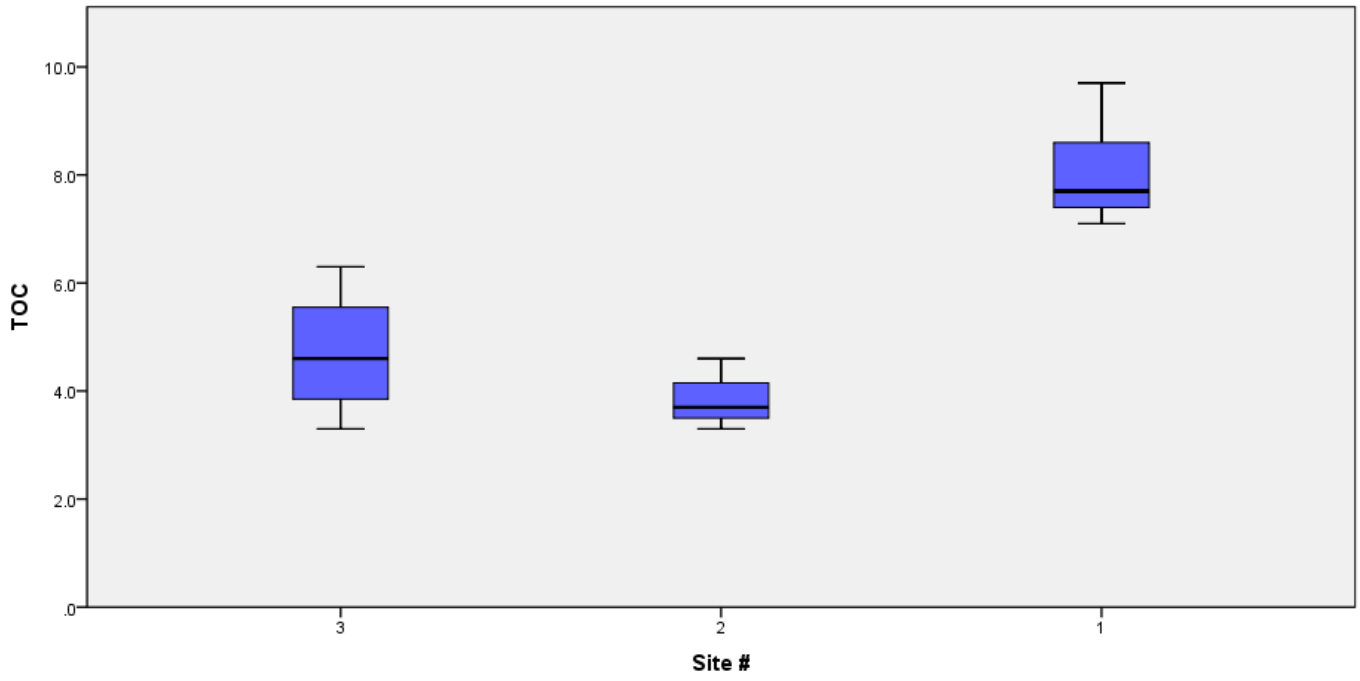

Figure 195 Box plot illustrating TOC concentrations within the Willow Creek Subwatershed

4.9.2.7 *Nutrients*

Figure 196 shows that none of the sites exceeded the 0.3 mg/L total phosphorus threshold. Site 1 had the highest median total phosphorus concentration which exceeded the 0.07 mg/L threshold. The median concentration at Sites 2 and 3 fell below the 0.07 mg/L threshold. There was a slight decrease in median concentrations from upstream at Site 3 to downstream at Site 2. Seasonally, total phosphorus concentrations were highest during the summer for Sites 2 and 3. However, statistically there was no significant difference observed across seasons.

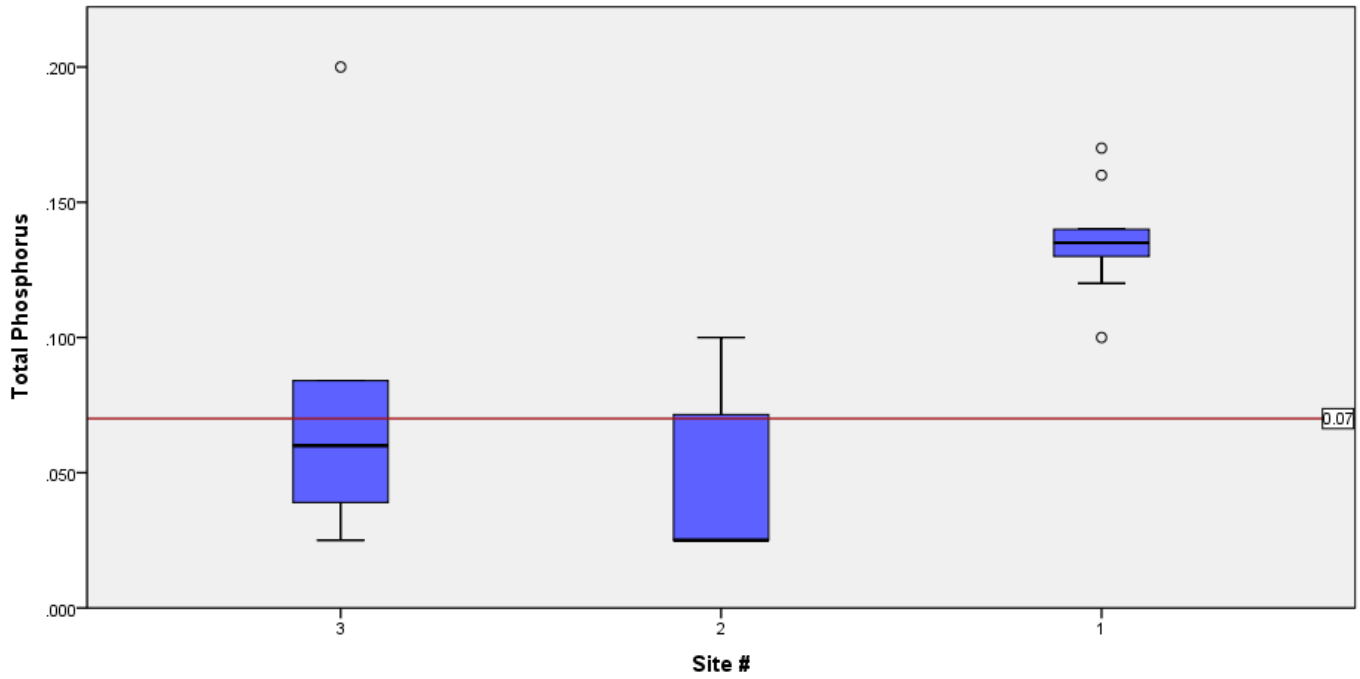

Figure 196 Box plot illustrating total phosphorus concentrations within the Willow Creek Subwatershed

Figure 197 shows that none of the sites exceeded the 10 mg/L nitrate threshold. However, Sites 2 and 3 had median concentration above the 1.09 mg/L threshold. The figure shows a decreasing trend in nitrate concentrations from Site 3 downstream to Site 2.

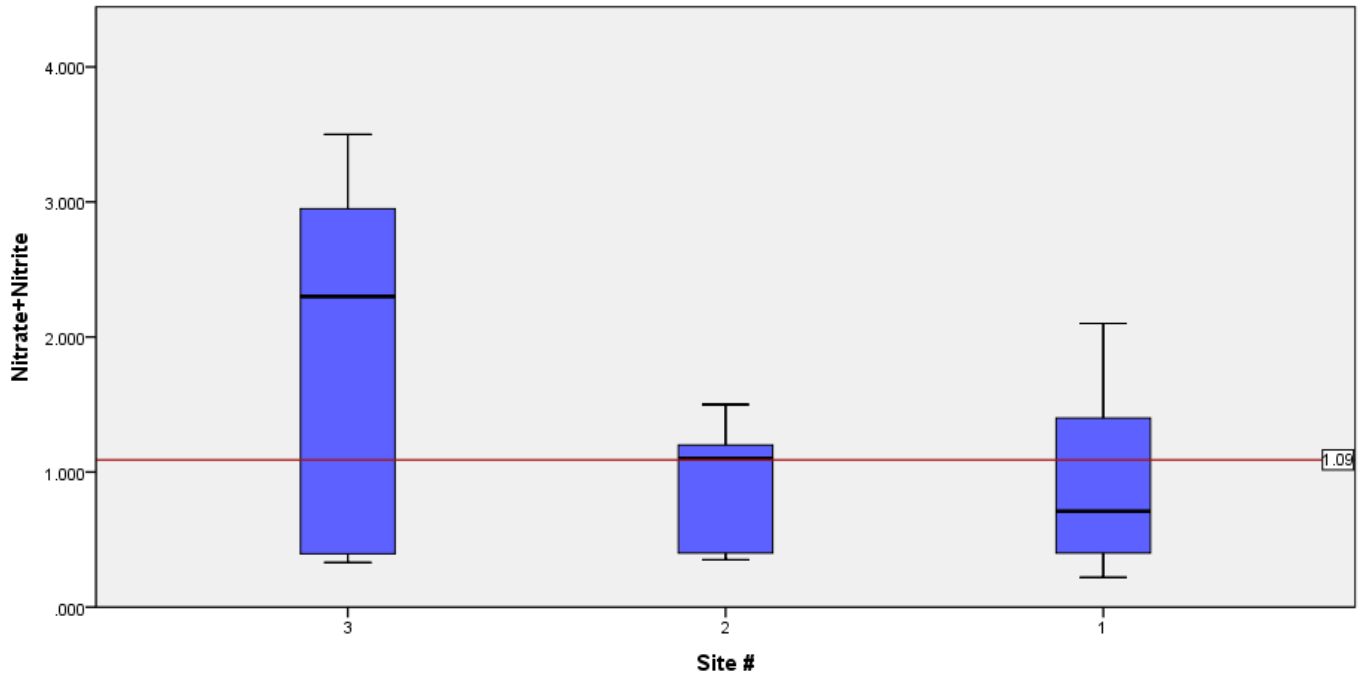

Figure 197 Box plot illustrating nitrate concentrations within the Willow Creek Subwatershed

Figure 198 shows that all site median total Kjeldahl nitrogen concentrations fell between the 1.27 and 0.4 mg/L thresholds. Site 1 consistently had the highest concentrations observed during the study period.

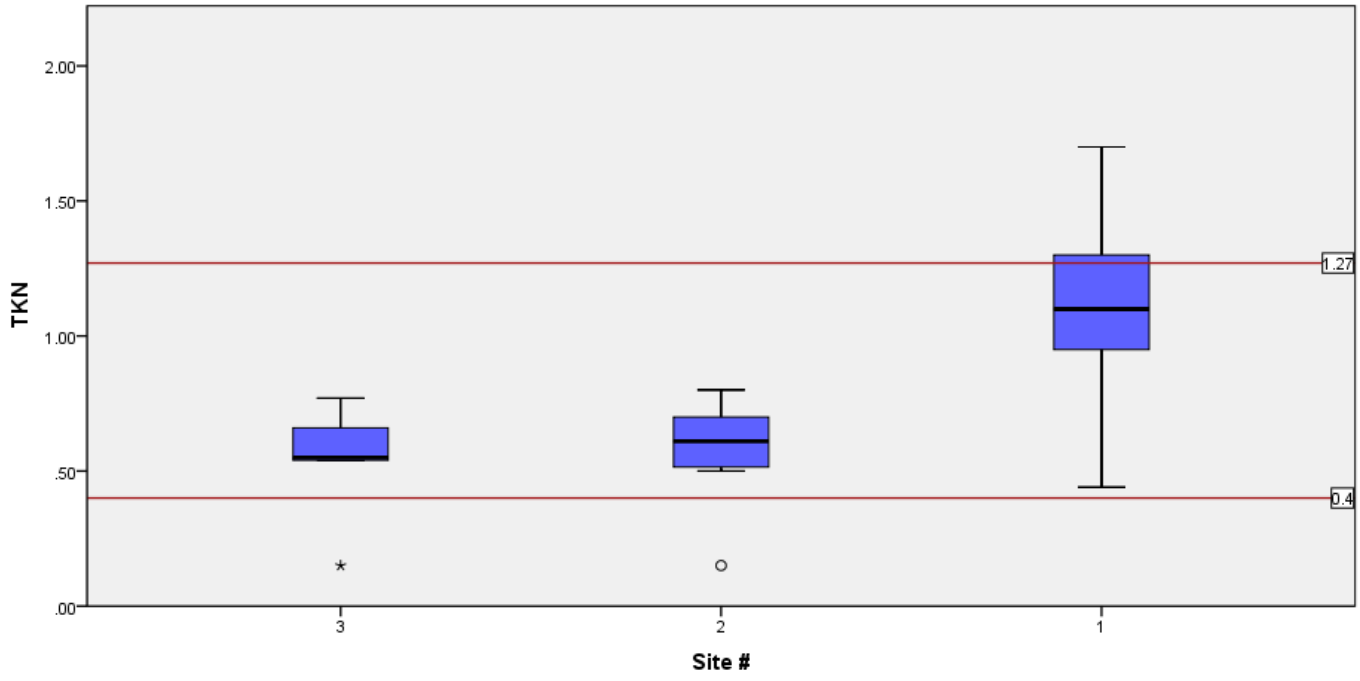

Figure 198 Box plot illustrating total Kjeldahl nitrogren concentrations within the Willow Creek Subwatershed

Figure 199 shows that none of the sites exceeded the maximum ammonia threshold of 0.21 mg/L. However Sites 1 and 3 have median concentrations above 0.03 mg/L threshold. Ammonia concentrations at Site 2 were typically

below laboratory detection limits. The maximum concentrations observed were 0.17 mg/L at Site 1, 0.20 mg/L at Site 2, and 0.16 mg/L at Site 3.

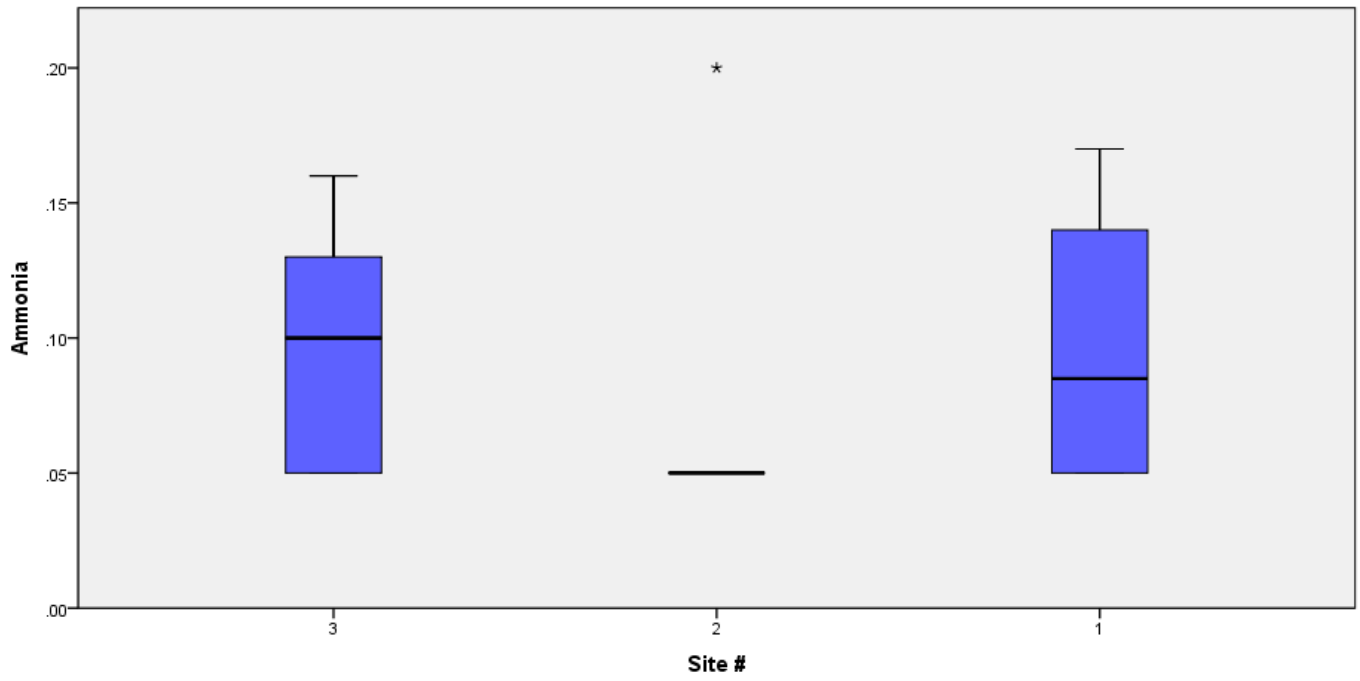

Figure 199 Box plot illustrating ammonia concentrations within the Willow Creek Subwatershed

4.9.2.8 *Suspended Sediment & Turbidity*

Figure 200 shows that site median total suspended solids concentrations fell below the 30 mg/L threshold.

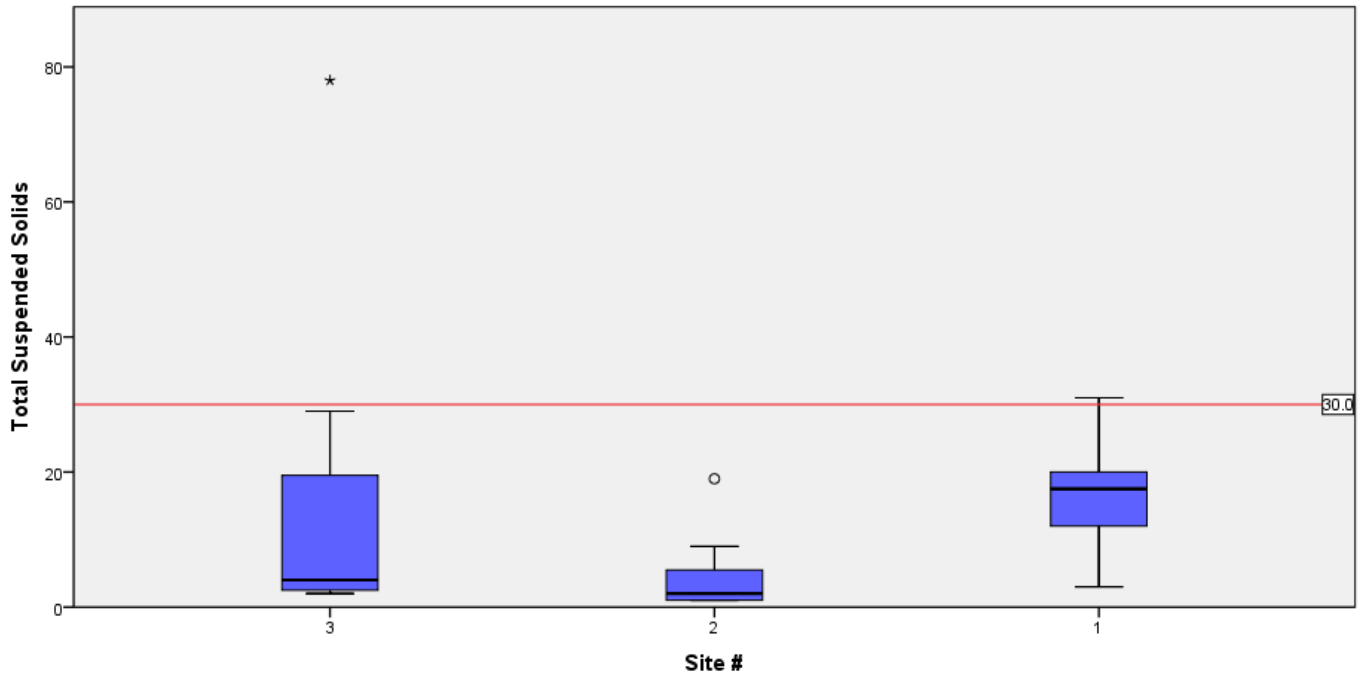

Figure 200 Box plot illustrating total suspended solids concentrations within the Willow Creek Subwatershed

Figure 201 shows similar site trends in turbidity levels to those observed for total suspended solids above. Median turbidity levels at Site 1 exceeded the 10.4 mg/L threshold.

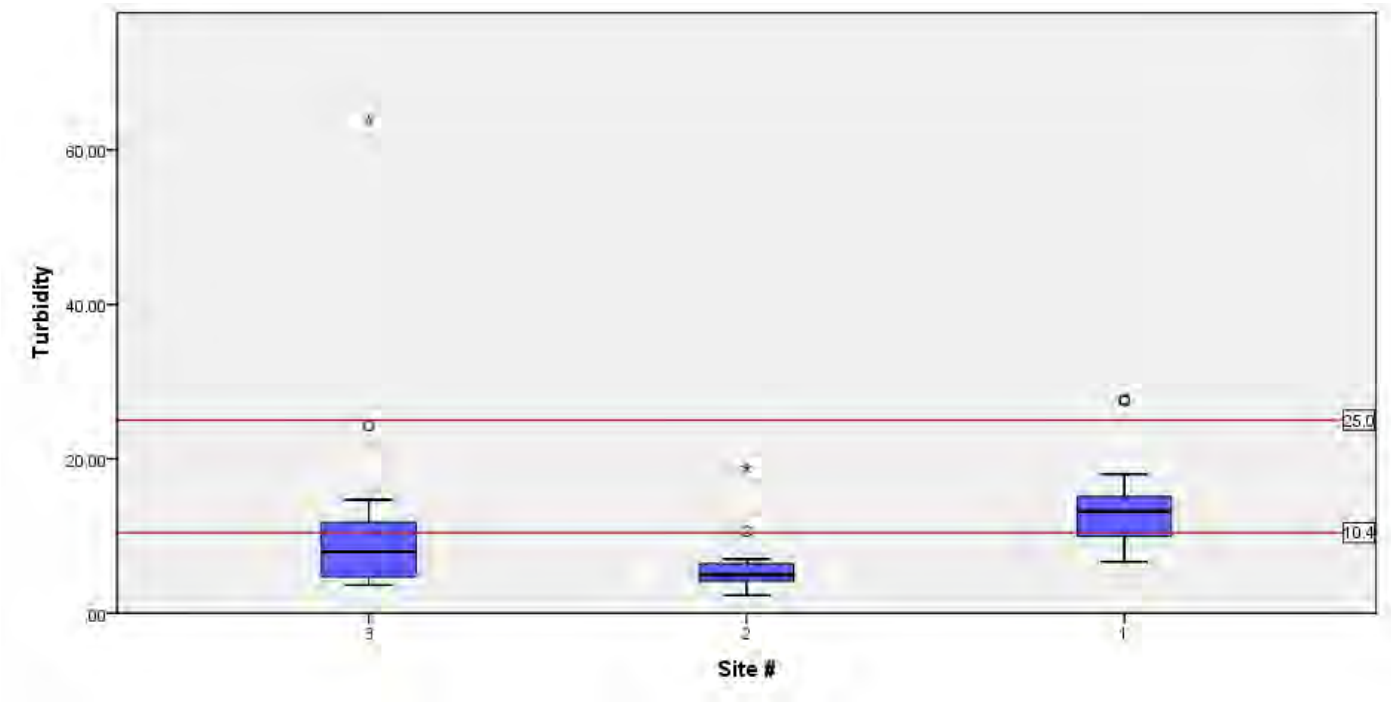

Figure 201 Box plot illustrating turbdity levels within the Willow Creek Subwatershed

4.9.2.9 *Habitat*

Figure 202 shows that Site 1 on Burns Ditch and Site 3 on Willow Creek generally do not possess habitat quality conducive of supporting a healthy warm water fishery (QHEI <51). The major habitat limitation at these sites include poor channel morphology and instream cover as well as relatively poor substrate quality. The habitat evaluation forms showed both of these stream reaches had been channelized in the past but were beginning to show some level of recovery. Upstream and downstream site photos at each site show the typical trapezoidal channel cross-section associated with drainage improvement. Channel stability was documented as moderate to low respectively. Substrates at Site 1 were primarily characterized as sand with strong inclusions of muck and silt. Silt cover and embeddedness were moderate. Substrates at Site 3 were characterized as sand with normal silt cover and embeddedness. Habitat complexity was low at each site and the amount of cover was sparse.

While Site 2 was found to have habitat quality that is generally conducive to supporting a healthy warm water fishery, the stream reach may be atypical in the Willow Creek system. Fish and macroinvertebrate assessments indicate that the reach is biologically impaired. The number of species and individuals collected were some of the lowest in the entire watershed. There does not appear to be a clear link between the biotic impairment and water quality. An inquiry to the DNR about any reported or documented fish kills came back negative which helped eliminate an episodic event. Further investigation points more towards a biotic response to a habitat stressor. Site visits conducted with City of Portage staff upstream and downstream of Site 2 showed areas of channel instability (slumping banks, unvegetated mid-channel and side bars, and leaning trees) and limited to no access to floodplain.

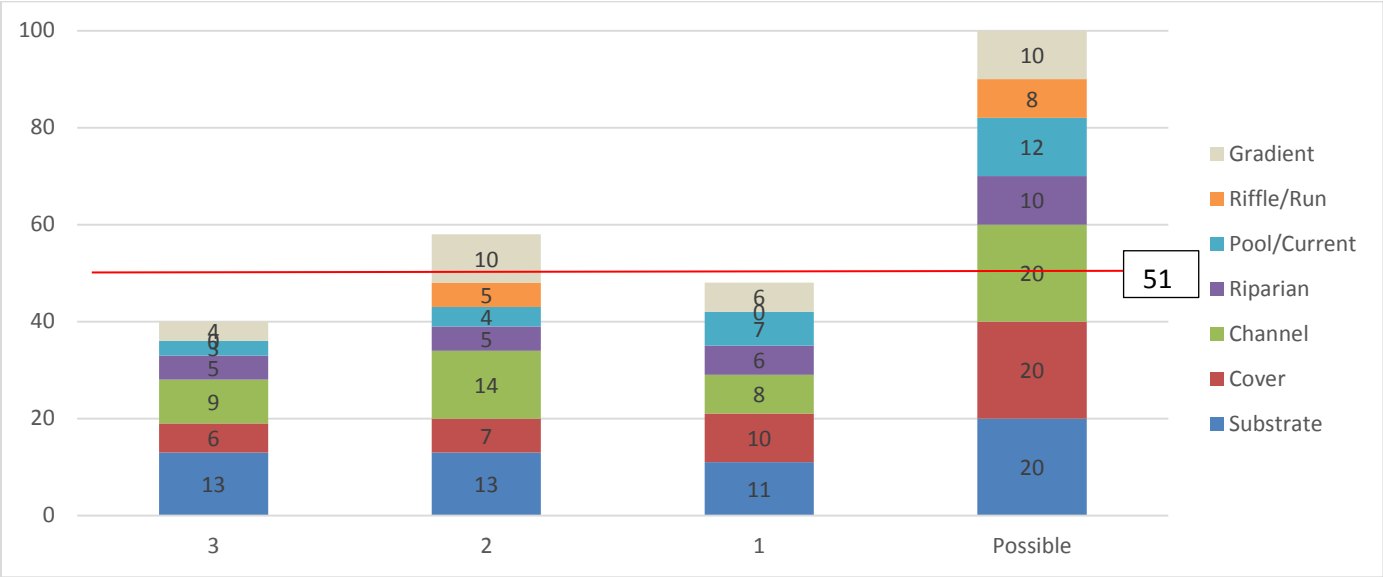

Figure 202 Site qualitative habitat evaluation index scores within the Willow Creek Subwatershed

The poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. Site 1 located on Burns Ditch is maintained as a county legal drain as are two of the tributaries to Willow Creek (Figure 204). Willow Creek is not a county legal drain, however, the City of Portage maintains it to improve drainage.

4.9.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed lands (56%) followed distantly by agriculture (20%) (Figure 203). Portions of Gary, Lake Station, New Chicago, and Portage are located within the subwatershed. Almost the entirety of Willow Creek's drainage area is located within Portage. There is one combined sewer overflow located on a ditch that feeds into the Little Calumet River in Gary. Most of the urbanized areas within the subwatershed are sewered.

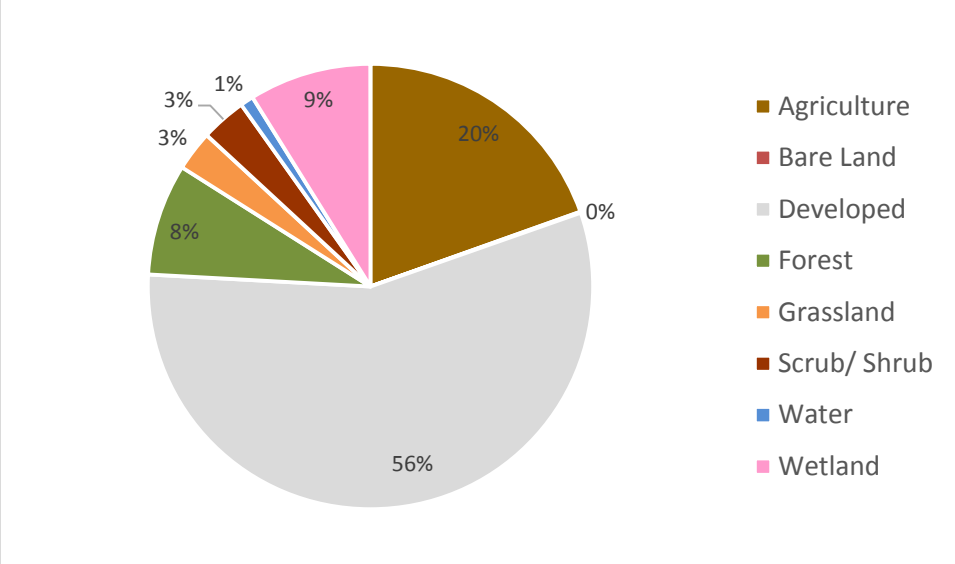

Figure 203 Percent land cover within the Willow Creek Subwatershed

Table 80 includes land cover information for each site's drainage area. Site 1 has nearly an equal mix of agricultural and developed land within its drainage area. Most of its agricultural land lies directly adjacent to the Little Calumet River between Interstate 80-94 and Interstate 90. Site 2 and 3's drainage areas are primarily developed except for the southernmost extent which is agricultural. No substantial natural cover is apparent along the Little Calumet River buffering it from adjacent land uses, however patches of forest and scrub/shrub habitat can be observed along portions of Willow Creek (Figure 204).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
3	46.7	0.0	45.4	1.8	2.5	1.8	0.2	1.6
2	29.3	0.0	56.4	6.2	1.7	3.1	0.1	3.1
1	28.5	0.3	43.8	9.5	5.9	3.5	0.9	7.7

Table 80 Site percent land cover within the Willow Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 81. There's a relatively equal contribution of human and natural land cover types within Site 1 and 3's riparian zones. The riparian zone in Site 2's drainage area is predominately developed with agriculture making a very small contribution.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
3	22.4	0.2	27.6	9.8	4.9	5.7	3.1	26.2
2	1.6	0.0	56.6	15.0	3.3	12.7	0.3	10.5
1	22.4	0.2	27.6	9.8	4.9	5.7	3.1	26.2

Table 81 Site percent riparian land cover within the Willow Creek Subwatershed

The TMDL identifies six NPDES industrial facilities that discharge to a waterway in the subwatershed. See TMDL for facility locations map). The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. The Portage WWTP and a SSO outfall are located on Burns Ditch downstream of Site 1 (Figure 204). The TMDL documents four inspections occurred between 2010 and 2013. Violations were observed in 2013.

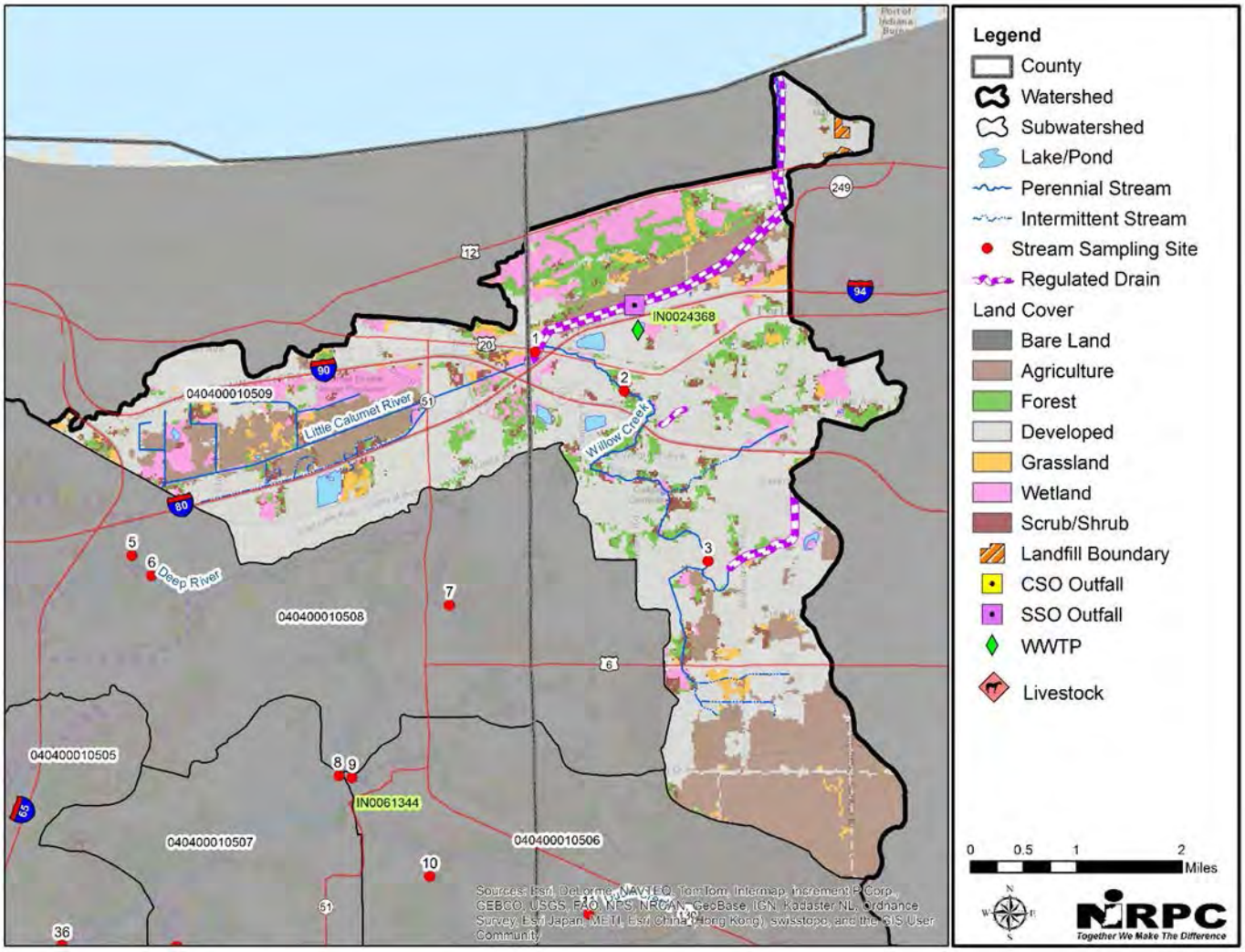

Figure 204 Land cover and land use within the Willow Creek Subwatershed

4.9.4 Soils

Figure 205 shows an extensive amount of both hydric and highly/ potentially highly erodible soils within the subwatershed. Most of the wetlands that these hydric soils developed in along the Little Calumet River were drained sometime around the 1920's when the river was channelized. Today many of these soils are either in agricultural production or have been developed on. The soils classified as highly erodible/ potentially highly erodible have also been developed on to a large extent except for the agricultural lands south of US Highway 6.

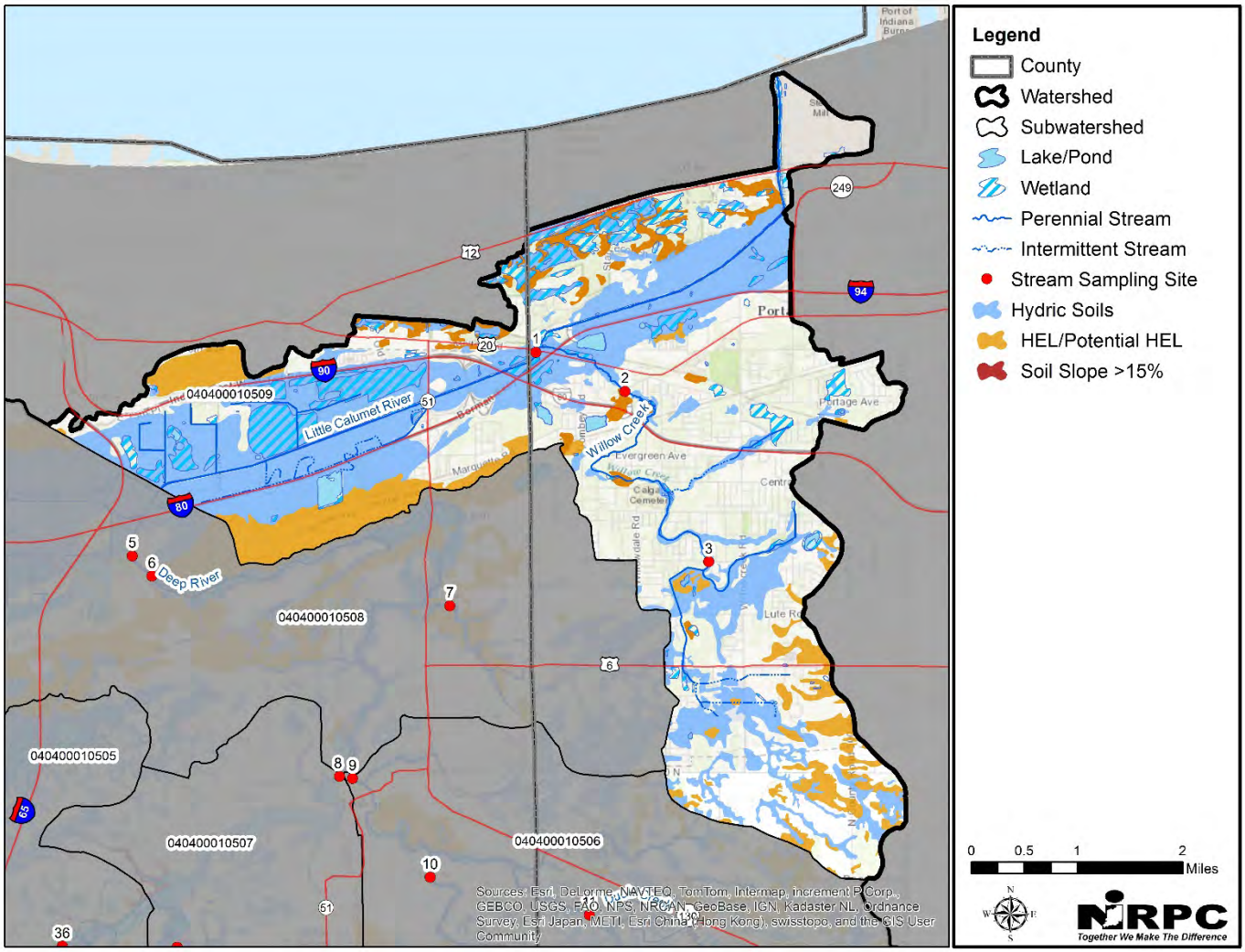

Figure 205 Soils within the Willow Creek Subwatershed